MIT UNIVERSITY'S – ABHIVRUDDHI JOURNAL

ISSN(Online): 2584-1025

VOL.2 (01) , JUNE , 2022 pp- 1- 8

Analysis of Robotic Process Automation Tools

Anand Pandey[1]
Department of Mechanical Engineering
MIT Art, Design & Technology
Pune, India
pandeyanandkumar218@gmail.com

Sandeep Thorat[2]
Department of Mechanical Engineering
MIT Art, Design & Technology
Pune, India
sandeep.thorat@mituniversity.edu.in

B.K. Patle[3]
Department of Mechanical Engineering
MIT Art, Design & Technology
Pune, India
bhuvneshwar.patle@mituniversity.edu.in

Abstract— The speed at which various operations are carried out, and therefore efficiency, becomes a significant aspect in this period and time when consistency is demanded from all sectors of the nation. Robotic Process Automation (RPA) is employed to meet these systems' accelerating requirements. Robotic process automation will hasten business administrative tasks, distant IT management jobs, and resource preservation in a range of industries. The purpose of this study is to analyze three of the top RPA platforms: UiPath Studio, Automation Anywhere, and Blue Prism. Many software platforms have been developed to deploy RPA. Our studies will be useful to commercial industries, not just Blue Prism. Our analysis will help the business sectors choose the platform that will work best for front- and back-office workers working together. The speed at which various operations are carried out, and hence efficiency, becomes a significant aspect in this period and time when promptness is demanded from all sectors of the nation. Robotic Process Automation (RPA) is employed to meet these systems' accelerating requirements. Robotic process automation may speed up administrative activities in business, remote management jobs in the IT industry, and resource conservation across a variety of industries. Several software platforms have been created to deploy RPA, and the goal of this study is to analyse three of the top RPA platforms: UiPath Studio, Automation Anywhere, and Blue Prism. Our study will assist the business sectors in identifying the platform that is best suitable for usage by front-office and back-office staff alike.

Keywords— Robotic Process Automation, UiPath, Blue Prism, Automation Anywhere, Structured Analysis

I. INTRODUCTION

Process automation is a method for automatically controlling manual or logical operations. Industry automation systems may now be used in every sector thanks to recent technological advancements. Hard automation and Soft automation are the two main divisions of process automation. Soft Automation (flexible automation) is a developed form of Hard Automation (fixed automation), as it permits the programming of various tasks in accordance with the requirements of the products. A machine or robot built to carry out a defined yet repeated duty is referred to as hard automation (fixed automation). Soft automation includes robotic process automation. Soft automation includes robotic process automation (RPA).[1,2] To lessen the stress of repetitive jobs, robotic process automation is software that may be configured to automate a range of manual operations carried out by human workers. A workflow with several phases and functions—such as receiving data, writing data, doing mathematical operations, updating and modifying data, etc.—is taught to the software bot. Many technologies, including UiPath Studio, Automation Anywhere, Blue Prism, Workfusion, Redwood, and Kryon, are now being utilized for RPA. [3]

A. What Is Robotic Process Automation?

Robotic process automation results in significant labour and time savings. It saves money in addition to time. Robotic process automation is characterised by intelligence, scalability, and independence from platforms.

Any RPA system has to be able to communicate with other systems via API integration or screen scraping, make judgements, and offer a programming interface for bots.

RPA Tools do not require any programming expertise to utilise. Small, medium, and large-scale businesses can employ RPA tools, but these companies should be able to heavily rely on the programme. [4-6]

B. What is RPA Software?

In order to carry out "if, then, else" statements on structured data, robotic process automation (RPA) systems commonly combine user interface (UI) interactions with application programming interface (API) connections to client servers, mainframes, or HTML code. An RPA tool is put into action by authoring a script in the RPA tool language, which the software "robot" will then follow; runtime is managed through the use of a control dashboard.

Robotics refers to a software-based solution that is designed to carry out repetitive activities, processes, or procedures that are typically carried out by people. As it was just recently introduced, this idea has gained acceptance and is often employed. The purpose of this research is to provide an introduction to the fundamentals of RPA, as well as to some of the technology components that support transactions, data alteration, response-triggering, and communication with other electronic systems.

According to the definitions provided, there are no real physical robots (i.e., hardware) and the goal of RPA is to simply develop an intelligent computer programme that can "learn" how to accomplish a straightforward task that will be carried out repeatedly. RPA is being used in normal business operations by many big organizations, including Amazon, Airtel, Ernst & Young, and American Express.[7 - 9]

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II. ROBOTS

A robot is a machine that is electromechanically constructed, completely automatable, and capable of doing a variety of challenging tasks on its own. A robot must travel into the real world to complete a mission. These robots' perception and behavior are connected in extremely complex ways. Robotics must heavily rely on AI if there is to be an intelligent relationship between AI and robots (Brady, 1985). Electrical, computer, and manufacturing systems engineering are only a few of the multidisciplinary scientific and engineering fields that go under the umbrella term "Robotics". A robot is a machine that is electromechanically constructed, completely automatable, and capable of doing a variety of challenging tasks on its own.

In order for a robot to successfully perform its goal, it needs to venture out into the real world. The perception and behaviours of these robots are intricately related to one another in a variety of ways. According to Brady (1985), in order for there to be an intelligent link between AI and robots, robotics must heavily rely on artificial intelligence (AI). The umbrella word "Robotics" encompasses a wide variety of subfields within the scientific and technical communities, including but not limited to electrical, computer, and manufacturing systems engineering. [10,11]

By this decade, 10% of significant businesses operating in sectors that strongly rely on supply chains will have a qualified worker acting as their chief robotics officer on a day-to-day basis. by Ankush and Douglas in 2017. Robot demand from consumers has increased dramatically. Artificial intelligence technologies are frequently used in industrial settings, especially those that are compatible with robotics. The robots perform better in a variety of applications, including assembly, auditing, driving, warehouse logistics, caretaking, package delivery, home cleaning, and surgery, by utilizing wireless connectivity, big data, cloud services, numerical deep learning, accessibility, and other resource sharing (Kehoe, B. et al., 2015). Assembly, auditing, transportation, warehouse logistics, caring for others, and surgery are a few of these uses. Swarm robotics is a cutting-edge method of managing a number of very basic robots. It draws inspiration from the cooperative behavior of social insects. [12,13]

According to Palgrave and colleagues (2000), the term "evolving robotics" refers to an innovative technique for the automatic generation of self-sufficient robots. This viewpoint, which was influenced by Charles Darwin's theory of natural selection and the phrase "selected reproduction of the fittest," envisions robots as autonomous artificial animals that learn their distinctive skills via continual contact with their environment without the assistance of humans. This viewpoint was shaped by Darwin's theory of natural selection. The development of co-adaptation and compatibility between service robot systems and supportive environments, in both a physical and an informational sense, is the primary emphasis of the field of ambient robotics. Using 3D visualisations, facility planners are able to generate alternative designs, programme robot courses, plan system layouts, collect data for discrete event simulations, and develop cell control programming.

The use of robotics in mundane tasks will become commonplace very soon.

C. Process

The word "Process" is frequently used and even directly influences how individuals go about living their everyday lives. It acts as the activity to complete a job and is a vital component of any system or organisation. One person or item, or a mixture of both, can do the task. No matter if the platform is closed or open, the process requires input from a variety of tools or users and is carried out in accordance with predetermined rules in order to create the required result. The procedure does nothing other than convert input to output. Yet, each technique or system has a unique set of time requirements, costs, labour requirements, and other quality criteria. Several process systems, including as admission, biological, manufacturing, and chemical systems, are well known to people. Analyze how a computer processing system renders.

A. tomation

"Automation" refers to the process of automating a tool, a technique, or a system. On the other hand, automation is already being put to use in ways that are advantageous to society. The computing power of any system can be utilised in robotics. Automation is a challenging process that requires the integration of people and systems. Integration is important. In the design of systems, human elements, particularly cognitive ones, are frequently neglected or handled incorrectly (Sheridan, 2002). A system for the creation, editing, running, checking, and repairing of application programmes for industrial automation mechanisms that involve logic, motion, and/or process control components. This system can be used to create, modify, run, check, and fix these application programmes. The curb energy system is utilised to monitor the amount of energy that is used in residential settings. [14]

A few of the more contemporary examples of smart home appliances include the Ecobee3 Intelligent Wi-Fi, Alexa, and Lutron Dimmer Light Switches. The embedded hardware and software in these intelligent gadgets allows them to carry out tasks on their own. According to Madakam (2015), the most impressive attribute of these high-tech devices is how they improve the quality of human life, the efficiency of processes, and the management of specific issues in circumstances in which the presence of humans is entirely impractical.

Automating routine jobs not only saves people the effort of doing them themselves but also frees them from the tedium of doing the same thing over and over again. These improvements have been made possible by advances in technology. The following is a list of the most advanced automation technologies now available for driverless or autonomous cars, including artificial intelligence and machine learning. Cognitive computing is used in autos that are connected to the internet of things as well as cooperative robots. The industrial sector has already begun using automation, or more specifically, the already available

ISSN(Online): 2584-1025

"Industry 4.0" technology. The robots are responsible for the majority of the work that is done on the assembly lines.

Fig 1-What are the benefits of the RPA [23]

III. Robotic Process Automation Operations

Robotic process automation activities do not have any recognized models of standardized operation that have been established. An illustration of RPA activities is provided by M/s. Info-Cap Networks LLC (Info-Cap), which is located in San Francisco, as well as by Mr. Kristina Romero and his technical staff. This technology paradigm, which automates manual work that is more labor-intensive, time-consuming, and visibly error-prone, will replace the entire company's system operations (Kristina Romero, 2017). This will result in the company's system operations being obsolete. The capacity of "Digital Labour" to reduce costs, errors, and dangers is the primary benefit of "Digital Labour" in this view [15-17]. The operational advantages offered by the RPA can be extremely beneficial to a wide variety of transdisciplinary businesses.

Credible Corporate Transformation: The implementation of corporate procedures will undergo significant adjustment as a direct result of the implementation of the new RPA technology. Because of the use of robotic process automation, companies may now significantly improve the effectiveness with which they utilise their labour by complementing a more productive staff with digital labour that is reliable, efficient, and competitively priced. This is made possible by the utilisation of RPA. Because of this, businesses now have the opportunity to cut expenses, as well as errors and risks.

Migrations of content: There is a massive amount of material being produced by all enterprises. If data collection, analysis, and report preparation become more complicated in everyday operations, there is a possibility that labour will be required. Businesses and organisations can only benefit from robotic process automation because it makes transferring content or making links to legacy systems more quickly and simply. This will speed up the consolidation of applications and the integration of older applications. Robotic process automation can only assist.

Web Crawling and Open Source Intelligence Robotic Process Automation (RPA) automates the process of collecting content in any format and from any source using a range of different types of equipment. Formats in the form of text, images, audio, and videos can all be produced. There are three possible formats for the presentation of the data: structured, semi-structured, and unstructured. This robotic process automation solution is able to acquire data from the deep web since it makes use of deep learning techniques.

According to the blog of the IT Department Enabler, robots are "software programmed to mimic the human conversations as well as implement a repetitive process, governing tasks like obtaining and contrasting data from various systems, reading from and composing to datasets, or retrieving and reconfiguring information into dashboards and reports." Robots are a key enabler for the IT Department. They keep a close eye on the hardware, the software, and the networking in order to spot any abnormalities and ensure that everything runs smoothly.

Fig 2-RPA Operations- Kristina Romero [11]

A. Overview of RPA Software

Robotic process automation (RPA) systems frequently mix user interface (UI) interactions with API connections to either power client servers, mainframes, or HTML code in order to execute "if, then, else" statements on structured data. [18-20].

B. Types of Robotic Process Automation

- Automation processes carried out by these tools will need to be attended by a human.
- Unattended automation: These devices have intelligence and the ability to make decisions.
- The features of both attended and unattended automation tools will be merged in hybrid RPA tools.

C. Industries utilising RPS

The banking, insurance, retail, manufacturing, healthcare, and telecommunication sectors are the principal users of robotic process automation.

- Healthcare: It will assist with scheduling, patient data entry, processing insurance claims, billing, and other tasks.
- Retail: It assists the retail sector with updating orders, notifying customers, shipping goods, tracking shipments, etc.
- Telecommunications: It will assist the telecommunications sector in monitoring, managing fraud data, and updating customer data.
- Banking: RPA is used by the banking sector to increase job efficiency, data accuracy, and data security.
- Insurance: To manage work processes, enter customer data, and create apps, insurance companies employ RPA.

ISSN(Online): 2584-1025

- Manufacturing: RPA tools support supply chain operations in the manufacturing sector. It aids in the administration, reporting, data migration, customer services & support, billing of materials, etc.

D. RPA-Operating Model Design

In their seminal piece from 2017, Rodger Howell and Tom Torlone emphasized the development of robotic process automation technology. They correctly noted that pilot programmers are where robotic process automation is actually coming from. To improve operational efficiency and cut costs, enterprises must create their own RPA models. These authors intend to convey that different businesses and industries have different RPA operational models. They believe that the operating models for robotic process automation are not "one-size-fits-all." But the core of an efficient RPA operating model revolves around three crucial roles.

E. Process Architects

There are many different kinds of processes, such as round robin, priority, First Come First Served (FCFS), and Last in First Out (LIFO). Process engineers are in charge of defining each process in both centralised and decentralised process systems. They must first understand how the present system works, find any holes in its design, and handle jobs while keeping in mind time limits, cost savings, and how well the system works. In some ways, the business experts are also in charge of automating processes. Process engineers come up with the methods, steps, and standards for the robotic process automation system. [21-23]

F. Technologists

There are more businesses on the market right now. These are the programmers who write the code based on the software requirement specs and feedback from the functionalists, designers, and executors (SRS). All of this coded software can help take care of routine jobs automatically and without human help, but only to a certain extent. RPA tools require less complicated technical knowledge than traditional application development.Staff for Ongoing Help and Maintenance.

They do the new tasks that have been automated and change the code as needed. To do this, a software provider or supplier will usually sign an annual maintenance deal. If the system software or apps have bugs or don't work right, they are easy to fix. They offer expert help 24 hours a day, every day of the year. This kind of technical help cuts down on the time and money needed to hire technical staff on the inside. There wouldn't be any costs for training. Continuous support plans are made by the companies to meet the needs of their business clients, not the needs of the general public. Whether a customer wants help with a specific problem or weekly reviews and advice, there is a package that will meet their needs and give them full peace of mind.

IV. Advance technology used in RPA

Business Process Outsourcing (BPO) companies have used RPA for a long time, and more and more end-user businesses are now using the technology on their own to build "virtual workforces" of robot workers. The word "robotic process automation" means that technology is used to do routine work that a person would normally do. The technology mimics an end user by doing things like going through an app or filling out forms like a user would, based on a set of rules (Barnett, 2015).

RPA is a type of cutting-edge artificial intelligence, along with virtual agents, machine learning, computer vision, and the classification of natural language. The insurance business can use artificial intelligence in a number of ways, such as by using image categorization for claims and text analytics for customer service. Because of these new technologies, more insurance processes will be automated and made better.

Blue Prism's programme for robotic process automation gives you some of the best choices, such as:

I. les-based processing with digitally organised data for catching fraud and activating credit cards

II. plex or mission-critical processing tasks, like cashing out a pension or balancing the books, involve repeated transactional tasks, like swapping SIM cards or processing invoices.

III. transaction volumes, like taking orders for new phones or bills, and problems with process adherence or quality, like policy renewals or policy migrations.

IV. ctuations in demand or backlogs, like those caused by the launch of new goods, or "Swivel Chair" procedures, like hiring new employees for human resources or launching a new online service without any integration

M/s. UiPath is at the forefront of the worldwide digital business revolution because of its ability to facilitate the rapid deployment of software robots that greatly improve corporate efficiency, compliance, and customer service across both back-office and front-office processes. According to UiPath, robotic process automation (RPA) systems are able to perform a wide variety of operations, including login into programmes, moving files and directories, copying and pasting data, filling out forms, extracting structured and semi-structured data from documents, scraping browsers, and more. As of March 6, 2018, UiPath was valued at $1.1 billion after receiving an investment of $153 million from Accel, CapitalG, and Kleiner Perkins Caulfield & Byers. Accel led the funding for the investment.

An additional prime illustration of RPA's usefulness in commercial settings is provided by the platform known as Automation Anywhere. This cognitive robotic process automation tool was developed with the goal of automating every business process that may be found in a contemporary company.With the help of the Automation Anywhere Bot Store, which is offered by the Automation Anywhere Company, businesses are now able to construct their digital workforce at a rate that is significantly faster than in the past. This results in an increase in the productivity of human workers and makes it possible for them to focus on more projects that are beneficial to people. For more than 10

ISSN(Online): 2584-1025

years, the most successful companies in the healthcare, financial services, technology, manufacturing, and insurance industries have depended on the M/s. Automation Anywhere organisation to deliver the highest quality robotic process automation and cognitive technology available anywhere in the globe.

Another UK-based specialist automation and cloud consulting company, M/s. Endpoint Automated Services (EAS), is expanding its breadth of automation expertise to the realm of robotic process automation, according to the M/s. Endpoint Automated Services Company. Robot automation can take on a variety of forms, some examples of which include automating a commercial process from start to finish as well as data entry into a financial accounting system. Robotic process automation has enabled the automation of tasks that were previously thought to be impossible to automate, such as those involving the use of the Microsoft Office software suite. RPA has emerged as the dominant codeless automation tool. The robots can be taught to scrape the screen, and once again, they are instructed to locate anchors on the screen rather than utilising a pixel-based coded screen scrape, which is more limited. The information that we have comes from M/s. Endpoint Automated Services Company.

K. RPA Application in Airtel

One of the most effective applications of robotic process automation is in the field of business process outsourcing. The software takes the place of a large number of technical staff employees and performs the same kind of routine work while offering round-the-clock technical help. It's possible that the clientele is dispersed across the entire country. This application is the best one for lowering the amount of labour that is necessary for processes that are performed frequently and continuously. On the other hand, some of the available personnel has been set aside for future responsibilities. For instance, the majority of the fundamental and everyday technical help tasks that the Indian telecom operator Airtel is responsible for are carried out by means of software. The same can be said about the ease with which chores can be completed in various local languages.

To receive support from Airtel operators for whatever reason, customers can contact the toll-free number provided at no cost to them. As a result of this, the programme supports a variety of languages as well as payments, caller tunes, ringtones, internet data usage, sim loss, and new tariff plans, among other things. In order to make use of any of these options, all you have to do is press one of the numbers 1–8 on the number pad, and depending on the characteristics of the option, this will cause it to be enabled. Additionally, voice input is supported. [25-27]

L. Methodology

The automation of robotic processes is currently considered to be one of the most cutting-edge technologies in the fields of computer science and information technology. Automation of robotic processes is a relatively recent development as a field of study. There is a lack of consensus among experts on its precise significance, and there is no consensus regarding its operational definitions, connotations, tried-and-true models, or derived theories. It carries with it an air of daring and excitement. As a result, the data that was utilised in the creation of this research study came from a wide variety of secondary sources that are available online. These secondary sources include research journals, company white papers, expert blogs, topical videos, and so on. Between the months of April and June of 2018, the information was gathered. In order to locate the study publications, the terms "Robots," "Robotic Process Automation," "Artificial Intelligence," and "AI" were utilised. The search engines Google and Google scholar are utilised in order to locate the articles contained within the databases. Auxiliary data was collected, compiled, analysed, and narrated in a thematic fashion so that a greater understanding of the phenomenon of robotic process automation could be achieved. The descriptive research subfield of exploratory study is the appropriate one to assign to this investigation.

M. System Overview

UiPath

In 2005, an outsourcing company was the pioneer in adopting the use of UiPath. They recognised the need for RPA (Robotic Process Automation) in response to the growing demand in the market, and as a result, they began developing a platform that meets industry standards for the management and training of software robots. Their source code is used on millions of computers all over the world, and it is incorporated into a wide range of products and businesses. Some of the activities that these goods and businesses perform include document management, call centres, healthcare, finance, data migration, process automation, and API enablement.

UiPath Orchestrator is the component that makes it possible to orchestrate robots. The UiPath Studio module is a piece of software that functions as a tool that allows for the development and maintenance of connections between robots, in addition to the convenience of package transfer and the management of queues. In addition to that, it makes it possible to build, model, and carry out workflows.

These features can be found in greater detail in a number of Artificial Intelligence techniques or algorithms, the most notable of which are recognition, optimisation, classification, and information extraction. These features are currently accessible through the UiPath tool through its UI Automation module, and they are disclosed on the tool's official page [28]. When it comes to the algorithms used by AI, the information that is examined makes use of character and picture recognition, optimisation, and classification.

Features:

- t provides security by managing credentials, offering encryption, and establishing access controls based on the user's function in the organisation.
- t has a faster capacity for automating processes. In addition, the speed of automation using Citrix is increased by a factor of eight to ten.

- t provides a free platform, and it is possible to manage any process, regardless of how complicated it may be, in any number.

Pros:

- he user does not require any prior understanding of programming to use it.
- ser-friendliness made possible by the drag-and-drop functionality.
- t provides a variety of helpful features at no additional cost.

Cons:

- here are just limited coding capabilities available.

Automation Anywhere

Tethys Solutions, LLC changed its name to Automation Anywhere, Inc. in 2010. The company's products are made to enable the execution of automated business and IT operations across numerous workstations, taking into account differences in system configurations, application load times, and Internet speeds. Users can create automation processes with centralised security, user management, collaboration, deployment, and backup using the Server edition, which is offered. Another tool designed for RPA processes is called Automation Anywhere, which has the unique ability to inform users about the applicability of AI methods and algorithms.

RPA is used in conjunction with a process referred to as "Digital Workers," which is the most automatic or intelligent method. A cognitive automation module as well as tools for applying data analysis to RPA operations are both included in the RPA toolkit. Because it is a multipurpose piece of software, it provides a collection of information that enables the configuration, utilisation, and deployment of RPA processes. The Bot tool of the Automation Anywhere tool uses a variety of artificial intelligence strategies and algorithms, such as fuzzy logic, artificial neural networks, and natural language processing, in order to extract information from documents and, as a result, improve the efficiency of document validation. This is accomplished by using the tool's internal execution of these strategies and algorithms. In this regard, it would appear that the IQ Bot platform, which is the driving force behind the Automation Anywhere intelligent word processing application, is in the process of making some AI strategies or algorithms available to users.

Contains the following features: offers security on par with that of a bank; provides security by means of credentials, encryption, and authentication.

- nalytics and reports generated in real time.
- nables compatibility with multiple operating systems.
- ser-friendliness is a strong point.
- ons: There is room for improvement in IQBot.

Blue Prism

Blue Prism was founded in 2001 by a group of people that specialise in the automation of business processes with the intention of developing software that would improve the productiveness and efficiency of companies. They focused their efforts on the white-collar back office, where they observed a significant demand for automation that was not being satisfied.

Among its features are the following:

- t enables the deployment model for various environments.
- t offers security for both network credentials and software credentials.

V. SULTS AND DISCUSSION

1.0 COMPARATIVE ANALYSIS:

We have included in the table below the factors that we believe to be the most relevant when comparing the best three RPA platforms to one another. The primary criterion determines whether or not the front and back offices can be computerized and automated. The capacity of an automation tool or platform to automate the very early phases of an industry is one of the most important factors determining its first level of success. After that, the Script Based Designer and the Visual Process Designer are shown to the user, and it is at this point that we establish whether or not a certain tool possesses a graphical user interface. The openness of a platform reveals whether or not the information necessary to use the tool, learn how to use it, and practise using various apps is made available to anybody and everyone. Macro recorders make it possible to apply designs and codes more quickly, which leads to faster development.

The manage by Coding criterion is essential because it demonstrates how well a user can manage how the software operates and the bots that it makes use of. The ability to execute automated test cases on remote machines is a critical factor in determining the level of protection offered by the solution. If there is a tool that can fulfil the requirements listed above without putting users' safety at risk, then significant headway will be made in this area. In terms of the fifth and final parameter, the future scope of a tool is what decides how valuable it will be once other technologies have advanced to an adequate level. UiPath is unequivocally the best option in this regard since, in contrast to the other two options, the endlessly flexible coding algorithms it employs make it possible to cover an infinite range of applications in the future.

A purely objective analysis may not be sufficient to convince the key stakeholders in various industries. This necessitates a thorough examination and comparison of the technical features of the tools. The performance evaluation of the several tools has been collated and organised in a table, categorised according to numerous technological aspects. The data presented in this report is derived on an analysis of reviews on RPA technologies undertaken by various enterprises, as well as our own firsthand experience with the implementation of UiPath. It is important to note that UiPath was the sole product available for examination throughout the period of our inquiry. [30]

The script-based design of Automation Anywhere enables the execution of core functionality and bot development with enhanced accuracy. However, because to its reliance on

ISSN(Online): 2584-1025

scripts, the number of users may be comparatively lower. UiPath and Blue Prism demonstrate exceptional proficiency in various domains, such as control room operations, system administration, reporting, and resilience. [31-32] These domains encompass the operational prerequisites and components of the aforementioned tools. The level of analytical proficiency exhibited by the RPA technology is denoted by the RPA Analytics rating. One notable feature of Automations Anywhere is its exquisite architectural design. Analysis refers to the mentioned Table1 and Table-2.

TABLE 1 COMPARATIVE STUDY ON TECHNICAL ASPECTS [17]

Technology Category	UiPath	Blue Prism	Automation Anywhere
Bot Development and Core Functions	3.28	2.56	3.74
Control Room, System Management, Reporting and Resilience	3.84	3.84	2.84
RPA Analytics	3.68	2.00	3.68
Architecture	4.00	3.68	4.34
Deployment, Governance and Security	3.68	4.00	3.68
Total RPA Technology Score	3.67	3.20	3.64

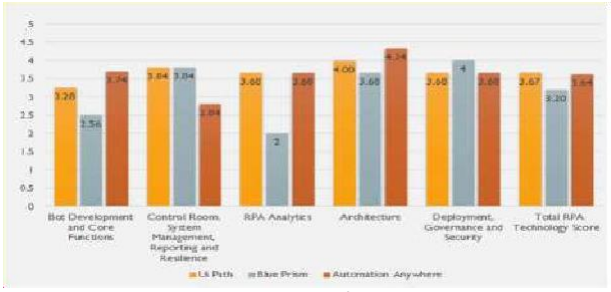

Fig 3: Graphical Representation of Technical Aspects [19]

A literature review is deemed suitable due to the nascent and insufficiently explored nature of the subject matter, namely Robotic Process Automation (RPA). This approach facilitates the identification of existing knowledge gaps within the field, provides recommendations for further research endeavours, and establishes a foundation for the exploration of novel research domains. Furthermore, this study employs the concept-centric approach advocated by Webster and Watson, as it is based on the examination and analysis of key concepts pertaining to RPA. To conduct an extensive literature review, we initially conducted a comprehensive search for scholarly papers in prominent databases including Elsevier, ASC, ACM, Scholarly Articles, and Research Gate. The search was limited to the period between June and October. The papers were collected by utilising the titles, keywords, and abstracts.

The findings were subsequently subjected to filtration based on the parameters stated below:

Articles that satisfy the above requirements should be published in the English language, have a direct relevance to Robotic Process Automation (RPA), and be readily accessible in an electronic format via internet platforms.

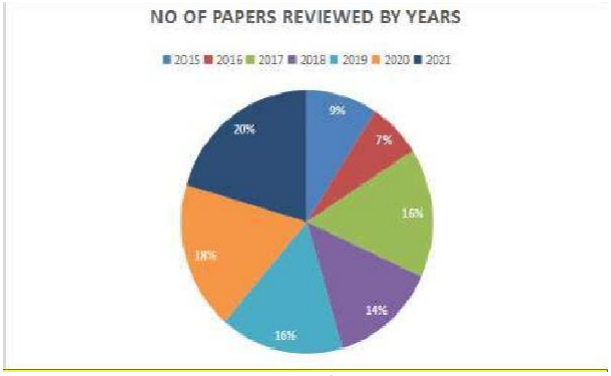

Fig. 4. Pie chart presentation of Research Paper studied

TABLE 2 ANALYSIS OF PARAMETERS ON UiPATH, BLUEPRISM AND AUTOMATION ANYWHERE

Parameters	UiPath	Blue Prism	Automation Anywhere
Front Office/ Attended Automation	Yes	No	Yes
Back Office/ Unattended Automation	Yes	Yes	Yes
Script Based Designer	No	No	Yes
Visual Process Designer	Yes	Yes	Yes but, is more script based.
Openness of the platform	Yes, has free forums and tutorials.	Yes but, all the forums are commercial.	Yes but, all the forums are commercial.
Macro Recorder for Process Mapping	Yes	No, due to their rather Outdated technology.	Yes
Control through Coding	No	Yes	Yes
Execution of Automated Test Cases on Remote Machines	No	No	Yes
Future Scope	Indefinite	Comparatively less	Comparatively less

VI. CLUSION

Due As a result of the quick improvements, many different industries are looking for ways to accommodate multiple occupations and processes in the shortest amount of time with the least amount of labour. Because it is necessary to be able to automate this process in order to know which tool to use for the benefit of various industries based on the kind of services they provide, automating the process has become a top priority.

In this work, a full study of all of the tools, including their advantages and disadvantages, as well as the optimal applications for each tool, has been offered. This article claims that UiPath is the greatest automation tool available today, and it presents a test implementation based on the analytic preview and the numerous possibilities for processes that may be enhanced for higher accuracy. In addition, this post contends that UiPath is the best automation tool available today. However, there is a possibility that the total number of users will decrease.

ISSN(Online): 2584-1025

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MIT UNIVERSITY'S – ABHIVRUDDHI JOURNAL
VOL.2 (01) , JUNE , 2022 pp- 9- 13
ISSN(Online): 2584-1025

Study of the Genesis of Fires in Electric Vehicles

Mayuresh S. Bhujbal
Dept. of Mechanical Engineering
MIT ADT University, Pune, India
bhujbalmayuresh510@gmail.com

Prof. Mangesh Dhavalikar
Dept. of Mechanical Engineering
MIT ADT University, Pune, India
mangesh.dhavalikar@mituniversity.edu.in

Abstract— The focus of the study is on the underlying factors that lead to electric vehicles fire incidents. Recently, there has been an abrupt rise in the number of electric vehicle fire incidents, which has resulted in enormous material damage and, to some extent, human harm. This serves as the primary motivation for the study. Due to the rapid advancement of Li- ion battery technology in the last ten years, electric vehicles (EVs) have had a profound impact on the worldwide automotive industry. Furthermore, the danger and risk of fire associated with this battery has proven to be an important concern for EV safety. Failure of BMS optimization, battery rupture, thermal runaway, electrolyte ventilation, rise in temperature, rough handling are some the reasons leading to fire incidents in electric vehicles. Currently, more than 13 lakh EVs are registered in India. According to a survey, Maharashtra, Uttar Pradesh, and Delhi are the top three states with the most electric vehicles on the road. The figures for electric vehicles were fairly small. 52 fires total, with 25.1 fires reported for every 100,000 vehicles sold. In hybrid vehicles, fire incidents may be linked to the combustion of gasoline in the energy-generating engine. But the EV fire incidents are rising, though, as a result of some variables. The study examines various case studies on past electric car fire incidents. It will help one understand the causes of fires in electric vehicles which can avoid future incidents. The precautions for such causes are identified and suggested to the industry. This study includes factors leading to electric vehicle fires, safety measures and firefighting techniques.

Keywords— Electric Vehicles, Survey, Li-ion battery, Fire incidents, Thermal Runaway, LIBs, BMS

I. INTRODUCTION

There are billions of automobiles on the road today powered by internal combustion engines, and these vehicles consume around 86% of the world's petroleum reserves, which translates to approximately 34% of its total energy. On the other hand, the finite natural resources of the world, an increasing population, and climate change all contribute to an intensification of people's worries about energy insecurity as well as the necessity of growing ecologically friendly transportation options.

For far too long, we have relied upon fossil fuels to power our enterprises, heat our homes, & power our automobiles. Several alternative energy sources are being used today for reduce CO2 emissions and contribute in the mitigation of global warming, includes nuclear, hydrogen, winds, solar, & geothermal energy [2]. Furthermore, hybrid electric cars (HEVs) & electric vehicles (EVs) are rapidly being developed and are expected to supersede conventional gasoline-powered automobiles. In addition to being the device that is most likely to be nominated as the most likely nominee to stockpile the electric energy that is produced by renewable energy in electric grids, lithium-ion batteries (Li-ion) are viewed as the key technology that will facilitate the transition to electric vehicles (EVs) and therefore replace the conventional vehicle design that is based upon the internal combustion engine [3].

LIBs are currently the most popular power sources for a wide variety of portable electronic devices because of their high working voltage, reduced memory effects, and higher energy density when compared to conventional batteries. As a result of these advantages, LIBs are becoming increasingly widespread. It is fair to assert that LIBs are undergoing phenomenal expansion throughout a very wide variety of business sectors all over the world.

However, the potential for fire and other hazards presented by this type of high-energy battery has emerged as a major concern for the safety of electric vehicles. The most recent concerns regarding the fire safety of electric vehicles are thermal runaway as well as fires in Li-ion battery packs. These issues are the primary emphasis of this review. The conditions of extreme abuse, which may be the result of a malfunctioning operation or traffic accidents, can lead to thermal runaway, which can then result in a fire. In the event that a battery fails, potentially dangerous gases combined with fire, explosion, and jet flames may be emitted. [1].

Road vehicles powered by lithium-ion batteries (LIBs) are expected to be involved in more accidents as they become more widely used. With an on-board energy storage system of conventionally fueled vehicles poses a risk to those involved in accidents or responding to them. While the dangers posed by traditional vehicles are well known and widely accepted in society. It will require time and knowledge to achieve this level of comfort for Li-ion driven road vehicles. When this pertains to EVs, there's the potential that the LIBs will re-ignite from being damaged or extinguished for an extended period of time [2]. This issue affects not only firefighters, but also people who work with damaged EVs in towing, workshops, scrapyards, or recycling operations.

There has been an increase in e - mobility fire incidents since March 2022, mostly involving two-wheelers. There were numerous other incidents in a similar vein. A recent large-scale fire at an Electric vehicle dealership resulted in 8 fatalities and 13 injuries. There was also significant material damage.

ISSN(Online): 2584-1025

In Mangalore, Karnataka, on June 24, 2022, an Okinawa Electric vehicle dealership caught on fire. Okinawa blamed an electrical short circuit for the total destruction of 34 electric scooters in this incident [29]. A 7-year-old boy was killed in an e - scooter battery outburst in Palghar on October 7, 2022, as it was being charged. A 7-year-old boy was killed in an e - scooter battery outburst in Palghar on October 7, 2022, as it was being charged. The incident happened in the Vasai region of the Palghar district. After the event, the boy was transported to a hospital where he succumbed to his wounds after sustaining serious injuries [3].

On October 25, 2022, a significant fire that started in an e - mobility dealership in the Parvatipuram district of Andhra Pradesh destroyed up to 36 electric bikes. On Monday morning, the incident took place at Manam Motors in Palakonda town. The fire destroyed battery packs and e-bikes that have been kept in the dealership for special Diwali discounts. Firefighters quickly responded to the scene and extinguished the flames. Authorities believe that a short circuit started the fire. The mangers of the showroom affirms that the fire caused them damages totaling about Rs.50 lakhs [31]. In Hyderabad, India, an enormous fire started in this e-bike dealership in September 2022, killing eight people [4-5].

The study's primary motivation is the rise in fire incidents. The study includes the causes of these occurrences and methods that first responders should use.

II. BATTERY ABUSE

Typical battery systems are vulnerable to external temperature, mechanical, and electrical influences that may occur during intense operating circumstances or accidents, as well as a low risk of self-ignition. For the majority of portable electronic devices, like the laptop and smartphone, electrical impacts and extreme operational conditions are relatively uncommon, but they are still regarded as the typical operating conditions. The operating conditions for an EV battery, on the other hand, are more demanding due to the frequent acceleration and deceleration in challenging road and traffic situations. Additionally, EVs have thousands of times more battery capacity than portable electronic devices, which increases the risk of fire in the event of thermal runaway and ignition.[6]

The three major categories into which battery abuses are Mechanical Abuse, Thermal Abuse and Electrical Abuse.

Mechanical Abuse: - Without protection of a battery module and/or pack enclosure or an EV structure, the majority of conventional LIB cells are fairly brittle. An EV's lifetime may experience a traffic accident, like any other regular car. However, the majority of collisions won't harm the battery thanks to the modern style of LIBs and EVs. To reduce the chance of being penetrated during a crash, LIB packs are typically integrated into heavily fortified areas of the vehicle [13]. Even the greatest level of protection, however, is insufficient to reliably prevent fire at high speeds, which some EVs seem to be capable of accomplishing in a very short period of time. When a vehicle is involved in an accident and the battery pack is struck, there is a chance that the internal battery structure will deform and the separator will tear. This will result in a short circuit because the anode and cathode will come into contact [7].

Thermal Abuse: - Users anticipate being able to drive their EV in all conditions, including extremely hot and cold ones, just like they would a conventional internal-combustion vehicle. For instance, EVs are anticipated to function both in the coldest and wettest conditions. The battery works best at room temperature, just like people do. Extreme heat and cold have a negative impact on battery performance and reduce battery life. Overheated batteries can result from unintended chemical reactions that take place in high-temperature environments . Battery thermal abuse can take the form of Over Heating of the battery pack . Such circumstances result in situations like the collapse of the separator in the battery which causes short circuits to happen [8-9].

Electrical Abuse: - The aims of rapid charging and discharge for electric vehicles, in addition to excellent driving performance, have a negative impact on the fire threat that these vehicles provide. LIBs are constructed such that they can take in and store a particular quantity of energy over the course of a defined amount of time. If these restrictions are surpassed, which can happen while charging very quickly or to an excessive degree, the device's performance may suffer, and it may fail sooner. The first one generates heat, whereas the second one might, at some point in the future, cause an internal short circuit. Some fires that start in electric vehicles could have been caused by incorrect operating conditions and internal faults, such as a short circuit in the high-voltage power circuit, excessive charging, or an environment that was too hot. It's conceivable that a major number of "self-ignition" or "spontaneous ignition" accidents are linked to poor manufacturing and design methods, in addition to defective electronically regulated systems, BMS, and electrical gearbox control mechanisms. This is in addition to the fact that battery cell failure is a potential cause of these incidents. [10].

III. THERMAL RUNAWAY

Thermal runaway (TR) is the most disastrous lithium-ion battery failure mode, must be prevented at all costs. Overcharging, internal cell short circuiting, and vehicle accidents are all potential causes of this condition.

A. What is Thermal Runaway?

A thermal runaway is defined as a series of uncontrollable exothermic events that result in an uncontrollable rise in cell temperature. Another definition of a thermal runaway is an accelerated release of heat from within a cell. [11-13]

B. Factors leading to Thermal Runaway in Lithium Batteries.

The term "thermal runaway" refers to an overheating event wherein exothermic chain reactions occur and outpace cooling. It is a commonly observed phenomenon in chemical and combustion processes.

ISSN(Online): 2584-1025

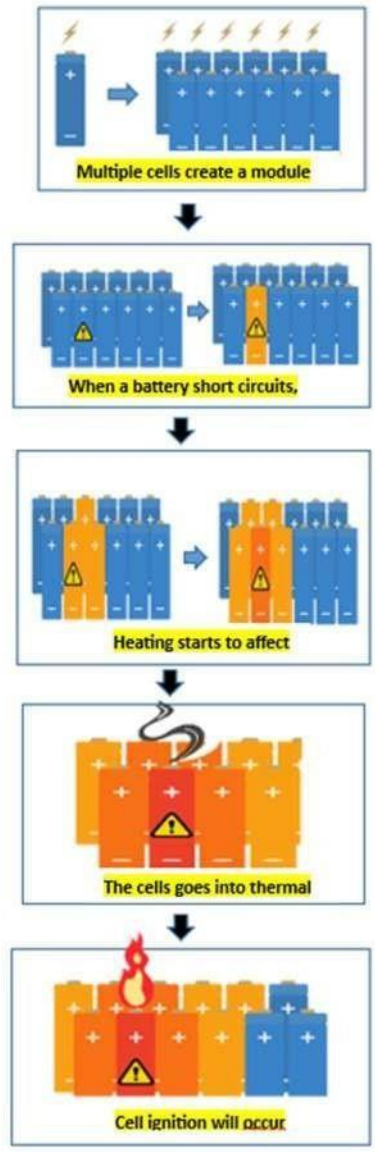

Fig. I Thermal runaway occurrence [25]

Thermal runaway for the LIB typically manifests as a rapidly rising battery temperature (higher than 10°C/min) or the activation of the safety vent, both of which signify the initiation of exothermic thermochemical and electrochemical reactions. When a battery thermal runaway occurs, a lot of black smoke, hot sparks, and strong jet-flames are frequently ejected as well. This process occurs within each individual cell, so the risk potential increases if a thermal runaway or fire is allowed to spread throughout the battery [14].
This study mentions a few of the numerous factors that can cause thermal runaway in lithium batteries.

Over Charging: - When the battery management system (BMS) is malfunctioning, overcharging is yet another common electrical abuse form. There was a lot of interest in the overcharge failure mechanism. The cathode's structure is altered as lithium is permanently removed from the cathode. If the cell is overcharged further, the cathode resistance will rise, increasing the cell's temperature due to Joule heating. Additionally, the electrolyte will interact with the highly oxidized cathode, rupturing its structure and raising the cell's temperature [15].

Over Discharging: - Dendritic crystals continue to form on the side of the negative electrode during the over-discharging cycle, pass through the separator, and then form a bridge between the positive and negative electrodes. This may result in the separator collapsing and creating an internal short circuit. Over discharging may not result in explosions or fires in the cells, but it may result in internal short circuits, which may ignite a fire [16-17].

Overheating: - Lithium batteries can become too hot for a number of reasons. The battery begins to heat up as a result of the additional charge accumulation when the BMS malfunctions and reduces the charging after it has finished. This might cause the separator to collapse due to development of dendrites. The system develops heating problems if the vehicle is handled roughly, i.e., a heavier load is carried than the vehicle is capable of. One of the main causes of overheating is improper ventilation [8]. Proper ventilation is critical for dissipating the system's heat. The age of the battery can also be responsible for the overheating.

Failure of BMS: - The battery and also the vehicle system are closely related, and the battery management system, or BMS (Battery Management System), is in charge of regulating the charging as well as discharging of the battery and instituting features like battery state estimation. If the red flags are ignored, BMS failure causes thermal runaway and also fires. When the BMS malfunctions, the connection between the BMS and the ECU is unstable or occasionally completely severed, which can result in a power supply that is unstable or non-existent [18]. The BMS is also in charge of estimating the battery temperature and power, so if it malfunctions, that could be irksome for the user or even result in fires [19]. There may be a risk of fires in electric vehicles as a result of these serious factors. The majority of the variables interact with one another.

IV. EV FIRE SAFETY PRECAUTIONS

Electric vehicle risks and hazards are not yet fully understood. Full-scale EVs and large-scale rechargeable batteries require costly fire tests, which are rarely divulged. With the growth of the electric vehicle market, EV owning is steadily rising. The energy density of LIBs keeps increasing despite unresolved fire safety issues [20]. As a result, there will be a greater chance of an EV fire. These fire risks are examined in this study. [20-22]
Safety measures related to the electric vehicle fires are mentioned below.

TABLE I. PRECAUTIONS FOR CHARGING AN ELECTRIC VEHICLE

Sr. No	Precautions
1	To keep the batteries' temperature constant, store them at room temperature.
2	Battery Swapping can be done to avoid the use of warm batteries.

ISSN(Online): 2584-1025

3	Do not charge the batteries within 1 hour of use.
4	Charge the battery using the standard charger provided by the supplier
5	Avoid fast charging, use the slow charger to maintain the health of the battery
6	Charge in a well-ventilated area
7	While charging, first plug the battery side and then the AC side. Do the opposite post charging.

TABLE II. PRECAUTIONS FOR WASHING AN ELECTRIC VEHICLE

Sr. No	Precautions
1	High-Pressure water cleaning is prohibited.
2	Cover the sensitive electric parts while washing the vehicle.
3	Ceramic washing is recommended for the vehicle.
4	Pressure below 0.5 Bar is recommended for washing

TABLE III. PRECAUTIONS FOR HANDLING AND MAINTENANCE OF AN ELECTRIC VEHICLE

Sr. No	Precautions
1	If the vehicle went through an accident, then it should be checked for battery rupture before washing it.
2	Do not park the vehicle as well as charge it under direct sunlight for longer period of time.
3	The vehicles should not carry weight more than its capacity, which directly impact on the controller, battery and motor.
4	Maintain the prescribed air pressure in tire in case of vehicles having In-Wheel / Hub motors. If not maintained it can cause damage to the motor if the vehicle goes through irregular road surfaces.
5	Avoid thoroughly draining the EV battery.
6	When not in use, avoid full charging the battery.

There will be decrease in the Electric Vehicle fire incidents if precautions are taken by the manufacturer as well as the vehicle owners. The manufacturers should not compromise in quality of components used and the vehicle owner should not compromise regarding the timely maintenance of the vehicle.

V. ELECTRIC VEHICLE FIRE FIGHTING TECHNIQUES

Electric vehicle fires differ from conventional vehicle fires in several ways. Compared to conventional vehicle fires, EV fires burn hotter, longer, and use more water and resources [11]. After a fire, there are two different types of responders. The first responders are in charge of taking over and putting out live fires, while the second responders are in charge of handling things like insurance claims, etc. In fire incidents involving EVs, distinct fire-fighting methods are used.

Fire-fighting techniques for Electric Vehicle fires are mentioned below: -

TABLE IV. FIRE-FIGHTING TECHNIQUES FOR EVs

Sr. No	Precautions
1	Use a lot of water to cool the high voltage battery if it burns, and is exposed to a lot of heat, or is damaged in any other way.
2	Never put out a fire with a little water. Always establish a supplemental water supply or ask for one.
3	Check the high voltage power pack is entirely cooled using a thermal imaging camera before leaving the scene.
4	Once it is assessed that the battery has completely cooled, it must be kept under observation for at least an hour.
5	Only after a hour has gone by with no warmth detected should the car be released to second responders such as police enforcement and towing staff.
6	Always warn second responders that the battery could re-ignite.
7	Always keep the car in an open space at a distance of at least 50 feet (15 meters) from any exposure.
8	Consider the whole vehicle to be energized when there is a fire. No part of the car should be touched.
9	When a battery smokes or becomes hot, toxic fumes are produced. Among the vapors are sulfuric acid, CO2, nickel, lithium, copper, & cobalt oxides.
10	Always put on full protective gear, including a breathing apparatus (SCBA)

Some EV manufacturers, like Tesla, have started offering first responders instructions on how to handle fire incidents involving various Tesla EV models. First responders can benefit from this education, and vehicle users will gain insight into what to do in the event of such incidents.

VI. CONCLUSION

The study is based on the factors that cause battery cells to enter a condition of thermal runaway, how that state develops, and what can happen if a cell enters that state. EV fires are more challenging to extinguish because of the possibility of battery re-ignition and the challenges associated with cooling the battery pack inside. Water is the most effective way to extinguish a flame in an electric vehicle, and lots of it is needed to cool the battery and to kill the flames. But fewer suppressors are needed when the battery pack is directly sprayed. Unfortunately, very less that is available on the fire risk caused by deserted EVs & battery packs. Additionally, a variety of Electric Vehicle firefighting techniques are included in this research because Electric Vehicles cannot be extinguished using conventional firefighting methods. Not only should the manufacturer take precautions to prevent such fire incidents, but the owner or user of the vehicle should also take the necessary measures to avoid mechanical, electrical, and thermal abuse of the batteries. The electric car manufacturers like Tesla have already begun giving their

ISSN(Online): 2584-1025

customers guides to get them ready for fire scenarios. The same provision should be made by every manufacturer to prepare their customers for the worst-case scenarios. To better inform first responders about EV fire incidents and the fire-fighting methods used to combat them, workshops should be held. Since the two types of vehicles' power sources differ, electric vehicles shouldn't be treated the same as those with internal combustion engines. If these vehicles are used in accordance with the manufacturer's instructions, numerous fire incidents can be avoided. This study's objective is to support researchers and companies engaged in battery, electric vehicle, and fire safety-related work.

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MIT UNIVERSITY'S – ABHIVRUDDHI JOURNAL
VOL.2 (01) , JUNE , 2022 pp- 14-16
ISSN(Online): 2584-1025

Time Table Scheduling System

Shamika Kadav
MIT ADT
UNIVERSITY
PUNE
+91 7030677003
shamikadavgmail.com

Apurva Patil
MIT ADT
UNIVERSITY
PUNE
+91 78210 93399
apurva122001@gmail.com

Aryan Tanwar
MIT ADT
UNIVERSITY
PUNE
+91 83027 56425
aryan.taanwar2001@gmail.com

Sachin Takale
MIT ADT
UNIVERSITY
PUNE
+91 96899 34042
sachin.takale@mituniversity.ed u.

ABSTRACT
In an organization timetable's are accessed by hundreds of users on the daily be it the faculty or students. There are various operations associated with the access of these timetables. The problems associated with the existing manual time table management system are the inability to maintain proper records of lectures, the difficulty to organize and arrange meetings of faculty members and the overall need for manual communication between users in case of rescheduling or exchanging lectures. So with the technology of developing web applications, it is feasible to create a timetable software to streamline this process of managing and effectively utilizing the faculty's time and organizations resources.The aim of this paper is to describe efficient and convenient time table management in academic institutions.

Keywords
Database; Web Application.

1. INTRODUCTION
The difficulties posed by an ineffective scheduling and time table management system are widely recognized. At the start of every academic year, there is immense pressure to create schedules, arrange time slots, allocate resources and account for unexpected teacher absences, among other things. Although there is computerization of all managerial tasks, the scheduling system is executed without automation. Everyone owns a smartphone in today's world. Therefore, with the technology at hand we can rely completely on the efficiency of this system.

The restraints involved in the manual scheduling system are clashing of one or more than one lectures and inefficient communication. While it is preferable for timetables to fulfill all of the required conditions, it is often challenging to meet them. All of the criteria should not be violated in order to create a feasible schedule that accommodates both students and faculty.

The objectives of this project are - to computerize all lecture details regarding student and faculty; to provide simple and easy to grasp scheduling service for faculty members so that the organization's facilities are utilized effectively and in an efficient manner; to streamline the process of scheduling unregistered remedial lectures if and when required.

In this project, we will be having two end users. To name them are - student and faculty. Therefore the login page will include the following fields - Name, Code, two Radio buttons namely, Student and Faculty. If faculty is selected, then a dropdown will appear which contains subject options. The dashboard pages for both users will include their schedule for the day. If there are any amendments to be made, the faculties can do so with the options at hand. The upgraded iteration will be displayed on the student webpage. The staff will also send notifications to the students 15 minutes prior to the next lecture. Therefore, these features help in the refrain of confusion.

2. LITERATURE REVIEW
An automated system for generating and managing schedules, such as those for schools, universities, or corporations, is known as a timetable management system. In this review of the literature, we will look at the relevant studies on timetable management systems, their advantages, drawbacks, and distinguishing characteristics.

Advantages of Timetable Management Systems: According to several research, employing a timetable management system has the following advantages:

Enhanced Efficiency: By reducing the time and effort needed to establish and manage schedules, timetable management systems free up administrators' time to work on other projects.

Increased Accuracy: By using these technologies, the likelihood of mistakes or conflicts that may occur when making schedules manually is reduced.

Improved Resource Utilization: With the aid of a timetable management system, administrators may allocate resources like employees or classrooms in the most effective way possible.

Improved Communication: These systems give administrators, teachers, and students a consolidated platform to monitor schedules, share information, and talk to one another.

Despite their many advantages, timetable management systems have a number of drawbacks that make them difficult to apply. Some difficulties include:

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Data management: These systems need correct and current data to generate efficient schedules, but obtaining and maintaining this data can be difficult.

Complexity: Configuring timetable management systems can be challenging, especially for businesses with specialized scheduling needs.

User Adoption: It might be tough to encourage users to accept a new system and adjust their old workflows.

Technical Problems: Technical problems might interfere with scheduling, such as system outages, sluggish performance, or compatibility problems with current software.

Key Features of Timetable Management Systems:There are several key features that a timetable management system should have, including:

An intuitive, user-friendly interface that is simple to use and navigate should be provided by the system.

Flexibility: The system ought to be adaptable enough to take into account a variety of scheduling needs, such as various course structures, faculty preferences, and resource limitations.

Automatic Scheduling: The system should have the capacity to automatically schedule classes, taking into account variables like the availability of classrooms, teachers, and prerequisites.

Reporting and Analytics: To track important performance metrics like student attendance, resource use, and teacher workload, the system should give administrators a variety of reporting and analytics capabilities.

In conclusion, a schedule management system can provide organizations with a variety of advantages, such as enhanced productivity, better accuracy, and more effective use of resources. These systems can, however, also be difficult to operate, complicated, difficult for users to accept, and have technological problems. A schedule management system should include essential elements such a user-friendly interface, adaptability, automatic scheduling, and reporting and analytics capabilities in order to handle these issues.

3. FIGURES/CAPTIONS

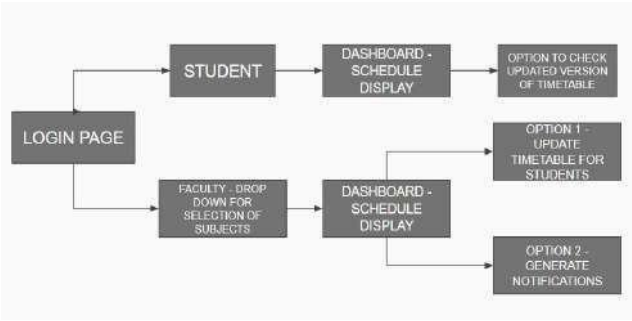

Figure 1. Flowchart

In this figure, we observe the series of flow of events for both the end users - Student and Faculty.

For student users, they can view the displayed timetable for the specific day and date. If there are any alterations in the day, they can check them by clicking on the CHECK UPDATES button. Also, they will receive notifications from the faculties 15 minutes prior to the next lecture.

For the faculty users, on the login page itself, they will have to choose their teaching subjects and then their timetables will be displayed too on the dashboard. They have the option of changing or rescheduling any lecture. Accordingly, they can generate notifications.

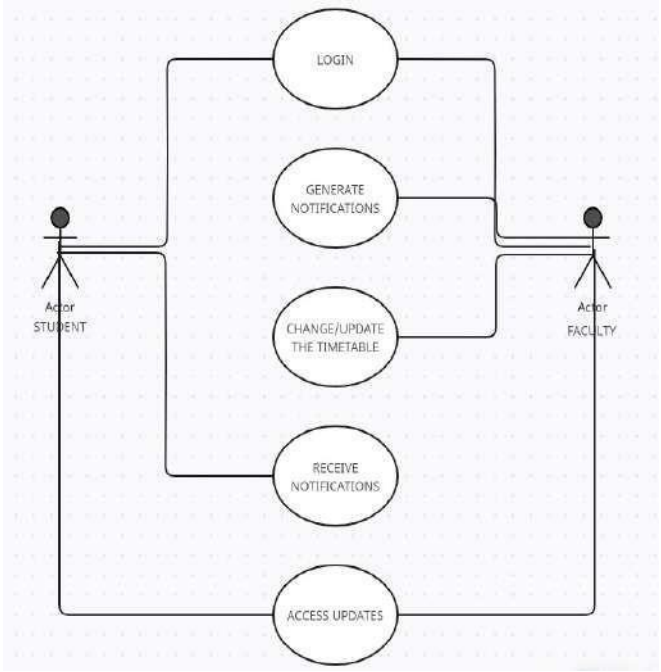

Figure 2. Use case diagram

UML diagram is a class diagram that represents the relationships between different classes in a software application.

Here in this diagram we analyze the factors that influence the requirements and showcase their interactions. As we can see, STUDENT and FACULTY are the actors here. Their relationship is defined through the five functionalities/use cases.

4. RESULTS

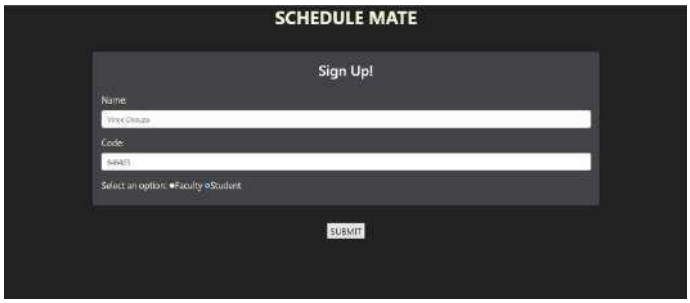

Figure 3. Login page - Student

Here, we observe the fields for entering name and code for a user. They will select if they are a student or faculty member using the

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radio button. On clicking the submit option, we will be directed to the dashboard.

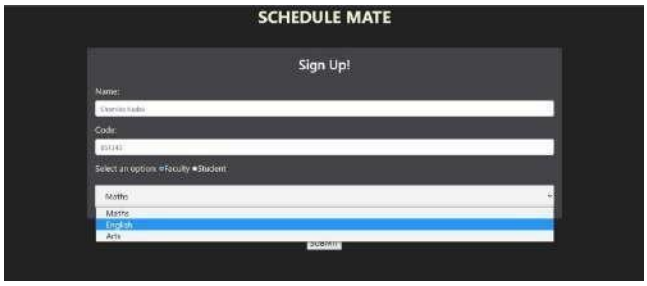

Figure 4. Login page - Faculty

In this particular page where the faculty radio button is selected, we can witness that a dropdown opens. Here the staff can click on the subjects they teach and proceed accordingly.

5. CONCLUSION

In conclusion, this timetable scheduling system can bring numerous benefits to organizations, including increased efficiency, improved accuracy, and better resource utilization. However, these systems can also present challenges such as data management, complexity, user adoption, and technical issues. To address these challenges, a timetable management system should have key features such as a user-friendly interface, flexibility, automated scheduling, and reporting and analytics tools. To effectively tackle the challenges associated with schedule management systems, it is important that these systems incorporate crucial components such as an intuitive interface, flexibility, automated scheduling functionality, and reporting and analytics capabilities.

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These references provide a range of approaches and ideas for developing a timetable management system project.

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[2] "Design and Implementation of a Timetable Management System for University" by O. A. Olaleye and O. T. Akanbi. This paper describes the development of a web-based timetable management system for a university, including its features and functionalities.

[3] "Timetable Management System using Genetic Algorithm" by Abhijeet Mahalle and Prachi Deshpande. This paper proposes a genetic algorithm-based approach to solve the timetable management problem, including the design of the system and the evaluation of its performance.

[4] "Development of an Automatic Timetable Generator System" by Emmanuel O. Omidiora and O. T. Akanbi. This paper presents an automatic timetable generation system for a university, including the system design, features, and functionalities.

[5] "A Comprehensive Timetable Management System for Educational Institutions" by Paul O. Adeniran and Kayode O. Oladele. This research paper presents the development of a comprehensive timetable management system for educational institutions, including its features, functionalities, and benefits.

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MIT UNIVERSITY'S – ABHIVRUDDHI JOURNAL
VOL.2 (01) , JUNE , 2022 pp- 17-26
ISSN(Online): 2584-1025

Multiple Object Detection, Object Tracking, Lane Tracking, and Motion Detection Shadow Robotbased on Computer Vision

1st Divya Pullivarthi
Electronics and Communication Engineering, School of Engineering and Science, MIT ADT University
Pune,India
divya.pullivarthi@gmail.com

2nd Shweta Raut
Electronics and Communication Engineering, School of Engineering and Science, MIT ADT University
Pune,India
raut.shweta2000@gmail.com

3rd Sakshi Maurya
Electronics and Communication Engineering, School of Engineering and Science, MIT ADT University
Pune,India
sakshimaurya586@gmail.com

4th Prof. Poonam Dhole Electronics and Communication Engineering,School of Engineering and Science, MIT ADTUniversity
Pune,India
poonam.dhole@mituniversity.edu.in

ISSN(Online): 2584-1025Y

Abstract—Multiple object detection, object tracking, lane tracking, and motion detection are the four crucial and difficult tasks in the Shadow robot. A dynamic background, clutter, occlusion, shadows, cluttering, noise, etc. make it difficult. The fundamental processes of a shadow robot's multi-camera video analytics include object detection, tracking, object matching across several cameras, and reidentification. Multiple object recognition and tracking of contents from resourceful city videos may be produced according to the suitability of society like Autonomous/Self-Driving vehicles, far- sighted clever inspection devices, traffic congestion administration devices, vehicle navigation, smart health management facilities, etc. Multiple object detection, object tracking, lane tracking and motion of moving objects are techniques used in computer vision and image processing. Several techniques are used to compare multiple consecutive frames from a movie to see whether any moving objects can be found. Results of the study show that the suggested technique may be used in areas such as object identification, motion detection, autonomous driving systems, and others.

IndexTerms—object detection, object tracking, lane tracking, motion detection, computer vision.

1. INTRODUCTION

Computer vision has emerged as an important technology in different applications such as autonomous driving, surveillance, robotics, and medical imaging. One of the most ambitiousquests in computer vision is multiple object detection, object tracking, lane tracking, and motion detection for moving objects. These tasks are crucial in many real-world scenarios, such as traffic surveillance systems, security surveillance equipment, and human-robot interaction.

Multiple object detection encompasses detecting and localizing multiple elements in a video or image stream. The approach of tracking an item's movement over time in a video stream is termed object tracking. Lane tracking refers to the process of identifying and tracking the routes on a road, while motion detection for things moving is the method for detecting and tracking items that are in motion.

In recent years, considerable improvements have been achieved in computer vision, including the invention of deep learning-based techniques, which have attained progressive level performance in multiple object detection, object tracking, lane tracking, and motion detection for objects moving. These techniques have permitted real-time and exact tracking and identification of multiple objects in challenging conditions.

In this research study, we present a detailed overview of current developments in multiple object detection, object tracking, lane tracking, and motion detection for objects moving using computer vision. We study numerous deep learning-based tactics, like convolutional neural networks, recurrent neural networks, and object detection frameworks, and their usefulness in these tasks. We also analyze the challenges and limitations of these approaches and provide alternative avenues for future research.

2. Objectives

- To find and determine the location of one or more useful targets using still photos or video data.
- To create a robot that can autonomously follow and track a colored item under computer control.
- To determine if an item is moving.
- To design a robot that can follow a course and get where it is going.
- The ESP32 AI Camera on the Android phone will be used to control all of these tasks. e.g., line tracking, object tracking, and object identification.

3. Literature Review

Shijie Sun, Naveed Akhtar, HuanSheng Song, Ajmal Mian, andMubarak Shah, Fellow, IEEE, Deep Affinity Network for MultipleObject Tracking, IEEE TRANSACTIONS ON PATTERNANALYSIS AND MACHINE INTELLIGENCE, VOL. 43, NO. 1,JANUARY 2021.

The proposed Deep Affinity Network (DAN), a

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deep learning-based approach for posture estimation and tracking, trains compact, CNN for simultaneous detection and tracking inside the detection framework R-FCN.

Arindam Sengupta, Lei Cheng, and Siyang Cao, RobustMulti-object Tracking Using Mm wave Radar-Camera SensorFusion, IEEE Sensor council, VOL. 6, NO. 10, OCTOBER2022.

The radar, an electromagnetic device, andcamera readings in a particular frame are connected using the Hungarian method. A tri-Kalman filter-based architecture is employed as the tracking strategy. The suggested technique delivers promising MOTA and MOTP metrics embracing notably reduced missed detection rates that might enable vast and limited autonomous or robotic systems applications with the safe perceived notion. system resilient by constant object tracking even with single sensor malfunctions using a tri-Kalman filter arrangement.

Hui Zhang, Member, IEEE, Liuchen Wu, Yurong ChenMember, IEEE, Ruibo Chen, Senlin Kong, Attention-GuidedMultitask Convolutional Neural Network for Power Line PartsDetection, IEEE TRANSACTIONS ONINSTRUMENTATION AND MEASUREMENT, VOL. 71,2022.

This research attempts to increase the identification precision of the model and offer an attention-guided multi-task convolutional neural network (AGMNet). The refinable region proposal network (RPN) structure and dynamical training method to increase the resilience of the network, CNN algorithm utilized for Object identification

Xiangkai Xu, Zhejun Feng, Changqing Cao, Chaoran Yu,Mengyuan Li, Zengyan Wu, Shubing Ye, and Yajie Shang, STNTrack: Multiobject Tracking of Unmanned Aerial Vehicles bySwin Transformer Neck and New Data Association Method, IEEEJOURNAL OF SELECTED TOPIC IN APPLIED EARTHOBSERVATIONS AND REMOTE SENSING, VOL. 15, 2022,

Swin transformer neck-YOLOX (STN-YOLOX) object detection technique is employed as the detection module and the G-Byte data association method as the tracking module.

Azarakhsh Keipour, Graduate Student Member, IEEE, MaryamBandari, and Stefan Schaal, Fellow, IEEE Deformable One-dimensional Object Detection for Routing and Manipulation,IEEE, VOL. ROBOTICS AND AUTOMATION LETTERS 7, NO.2, APRIL 2022.

Deformable one-dimensional object detection techniques and Traversing contours for the DOO chain are used to identify the color-based segmentation of the DOO area.

4. Research Methodologies

Esp 32 cam typically uses pre-trained models.

There are just 2 pre-trained models available at present i.e., YOLO and COCO SSD models. From which YOLO pre-trained model is utilized for this project.

4.1 OpenCV

OpenCV is an open-sourced image processing toolkit that is frequently utilized not only in business but also in the area of research and development.

4.2 YOLO Model/Algorithm

YOLO (You Only Look Once) is a common object detection model/algorithm that can identify and categorize several things inside an image or video frame in real-time. YOLO has been trained on big datasets such as COCO (Common Objects in Context) dataset to understand how to distinguish distinct items.

Pretrained YOLO models are accessible to be downloaded, which may be utilized for numerous applications without the requirement for training from scratch. These models have been developed on big datasets and have learned to identify a broad variety of objects, making them appropriate for numerous applications.

For object detection, the cvlib library has been utilized. The package employs a pre-trained AI model using the COCO dataset to recognize objects. The nomenclature of the pre-trained model is YOLOv3.

In ESP 32 Cam AI thinker algorithm is applied for object detection and tracking. There is a particular "AI Thinker algorithm" in ESP32-CAM, which is a development kit made by AI Thinker that integrates the ESP32 microcontroller with a

camera module. Nevertheless, the ESP32-CAM is meant to be utilized for multiple AI and computer application areas, which might include putting various AI algorithms on the boards.

To implement object detection, object tracking, lane tracking, and motion detection on ESP32-CAM, developers can use various software libraries and frameworks such as TensorFlow, OpenCV, and Arduino IDE. These libraries and frameworks provide pre-trained models and tools that can be used to implement various AI algorithms on the board.To perform object detection, object tracking, lane tracking, and motion detection using ESP32-CAM, developers may utilize several software libraries and frameworks like TensorFlow Lite, OpenCV, and Arduino IDE. These libraries and frameworks include pre-trained models and toolkits that may be used to create different AI algorithms on the board.

4.3 CNNs(Convolutional Neural Networks)

Convolutional Neural Networks (CNNs) have been enormously employed in applications involving computer vision including object detection, object tracking, lane tracking, and motion detection. CNNs are a sort of neural network that are especially well-designed to suit image processing applications since they can learn to extract characteristics straight from raw picture data.

Convolutional Neural Networks (CNNs) is a framework of artificial neural network that are meant to interpret and evaluate visual images. They are commonly utilized in computer vision applications like pictorial classification, object identification, and image segmentation They comprise layers of linked processing units that are trained to detect visual elements in pictures. The layers are often stacked hierarchically, with lower layers gaining knowledge of basic elements like edges/corners, and higher layers acquiring knowledge to recognize greater advanced structures and objects.

Convolutional Neural Networks (CNNs) are often employed for object recognition, tracking, lane tracking, and motion detection because they are capable of autonomously learning key characteristics straight from raw picture data.

CNNs may be utilized both for two-stage and one-stage object identification techniques. Two-stage techniques, such as Faster R-CNN, employ a region proposal network (RPN) to find areas of interest within a photograph, which are subsequently given to a hierarchical web for enabling object classification and localization. One-stage techniques, like YOLO (You Only Look Once), execute object detection straightly on the full picture in a single pass, which may be more rapid and effective than two-stage systems.

In summary, CNNs are often used for object recognition because they can learn key aspects out of unprocessed raw image data, can be trained using huge datasets of labeled pictures, and can be utilized for both two-stage and one-stage techniques

4.4 Object Detection

Object detection runs on computer vision methods that comprise of detecting notable things within an image or video stream and estimating their location and boundaries. Object identification techniques commonly apply a combination ofmachine learning and image processing methodologies, like convolutional neural networks (CNNs), to analyze the input data and identify the objects within it.

Figure 1. Object Detection

4.5 Multiple Object Detection

Multiple object detection runs on computer vision that demands detecting and localizing many entities of different types within an image or video stream. Unlike mono object detection, which only detects one item, multiple object detection systems must be able to identify and find several things simultaneously.

ISSN(Online): 2584-1025

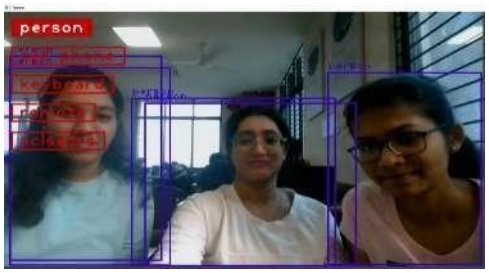

Figure 2. Multiple Object Detection

4.6 Object Tracking

Object tracking is the process of locating and following an object of interest in a sequence of frames of a video stream. It involves identifying and tracking the object as it moves through the frames, even if the object changes in appearance or motion. Object tracking is a critical component of many computer vision applications, including surveillance, robotics, and autonomous driving.

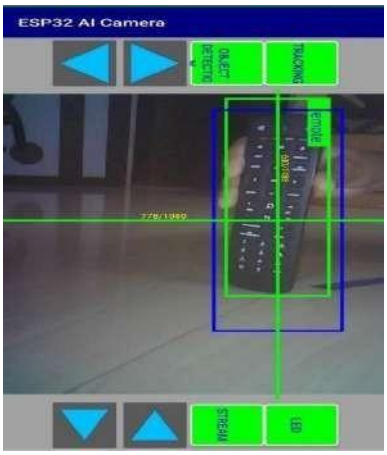

Figure 3. Object Tracking

4.7 Lane Tracking

Lane tracking is the technique of distinguishing and tracking the routes on a highway using techniques of computer vision. Lane tracking is a critical aspect of various advanced driver assistance system(ADAS) technology and self-driving vehicle mechanizations because it enables the car to identify the road layout and keep within the allotted driving lanes. Lane tracking algorithms generally apply image processing techniques to distinguish the lane markers in a video stream recorded by a camera that is affixed to the vehicle. The algorithm then extracts the location and orientation of each lane marker and applies this information to estimate the position of the driving lanes on the road.

Figure 4. Lane Tracking

4.8 Motion Detection

The technique of determining a shift in an object's location in relation to its environment across a period is referred to as motion detection. In this area of computer vision, motion detection is typically used to recognize and trace moving objects in a video stream. The method of motion detection generally includes comparing successive images of a video feed to find locations where there's a substantial shift in pixel values. This shift may be caused due to the mobility of an item in the frame, changes in illumination, or camera movement.

4.9 PROPOESD SYSTEM

4.9.1. Block Diagram

This diagram is a graphical representation of our system process that shows the components used for our robot. In this block diagram, each block represents the components we have used. The selectivity of our components is as follows:
ESP32- ESP32 cam used for object detection, lane tracking, and object tracking.

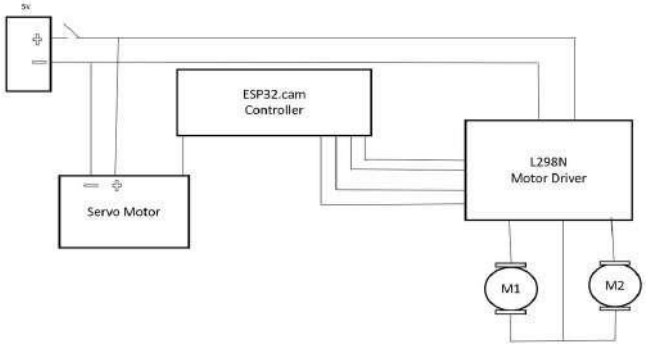

Figure 5. Block Diagram for our robot

Motor Driver i.e., L298N- it is a high-power

ISSN(Online): 2584-1025

dynamic motor driver.
Use to administer the direction and acceleration of DC motors. Lithium Battery- A lithium battery is a type of rechargeable battery. Constant power is provided. It is temperature tolerant.
Servo Motor- It is an electrical device that can push and rotate objects with great precision.
DC Motors- Converts direct current into mechanical energy helping for rotation of the robot wheels. It operates using direct current.

4.9.2. Circuit Diagram

In this project ESP32 cam for multiple object detection, and tracking of objects and lanes. It is provided with a pocket size lowconsumption of energy, camera module based on ESP 32. It coexists with an OV2640 camera module. It has 10 general input and output pins which are used to interface peripheral devices. It has built-in Wi-Fi, and Bluetooth to develop a web-based user interface that will enable us to operate the robot and give video camera output.

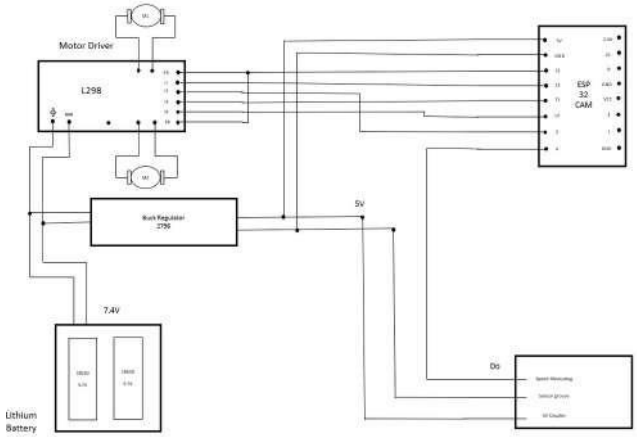

Figure 6. Circuit Diagram

For this project, L298N motor driver module is used. This driver module drives 2 DC motors with 7.4 V DC supplied from a Lithium battery. The direction and speed of the robot are controlled by this unit.
There is a need for 2 lithium batteries each of 3.7V connected in series to give 7.4 V. For ESP32 operating voltage is from the range of 3.3 V to max 5
V. So, for that a buck regulator is used to reduce the voltage from 7.4 V to 5V. A buck regulator i.e., LM2596 is a Step-Down voltage regulator. HC-SR04 module is an ultrasonic sensor module. It is used to measure the distance of the object in front of the robot. Therange of the Ultrasonic sensor is a max of 4m. For speed measurement speed measuring sensor groove couple is used. It counts how many pulses occur per second.

5. Data Analysis and Interpretation

Data analysis and interpretation for object detection, object tracking, lane tracking, and motion detection of objects frequently comprise the following steps:
Data gathering: The first stage in data analysis and interpretation is data collecting. For object detection, object tracking, lane tracking, and motion detection, data is often acquired by different sensors, such as cameras, lidars, and radars.
Data pre-processing: After the data is acquired, it has to be pre-processed to eliminate noise, manage missing values, and normalize the data.
Object detection: Object detection is the act of recognizing items inside an image or video frame. This is often performed by utilizing deep learning-based methods such as YOLO, Faster R-CNN, and SSD.
Object tracking: Object tracking entails monitoring the movement of an item over time. This is commonly done by employing different tracking algorithms like the Kalman filter, Particle filter, as well as correlation filters.
Lane tracking: Lane tracking entails recognizing and monitoring the lanes on a road. This is often done using computer vision-based methods like Hough transforms, Canny edge detection, and Sobel edge detection.
Motion detection: Motion detection entails identifying any changes in the location of objects over time. This is commonly done using background subtraction methods, optical flow algorithms, and frame differencing algorithms.
Interpretation: After the data has been analyzed, object detection, object tracking, lane tracking, and motion detection techniques may be utilized to extract insights and create predictions about the behavior of objects in the environment. Thisinformation may be utilized for a multitude of

ISSN(Online): 2584-1025

purposes, like automated driving, surveillance, and robots.

Altogether, data analysis and interpretation for object detection, object tracking, lane tracking, and motion detection entail gathering and processing data, using different algorithms to extract insights, and utilizing those insights to make predictions and judgments.

6. RESULTS

True Positive(TP)-the number of cases accurately labeled as the given class.

False Positive(FP)- the number of cases wrongly labeled as the given class.

True Negative(TN)-the number of cases appropriately labeled asthe given class.

False Negative(FN)-the number of cases falsely labeled as the given class.

Accuracy= TP+TN/TP+TN+FP+FN

Table I. Accuracy Result

Total	Identified (TP+TN)	Unidentified (FP+FN)	Accuracy in % TP+TN/ (TP+TN+ FP+FN)
50 people	45	5	90
75 books	69	6	92
150 Cell-phones	135	15	90

Calculating average accuracy from the above table

Average Accuracy = 90+92+90/3 = 90.6%

6.1. Robot

This figure shows the actual hardware structure of the robot. It's the view of the robot from the front side and upper side.

Figure 7. Robot Structure

6.2. Object Detection

The resulting figure of the object detection shows the performance of the model in identifying and localizing objects within an image. It may display the bounding boxes around the detected objects, and any relevant classification labels.

Figure 8. Detected objects such as book, mouse, person, cellphone, scissors respectively.

6.3. Object Tracking

Tracking of the book is done whenever it is moved i.e., it will track whenever the object is moving. In a similar manner, whenever the object is in motion it will track it.

ISSN(Online): 2584-1025

Figure 9. Tracking of the book

6.4. Lane Tracking

The robot is following the lane and accordingly will change its direction. The figure displays the detected lane markings, the predicted trajectory of the vehicle, and any relevant performance metrics such as lane deviation. It is also called a line follower robot.

Figure 10. Tracking of lane/path

6.5. Motion Detection

This figure shows how motion detection will detect the change in the position of an object relative to its surroundings the position of the object during its motion will also be detected and from this figure, we can see the x-axis and y-axis values to determine that the object is in motion.

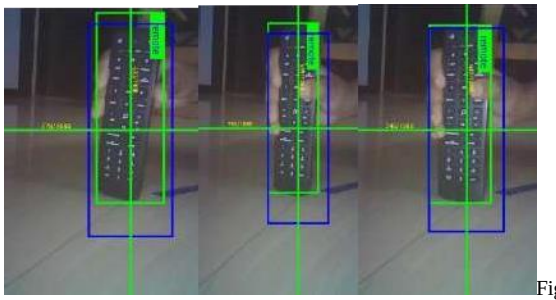

Figure 11. Motion Detection of Remote

7. APPLICATIONS AND LIMITATIONS

Object detection, object tracking, and lane tracking are crucial components of several computer vision applications, including autonomous cars, surveillance systems, and robots. Listed below are a few examples of how these strategies may be applied:

Automated cars: Item tracking and detection are needed for automated vehicles to move through their surroundings safely. By recognizing and monitoring items such as people, other cars, and signposts, an autonomous vehicle may make judgments on how to proceed safely through traffic. Lane tracking also is necessary for autonomous cars to remain inside their allotted lane.

Surveillance systems: Object tracking and detection may be used to monitor a certain region for any suspicious activities or items. For instance, if a surveillance system has been set up in a parking area, object detection may be used to identify and track any automobiles or persons moving in the vicinity. Lane tracking may also be beneficial for surveillance systems to monitor any cars that may be attempting to enter or exit the area.

Robotics: Item recognition and tracking are necessary for robots to recognize and operate things in their surroundings. For instance, a mechanical arm in a manufacturing plant may employ object detection and tracking to gather up and move products on a conveyor belt. Lane tracking may also be beneficial for robots to access a warehouse or industrial plant.

Overall, the applications of object recognition, object tracking, and lane tracking are numerous and have many potentials uses in many industries. Motion detection seems to have a range of uses, including:

Surveillance cameras: Motion detection is also utilized in video surveillance systems to initiate recording when movement is detected. This may assist reduce storage capacity and make it simpler to discover certain moments in the recorded film.

Home automation: Motion detection is widely used in home automation systems to initiate particular activities, such as switching on lights whenever anyone enters a room or shutting off appliances when a room is vacant.

Games: Motion detection is utilized in gaming systems to monitor player movements and enables even more realistic gameplay experiences.

Health monitoring: Motion detection may be used in health monitoring devices to measure

ISSN(Online): 2584-1025

movement and identify changes in levels of activity, which can be beneficial for persons with chronic diseases or for older folks who might need further support.

Industrial automation: Motion detection is often utilized in industrial automation systems to identify whether the equipment is working outside of typical parameters or when there is an unexpected item or person in an unauthorized area.

The issues thataffect object recognition, object tracking, lane tracking, and motion detection are as specified:

Luminescence variation: Surface light variation carried on by daylight variations, weather, obstructions to light sources, etc.

Noise in images: Noise is the component that most impacts the visual attribute of the video frame. A poor-resolution video might make moving object detection and tracking might be challenging. In real-time, the topic might be obscured by other objects totally or partly. Yet, the approach is prone to complete occlusion.

Existence of shadow: Shadows arise whenever the source of light is obscured. monitor both extremely slow as well as very fast-moving objects.

Clutter: It suggests a complex backdrop that renders detection and tracking harder.

Complicated object motion: It could be challenging to track both extremely slow and rapidly moving objects.

8. CONCLUSION

In conclusion, object detection, object tracking, lane tracking, and motion detection are significant computer vision methods that are extensively employed in diverse applications such as autonomous cars, surveillance, and robots.

Object detection is the act of recognizing and localizing objects in an image or video, whereas object tracking is the process of tracing an item's movement through time. Lane tracking includes identifying and pursuing the lanes on a road, which is helpful for autonomous vehicle systems. Motion detection is the technique of recognizing changes in the location of items in a scene over time.Each of these strategies has its benefits and disadvantages, and the option of which one to utilize relies on the unique application needs. Item recognition and tracking are especially valuable for security and surveillance purposes, while lane tracking is vital for self-driving automobiles. Motion detection is a pivotal building element for several computer vision approaches and may be utilized in a broad variety of applications.

Overall, these strategies have transformed the way machines see and comprehend the world around usallowing the creation of breakthrough innovative technologies that havethe possibility of enhancing our lives in countless ways.

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MIT UNIVERSITY'S – ABHIVRUDDHI JOURNAL
ISSN(Online): 2584-1025
VOL.2 (01) , JUNE , 2022 pp- 27-35

Labour Safety & Skill Training Using Virtual Reality, A Case Study- Of Higher Altitude Work.

Pranit P. Merchant
Dr. D. Y. Patil College of Architecture,
Savitribai Phule Pune University,
Pune, India
merchant.pranit@gmail.com
Sayali V. Desai
MIT School of
Architecture, MIT-ADT
University,
Pune, India
sayalid19998@gmail.com

Abstract—As the construction industry has boomed, urban migration has surged, triggering an increase in demand for housing in crowded urban spaces, which leaves us with only one option besides high-rises.
With a background in high-rise construction, labor safety is one of the foremost concerns. This type of construction has a relatively high accident rate. Researchers and professionals have been motivated by this scenario to find innovative ways to solve the problem. To address this issue, after a given period of time, regular safety training should be implemented. Effective training may refresh the comprehension of existing employees as well as convey critical safety knowledge to new personnel. Virtual reality using hardware meta oculus has enabled us to better understand work fatalities without putting our lives at risk. This paper is based on a case study of planning and creating a VR module for high-altitude safety training. Using an experimental methodology, several features of the VR module were investigated. The results showed that the VR module positively improves high-altitude professionals' perceptions of VR applications as additional training tools.

Keywords—Virtual Reality, Training, Technology, Project Management, Construction, Meta-Oculus.

I. INTRODUCTION

According to the Occupational Safety and Health Administration [OSHA], the construction sector has one of the worst rates of work deaths, and the best way to improve the industry's safety performance is to prevent accidents from occurring in the first place. One approach to achieve this goal is to raise construction workers' awareness. Previously, various tactics such as video recordings, handouts, and hands-on training were utilized to instruct construction workers on safety. Each of these strategies has benefits and drawbacks. Virtual reality and other forms of mixed reality technologies have completely changed several facets of the building sector. It provides a distinctive and efficient training technique for personnel in the construction industry, reducing the need to expose them to hazardous site situations. In the context of safety instruction, this immersive and realistic technology outperforms more conventional training choices like movies and handouts. The capacity of this technology to recreate high-risk scenarios is one of the main goals of using it. There are several potential advantages of new technologies for construction training, including cost-effectiveness, accessibility, repeatability, and user customization. They do, however, have certain shortcomings. High upfront expenditures, protracted development times, difficulties with customization, and restrictions on hardware and software are a few of these. However, efforts are still being made to improve VR technology, eliminate these drawbacks, and increase the number of applications for VR-based solutions.

II. AIM

Analyzing the safety issues associated with high-altitude construction work and developing an effective solution utilizing Virtual Reality (VR).

III. OBJECTIVE

1. To study the concept of Virtual reality in labor safety programs working at high altitudes.
2. To analyze problems associated with high-altitude construction work.
3. To find the issues regarding the existing safety training model for high-altitude work.
4. To propose a safety training module for high-altitude construction work using virtual reality.
5. To study the impact of Virtual reality training for high altitude on user groups through survey forms.
6. To suggest Preventive measures for the high-altitude safety training model.

IV. HYPOTHESIS

The construction industry should adopt to VR-based training to overcome accidents & fatalities on-site.

V. SCOPE

The research work is undertaken at Pune locations for the use of VR in the safety training of high-altitude construction work.

ISSN(Online): 2584-1025

VI. LIMITATION

The paper is limited to higher altitude construction work for the Pune region.

VII. LITERATURE REVIEW

Extensive research conducted in recent years has focused on the utilization of VR technology in construction training. Numerous studies have demonstrated that training programs based on VR can lead to significant enhancements in both safety and skill levels among workers.

Similar to this, research by Gok et al. (2018) discovered that VR-based training was successful in enhancing employees' abilities to carry out electrical activities. The study concluded that workers' knowledge, abilities, and confidence in carrying out risky activities may all be improved with the use of VR-based training programmes. Another research by [Rajan et al., 2019] looked at the efficiency of VR-based training in enhancing construction workers' safety and productivity. According to the study, VR-based training programmes increased worker productivity and safety more than conventional training techniques.

When it came to monitoring site activity in the past, safety managers in the construction sector depended on their professional expertise and visual observations. Virtual reality (VR), on the other hand, has become a potent method for visualising digital information as a result of the rapid improvements in information technology (IT). Users may fully immerse themselves in computer-generated models thanks to VR technology, which allows for the construction of immersive and realistic settings. Highly responsive and dynamic computers that can react fast to human interactions, choices, and manipulations underpin this technology. Different inputs, including speech, movement, sound, and location, can be included in VR models. The discipline of advanced construction management has benefited greatly from VR as a result. Virtual reality (VR) technology has been successfully applied in numerous facets of construction management in recent years. They are useful resources for worker training, safety management, quality and defect control, and visualization. VR technologies help to lower the number of accidents on building sites by offering platforms for monitoring, regulating, and teaching projects. [Ahmed, 2018]. The use of VR in safety management was explored by Li et al. in 2018, and they emphasized the technology's potential in a number of safety-related fields, including hazard risk detection, workforce education, skills transfer, ergonomics, and more. By simulating building operations with VR technology in 2020, Getulietal also enhanced the traditional planning procedure on construction sites. Li et al. divided the uses of VR methods in construction safety into three primary areas in a review study published in 2018: safety planning, safety inspection, and safety training. A minimum level of acceptability for VR in safety training, which attempts to improve danger awareness skills, was typically seen among safety professionals, who frequently favored hands-on activities.

To sum up, VR technologies have demonstrated a great deal of promise in the management of construction safety, delivering prospective advantages in a number of domains while acknowledging the desire for hands-on training among safety experts.

VIII. METHODOLOGY

This project's primary goal was to determine whether VR technology might be used for safety instruction.

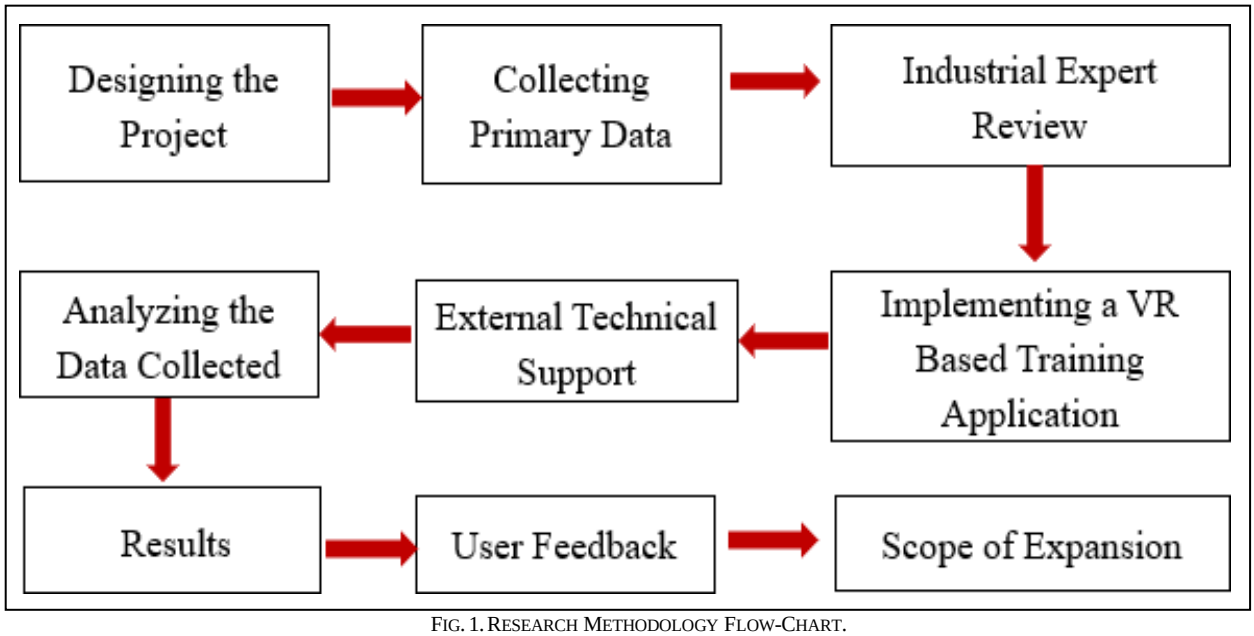

FIG. 1. RESEARCH METHODOLOGY FLOW-CHART.

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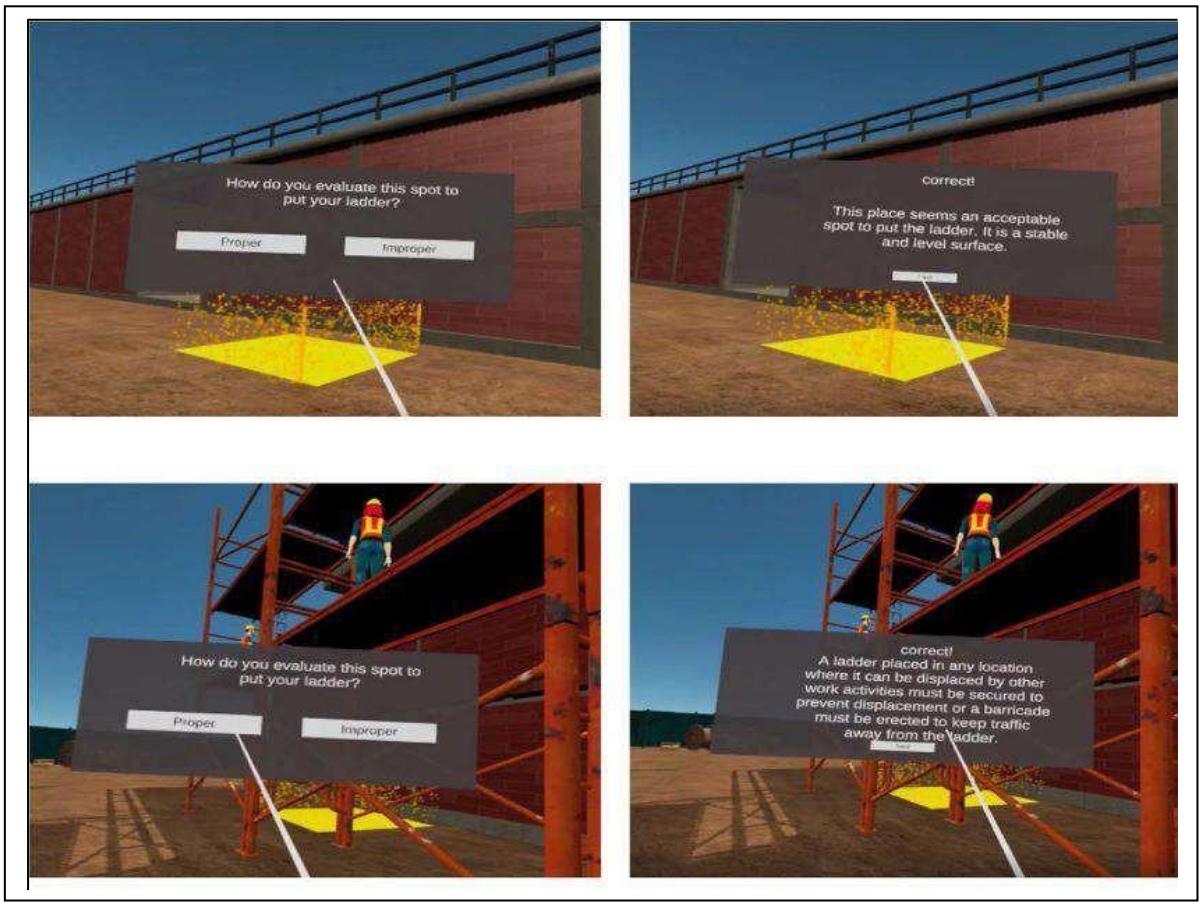

FIG. 2. VR INTERACTION SNAP SHOTS (SOURCE: SAEED ROKOOEI ET-AL (2022)

In addition to user impressions. As the primary users of the module, high-altitude working professionals were given priority in the study's approach. After reviewing the ten distinct parts made utilizing the software programs 3D Sketchup and Unity to do ladder-related duties, a scenario was presumptively created.

Participants in the Saeed Rokooei et al. 2022 research were immersed in a pre-designed 3D model utilizing virtual reality technology called Oculus or online meetings. The participants completed a standardized questionnaire, which was given to the researchers via an Internet platform. After a section on demographics, a five-point Likert scale was used to gauge participants' degrees of agreement or their perceptions of the significance of various impacts. Participants were asked to respond, and the researchers collected their replies. After analyzing the data, the researchers found that 30 responses were appropriate for further examination. Using software like Microsoft Excel or Word for descriptive analysis, the replies were collated, processed to remove any mistakes and inconsistencies, and suitably categorized to assure accuracy.

IX. ACTION PLAN

After reviewing the 10 distinct portions that were created using the 3D Sketchup studio and unity, software, and duties linked to ladders. Action plans included safety guidelines and directives for the corresponding circumstances.

The area's primary topics include:

1) determining the optimal placement for the ladder on the job site.

2) Choosing the ladder to use depending on the weight rating and height of the structure,

3) Examining the ladder for mud, grease, structural damage, and missing parts; 4) erecting the ladder; 5) securing the ladder; 6) maintaining secure contact with the ladder; 7) using the ladder to transport materials; 8) dismounting the ladder at the roof; 9) un-securing and descending the ladder and lowering the ladder to the ground; 10) safe roof work inspection; and 11) loading the ladder on the truck for safe transport. The study's approach Every part made the premise that the user was a freshly hired high-altitude worker who was responsible for assessing the hazards and safety issues associated with various ladder-related jobs. The primary topics of traditional safety training and the viability of VR technology as supplemental aids were covered by the survey's questions.

The VR interaction window shows where a ladder should be placed and underlines the important details to consider while utilizing it at a high height.

The VR training program educates workers on potential risks and dangers through a variety of situations.

ISSN(Online): 2584-1025

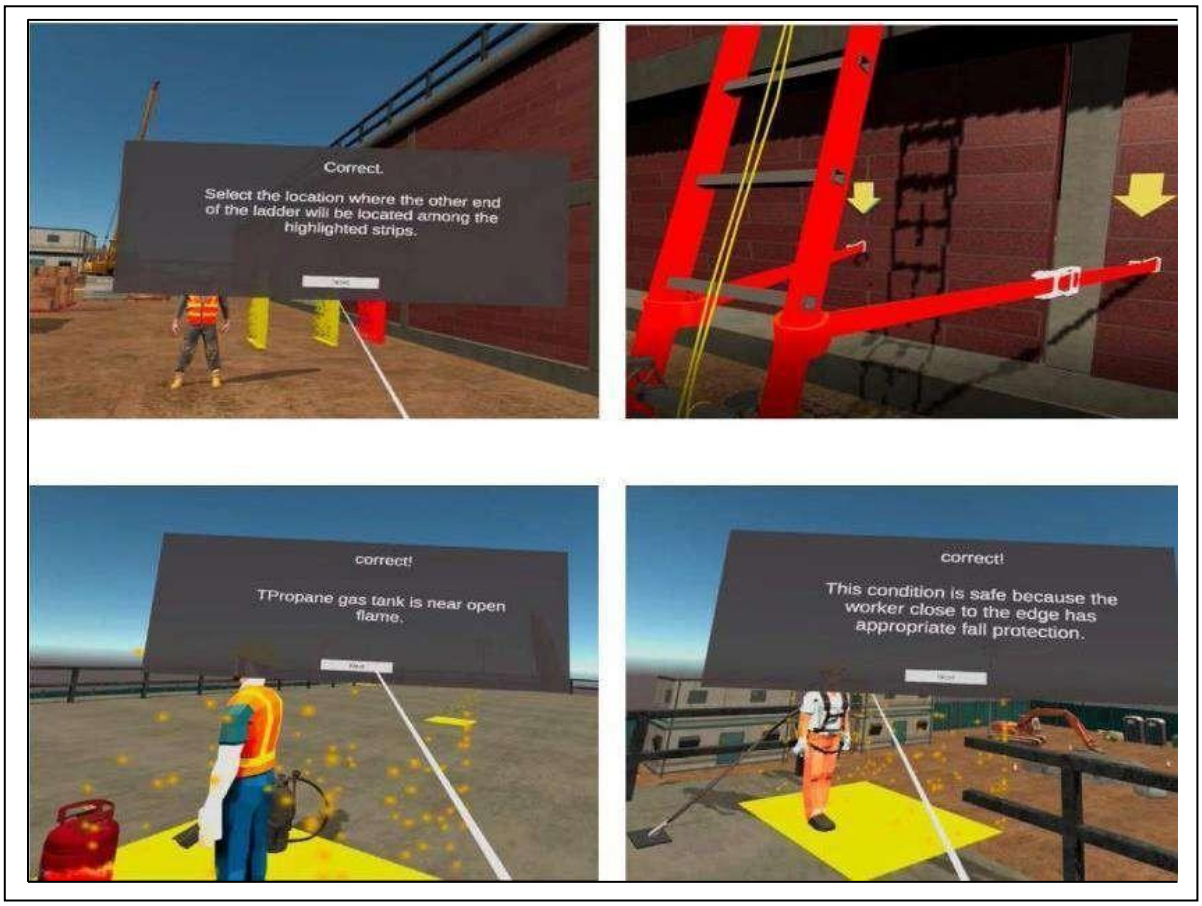

Fig. 3. VR Interaction Snap shots (Source: Saeed Rokooei et-al (2022)

safety precautions necessary for working at heights, enabling them to make decisions with knowledge in the worst-case situation.

the participants were mostly high-level executives from companies. The next questionnaire was safety-related.

X. DATA ANALYSIS

The demographic information of the participants In [Table 1]. Shows that the majority of Participants were male, above 51 years old, and with experience above 25 plus years. Also, hours of training that must be mentioned for new hires As shown in Table 1, forty-five percent of participants said that new

More than 16 hours are spent on staff training. Moreover, 85% of interviewees said that their present workers must

Gender	**Male (%)**	**Female (%)**			
	68	32			
Age	**21-30 (%)**	**31-40 (%)**	**41-50 (%)**	**51-60 (%)**	**61+ (%)**
	28	9	20	39	4
Experience	**1 to 3 (%)**	**4 to 7 (%)**	**8 to 15 (%)**	**16 to 25 (%)**	**25+ (%)**
	12	40	24	10	14
Position	**CEO (%)**	**Project Manager (%)**	**Sales Manager (%)**	**Office Engineers (%)**	**Labors (%)**
	9.5	48	14	19	10
New Hires Experience years	**1 to 3 (%)**	**4 to 7 (%)**	**8 to 15 (%)**	**16 to 25 (%)**	**25+ (%)**
	51	39	4	2	4
Training Hours	**0 to 4 (%)**	**5 to 8 (%)**	**9 to 15 (%)**	**16+ (%)**	
	20	22	13	45	
Training Interval	**Within 3 mo. (%)**	**Within 6 mo. (%)**	**Within 1 year (%)**	**At will (%)**	
	56	18	21	5	

TABLE 1. DEMOGRAPHIC PROFILE

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attend training programs on safety to update their expertise. Participants were also questioned on the frequency of ongoing safety training that their staff members must attend. [Table 1] displays the proportion of time intervals.

The following inquiry asked participants to identify the primary cause of accidents in the high-altitude industry. Although a substantial majority of workers showed a reckless attitude, 51% of participants said that accidents were caused by a lack of information or insufficient training. [Fig. 4].

Using a Likert scale with a maximum score of 5, participants also judged how much they think various factors have an influence on high-altitude industry accidents [Very Low: 1; Very High: 5]. [Fig. 5.] displays each level's percentage.

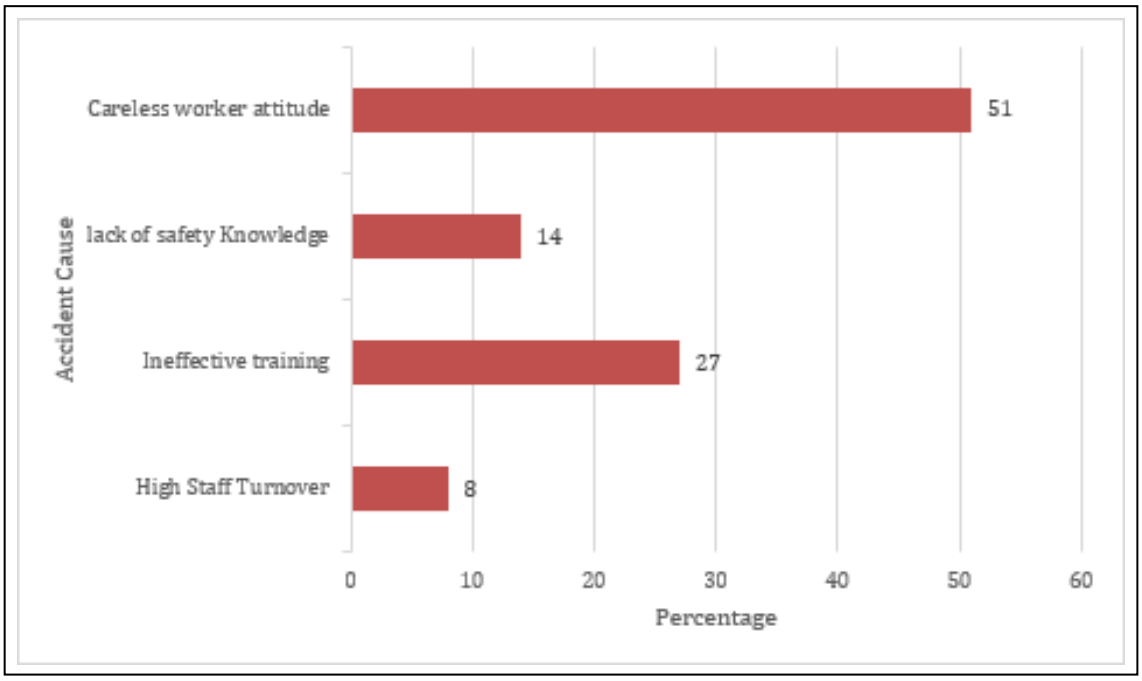


FIG. 4. MAIN CAUSE OF ACCIDENTS

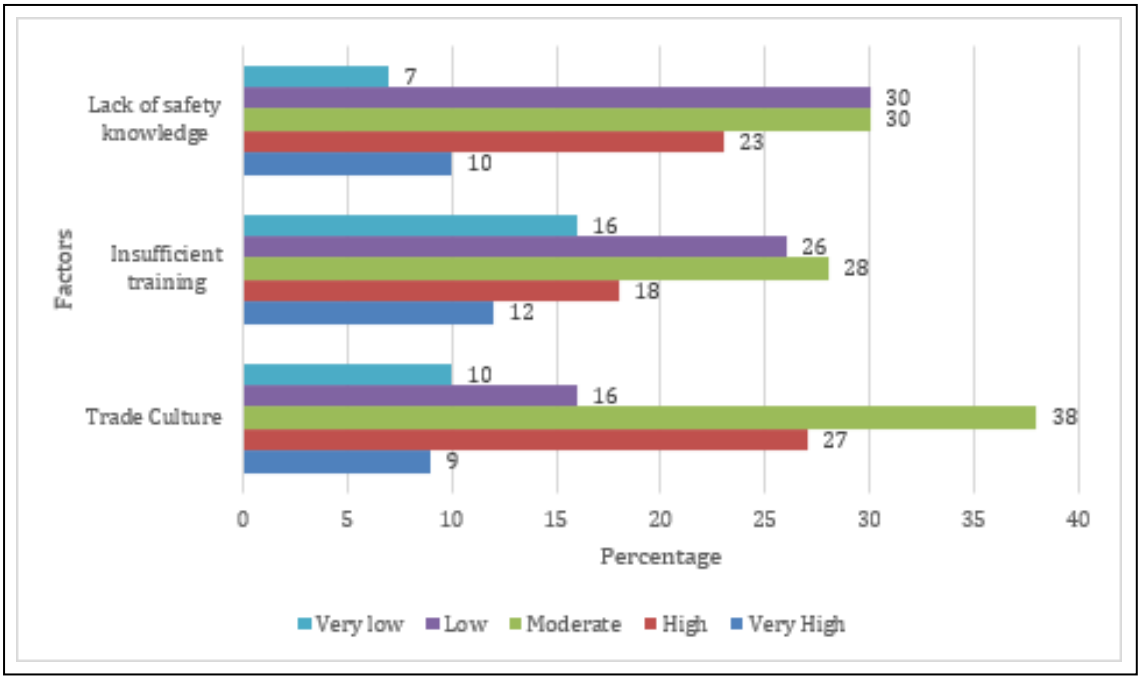


FIG. 5. FACTORS IMPACTING ACCIDENTS

ISSN(Online): 2584-1025

The survey's next portion included inquiries about virtual reality and its use in safety instruction. First, using a five-stage Likert scale, participants were asked to assess how familiar they were with VR in general. [Fig. 6.] displays each level's percentage.

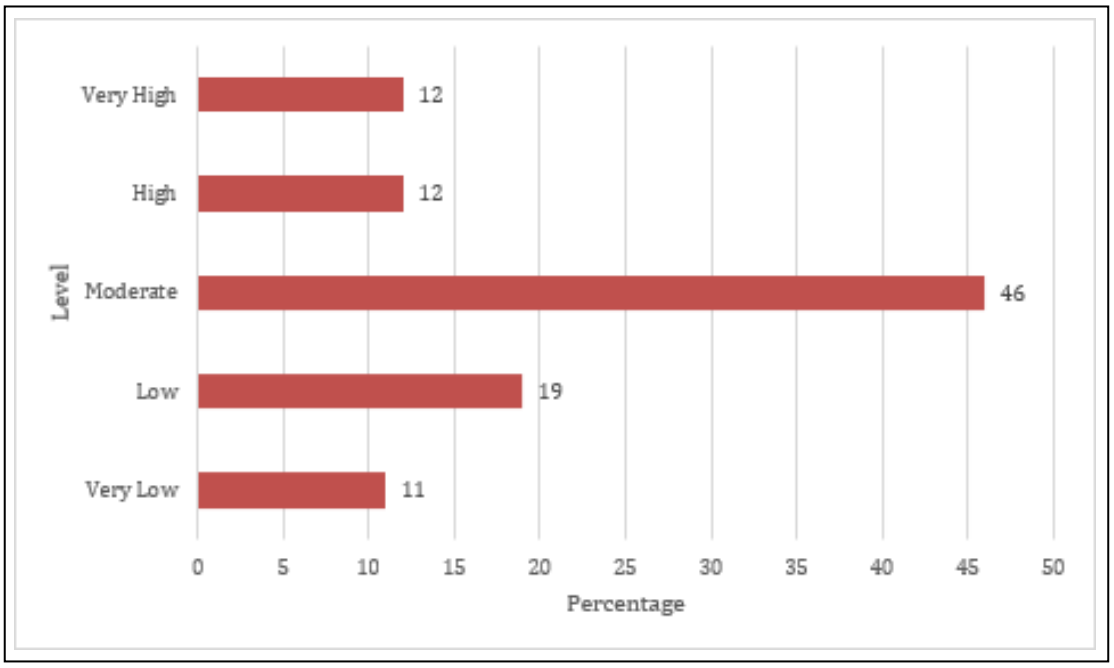


FIG. 6. VR FAMILIARITY.

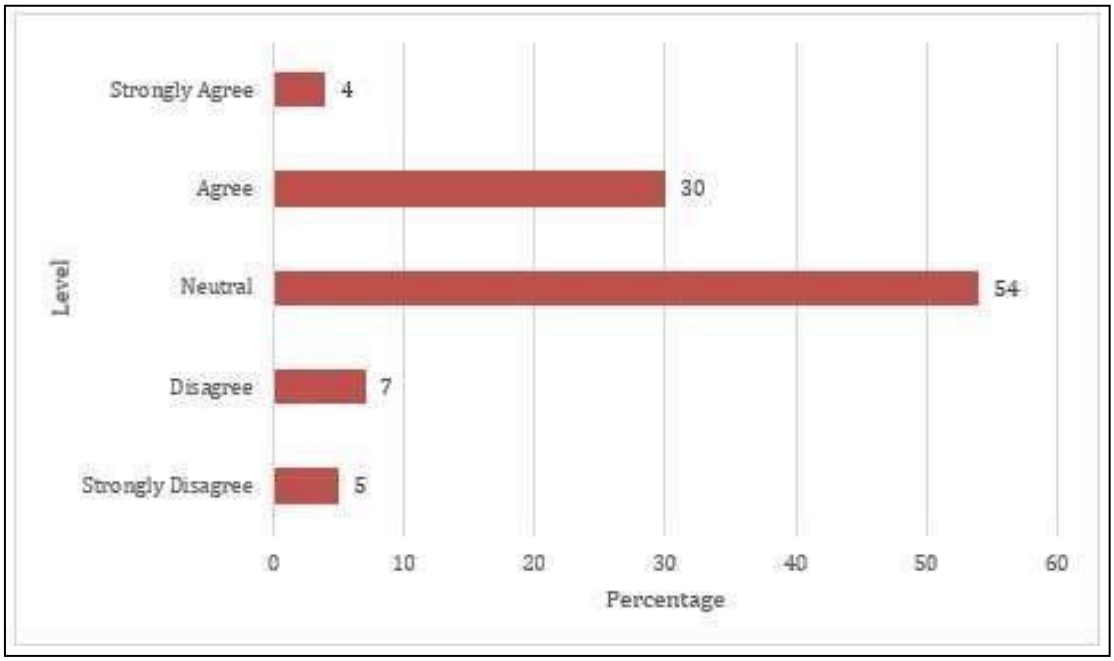


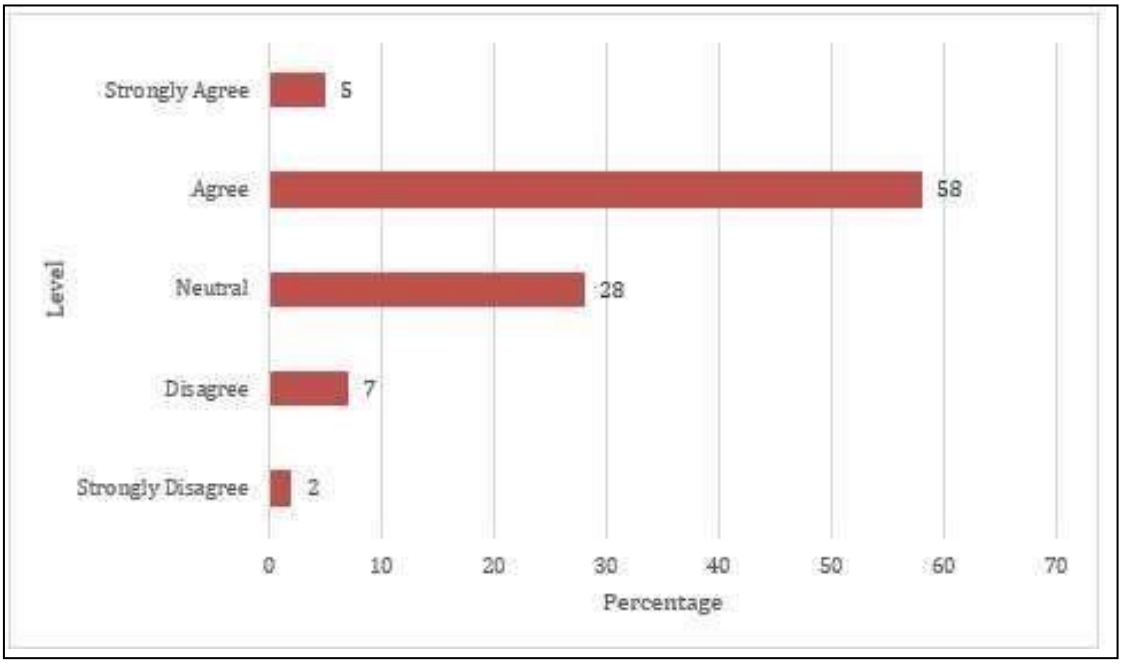
FIG. 7. VR APPLICABILITY

The answer to the following question's statement, "Virtual reality is highly appropriate for workforce development in the high-altitude industry," showed the contributors' level of settlement. Only 5% of participants disagreed with the statement, while 30% agreed and the rest 54% were neutral [Fig. 7].

In a similar vein, participants were questioned about whether they thought virtual reality may assist the next generation of workers in learning the necessary safety guidelines while still

ISSN(Online): 2584-1025

enjoying the surroundings. The majority of participants (63 percent agreed, 28 percent were indifferent, and 9 percent disagreed) had favorable opinions about VR's suitability for modern training. In [Fig. 8], the proportion of each level is displayed. Participants also stated that they intended to look for chances to implement virtual reality programs for safety training in their organizations. Only 9% of participants disagreed with the strategy, while 55% were indifferent and 36% of participants said that they were in favour of using VR for training.



Only 9% of participants disagreed with the strategy, while 55% were indifferent and 36% of participants said that they were in favor of using VR for training.

The proportion of each agreement level is displayed in [Fig. 9]. After taking part in the safety lesson, participants also responded favorably to the VR application. On a five-stage Likert scale, participants were asked if their confidence in the usage and application of digital reality increased after they gave it a try.

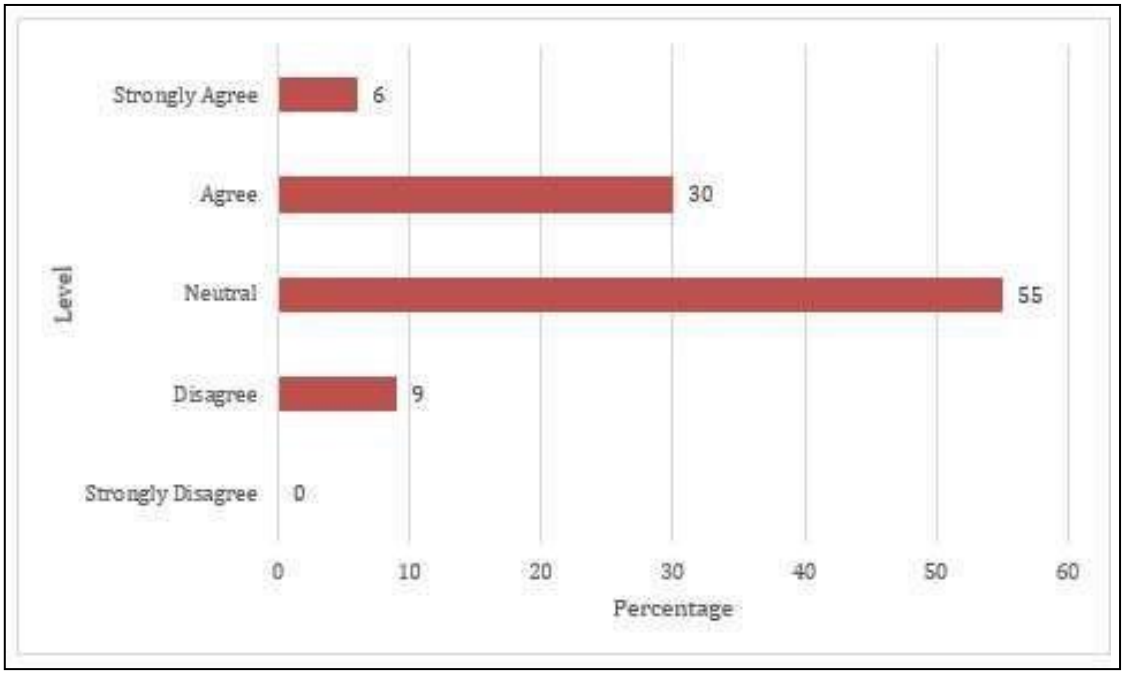


FIG. 9. VR AGREEMENT FOR TRAINING PURPOSE

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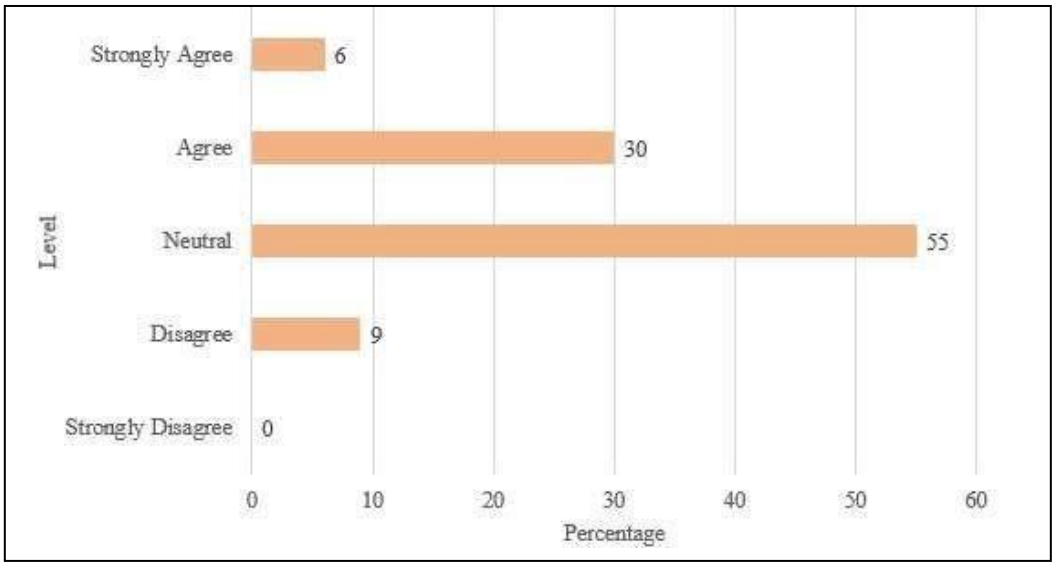

FIG. 10. VR AGREEMENT FOR ENGAGEMENT

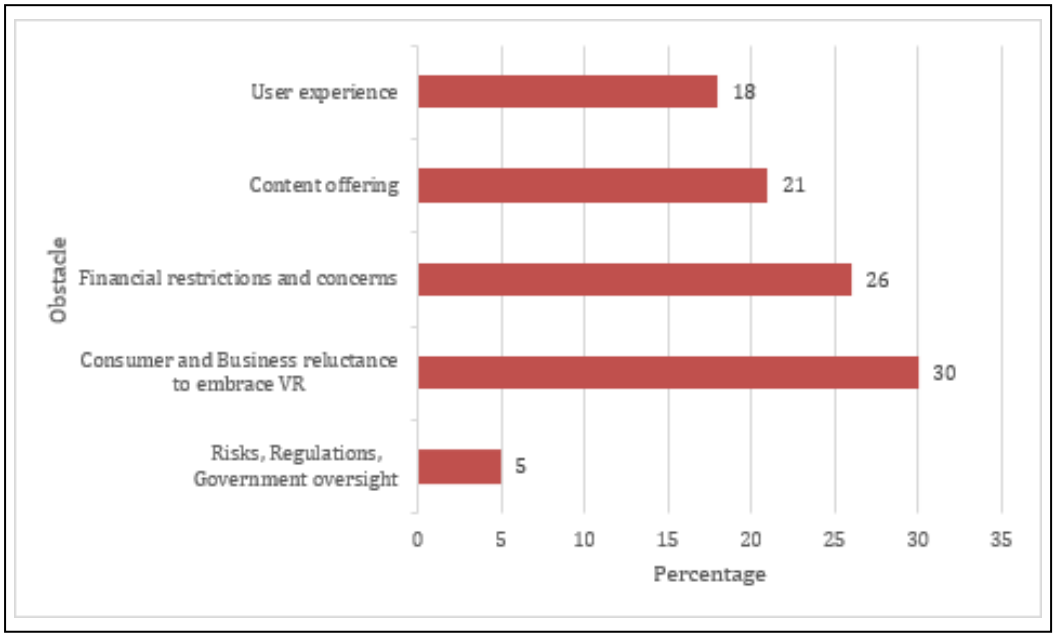

FIG 11 MASS ADOPTION PERCENTAGE OBSTACLE

On a five-stage Likert scale, participants were asked if their confidence in the usage and application of digital reality increased after they gave it a try.

The proportion of each agreement level is displayed in [Fig. 10]. Participants were also given a variety of VR characteristics to score on a Likert scale with a total of five stages. the average of all factors, weighted. The three qualities of "ease of use," "detailed and complete instructions," and "engaging audio/visual components" were among the most sought-after features, despite the fact that all elements were judged as being of interest (above mid-point). The top five well-known hurdles were conditioned to be chosen when participants were asked to identify the largest barrier to the widespread use of virtual reality technology in the high-altitude working sector. [Fig. 11] displays each obstacle's proportion. As shown,

XI. DISCUSSION

VR has created a new platform for immersive learning. It is especially useful for simulating potentially hazardous locations, like construction sites. Construction employees may receive safe training there without having to worry about failing or suffering any negative consequences. The findings of the safety-related section questions revealed that most businesses require new hires to undergo more than 16 hours of training, with breaks typically occurring every three months. This demonstrates the value of safety training for employees who work for the questioned organizations. On the other side, some businesses mandate shorter training sessions and don't mandate breaks. This demonstrates that some businesses still do not prioritize safety. Nearly half of the participants had some VR experience, however the majority of the relaxation had little to very low VR experience. Contrary to interior design, this fact is supported by statistics from more established crafts in the building

ISSN(Online): 2584-1025

sector, such as concrete, structural, and cladding. Therefore, raising public knowledge of VR applications in safety training needs to be a top focus.

XII. CONCLUSION

The results of this study point to the potential of VR-based training programs to improve worker safety and skill development for those doing higher-altitude construction work. The study's findings suggest that by offering accurate simulations of hazardous circumstances that workers may come across when working at high altitudes, VR-based training programs can dramatically increase workers' safety and skill levels.

Given the enormous advantages of VR-based training programmes, it is advised that construction organisations use these initiatives to raise the safety and competence levels of their workforce.

Additionally, construction firms want to keep spending money on creating tailored VR-based training courses that address the individual requirements of their employees. In conclusion, VR-based training initiatives have the power to fundamentally alter how employees are prepared for dangerous professions like high-altitude construction.

These training programmes may greatly increase employees' safety and skill levels by giving them accurate simulations of dangerous circumstances, thereby lowering the likelihood of accidents and fatalities in the construction sector.

The few negatives of VR training include eye irritations, high investment costs, the need for ongoing site-specific adjustments, and the inability to use it in crowded areas.

ACKNOWLEDGMENTS

Acknowledgments to the professional experts who help during the study of VR training, & the workers who participated in the training program, also Professor Ar. Asmita Patwardhan & Dr. Pooja Merchant for complete guidance during this process.

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MIT UNIVERSITY'S – ABHIVRUDDHI
JOURNAL VOL.2 (01) , JUNE , 2022
pp- 36-41
ISSN(Online): 2584-1025

Digital Interventions Of 3D Printing Technology In Architecture

Author: Mr. Amit Pisolkar
Co-Founder, Inpro Interiors.
Dubai, UAE
Email: aramit.pisolkar@gmail.com

Co Author: Mrs. Madhuri Patil
Associate Professor, Dr. D.Y. Patil School of Architecture
Lohegaon, Pune, India
Email: pramad2011@gmail.com

Abstract—The architecture and planning industry is constantly evolving, and digital technologies are driving many of the emerging domains and innovations in the field.

In this research paper, the aim is to study application of 3D printing technology in architecture and construction industry

Through digital interventions, the use of 3D printing technology in architecture and planning has the potential to radically transform the design and construction process.

With the review of existing literature and book case studies, this paper will examine the ways in which 3D printing can improve various aspects of design customization, sustainability, and efficiency in building construction. Additionally, this paper will also explore the future potential and current limitations of 3D printing technology in architecture and planning.

The results of this research are mainly to explore advantages over conventional construction methodologies and valuable insights for architects and designers on how to fully leverage the capabilities of 3D printing technology to improve the built environment.

Keywords—Architecture, 3D printing, digital interventions

I. INTRODUCTION

The integration of digital technologies has brought significant changes in architecture and planning in the last few years. The advent of 3D printing technology has revolutionized the way architects design and construct buildings. This paper examines the application of 3D printing technology in architecture and planning, highlighting its potential to improve the design process and construction industry.

3D printing, also referred to as additive manufacturing, is creating objects using layers of material to form three-dimensional objects. The technology has been applied to various industries, such as healthcare, fashion, and even food. Despite being a relatively new idea, the implementation of three-dimensional printing in both architecture and construction is already demonstrating significant prospects.

The advancement of technology is changing the construction industry. The introduction of 3D printing has proved many advantages over Conventional Construction Methodologies. Architects can take benefit of 3D printing for creating anything from concept models to fully functional buildings.

ISSN(Online): 2584-1025

Here is a list of the some of the many major advantages of the use of 3D printing for architecture, whether in the design or construction phases.

A. Advantages :

- Speed and Efficiency: 3D printing can significantly speed up the design and construction process, compared to traditional construction methods that require manual labor and tooling.
- Customization: 3D printing allows for greater customization, as the printing process can produce complex shapes and geometries that are difficult or impossible to create with conventional methods.
- Improved Accuracy: 3D printing offers improved accuracy and precision, as the printing process can be precisely controlled and errors can be easily corrected.
- Reduced Material Waste: 3D printing uses significantly less material than traditional construction methods, reducing waste and conserving resources.
- Increased Design Freedom: 3D printing enables architects and builders to explore new design possibilities and push the boundaries of what is possible with conventional construction methods.
- Improved Sustainability: 3D printing can have a positive impact on the environment, as it can use recycled materials, reduce waste, and minimize the carbon footprint of the building process.
- Flexibility: 3D printing enables the creation of complex and customized building components off-site, reducing the time and disruption on construction sites.
- Prototype Testing: 3D printing can be used for prototyping and testing of building components, allowing for improvements to be made before full-scale construction begins.
- Safety: By lowering the need for human labor and removing the requirement for humans to work in hazardous situations or at heights, 3D printing technology has the potential to increase safety on construction sites.
- Innovation: 3D printing technology has the potential to inspire and facilitate the development of new and innovative building designs and construction techniques.

Though some are still in an experimental stage, but it’s foreseen to have a significant impact in the near future.

II. Research Methodology

To achieve this aim, this paper draws on an extensive review of the existing literature on 3D printing technology in architecture and planning. The review includes a range of case studies and research articles from various sources, including academic journals, and industry reports. The data was analyzed to identify the main advantages, limitations, and trends in the application of 3D printing technology in architecture and planning.

Literature Review: The use of 3D printing in architecture and planning has the prospective to advance numerous elements of the design and construction process. The ability to create intricate designs and structures using the technology of 3D printing is one of the most important benefits over conventional construction techniques. In addition, the process of printing can reduce the quantity of waste material generated during construction and improve efficiency by reducing the time needed to produce components and structures.

ISSN(Online): 2584-1025

Case Studies

A. Office of Future, Dubai, UAE

World first 3D Printed fully functional Office building constructed using 3D printing technology. The building was constructed in just 19 days at site, reducing the on-site construction time significantly than a traditional building. The building's exterior has a unique design with curves and undulating shapes that were difficult to achieve using conventional construction methods. The building components were printed in workshop in china and assembled onsite.

Key benefits

- Minimizes on-site wastage, reducing environmental footprint
- Efficient and rapid printing process shortens construction time to 19 days.
- Improves accuracy and reduces manual labor.
- Reduces carbon footprint of transportation and delivery of building materials.

Office of the Future, Dubai. [1]

B. MX3D 3D Printed Bridge, Amsterdam

The MX3D 3D Printed Bridge, is a 3D printed steel pedestrian bridge that was designed by Joris Laarman Lab. The bridge was constructed using a 3D printing technique known as wire and arc additive manufacturing, which allows for the printing of metal structures. The bridge's design was based on generative algorithms, resulting in a unique and intricate design that would have been difficult to achieve using traditional construction methods.

Key benefits

- Reduces material waste and energy consumption
- Allows for precise construction, reducing excess materials and rework
- Made entirely of durable, low-maintenance stainless steel, reducing environmental impact
- Offsite production reduces carbon footprint of conventional constructions logistics.
- Supports sustainable transportation modes like walking and cycling, reducing carbon emissions.
- Installed on site in one day, reducing all the logistics, environmental impact and carbon footprint of conventional on-site construction.

MX3D Bridge: fully functional stainless-steel bridge [2]

C. Tecla house, Massa Lombarda, Italy

The Tecla house, a pioneering example of 3D-printed eco residential architecture, was created using mainly local earth and water, making it the

ISSN(Online): 2584-1025

first house in the world to be 3D-printed entirely from a clay-based mixture. The word "technology" and "clay" are combined in the name of the house, which was created by Mario Cucinella Architects (MCA) and constructed by Italian 3D printing experts WASP.

Key benefits:

- Composition of the earth mixture responds to local climatic conditions.
- Use of biodegradable and recyclable material which makes the building zero-waste.
- Parametrically optimized filling of the envelope to balance thermal mass, insulation, and ventilation in accordance with climate conditions.
- Delivered in 200 hours of printing,
- Use of minimal energy- 60 cubic meters of natural materials and less than 6 kW of energy on average.

Tecla 3D printed house [3]

III. CHALLENGES

However, despite the many benefits of 3D printing, there are also challenges that must be overcome before the technology can be fully integrated into the architecture and planning industry.

Cost: One of the main challenges of 3D printing in architecture and planning is the cost. While the technology has the potential to save time and money in the long run, the initial cost of a 3D printer can be substantial. In addition, the cost of materials and other supplies can also be high, especially for large-scale projects.

Technical Challenges: Another challenge is the technical knowledge and expertise required to use 3D printing technology effectively. Architects and builders need to have a good understanding of the technology, as well as the skills to operate the printers and produce high-quality prints.

Regulation: There are also regulatory challenges associated with 3D printing in architecture and planning. Building codes and regulations may need to be updated to take into account the use of 3D printing, and there may be safety and performance requirements that must be met.

IV. APPLICATION/FUTURE SCOPE OF THE RESEARCH

The research conducted in this paper has highlighted the potential for 3D printing technology to be used in various applications in architecture and planning. In addition to the case studies discussed in this paper, 3D printing technology has a wide range of other possible applications, including the construction of big buildings and use in restoration and preservation projects.

Moreover, the future scope of 3D printing technology in architecture and planning is promising, with ongoing research and development in the field. As the technology continues to improve, it has the potential to reduce construction time and costs, improve energy efficiency, and increase design flexibility. On-site 3D printing of building components and structure has the prospects to completely transform the construction

ISSN(Online): 2584-1025

sector by lowering the amount of waste and transportation required and boosting productivity.

Furthermore, the integration of 3D printing technology in architecture and planning has the potential to address some of the most pressing issues in the field, such as sustainability and customization. The ability to 3D print structures using sustainable materials reduces waste and contributes to the development of eco-friendly buildings. Additionally, the ability to customize building components and structures using 3D printing technology allows for greater flexibility in design and the creation of unique structures that can meet the specific needs of clients and communities.

As 3D printing technology becomes more affordable and accessible, it has the potential to empower communities and individuals to participate in the design and construction of their own homes and structures. This could lead to greater community involvement, as well as the development of more sustainable and efficient structures.

Overall, the research conducted in this paper demonstrates the immense potential of 3D printing technology in architecture and planning. By incorporating this technology into the design and construction process, architects and designers can improve efficiency, sustainability, and customization while also creating complex and unique structures that would not be possible using traditional construction methods.

The case studies presented in this paper provide concrete examples of the versatility of 3D printing technology in construction, including the construction of large-scale structures, the creation of unique shapes and forms, and the use of sustainable materials. These case studies serve as valuable examples for architects and designers seeking to incorporate 3D printing technology into their own projects.

Looking to the future, there is significant potential for further development and application of 3D printing technology in architecture and planning. Ongoing research and development in the field are likely to result in improved efficiency, greater design flexibility, and increased sustainability. Additionally, as the technology becomes more affordable and accessible, there is the potential for greater democratization of design and construction.

V. Conclusion

The application of the technology of 3D printing in architecture and planning has the ability to fundamentally transform the process of designing and building. The three case studies presented in this research paper demonstrate the diverse range of projects that can be constructed using 3D printing technology, including an office building, a house, and a pedestrian bridge. However, while 3D printing technology has many advantages, it is important to consider its limitations, such as the size of the 3D printer and the cost of the equipment. Despite these limitations, the future scope of 3D printing technology in architecture and planning is promising, and further research in this area is essential to fully leverage the potential of this technology. Architects and designers can benefit from the insights provided in this research paper, to better understand how to incorporate 3D printing technology in their designs and construction projects, and to contribute to the advancement of the field.

In conclusion, the integration of 3D printing technology into architecture

ISSN(Online): 2584-1025

and planning represents a significant opportunity for the field.

By leveraging the capabilities of this technology, architects and designers can create more efficient, sustainable, and unique structures that are tailored to the needs of their clients and communities.

ACKNOWLEDGMENTS

This paper and research behind it would not have been possible without the exceptional support of all who have contributed to explore the topic. I also want to express my gratitude for my colleague who have contributed to complete this research.

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MIT UNIVERSITY'S – ABHIVRUDDHI JOURNAL ISSN(Online): 2584-1025
VOL.2 (01) , JUNE , 2022 pp- 42-48

Digitally Reconstructing the Past: Mapping the Historical Water Storage Structures at Gwalior Fort using GIS-based Inventories

Richa Mishra[1*], Harshita Mishra[2], S.S. Jadon[3], Akash Meena[4]

[1]Assistant Professor, Madhav Institute of Technology & Science, Gwalior
[2] Assistant Professor, Madhav Institute of Technology & Science, Gwalior
[3] Professor, Madhav Institute of Technology & Science, Gwalior
[4] Student 3rd Year, Madhav Institute of Technology & Science, Gwalior
[*]Corresponding Author: ar.richamishra01@gmail.com

Abstract— Gwalior Fort is one of the known examples for its Architectural as well as engineering interventions, one of its significant marvels is water management, including an extensive system of water collection and storage through a network of tanks, Baolis, wells, reservoirs, etc. This paper aims to use Geographic Information Systems (GIS) as a tool to develop heritage inventories which could help decision-makers in the cultural significance of these structures. The site visit was conducted to collect the required data and further GIS techniques adopted to achieve the objectives. The paper structure first highlights the historical significance of the study area and how water management evolved over a period of time through primary and secondary data. Looking at the present scenario these structures have lost their importance and their functionality has declined to leave behind them as a tourism element. With the help of GIS, their spatial context could be understood along with architectural, historical, social, and cultural significance. The paper depicts the results which will include a study area map with prominent structures and associated attributes that may be an efficient tool in Heritage management. The paper concludes by highlighting the potential for GIS technology to be used in future research on historical sites and structures.
Keywords— GIS, Heritage Inventories, Water storage structures, Gwalior Fort

INTRODUCTION

1.1 Background of the Study

The integration of Geographic Information Systems (GIS), Remote Sensing, and modeling technologies have become increasingly important in recent years, providing decision-makers with a crucial tool for analyzing spatial data and developing management strategies for the preservation and protection of cultural heritage sites (Droj, 2010).

GIS can prove to be a powerful tool for the inventory and mapping of heritage sites and facilitates the identification, documentation, and conservation of cultural heritage. GIS-based inventories can provide detailed information about the existing conditions and determine the values/ significance of these structures which may help prioritize their protection measures as per the present conditions and determine the level of interventions. This information can help heritage managers develop effective conservation and management plans that consider the water structures' importance and sustenance to the site's heritage.

Gwalior Fort, located in the state of Madhya Pradesh, India, is a significant historical monument that has played a crucial role in the history of India. The fort has witnessed the rules of the Gupta, Hunas, Pratihars, Kachhwahas, Tomars, Pathans, Mughals, English, and Marathas who have left their significant landmarks (Archaeological Survey of India, n.d.).

One such landmark includes its effective Water management system which has also addressed various cultural diversities. To better understand the evolution and management of this complex site, a GIS-based inventory was created to explore the Historic Water management system.

Through the case of the water structures of Gwalior Fort, the possibility of GIS-based inventories has been explored to manage and

ISSN(Online): 2584-1025

preserve cultural heritage over the traditional inventory procedure.

1.2 Objectives

Objective 1: To create a comprehensive inventory of the historical water storage structures at Gwalior Fort using the GIS tool by adding attributes related to location, age, capacity, present status, associated values, and conservation needs.

Objective 2: To digitally document the historical water storage structures using GIS, thus contributing to the documentation and preservation of cultural heritage and also analyzing the historical, social, and cultural significance of the water storage structures in the context of the fort's history.

Objective 3: To leverage the information collected through GIS-based inventories of the historical water storage structures at Gwalior Fort for effective management.

METHODOLOGY

2.1 Primary Data Collection

The site visit was conducted to collect tangible data for the documentation of water structures and intangible data through stakeholder interviews.

After having a basic idea about the site context through a literature study, the site visit was conducted to have an insight into the water structures to be listed. A set of structured questionnaires has been made for the collection of on-site data to develop digital inventories.

For understanding the current usage and maintenance status of water structures a qualitative survey for different stakeholders has been conducted through open-ended questionnaires. The stakeholders identified to extract such data were local tourist guides, management staff, and residents living in site proximity for ages.

2.2 Secondary Data Collection

The historic books and maps (Error! Reference source not found.) were collected from the local library and museums. Historical and cultural significance has been referred from the Archeological Survey of India published reports. The historic text has also helped in identifying the quantitative data (like, year of construction, dimensions, reconstruction if occurred, etc.) of targeted water structures.

Figure 1 Historic Map of Study Area (Gwalior Fort), (Murray, 1911)

2.3 Base Map Preparation

GIS tool has been used to synthesize data on a single platform, accordingly, the base map of the study area is created through Google imagery and later the historical map of the study area has been georeferenced to have the location of water structures. The site contours at the interval of five meters have been extracted from the digital elevation model (DEM). The road networks have been taken from the open street map. The neighboring built-up of fort water structures have been marked within the study area to understand their influence and dependency on the water structures.

2.4 Making Digital Inventories

Through GIS all the collected data were synthesized on a single platform. To achieve that the questionnaires and survey forms provide all the available information for each water structure and were converted into digital format i.e. excel format. This file shows the inventories which are ultimately linked with the spatial dataset on GIS in the form of attributes. The attributes listed

ISSN(Online): 2584-1025

below have been incorporated for water structure inventories-

- Historic name of Water structure
- Typology (tanks, baolis, wells, reservoirs, etc)
- Water source (runoff, groundwater recharge)
- Age
- Indigenous/New
- Dimension
- Construction Material
- Current condition
- Significance/Relevance
- Associated Values
- Grading/Prioritization

LITERATURE REVIEW

3.1 About the Site

Gwalior Fort is a hill fort measuring about 3 km long and 1 km wide, measuring about 3 square km located in Madhya Pradesh at a latitude and longitude of 26.2313° N, and 78.1695° E respectively. The fortress is rich in cultural heritage including Palaces, temples, water structures, etc.

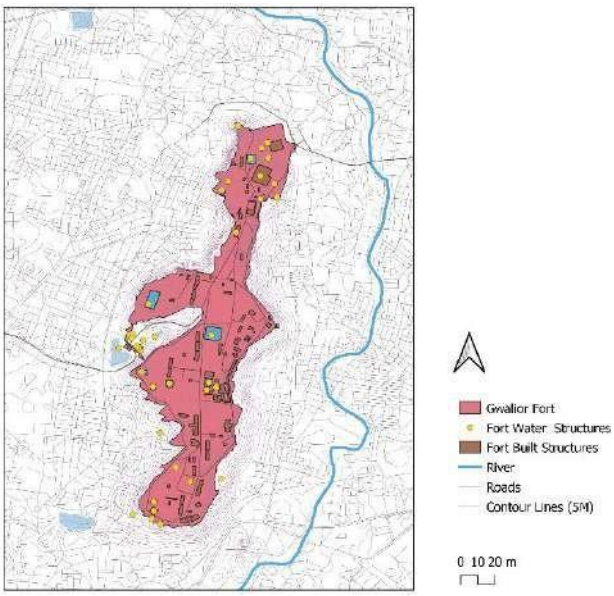

Figure 2 Study Area Map (Gwalior Fort) with water Structures

Figure 2 above represents the base map of the study area which has been generated on QGIS. The map represents the road network which is connecting the city to the fort complex, along with other details of the fort complex like buildings (fort-built structures), water bodies of all typologies (fort water structures), and others.

3.2 Existing Literature and Secondary data

Gwalior Fort lies at an elevated citadel that rises to a height of around 100 meters where a network of natural and manmade water sources was integrated to collect, store and supply the water demands of the fortress. Varied water heritage structures here include structures for water collection and structures for water storage. The water-collecting structures are composed of Taals (which serve as a catchment area that collects rainwater), Baolis (step-wells that store the rainwater), and Kunds (small reservoirs that collect water). The water storage structures include Tanks and Baolis.

The Fort has witnessed various reigns which have also evolved its water management system in terms of functionality as well as in terms of social, political, and cultural events. Gwalior's fort has been successful in terms of water supply because in historic times no enemy could ever capture it due to lack of water, its reservoirs are of adequate size and do not dry up even in extreme heat, and water supply in times of crisis.

For the management of water on the Gwalior Fort, ponds and step-wells were constructed so that the water requirements of the residents of the fort, members of the royal family, and soldiers could be met throughout the year (Batham, 2016).

The various water structures explored during the research includes about 39 water bodies including Gujari Baoli, Assi Khamba, Dhondha Baoli/Ek ankh ki Baoli, Shrad anar, Gargaj Baoli, Suraj Kund, Trikoniya taal, Johar Taal, Shah Jahan Taal, Mansarover taal, Rani Taal / Cheri Taal, Gangola Taal, Katora Taal, Ek Khamba Taal, Dhobi Taal, Noori Sagar, Saas Bahu Taal, Ek Pathar ki Baoli, Laxman Talaiya, wells, etc. which were mapped and laid based on various attributes like Location, Historic name of Water structure, Typology (tanks, baolis, wells, kunds, reservoirs, etc), Water source, Age, Indigenous/New, Dimension, Construction Material, Current condition, Significance, Associated values, and Grading.

ISSN(Online): 2584-1025

These mentioned water structures have not only served the water needs of the population but have also contributed to shaping historical, cultural, political, scientific, architectural, and religious significance. Few water structures are discussed highlighting their value and significance.

a) Suraj Taal: The Suraj Kund, the solar reservoir, is an important historical and cultural structure in Gwalior. It is the earliest tank in the city, measuring 350 ft. x 150 ft., and was dedicated to the all-purifying sun by Sürajpál, who was cured of leprosy after drinking from its bed. The temple of Surya, located on the west bank of the tank, is a testament to the religious significance of the structure. Additionally, the large fair held at this place every year on the last Sunday of Kartik showcases the cultural importance of the Suraj Kund. (Chakravarty, 1984)

b) Gujari Baoli: The Gujari Baori is a small deep tank with steps down to the water's edge about 80 feet long by 30 feet broad. It is situated at the foot of the cliff in the Gujari Mahal outwork (Cunningham, 2000). Its historical significance lies in the fact that the establishment of this baoli was due to the water source which was to come from Rai village through canals and drains for Mansingh Tomar's beloved wife Mrignayani. (Dr. Shanti Dev Sisodhiya, 2016)

c) Johar Taal: Johara Talao is a 200-foot square tank situated at the north end of the fort, named after the Johar sacrifice performed by the females of the garrison when the fortress was captured by Altamsh in A.D. 1232. It holds historical significance for the sacrifice and the events surrounding the capture of the fort. (Cunningham, 2000)

d) Ek Pathar Ki baoli: The rock-cut Jain caves in Gwalior fort were built by Tomar rulers and consisted of 24 caves and a stone stepwell, showcasing the religious significance of Jainism in the region during that time. (Dr. Shanti Dev Sisodhiya, 2016)

e) Assi Khamba Baoli: There are three different parts of this Baoli, which there are doors, pillars, and steps. Large stones have been used in its construction. The doors are made in Mughal style and the building is mandapnuma which is dependent on the pillars. The number of pillars in the mandap is about 80, which is why it is called Assi Khamba. According to popular legends, at the time of Rajamansingh, this construction was a Shiva temple, in which he used to worship Shiva in the morning. On one side of the building, there is a stone stepwell in which stairs have been constructed to go inside. The water in the stepwell does not dry up even in summer and probably its water was used for drinking purposes. (Dr. Shanti Dev Sisodhiya, 2016)

f) Shard Anar Baoli, is constructed by making a small arched entrance in Sharad and Anar Baoli, a square tank has been made by cutting it inside the hill, in length, width, and depth. Its roof is based on pillars cut into the hill (Batham, 2016) significantly demonstrating the procedure of rainwater harvesting, water filtration, and the collection of clean water into the stepwell.

g) Man-Sarovar: This lake is in the west part of the fort and near Urvahi Gate. It is said that the lake is built by Tomar Raja Mansingh Sir from 1486 to 1516. It is believed that the stones for the building of various monuments have been drugged, shaping this area as a pond that came to be known as Mansarovar. (Batham, 2016)

3.3 Heritage management through GIS Based Inventories

Heritage Protection and management is a complex issue in a country like India, catering to varied typologies and scales of heritage, and varied social, political, geographical, and cultural circumstances. Heritage inventory may emerge as an important tool in Heritage Management. It may include the Identification, Location, Boundary, physical features, functions, present conditions, and value as well as in prioritization which may be helpful in decision-making related to conservation and management (Shah, 2016). GIS may emerge as a tool to protect and manage all typologies of heritage under one umbrella so that the overall layers can be looked upon

ISSN(Online): 2584-1025

together as well as in isolation for efficient decision-making.

It can offer a variety of features including automated cartography display, historic property characterization and inventory, past landscape visualization and view sheds, impact assessment, and predictive modeling, etc (Limp, 1999). In terms of heritage protection, GIS can provide the following benefits over regular inventories accessibility and dissemination of information, efficient and accurate map storage and updating, Monitoring and risk preparedness, Site maintenance, and preservation plan and analysis (Hardy, 1997).

The paper covers the listing of water structures and linking inventories spatially through GIS. Figure 3 attached below shows the attribute table linked to each listed water structure.

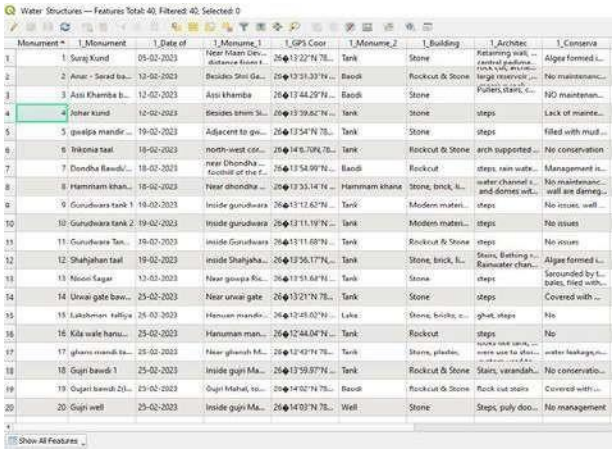

Figure 3 GIS Atributte table showing Inventories

RESULTS

Our analysis of the historical water management system at Gwalior Fort revealed several key findings.

First, we were able to identify the location and spread of water resources throughout the fort. We found that there were numerous natural springs and wells as well as numerous manmade baolis, tanks, kunds, etc. located throughout the fort, which were used to supply water to different areas within the fort complex. Visualization of the overall Historic water landscape could be done through the produced maps.

Second, we analyzed the water network designed to supply water to different areas of the fort, including the palaces, temples, and residential areas as per the distribution pattern. Thirdly, the current conditions were explored as compared to the historic maps for clear demarcation of shrinkage of existing water bodies and the evolution of newer ones. As a result, it has been the observation that the water structure footprint does not look much changed compared to that of historical data. Also, the current conditions give a fair idea of the functionality and level of interventions required for protection and management. In most cases, the water is covered by a layer of algae and the structures are facing deterioration. If the water harvesting channels could be revived, it may ensure clean water.

Finally, we determined that the water system had a significant impact on the fort's development over the centuries, and GIS can be an effective tool for its management and sustenance as varied stakeholders are involved in its protection. The produced set of inventories can be updated and maintained centrally, with ASI and other stakeholders. A centralized monitoring system can help in effective and collective decision-making for the protection and management of the site as well as visitors. The status of heritage could be monitored.

Through GIS we have synthesized all the above points on a single platform. The collected data has been converted to excel format (inventories) which is ultimately linked with the spatial dataset on GIS. Kindly refer to the GIS map (Figure 4) mentioned below showing the typology of structures. With the help of GIS, the collected inventories (example-typology) have been marked on actual location/coordinates.

ISSN(Online): 2584-1025

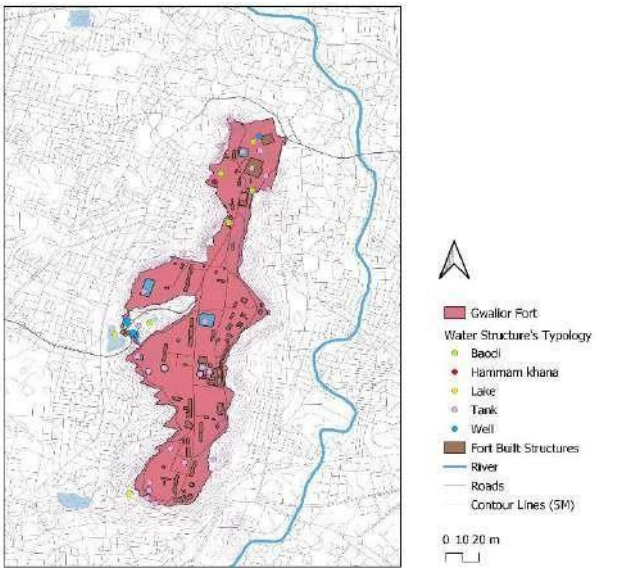

Figure 4 Map showing different Typology of water structures

Similarly, Figure 5 and Figure 6 depict the used construction material for each water structure and the status of restoration or reconstruction that occurred in the past for each water structure within the fort complex respectively.

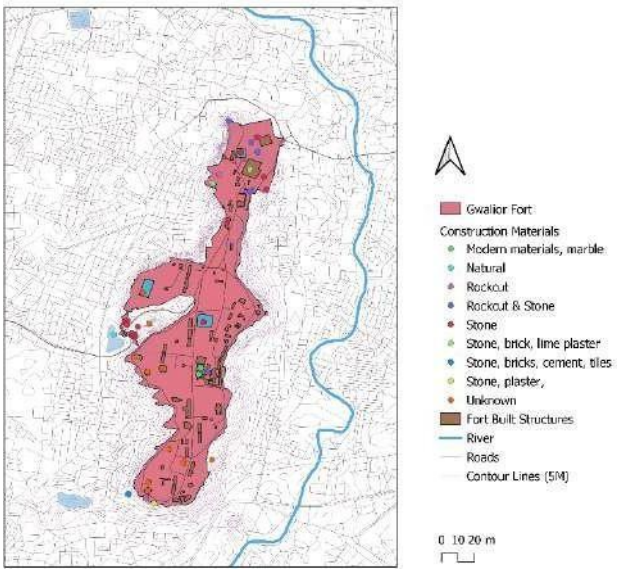

Figure 5 Map showing construction material used per water structure

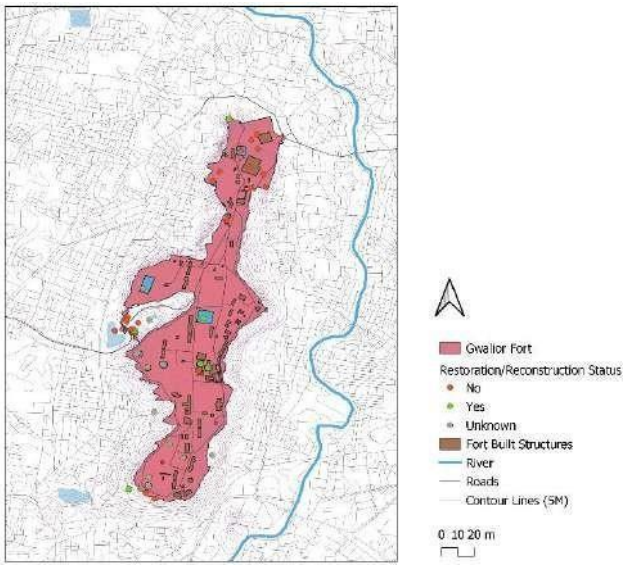

Figure 6 Map showing the restoration/reconstruction status of water structures

Thus various attributes could be analyzed and help in coming up- with effective actions and measures to protect and conserve historic structures by helping the decision-making process.

CONCLUSION

In conclusion, our research demonstrates the potential of GIS technology for mapping and analyzing historical water management systems. Our analysis of the historical water management system at Gwalior Fort provides new insights into the fort's history and highlights the importance of water management in ancient times. Our findings also demonstrate the potential for GIS technology to be used in future research on historical sites and structures.

According to (M.G. Masciotta, 2019), for effective Conservation and monitoring of cultural heritage, integrated documentation is crucial to support decision-making processes for preventive conservation purposes as well as for accessibility and longevity of the information. Digital Tools like G.I.S may prove beneficial in implementing such integrated decision-making.

Overall, this paper demonstrates the value of GIS as a tool for reconstructing and analyzing the past, and for informing the management and conservation of historic water storage structures.

ACKNOWLEDGMENTS

We would like to thank Mr. S.K Rathore, ASI for his support and input on the research.

ISSN(Online): 2584-1025

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MIT UNIVERSITY'S – ABHIVRUDDHI JOURNAL
ISSN(Online): 2584-1025
VOL.2 (01) , JUNE , 2022 pp- 49-74

Analyzing BIM use and application in the building industry from 2008 to 2023

Gayatri Mahajan[1] and Dr. Parag Narkhede[2]
[1]Assistant Professor, Allana College of Architecture, Pune.
[2] HOD, BKPS' College of Architecture, Pune.

Abstract

The Construction Industry (CI) is in a moment of enormous change. By 2025, India is anticipated to grow significantly and overtake China as the third-largest building market worldwide. Building Information Modelling (BIM) has become a potentially useful technique for improving construction projects. BIM is currently considered the most innovative methodology in the building industry as a model-based talented/enclosed nD ('n' dimensions) aims to provide tools for Architecture, Engineering, and Construction (AEC) experts to plan, design, and control construction projects further skillfully. In this paper study more than 130 papers are studied in- depth, out of which 79 papers found on review- based use of BIM in the CI. Among these, 42 are general reviews, 9 bibliometric and scientometric analysis, 8 papers each for a systematic and 9 critical reviews, 7 papers for overviews and 8 are for miscellaneous. Literature review research papers based on BIM use in the.CI, published during the last 15 years are analysed. Some BIM features like: Adoption (18), Benefits (14), Barriers (10), Challenges (10) and Risk Management (8). Rest of articles are based on safety, practice, scope, and framework, use and implementation are elaborated in the present study. Integration of BIM reviews with IoT, AR/VR, Digital Twin, Drone Technology, and AI offer enormous potential to enable a range of future applications in the construction business. It is equally important to incorporate BIM, its integration with cutting edge technologies academic institutions seeking to comprehend the significance and apply them in AEC in university curricula. The future of BIM in usage and applications in construction industry, construction management (CM) and construction projects (CPs) are discussed.

Keyword: BIM Dimensions, Barriers, Benefits, Risk Management, Construction safety, Challenges

1. INTRODUCTION

Building information modeling (BIM) is a trying to cut technology/process that makes it possible to construct structures that are better. Building Information Modelling (BIM) proffer a unique method to design, construction, and facility management in which a digital representation of the building product and process is employed to promote the sharing and the compatibility of digital information. Building information management (BIM) is a process that provides flexible design, simple interoperability, and other characteristics. This method has many benefits, including increased efficiency, lower costs, less rework, better coordination, and more. There are various BIM service categories, including 3D modeling, mechanical, and structural BIM services. India's population is growing at an exponential rate. By 2025, India's population is predicted to overtake China's as it would have 1.4 billion people, according to sources.

Amongst the most significant advancements in the architectural, engineering, construction, and operation (AECO) sector during the past 20 years is building information modeling (BIM). Government agencies have made using BIM while completing projects a requirement for contractors. BIM technology has been embraced by several nations, including the United States, the United Kingdom, Singapore, China, the Scandinavian nations (Norway, Denmark, Finland, and Sweden, among others), France, South Korea, etc. Government companies have an important role in advocating the use of BIM and raising public knowledge of it by establishing regulations, producing BIM standards, and developing BIM best practices that the private sector can accept and put into practice.

The deployment of BIM technology by the whole Indian AEC industry made the turn of the new millennium rather remarkable for India. Due to technological constraints, there was initially some

ISSN(Online): 2584-1025

hesitation and resistance to adopt fully-featured BIM technology for building, although this has changed recently. The necessity for infrastructure arrangements like building Public Utility amenities like roads, highways, ports, hospitals, etc., has been prompted by the rapid industrialization and urbanisation of society. Drones, robotics, augmented reality, and other technologies have changed how construction activities formerly took place on job sites. Integration of BIM technology into modern information technology has guaranteed that projects are streamlined with a low chance of differences resulting in changes.

India is not an exception to the emerging nations' quick adoption of BIM technology. The introduction of BIM technology in India has been a lengthy process, but in recent years AEC professionals have taken a huge interest in it. Future trends tend to be beneficial, and BIM technology has a promising future in the Indian construction industry (ICS).

II. LITERATURE RESEARCH REVIEW

The implementation of BIM in India is still in its infancy due to a lack of knowledge on its advantages. Also, there aren't many case studies about BIM that have been done in India. According to past study (2008–2015), there are a various reasons for which BIM is not being adopted in the Indian construction sector in a meaningful way. Some of these include technical know-how, qualified managers, technicians, and operators, ignorance of BIM's methodology among industry professionals, a passive attitude towards researching cutting-edge technology, and a reluctance to switch from traditional practice to new technology. Several literary sources are used in the current paper. It includes studies pertaining to recent aspects based on literature sources. A review of the literature on BIM technologies that are often used in building processes was conducted by gathering references from journals, websites, conference papers, books, theses, surveys, and other reports. Journals make up the largest proportion of the resources discovered since 2015, followed by conference papers, websites and blogs, theses, books, and surveys, reports, and initiatives. This holds true for the use of BIM in building. The current paper uses published review research sources for literature-based BIM. Only 35% of literature review available Indian origin, however, worldwide is 65%. We have divided this paper description in (i) reviews (ii) critical reviews(iii) over reviews (iv) bibliometric and scientometric analysis (v) study on (semi review) i.e., very close paper to review(vi) theses (vii) research papers on BIM use in construction. Emphasis has been given to analyze reviews recently published particularly during post Covid 19 period. Table 1 gives distribution of various types of reviews, research papers on BIM use and application in CI studied during 2008-2022.Here is the description of BIM reviews for preparation of fresh review-based use of BIM in the CI. Figure 1 gives year-wise distribution of reference sources on BIM use in CI and Figure 2 shows various types of resources use to synthesis this review paper.

Table 1: Distribution of different types of reviews

Type of Paper	Review	Over review	Critical review	Bibliometric review	Semi review/other paper	A study on	Thesis	Report/survey/ Conf. paper	Web site	Total
No.	42	7	9	9	52	6	6	4	08	143

ISSN(Online): 2584-1025

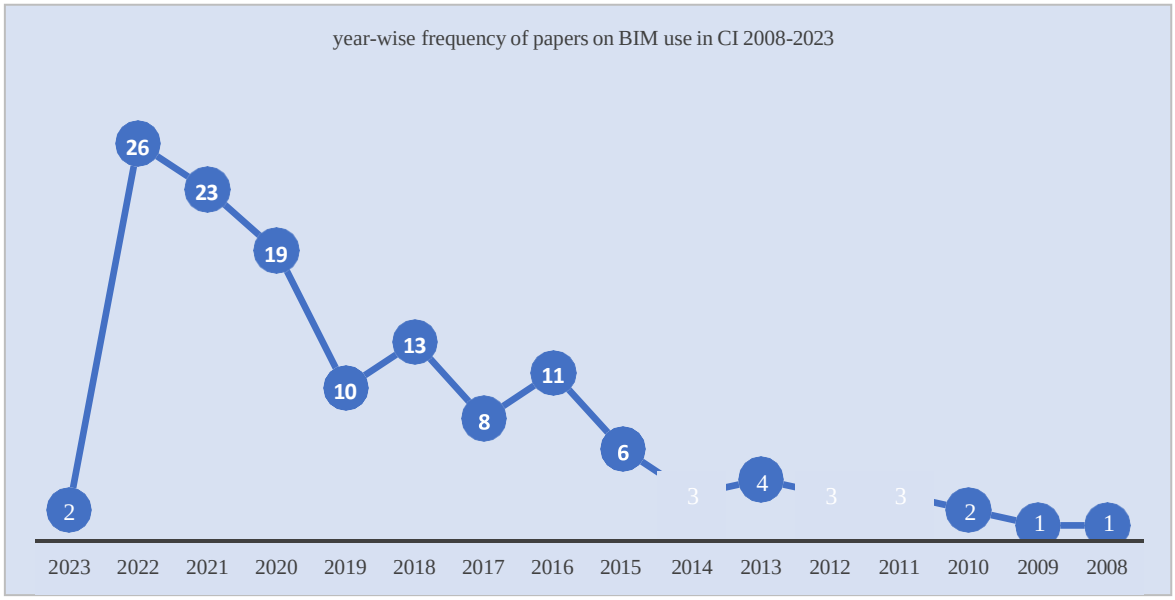

Figure 1: year-wise frequency of papers on BIM use in CI 2008-2023

The Architecture, Engineering, and Construction (AEC) business has emphasised Building Information Modeling (BIM) as a potent collection of design management's tools. BIM has significant advantages throughout the whole building lifecycle, including design, construction, and facility management. The entire implications of BIM on the advancement of design tools in the AEC sector have been the subject of recent research. Two major forms of BIM risk are legal (or contractual) and technological [1]. The first issue is that it is impossible to determine who is the owner of the BIM data, necessitating its protection through copyright laws and other legal channels. Another contractual concern is how to enter information into the model and who is accountable for any inaccuracy. BIM contributes to minimising physical risks and raising construction safety by spotting problems before they arise and anticipating site logistics. Safety evaluations and visual risk analysis can help ensure safety throughout project execution. The BIM technology still has to be developed, and it will take some time for the AEC industry to fully adopt the technology [2].

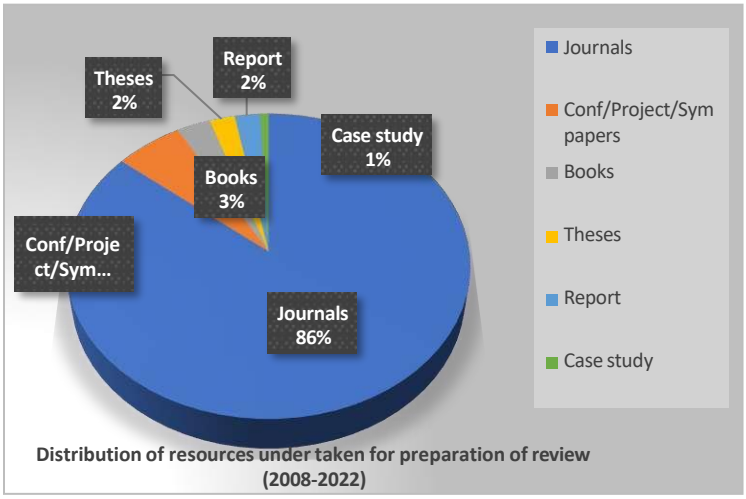

Figure 2: Distribution of resources under taken for preparation of review (2008-2022)

There has not yet been a BIM mandate in India. Recent research has revealed that the Indian construction industry (ICI) is adopting BIM technology/process for the reasons listed below: The benefits of BIM include: I a realistic image of the construction project; (ii) the elimination of unplanned alterations; (iii) cost monitoring; and (iv) the streamlining of the activity (v) Clash detection in BIM aids in addressing possible conflicts. It is noted that the distribution of references worldwide on BIM for CI review papers corresponds to Indian References 35% and International references 65 %. The construction business today demands high precise in planning, scheduling, and control of the project's progress in order to enable total cost, time,

ISSN(Online): 2584-1025

and resource optimization. It has been discovered through the analysis of real building data from the construction site and the building simulation model that any duplication and rework can be prevented [3].

Building information modeling (BIM) is an integrated process for generating and managing buildings by examining a digital model both before and after the project is actually built, as well as during installation, use, and maintenance. According to [4], BIM has been embraced by architects and building contractors in the US and UK to enhance the planning and administration of construction projects. However, at that this was not a situation for Indian architect, contractors as they were lacking skill and fully aware of its use in building construction. In our country, architects have not fully incorporated this new thinking and technology into their working methods. And suggested need for development of a BIM implementation strategy. A comprehensive and exhaustive account on a guideline of various issues raised for adopting BIM in CI.[5] has investigated and summarized various strategies for adoption of BIM in construction industry. With the implementation of BIM to enhance the design, construction, and facility management of construction projects, the Indian architecture, engineering, and construction (AEC) sector is still in its very early stages. Indian AEC firms have been given advice on how to successfully integrate BIM into their current working procedures by [6]. The study methodology created by her providesa sense of the current level of BIM expertise in the ICI along with an online survey used to obtain information about the problems experienced by Indian AEC firms. Inferential statistics analysis of the data provides the most efficient means via which Indian AEC firms can use BIM.

In India, the BIM is a new and exciting strategy which is increasingly satisfying over owners, architects, engineers, and builders. BIM enables effective work processes and smarter judgements when utilized in the field to better communicate and integrate construction information across many trades. According to [7], using BIM allows for significant material and time cost savings, and architects and engineers in the CI greatly value its advantages. The adoption of BIM, [8] has brought a new approach to building design and construction management that has altered how industry professionals and people collaborate. [9] has demonstrated that BIM does supplement conventional scheduling and cost-estimating techniques with automated and more trustworthy technology. According to the data, the following conclusions can be drawn: (i)if BIM technology advances, higher levels of detail (LOD) will be possible; (ii) To give a scheduled financial analysis, building model BIM components will be linked to time and cost parameters concurrently; and (iii) resource allocation on a 4D BIM model will allow for analysis and planning of resource usage based on the most recent design, and also simulation of resource allotment. [10] has defined and identified thirty-two different BIM applications for commercial construction, with clash detection, 3- D modelling, team collaboration, constructability difficulties of design, and sales being the most used ones. Businesses reported that using BIM have a positive effect on profitability, construction time, and marketing.

According to [11], India needs to set up centres that will focus on broadly promoting BIM. As has been done in many other countries, the government must work with enterprises in the private sector and take the initiative to encourage the use of BIM. It is vital to research[12] both the favourable and unfavourable elements influence the adoption of BIM in the AEC sector. The principles for using BIM on a wide scale are discussed in [13]'s conclusion. [14] outlines three significant findings that revolve around employing BIM in the scheduling and management of construction projects. This study focused on enhancing the effectiveness and successful completion of building construction projects by examining the grade of BIM application and the BIM tools used in the Port Harcourt, Nigeria, construction industry. In his work, [15] outlines several crucial details regarding the practical application of the project management function using the BIM paradigm. By synchronising all these parameters, BIM allows us to integrate virtual three-dimensional models with real project time and actual construction cost, making it simple to maximise the project's overall efficiency. BIM is a holistic and collaborative methodology for the management of information for construction projects that has revolutionized the CI. The management of information for construction projects using BIM has completely changed the construction industry. India is now one of the nations with more potential for investors and BIM-qualified personnel due to the recent growth of BIM execution in the country's construction industry, in the public and private sectors. IBIMA is the primary national professional society for building information modeling and digitalization in the Indian AECO-Architecture, Engineering, Construction, and Operation sector. He founded the India BIM Association, or IBMA, which supports and advocates

ISSN(Online): 2584-1025

on behalf of the entire Indian BIM community in order to create a favourable business environment for the successful usage of BIM technologies, procedures, and guidelines. [16]. Studying Ahmadabad City as an example,[17] implementation of BIM for real estate.

BIM is an innovative approach to design, construction, and facility management that uses a digital representation of the building product and process to enable information sharing and interoperability. Structures' appearance, functionality, and construction are starting to change as a result of building information modelling (BIM). Rafael et al. An in-depth overview of BIM technologies, as well as the commercial and organizational difficulties related to its implementation, is presented by [18] in their BIM Handbook (2018). [19] asserts that the use of BIM by Indian architectural firms is still in its "experimental" stages, with managerial backing, trialability, and expertise having a strong positive influence on its acceptance. The adoption status of BIM in India is also described in the paper using a multi-level social construct. With the use of this construct, the micro- and meso-levels of organizational sizes in India is where BIM adoption is at its highest level. The report discusses parallels and differences with prior studies in order to highlight the findings of this investigation.

Building Information Modelling (BIM), among the most intelligent 3-D models now showing promise, improves the administration and construction of design projects. One of India's largest and fastest-growing industries is the built environment. [20] has done research on the parameters that affects and hinder the use of the proposed paradigm. Design and construction information are both included in BIM. It includes both visual display and a simulation of state creation. [21] has examined the application of BIM in various construction phases, the barriers to its acceptance, and discussed how using BIM technology might be advantageous over using the traditional method employed by architects or designers and buildings built by contractors. The breadth of and obstacles to implementing BIM have been thoroughly discussed by Maan Singh [22] in his thesis[23] has demonstrated the significance of BIM application in the Indian construction and management business through awareness of BIM, implementation, and utilities in the country's established building structures and industries. The AEC sector needs to adopt BIM as soon as feasible in order to keep up with expanding technologies and developing problems. The authors discuss the general adoption of BIM in India at various levels of the construction procedures as well as challenges encountered throughout subsequent implementations. BIM software. [24] has substantially altered the architectural design process is organized, and it is anticipated that it will have a big impact on future advancements in product quality and industry productivity. Using questionnaire surveys for various users, [25] has highlighted the growth factors and the obstacles experienced for the usage of BIM in Indian construction projects with an emphasis on the risk, challenges, cause, and interest in adoption for ICI. He suggested that organisations make use of his findings to assess their existing BIM appropriation. [26] examined the volume of research on the application and uptake of BIM in several construction project domains. Author has analysed and established a cumulative analysis of the study disciplines and publishing advancement after looking at 130 publications from various sources. This report shows a steady rise in research into many aspects of construction projects. [27] concluded that the lack of government leadership for SMEs in the CI is the reason why New Zealand's BIM adoption assistance system is ineffective. The AEC industry has seen loose collaboration and a lack of coordination among its participants due to inconsistent standards and classifications. The research results are anticipated to deepen our understanding of the obstacles to BIM adoption in New Zealand. [28] has conducted study to comprehend the role that BIM plays in the improvement and application of Knowledge Areas (KAs) in the AEC business in Palestine. The findings showed how far BIM technology has advanced the application of KAs in the AEC industry.

The Architecture, Engineering, Construction, and Operations (AECO) sector typically adopts new technology slowly, which inevitably limits performance growth. According to preliminary results from [29], BIM drivers have a notable influence on BIM understanding during the project lifecycle's operating stage. The average R2 value for the Structural Equation Modelling (SEM) model is 23%, which is moderate. As a result, this research contributes to the pool of knowledge by providing crucial insight into how BIM drivers affect BIM awareness across the project lifecycle. Acquired information would assist government officials and industry stakeholders in creating policies that would promote the use of BIM in modern practise. BIM is quickly becoming a cutting-edge method for visually managing and designing projects. [30] discovered that the lack of modelling standards and the constant requests for design variation make the deployment of BIM in Malaysian CI somewhat ineffective in terms

ISSN(Online): 2584-1025

of time and cost. The findings also suggest that Malaysian BIM has the potential to be as effective as that in other industrialised nations, provided that the key issues raised are resolved. [31] has expanded her research on the use of drone, BIM, IoT, and AR/VR technology in the field of digital construction technology trends. She places emphasis on the inclusion of these technologies in architectural engineering graduate and postgraduate curricula in Indian universities. These claims about using BIM in the educational ecosystem are backed up by a review published by [32]; [18]; [33]; and [34] as well as other recent academics.

Building information modelling (BIM), one of the most recent advances, offers the potential to manage safety on the construction site. This study examines the current level of BIM awareness in Indian construction, as well as its advantages and potential challenges. The advantages that BIM deployment can have for safety management are also discussed in this paper. According to a survey [35] performed on the Indian construction industry, there are three key areas that must be improved: corporate training in construction organisations; knowledge of BIM and its benefits for enterprises; and accumulation of BIM in the tertiary education system.

The collaborative BIM technique is growing in popularity in the building sector. BIM is a methodical procedure that combines all other geometric computer-generated models, or data, to produce simulations that the project manager, owners, facility manager, or other parties can use to manage the project and complete it more quickly. Due to ignorance about the benefits of BIM, the deployment of BIM in India is still in its infancy. A case study of a residential project in Gujrat has been presented by [36] for the study of benefit-cost analysis. Before construction, 8 flaws in the project's 3D and 4D models were found and detected.

The management of business information (BIM) has become an essential strategy for reducing project risks. The project life, starting with planning, design, and construction management, depends on BIM technology. BIM has been used successfully in many projects, but its application in the construction sector III.MAJOR STUDIES AND CHARACTERISTIC FEATURES OF BIM FOR CI

The architecture, engineering, and construction (AEC) sector is undergoing a digital change. The way information is shared, how procedures are employed, and how things are handled are all being changed by

is questionable. BIM has been looked into and its relevance as the best solution for reducing project risks has been examined and studied [37]. Although many stakeholders use BIM as a modelling tool, he has stated that the first step in avoiding dangerous projects is defining clearly how these stakeholders can use BIM.

Very significant technology that covers a range of dimensions and maturity levels (Level 0, 1, 2, and 3) is building information modelling (BIM) (3D, 4D, 5D, 6D and 7D). Numerous past studies have demonstrated that the construction sector is however adopting technology at the rate that it should be, particularly in emerging nations like India [(https://biblus.accasoftware.com/en/), [38]; 39].

The literature on the obstacles to BIM adoption in the CI has numerous references. According to [40], BIM is not important for construction projects in India. [41] has looked into the dynamics of various BIM capabilities and used the Interpretive Structural Modeling (ISM) technique to understand how BIM capabilities are represented as a collection of connected pieces. This study provides a road map for BIM implementers by highlighting the driving and dependence power of each BIM element that is deemed to be helpful for enhanced delivery of construction projects. For both researchers and project managers, the findings of this study are anticipated to have major theoretical and practical consequences. This study [42] was expanded upon with more thorough research on the variables influencing the adoption of BIM in emerging countries, namely the instance of India. In the context of Indian architecture firms, the technological, environmental, and organizational aspects responsible for the adoption of BIM are investigated. [43] has thoroughly studied the development of BIM in the Indian AECO industry, with an aim in the past 15 years. Recently, [134] examined a real-world circumstance involving the use of project management knowledge areas (PMKA) in the sector of the construction business. Moreover, advantages and disadvantages of using technology as a tool to promote the implementation of PMKAs. BIM and knowledge technologies have an impact on how effectively building projects are managed.

technology. BIM is the method used to incorporate these technologies into a construction project. In what ways is BIM affecting the construction business, then? What are the advantages, obstacles, difficulties, risk management, and safety? To address these inquiries, please see the description below.

3.1. Benefits use of BIM in the Construction Industry

Initial literature text on benefits of BIM for CI before 2015 has been appeared in the literature as a basic guideline for use of BIM in CI in the form of textual text(matter) and not noted as a strong review. Figure 3 depicts some benefits for use of BIM in CI.[1] and [2] has given very initially some benefits and barriers of BIM use for construction industry.

Figure 3: Some benefits of BIM in construction Industry [Source https://www.bimspot.io/blogs/]

BIM has provided a detailed overview of the trends, advantages, dangers, and difficulties facing the AEC. The project benefits of BIM have been highlighted by [44]; in the same year, [45] and [46] have assessed the advantages of adopting BIM for the efficiency of construction projects. [47]]has examined the advantages of adopting BIM to boost performance in Iraqi CI. The advantages, characteristics, applications, and implementation of BIM for construction projects have recently been examined by [48]. The same year, [49] conducted a critical analysis of BIM implementation for CI with regard to adoption, difficulties, and advantages. BIM has provided a detailed assessment of the trends, advantages, risks and difficulties facing the AEC. [44] has given importance of the project benefits of BIM, and in the same year [45]] and [46] has reviewed BIM benefits on adopting BIM for construction project effectiveness .[47]]has reviewed on benefits of BIM adoption to improve performance in Iraqi CI. Recently, [48] has reviewed on benefits, features, applications and implementation of BIM for construction project. In the same year [49,] has critically reviewed BIM implementation for CI with respect to adoption, challenges and benefits. [39] has analysed the n-dimensional BIM's underutilised features with relation to an Indian building context. Many reviews on the advantages of BIM in CI were also published at the same time. [50] has discussed the advantages and difficulties of adopting BIM in UK residential projects. [51] has provided a summary of BIM adoption in the CI with regard to two concerns, namely advantages and industry constraints. Figure 4 highlights the drawbacks of safety application in addition to the advantages [https://springer.com].

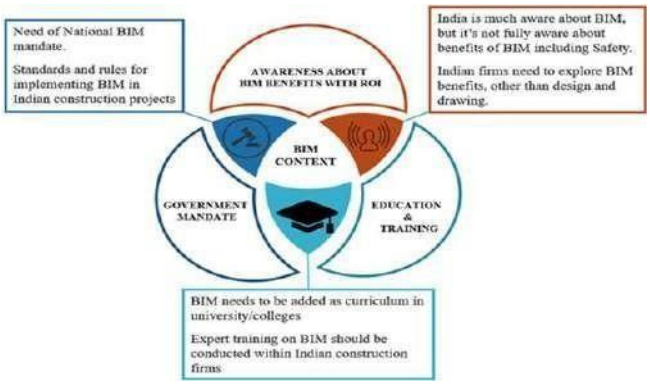

Figure 4: BIM usage benefits and challenges for safety application (https://link,springer.com/10.007/s42107-021-00379-8

3.2. Barriers in BIM for CI

Figure 5 displays an overview of the challenges to implementing BIM in CI. In order to execute the BIM process in construction projects, [45] examined the obstacles preventing BIM adoption in the AEC sector. The challenges to the implementation of BIM and the barriers to the implementation of BIM to the CI have been examined and investigated, respectively, by [52] and [53]. The factors, hurdles, and enablers of BIM Innovation in Developing Countries were recently reviewed and comparatively analyzed by [54], while [51] highlighted 18 barriers in his study.

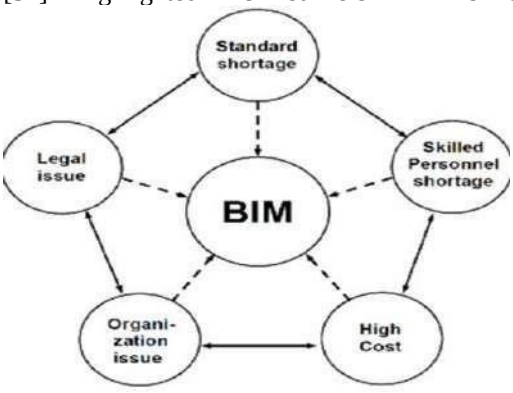

Figure5: Relationship between main barriers

(Source:https://www.researchgate.net/figure/Summary-of-barriers-in-BIM-implementation_tbl1_285630389

BIM compiles numerous project-related data into a centralised and easier-to-access format. Sharing this

ISSN(Online): 2584-1025

with other team members and planners is simple. From the standpoint of project management, it enables more cooperative decision-making. This is due to the fact that everyone engaged has the opportunity to study building designs at most stages of the project life cycle [https://www.bimspot.io/blogs/]. Implementing BIM for construction safety is hampered by a lack of internal expertise, a lack of BIM training or education, a shortage of awareness, a lack of cooperation, consumer interest, ambiguity regarding the government's commitment to BIM, as well as the high cost of software. The following are some major obstacles to BIM adoption in the ICI: (i) Lack of knowledge, (ii) ignorance, cost-effectiveness for minor projects, (iii) cost-effectiveness for large projects, and resistance to change.(iv) Lack of collaboration among stakeholders[40].

3.3. Challenges in use of BIM in AEC

A paradigm shift is occurring in a variety of industries as a result of the creation and uptake of innovative technologies. The construction industry is not an exception. Since the introduction of BIM Technology and particularly in the last several years, the way the construction industry operates has undergone tremendous transformation. In many countries, including the UK, using BIM has become crucial for large-scale public projects. [https://excelize.com/blog/the-most-common-bim-adoption-challenges. The difficulties in applying building information modelling in the construction industry have been reviewed by [55]. We have already seen how [25] has discussed the ICI's knowledge of BIM, its motivators, and obstacles. [40]. Applications and difficulties with implementing BIM for the creation of smart buildings have been reviewed by [56]. Recognising the challenges of using immersive technologies in CI and architecture has been well reviewed by [57] the identical year. A critical analysis of the effects of successful technological applications in building has been done by James O. (2022) [58]. The ranking study's findings revealed that the top five important barriers were "lack of rules and guidelines," "lack of BIM schooling," "lack of skills," "high cost," and "lack of study and BIM implementation."

3.4 Risk and risk management in use of BIM in CI

Construction risk management is the process of determining and implementing strategies to mitigate the effects of hazards in construction projects. This methodical planning process results in the development of a risk management strategy that enables project managers to identify, monitor, and mitigate risks as they emerge. Building schedule risk simulation utilising BIM and the Monte Carlo technique has been evaluated by [59]. Critical risk considerations for the use of modular building have been assessed by [60]. A study of the literature on the combination of BIM and risk management has been conducted by [61]. The use of BIM in reducing hazards for construction projects has been examined by [62]. [63] studied how risks affected the implementation of BIM throughout the building phase and listed the critical success factors for BIM. [64] has examined the risk factors associated with applying BIM in the operation and maintenance phase of construction projects. A systematic literature review on collaboration and risk in BIM has been written by [65]. The observations of [37] on project risk mitigation provide strong support for the conclusions of earlier authors.

3.5. The future of BIM is being shaped by innovative trends, and it will be integrated with new digital technology.

Several authors working in the field of study have described recent rising digital trends addressing the types of innovative trends driving the future of BIM through its integration with emerging digital technologies. [58] [,66]. [67],[68]. Building information modelling (BIM) software had a successful year in 2021 in the architecture, engineering, and construction (AEC) industry. Yet, because technology is advancing so quickly, new BIM trends are continually showing up in the building industry. The use of digital information tools in the building sector fosters an atmosphere that is favourable for the establishment and growth of companies that specialise in the use of technology to design and construction. While some of the technologies are unique, many of them implement ideas from construction research that were impracticable decades ago without a strong digital building knowledge base. Building information modelling (BIM), ideas for artificially intelligent design and code checking tools, and construction robots have all been present since the middle of the 1980s and have spent decades working in research labs. [69] explores their reliance on digital information, their known past, uncertain present, and increasingly optimistic future to give a number of recommendations for advancements in digital construction. The evaluation finds new problems, producing a list of research questions that could lead to a variety of potential uses for artificial intelligence (AI) in the future. [70] has examined the application

ISSN(Online): 2584-1025

of Blockchain Technology (BT) and given a summary of the various BIM adoption levels in the building industry. In order to comprehend the current research trend, authors looked at the numerous application areas within the BIM process. Also, they spoke about drawbacks and provided advice on how to best carry out upcoming BIM-blockchain integration work.

In recent years, cloud technology has developed into an extraordinarily practical way for users to store data and quickly retrieve it as needed. Throughout time, the BIM industry has gradually increased its adoption of this technology. As many participants in the project as possible can access the most recent project information in real-time thanks to cloud computing, which also fosters enhanced cooperation, productivity, and idea sharing throughout every stage of the project [https://www.digitalschool.ca/]. There have been four things made extremely clear: (i)BIM Software may become more (ii)cloud-focused, and cloud technology may speed up project processes (ii)sustainability and environmental friendliness are also hot topics with BIM (iv)AR/VR are current and upcoming trends in BIM technology in CI and CM (i)BIM Software may become more (ii)focused on the cloud [71] . According to [72], the primary study themes are BIM, IoT, and DT in the construction industry, Heritage BIM (HBIM), Smart Contracts, BIM, and Ontology, and VR and AR in BIM and DT. Also, they documented and noted a number of potential research fields, including BIM and Metaverse technology, BIM and Artificial Intelligence (AI), Metaheuristic algorithms for BIM optimization, and the Circular Economy using BIM and IoT. In order to advance end-of-life decision-making, [73] has contributed by installing the software module that creates a link between BIM and machine learning technologies.

BIM implementation in CI is evolving towards greater adaptability. The purpose of [www.intechopen.com, 2022] was to provide students, academic researchers, and practitioners with an in-depth, current analysis of the significance of integrating BIM with developing technologies in architectural educational programmes. These technologies included artificial intelligence (AI), cloud technologies, the internet of things, virtual and augmented reality (VR/AR), laser scanning, 3D printing, and drone technology. The time is right for the construction sector to embrace cutting-edge, innovative technologies like BIM, GIS, and Digital Twin. It must be required by the decision-makers throughout the course of the project. By utilising geospatial and other digital technologies like BIM, Digital Twin, and Artificial Intelligence, projects are delivered on schedule and run smoothly on the job site [65]. The foundations for increasing productivity and efficiency in the Indian building and infrastructure sectors are BIM and Digital Twin [74]. In order to comprehend the difficulties encountered when mainstreaming immersive technology (ImT) within the A & C business, [58] undertook a systematic review. 51 publications published between 2010 and 2019 were found using a systematic process (inclusive). The research develops a broad taxonomy with several features. The results led to the identification of nine major challenges, which were then ranked in the following order: infrastructure, algorithm improvement, interoperability, universal health and safety, virtual content modeling, cost, skills availability, multi-sensory constraints, and ethical considerations. The phases of the construction project life cycle are, in fact, at dramatically varied levels of automation and digitalization, as shown by [67]. The phases of initiation, design, and planning all had low levels of automation and digitalization, while the execution phase had higher levels of automation but lower levels of digitalization. Since the subject is always evolving, this research might be carried out soon to see how far the current findings have progressed. [75] has conducted a thorough analysis of the benefits of BIM and IoT technology. He introduces the fundamental work and explains how to design a sophisticated management system for building materials using IoT and BIM technology. Further reviews based on usage and applications in CI are elaborated with respect to authors name, year, title, key findings, significance and remarks in the tabulate form (Table 2-7).

Table 2: Reviews on implementation of BIM in CI

Sr No.	Author/Year/Reference No.	Contents	Key Findings
1	Annilise Nairne Schamme and	Contributes to the analysis of the improvement of BIM research and helps to clarify the limitations of its	BIM supports in reaching some sustainability goals, but the software's interoperability issues make it impossible for an integrated study to pull

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	Andre Nagalli (2022). [76]	applicability to sustainability rating systems. (ii) highlights the need for increased BIM use in building sustainability assessments, (iii) Using BIM to manage waste and meet material and resource needs on building sites.	data directly from the programme to satisfy the needs of building sustainability assessments (BSAs).
2	Chavan Sayali, and Gorade S. B. (2022). [48]	(i) Studied literature for application of BIM. (ii) Implementation of BIM for 3D,4D,5D,6D,7D & 8D	The paper explores the features and advantages of BIM, its uses, and the state of BIM adoption in various nations. This study also clarifies the application of BIM and the difficulties encountered in doing so.
3	Hafez Mohammad Faisal Shehzad et al. (2022) [77]	Identifies the study's challenges and evaluates the models utilised, the state of BIM adoption, and technology acceptance theories. acknowledges the roles played by mediators, independent and dependent constructs, and moderators in the analysis of BIM adoption.	(i) Finding provides an detail description of the various stages of BIM adoption. (ii) Maslow's theory and the diffusion of innovation theory both shed light on how cognitive concerns affect adoption.
4	Moustaf S. Algjamdiet et al.,(2022). [78]	Identified some issues in South Arabia(i) the failure to achieve sustainability (iii) the failure to use BIM in both public and private projects (iv) the development of BIM-supported methodologies for both public and private projects.	(i) Findings and evaluation of the many perspectives on sustainability held by specialists and the general public; (ii) creation of a framework of sustainable design measures for buildings that takes into account particular elements. (iii)indicating the present level of BIM technology use.
5	Pinti Lidia; Codinhoto Ricardo; Bonelli Serena (2022). [79]	(i) Use information on BIM-FM that is already in the public domain by examining and categorising articles that were written between 2010 and 2021. (ii) examines the application of BIM for FM purposes in various public buildings.	(i) Findings indicate there are number of publications concerning BIM-FM. BIM-FM for public and private companies differ, although not equally. (ii) BIM-FM research is still in its infancy for public organisations and is not uniform.
6	Sahil Salvi et al. (2022). [80]	Reviews the use of BIM for life cycle assessment (LCA) of buildings. This technique aids in understanding the effects of the built environment.	The findings of the research imply that BIM can be utilised to lessen the negative effects of building on the environment.
7	Silva, T. F.et al. (2022). [63]	Identified areas for improvement and the direction of upcoming research in the realms of risk management and BIM. It also looks into the connections between project success factors and risks related to BIM deployment.	(i) The three concerns that are identified the most commonly are technological programme interface, interoperability problems, and a lack of understanding. (ii) The risks connected to BIM, particularly during the design phase, are shown to be positively correlated with key BIM success factors.
8	Shubham A. Bhendkar, and. Prakash S. Pajgade (2022). [81]	Increasing use of BIM in civil and structural engineering, professionally practice and focus research on BIM use.	BIM aims to increase project efficiency and produce better outcomes. Construction management can more efficiently collect and communicate data and information from the relevant disciplines thanks to BIM.

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9	Sood, R. and Laishram, B.,(2022). [39]	Various key factors reported. (i)various dimensions, (3D, 4D, 5D, 6D and 7D).and level of maturity and present situation in ICI (ii) presented some future research work.	Policymakers and practitioners may find the findings to be extremely helpful in implementing a BIM-based framework that is mandatory for ICI and other developing countries.
10	Zul-Atfi Bin Ismail (2022). [82]	(i)employing BIM technology that includes automated evaluation methods, (i)identified the various system approaches (ii) The majority of BIM research has been on theoretical frameworks for acceptability in the green building (GB) maintenance sector.	(i)Building information modelling (BIM) offers the ability to improve building control instrument performance and design understanding (BMC). (iii)BMC and its impact on maintenance planning have not received enough attention.
11	Abubkar Altohami,Nuzul Azam (2021)' [83]	(i) Covers obstacles that prevent BIM-IoT integration while also addressing interoperability problems and cloud computing. (ii) investigates and discovers common growing application areas and common design patterns of the traditional BIM-IoT integration, then develops better integrating IoT in BIM methodologies.	(i) This method and discovery are based on combining real-time data from IoT devices with BIM studies in order to increase operational and construction efficiency and produce high-fidelity BIM models for a variety of applications. (ii) draws the conclusion that a high-tech solution is necessary to connect IoT devices more effectively across the Internet infrastructure.
12	Ang Yang et al. (2021) [56]	Provide the key findings and implications regarding the research needs and trends, including (i) enhancing the software's interoperability; (ii) examining the role of BIM during the maintenance and renovation stage of smart buildings; and (iii) concentrating on BIM technology in the field of transportation infrastructure.	(i) Provides a thorough understanding and encourages critical thought about how BIM and smart buildings are related. (ii) Proposes a three-dimensional framework with BIM attributes, project stages, and smart attributes for the intersection of BIM application in smart buildings.. (iii)Explicitly defining the financial advantages of BIM projects
13	Manoj U. Deosarkar et al., (2021). [84]	(i)Designed building by using Autodesk Revit Software. Autodesk Revit BIM software for landscape architects, landscape architects, structural engineers, MEP engineers and contractors(ii) estimations of building also using Revit Architecture (iii)planning, modelling, scheduling commercial building.	provides authentic families of furniture and lighting fixtures, as well as the ability to import pre-existing models from other programmes like Auto CAD. Authors have developed families for both residential and commercial structures.
14	Narendra A.1., L Pinky Devi (2021).[85]	(i) BIM may be able to satisfy an owner's desire for predictable pricing, high quality, and on-time delivery. (ii) . Implementation of BIM for ,4D,5D, and ,6D,	recognised the essential components of BIM awareness, benefits, obstacles, and implementation options.
15	Yidan Zhang, Yi Yang, Wei Pan and Mi Pan (2021). [86]	Key performance indicators (KPIs) for Construction Supply Chains (OSC) supply chains from December 2000 to March 2021 have been identified. Additionally, by examining and analysing current measurement efforts from a variety of angles, this research	Authors created a measurable assessment technique, built on the framework, and gave ignored KPIs, particularly those related to social and environmental issues, greater attention.

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		helps to improve understanding of OSC supply chain performance..	
16	N.Zaini et al.(2020). [87]	(i)Identify the essential components of BIM implementation, including its benefits, methods, and execution. (ii)Top ten ranking of BIM awareness, advantages, obstacles, and adoption methods for industry players (ii) The application of BIM technology is focused on meeting customer demands in Sarawak CI	(i)BIM process execution, productivity improvement through efficient teamwork, increased return on investment, and decision-making assistance (ii) increased effectiveness brought about by an integrated design process, (iii) precise and trustworthy cost estimates, (iv) decreased financial risk, and (v) avoided possible conflict.
17	Vimal kumar, et al .(2020). [88].	Use of BIM in industry and comparison and synthesis of pertinent research findings. The BIM tools intend to expand their industrial applications in the future.	The outcomes demonstrate many effects from BIM adoption, including 3D/4D/5D/6D functionality. The article's final goal is to promote the full range of BIM capabilities that can be used in construction activities.
18	Jingming Li et al.(2020) J.of cleaner production (2020). [33]	The first review-based study evaluating current BIM developments in AEC-related fields in higher education. This study presents the most recent developments in BIM adoption in AEC education and surveys the state of the BIM education literature.	The current research predicts that there will be some ongoing effort in BIM education, including (i) interdisciplinary collaboration to reduce fragmentation among AEC disciplines and (ii) creative teaching techniques that include both technical and management aspects of BIM.
19	Wang, L, Huang, M, Zhang, X and Jin, R (2020). [34]	Identified relevant publications of BIM educational research outputs, such as journals and conference proceedings, and examined current research keywords.	This Technical Note examines current BIM adoption patterns in higher education for AEC and (AEC)-related fields and is one of the first review-based studies in the area.
20	Zaid Saad Hadi (2020). [47]	(i)The key reasons for Iraq's poor project performance were highlighted (ii) exploited to improve project performance, raise project competency, time, and cost, and (iii) strengthen stakeholder engagement and communication.	(i)BIM has significantly enhanced all phases of the project life cycle—design, pre-construction, construction, and post-construction. (ii)BIM offers comprehensive, cutting-edge management and maintenance plans.
21	Mohammad Firdaus Razali et al., (2019) [89]	The deployment of building information modelling (BIM) over the course of building life cycles is reviewed in this article with an eye towards addressing problems and identifying potential areas for further research. The report finishes by stating that the majority of BIM research primarily focuses on the planning and construction phases (iii) Three phases were studied.	Classified Virtual Design and Construction (VDC) development into three main phases: Phase 1 (Visualization). II. Phase 2 (Integration). III. Phase 3 (Automation). (ii) The AEC industry will reap the most financial benefits from BIM through ongoing professional development and increasing awareness. (iii) The AEC industry acknowledged the advantages of BIM.
22	Sachin Nalawade et al (2019) [24]	The architectural design process has undergone significant organisational change as a result of BIM technology, and it is expected to continue to play a significant role in improving product quality and industry efficiency.	BIM use, application, benefits and limitations of BIM are discussed.
23	Yin Rui (2019). [90]	(i)analyzes BIM application in practices and compare(ii) explores relevant	(i)The outcomes show different effects from BIM adoption, including 3D/4D/5D/6D functionalities.

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		articles systematically, including BIM 3D/4D/5D/6D applications.	(ii)promote the full implementation of BIM functionality in construction-related activities.
24	Ziwen Liu, Yujie Lu and Lu Chang Peh (2019). [91]	(i)Outlines the difficulties the AEC sector has had adopting and implementing BIM technologies. In this regard, differences are noted between emerging and (ii) established nations in terms of the pros and cons of adopting BIM, as well as potential issues and fixes.	(i)Researchers and industry experts believe that the widespread use of BIM in the construction industry would result in many benefits and increased efficiency. (ii)SWOT analysis was performed when researching the usage of BIM in construction.
25	Debasis Sarkar and Harsh Shah (2018). [61]	The risks associated with the deployment of BIM ensure the potential advantages. Model the risks' routes and identify the dangers related to BIM AEC projects.	Explores an integrated BIM and risk management model for infrastructure projects possibility of develop
26	Ensar Ademu and Selin Gundas (2018). [92]	Explains the difficulties BIM adoption and implementation have experienced in the AEC industry.	In this regard, a distinction is drawn between emerging and established nations in terms of the strengths and weaknesses of BIM adoption as well as potential issues and solutions.
27	Shakil Ahmed (2018). [53]	In this study, a number of factors were discovered, including (i) social and habitual reluctance to change, (ii) conventional contractual practises, (iii) expensive training expenses, (iv) high software acquisition costs, and (v) a lack of knowledge of BIM.	Because BIM technology offers so many advantages, it is critical to eliminate the barrier based on priority with the aid of the government and other project stakeholders. A barrier that prevents the use of BIM technology in the construction sector has also been documented.
28	S.Meganathan and N.Nandhini Jan (2018). [55]	(i) Advocates a plan for Indian construction companies' current working procedures to properly incorporate BIM. (ii) The research method entails examining the current BIM information situation in the Indian manufacturing sector.	Inadequate project experiences, management process damage difficulties, a lack of top management commitment, high software costs, low client demand, inadequate project experiences, unclear legal liabilities, and a lack of skilled and trained employees are just a few of the numerous factors and conditions.
29	Srimathi. S and R.N.Uma (2017), [93]	Presented (i) BIM tools with 4D capacity (ii) use of 4D BIM tool link the 3D BIM model with project schedule	(i)BIM creates competence and enables users to gain a number of advantages (ii). helps to better manage the construction process, increase collaboration, and schedule the work.
30	Subhi,M and Uma ,R.N. (2017). [127]	Current study is concept of BIM derives a platform (ii) recognize potential design, construction and operational problems	This review gives a clear view on implementing the 5DBIM technique in the residential projects
31	Yang Zou,et al. (2017). [94]	(i)Designing a framework for general risk management developing a knowledge-based system (ii), proposing safety risk management using reactive IT-based safety systems (iii), and concentrating on analysing technical advancements and managing risks related to the safety of construction workers	Future study is recommended to: (i)have a multidisciplinary system-thinking approach, (ii) examine implementation methods and procedures, (iii) integrate conventional risk management with new technologies, and (iv) assist the development process in order to close this gap.
32	Saundharya R .and Uma R.N. (2016). [128]	Due of their distinctive features, BIM is commonly employed in major construction projects. The usage of BIM technologies has also spread to the small-scale construction sector. They provide	Using BIM in CI is explained in this study. BIM has a helpful method for CI that increases customer satisfaction and cuts down on time.

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		thorough descriptions of a structure, which aids in documentation.	
33	Abuzar Aftab Shaikh, et al.(2016) . [133]	The survey information is (i)gathered from various research materials, including the Smart Market report, NBM National BIM reports, and BIM surveys. (ii) The study looked at the awareness and acceptance of BIM in various countries; (iii) India had the lowest levels, at 22%.	(i) involves the identification of BIM adoption and awareness in a subset of eight nations with significant construction markets. (ii) investigates the usage % for BIM.
34	Rafed Sackset al.,(2016) . [95]	(i) The set of guidelines offered for significant construction client organisations to assist with the creation or updating of their own BIM guides (ii)contributes a checklist of the crucial topics that must be covered, including subjects that are not yet covered in the majority of the ground-breaking BIM documents	In order to find both recurring themes and unrecognised details, the author presents a qualitative content analysis of fifteen BIM guidelines, standards, and protocol documents that have been published thus far. While the primary subjects covered by all of the standards and guidelines - interoperability, cooperation modes - are identical, there is still a need.
35	C.Allen and W.Shakantu (2016). [96]	(i) Indicates a rethinking of the structure of the construction industry and the manner in which projects are delivered; (ii) indicates the development of more effective project delivery methods and the onset of a process that will fundamentally alter the construction industry.	(i) BIM, a tool for business process re-engineering, can be utilised as the foundation for changing the project delivery process, enabling the construction industry to undergo a digital revolution. (ii)BIM will be essential for enhancing project delivery outcomes.
36	Doumbouya, L., Gao, G. & Guan, C. (2016). [46]	(i)It is important to better understand the advantages of BIM, study its adoption, and assess its value at different phases of construction projects. (ii) Identifies pertinent BIM elements and results, and establishes a framework for further research. Reviewing the advantages of BIM adds to the corpus of material already written about AEC and BIM.	(i) Throughout all stages of the construction project, BIM succeeds in achieving its objectives, offering benefits like improved design quality, simplicity in implementation, and information sharing capability. (ii) Reduction of construction costs and design errors, quicker work and shorter construction times, increased energy efficiency, and support for construction and project management.
37	Nam Bui, et al. (2016). [97]	(i)Discusses various BIM implementation challenges and offers solutions that are specific to low- and middle-income economies. (ii) identifies gaps in previous studies on the use of BIM in underdeveloped nations	According to research, construction companies in developing nations frequently outsource their IT needs or create workarounds to cut costs and enable BIM, such as employing "fake" IT licences. (ii) offers recommendations for implementing BIM in poor nations
38	Volk, R., Stengel, J. & Schultmann, F. (2014). [98]	BIM implementation in existing buildings will be encouraged and extended by new technologies like cloud computing, semantic web technology, and mobile BIM devices as well as long-term trends like increased digitalization and automation, a growing stock of existing buildings, and sustainability requirements.	Results show that BIM implementation in existing buildings is still risky due to difficulties with (i) high modeling/conversion effort from captured building data into semantic BIM objects, (ii) updating information in BIM, and (iii) handling of uncertain data, objects, and relations in BIM occurring in existing buildings.
39	Hassan Suhall and Yaqoob	(i) The value of teamwork in design management and what it can contribute	When used in design management as a collaborating tool, BIM was found to be most

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	Nowsheeba (2013) . [99]	to collaborative design (ii) The discovery that organisational culture and the human element are still lacking in collaborative design using BIM (iii) The automatic introduction of lean thinking into the industry	effective (i) in collaborative environments (ii) for reducing the amount of rework (iii) and for detecting collisions much earlier in the design stage (iii), among other benefits covered in the paper.
40	Cristoph M erschbrock. ans Bjerm E. Munkvold, (2012). [100]	Research reveals that, to a certain extent, IS serves reference discipline. Modern BIM research is informed by (i) IS research theories (ii) the planned and recognised value of BIM	Area identified: interactions between functional affordances, human agency, and BIMs adoption and application of BIM for cross-organizational cooperation, the impact of corporate culture on BIM practises, and the capacity of BIM to change industrial practise
41	Maria Bernardete Barison and Eduardo Toledo Santos (2010). [130]	(i)The procedure of content analysis was utilised as the research methodology to investigate a collection of articles and course outlines that detail experiences in schools that have been recognised as leaders in BIM education. (ii) a focus on course preparation, including prerequisites, aims and objectives, material, teaching methods, evaluation, and activities	determined types of BIM courses based on students' actions and to propose a fundamental structure for a BIM-enabled curriculum along with recommendations
42	Jorge Jerez Cepa, et al. (2023). [135]	The key drivers of smart construction include the usage of BIM in various project phases together with IoT, Big Data, Blockchain, and GIS.	BIM's integration into FM through ICTs enables decision-making based on data analysis and resource optimization.

Table 3: A systematic review on BIM use in construction building sector

Sr.no	Author	Content	Key findings
1	Ali, K.N.; Alhajlah, H.H.; Kassem, M.A. (2022). [65]	Focuses on the research materials gathered from databases and WOS that are connected to risk management and BIM cooperation.	(i) Talk about the BIM for CI collaboration risk concern. (ii) Supports the need for research on the subject in order to increase the likelihood that a BIM project would be successful.
3	Bernardus Ariono, et al. (2022). [54]	(i) identified the influences on BIM innovation in six developing nations from three distinct continents, including their motivators, constraints, and facilitators. (ii) Developing countries have developed BIM adoption in light of global problems.	(i)investigated the value of BIM's innovation aspects in underdeveloped nations (ii). The findings of this study will help AEC stakeholders develop effective BIM deployment strategies.
3	Ali Saad, and Ajayi, SO and Alaka, HA (2022). [101]	(i)presents a framework that makes it easier to comprehend the programming dynamics involved in creating BIM-based plugins (ii) captures how BIM has evolved to have additional problem-solving capability.	Indicate that key building is a crucial feature of custom-built plugins that has been shown to: (i) increase productivity and efficiency towards cost (ii) decrease time spent and the likelihood of error.
4	Alia Besné , et al. (2021)	According to the analysis, there is agreement that academic guidelines that	A set of legislative standards that could serve as a uniform framework for institutions to boost this

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	[102]	are common to all university centres and specify a plan for curricular changes as well as teaching and learning techniques are needed. Future study directions are then determined.	integration process is identified after analysing the methods higher education institutions used to implement BIM in AEC degrees around the world.
5	Behzad Abbasnejad et al. (2021). [131]	Identified to contribute wide utilization of BIM at organizational level in AEC firms.	AEC companies in assessing organisational preparedness for the implementation process, as well as the necessary innovations and capability development for BIM application.
6	Yu Cao, et al.(2022) [103]	The goal of the authors was to encourage the use and enhancement of BIM capabilities during the development of green buildings.	Facilitate for BIM during three construction phases of the green building
7	Min Deng et al. (2021). [74]	As a starting point for more research, they suggest the idea of an advanced digital twin for building management..	It was discovered that the majority of earlier research projects have not fully utilised or realised the imagined concept of the Digital Twin, which inspires trends in ongoing study.
8	Hamid, A., & Dossic, C.S. (2016). [104]	(i) Brings attention to the need for additional varied study settings and designs to close the gaps seen in the BIM curriculum research conducted so far. (ii) developing pedagogical methodologies for BIM teaching in AEC programmes	Outlines a framework for BIM curriculum design methodologies based on the literature as (i)a list of suggestions that BIM educators and researchers (ii)can utilise as (iii)a guide for creating or assessing their BIM curricula in future studies.Discussion of benefits and drawbacks

Table 4: An overview review on BIM in construction building sector

Sr no	Author /year	Contents	Key Findings
1	Bipin Kumar (2022). [105]	Published BIM- overview as a book chapter Author explains the concept of BIM-ecosystem, include client and service organization in AEC industry	Identified and suggested various elements of BIM-ecosystem
2	Gayatri Mahajan (2022). [106]	This study extends & cover objectives based on (i) to set a revolution in construction technology (CT)trends (ii) How technology is changing the CI and CT (iii) Advanced BIM application in CI (iv) the new age of Civil Engineering CE&. Practicing these technologies, in CT/CI/CE increases levels of quality, efficiency, safety, sustainability, & economics.	The results reveal that construction trends vary from 5 to 10; however, it reaches 27 in case of CE. In the near future, a perspective on the most recent innovations, trends, tools, problems, and solutions used in the fields of building construction and civil engineering has evolved. (ii) Tabulated various aspects and significance of BIM technology adoption in CI for the period 2016-2020
3	Keshav Er. and Harvinder Singh (2022). [71]	(i) increasing curiosity, being able to increase project facilitation through 3D modelling and 3D viewing, (ii)implies the advantages of CM integrating BIM AR with CM to create transparency in design, costing, and progress.	(i)visualization for the addition of 3D-live viewing to do away with time-lapse and local data impediment (ii). Also, this study offers future paths for dealing with technological changes that could significantly increase on-site efficiency.
4	Corbett, (2021) [107].	(i)includes information about restoring buildings and other stationary structures, building roads and operating service facilities. (ii)From planning	The study provides information on market dynamics like drivers, barriers, and opportunities in this industry. The profiles of current leading companies provide an overview of the Indian

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		through completion, the process of building a structure, a piece of infrastructure, an industrial facility, as well as other operations, is referred to as construction.	construction market's competitive environment .The paper also includes market effects and forecasts for COVID-19.
5	Georgiadou, M. C. (2019). [50]	investigates which general BIM ready drivers and barriers are more pertinent to the planning and execution of housing projects.	Widespread knowledge of BIM but a financial barrier preventing investment in developing digital capabilities, especially for small- and medium-sized firms (i)indicates that the most frequently highlighted advantages are linked to collaboration, usage of software, and process innovation.
6	Kaleem Ullah ,Irene Lill and Ernlyn Wilt (2019). [51]	(i) A survey can be used to model the barriers to BIM adoption in the Estonian CI based on the results. (ii) This study offers information on BIM adoption in the CI and will lay the groundwork for further investigation.	This study looked at how BIM was used in the construction industry across several countries and showed how it was advantageous at every stage of the building lifecycle. There is study on the widespread use of BIM and discussion of 18 barriers.
7	Noor Akmal Adillah Ismail et al.et (2017). [108]	The adoption of BIM in several Asian developing nations is reviewed in the paper, which also looks at how widely it is used in Asian regions.	Given the forces driving and impeding the adoption of the technology in these nations, and how this is expected to alter in the near future, (i) In the majority of underdeveloped nations, BIM is not as advanced. (ii) Share some information about how BIM is evolving in those countries.

Table 5 : Critical review/analysis on BIM in CI

Sr no	Author /year	Content	Findings
1	James O. Toyin and Modupe Mawomo (2022). [58]	(i)Researched how BIM-t installation affected how quickly construction projects were completed. The information in (ii) includes reports on knowledge gaps and suggested future research initiatives. (iii)used a methodical study of pertinent literature from 2008 to 2021 on the subject of BIM-t.	The results show that out of 41 examined papers, there have been seven (17) favourable impacts. The various building phases were used to group the stated advantageous effects.
2	Satyajit B. Patil (2022). [49]	(i)offers a workable answer to a variety of problems (ii)listed numerous strategies for overcoming the difficulties encountered throughout the construction project. focuses on recent research conducted between 2015 and 2022	Examines the adoption, challenges, and benefits of BIM in CI by taking into account studies from the greatest number of nations in the world.
3	Abdulkadir Ganah and Gavin Lea (2021). [68]	(i) Identifies and contrasts BIM guidelines, standards, and templates from throughout the world (ii) Used a qualitative research methodology approach supported by document analysis of BIM standards created in various nations across six continents.	(i)Provided suggestions for standards development based on the gaps identified (ii) government, industry organisations, or academic institutions to assist in the establishment of BIM standards to close the gaps in contract and design documents
4	Albert P.C. Chan et al., (2018).	The institutional framework and regulatory governance of BIM in putting	(i)analyses data to create a study plan for project management BIM studies. (ii) concentrates on

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	[109]	project management strategies into practise, the scopes and integration issues of BIM research for project management, and studies of the outcomes and strategies of BIM adoption and implementation in projects	how the various research trajectories relate to one another as well as the contributions and theoretical ramifications of this review.
5	Druv Gor, et al. (2018) [132]	The perceived relevance of 6 variables varied significantly between BIM writers and BIM consumers, according to an analysis of perception variations across different respondent groups. There were 26 factors used in total.	The findings show that the questioned architects and contractors concur on the majority of the offered features, including model economy, model usefulness, and model productivity.
6	Rajesh Gangani, et al.(2018). [110]	Each phase of the project—Pre-Construction, Construction, and Post-Construction—uses BIM. Construction materials cost between 40 and 60 percent of the entire project cost. Cost	BIM-based dynamic inventory control model with an emphasis on inventory management in the construction industry
7	Y. Araya and Shakilmeya S. Malek (2018). [111]	Provided a mixed review of prior reviews, compared benefits of BIM	(i)Discussed BIM use in different phases of construction (ii)Stated the future of BIM as a compulsory practice in India.
8	F.H. Abanda et al. (2015). [126]	The various BIM software systems now being used to handle construction project information are thoroughly and critically evaluated using the following five key methodologies.	Examines the entirety of BIM systems; the study employs a holistic approach, looking at 122 application cases that are typical in the AEC sector and most of the major BIM system types.
9	Z. Sriyolja ,N.Harwin and K. Yahya (2021). [113]	Recognises, classifies, and examines the challenges that come with implementing BIM as a digital information technology in the CI and offers critical insights for future research to overcome those challenges.	According to the study, from the 26 articles that were selected, 15 categories of barriers could be successfully retrieved and addressed. Among the 15 different types of barriers are those related to cost, legality, knowledge, interoperability awareness, culture, processes, management, demand, project scope, technology, skills, training, contracts, and standards.

Table 6`: Bibliometric and Scientometric analysis on BIM use in CI

Sr no	Author /year	Content	Findings
1	Shishehgarkhaneh, M. et al. (2022). [72]	The study demonstrates the application of Heritage BIM (HBIM), Smart Contracts, BIM, and Ontology in the construction industry, as well as BIM, IoT, and DT. The usage of BIM and Metaverse technology, BIM with AI, Metaheuristic algorithms for BIM optimisation, and the Circular Economy with BIM and IoT are among the recognised trends.	The study's key findings include (i) the use of metaverse technology in BIM and the construction sector; (ii) the integration of AI and digital twins with BIM; and (iii) the implementation of the circular economy in the construction sector utilising BIM and IoT. The primary study themes are VR and AR in DT and BIM.

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2	Amarnath C.B. (2021). [124]	(i)A study provides a bibliometric examination of the global and ICI use of BIM. (ii) The analysis was done twice, taking keywords into consideration. as well as the volume of materials and research	Reviewing adoption globally while focusing only on BIM adoption in ICI, (i)examines the use of BIM in worldwide construction for safety and restricts the outcomes to BIM usage for safety in India
3	Shalaka Hire, et al. (2021). [114]	gives a bibliometric examination of the worldwide construction industry's and Indian CI's use of BIM. The use of BIM for safety in the international and Indian CI is also reviewed. examines the global adoption of BIM	(i)Examines the implementation of BIM for safety in worldwide construction, focusing on India, and presents the findings. (ii) BIM could provide the ICI with significant advantages. (iii) Several supplementary products for building site safety, such as VOSviewer and iMapbuilder
4	Saka, Abdullahi B., and Daniel W. M. Chan. (2019). [115]	(i)Provides a scientometric analysis and meta-synthesis of BIM development in the African AEC sector. (ii) Examines the conceptual development of BIM, the current state of BIM in various areas, and any potential roadblocks to BIM adoption.	The key obstacles to BIM adoption were identified as being people- and process-related. I Results demonstrated a diverse amount of BIM growth, with North Africa, West Africa, and Southern Africa leading the research development, while East Africa and Central Africa are slightly lagging behind.
5	Tatjana Vilutience et al., (2019). [116]	shows that efforts to conduct study in this area have mainly focused on addressing generic BIM issues, such as information management; however, technical structural challenges in engineering that could be resolved using BIM capabilities have gone ignored.	(i) Shows how after 2014, research on the application of BIM in structural engineering grew rapidly. (ii) Discusses a variety of issues relating to research gaps and crucial areas required for project completion.
6	Ziwen Liu, Yujie Lu and Lu Chang Peh (2019). [91]	(i) Create the 3 stages of formulating, accelerating, and transforming. (ii) examined Singapore's BIM policy and noted the connection between the development of BIM policy and international BIM research.	Findings highlight the need for additional study in the field of BIM and visualise the current state of the subject's advancement for researchers, practitioners, and policymakers.
7	Ruben Santos ,et al. (2017). [117]	(i) Recognized interoperability and collaborative settings, sustainable building (ii) The academic contribution of BIM, parametric modelling, and quantity take-off is quite limited.	It was noted that the creation of BIM tools, analysis of BIM adoption globally, energy simulation using BIM-based data, and, more recently, semantic interoperability and ontology, were the topics that had received the most research.
8	Yalcinkaya, M. & Singh, V. (2015). [118]	The study's twelve main research areas are revealed by applying Latent Semantic Analysis (LSA), a method of natural language processing, to the abstracts of 975 academic papers.	Recognized numerous distinct research themes connected to each major area These main research issues and areas of study highlight the patterns and developments in BIM research.
9	Tsengunn Ganbat Et al. (2018).	Research trends and possibilities for risk management in BIM-enabled international construction have been identified and explored, and frameworks for BIM risk management in international construction (BIM-RM-INTL) have been developed.	findings demonstrate the increasing BIM adoption not only piques the interests of all stakeholders but also carries some dangers. Current research findings and their connections were mapped for use in risk management in BIM-enabled international building.

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Table 7: Miscellaneous research paper on BIM for Construction industry

Sr no	Author /year	Contents	Findings
1	Sonali Dhopte and Arti Daga (2022). [43]	(i) Examines the past, present, and future of BIM adoption in India from the viewpoint of the business community. (ii) Studied and Excelize, an Indian BIM service provider with nearly 20 years of experience in the AECO sector.	(i) Finds that BIM offers a number of benefits for a project's general efficacy and wellbeing throughout its entire life cycle. The study includes both project participants and BIM service suppliers (ii). BIM adoption still encounters a variety of challenges.
2	Abdullahi B. Saka and Daniel W.M. Chan (2020). [120]	(i) The SMEs that make up the construction industry's backbone are examined holistically from the standpoint of existing BIM research in this article. (ii) Created a conceptual model based on a literature review and the framework, model, and institutional theory of innovation diffusion.	(i) Results showed a lack of BIM studies in SMEs, the adoption state, and identified motivations, benefits, and constraints. (ii) The report makes significant arguments for promoting BIM in SMEs.
3	M F Antwl-Afari ,et al. (2018). [112]	Analysis shows that certain nations have created distinct critical success factors (CSFs) for gauging the success of BIM deployment. Common CSFs include: Planning and site safety; cooperation between design, engineering, and construction stakeholders	(i)research on CSFs used for BIM deployment from 2005 to 2015. (ii)better site layout, coordination and planning of construction projects, sooner and more accurate 3D representation of designs, increased information exchange, and knowledge management
4	Sharma Piyush, Gupta; (2016). [121]	(i)Presented an overview of BIM with a focus on its core ideas, difficulties, applications, and management issues among project stakeholders at all phases of the project life cycle. (ii) The ACE industry needs more time to use BIM technology.	Software addresses project complexity while managing the diverse demands and standards of designers and contractors. BIM is backed by its potential to bring about positive, long-lasting change and by its commitment to continue playing a vital role in the industry's efficiency gains and enhancements to product quality.
5	Sawhney, Anil (2014). [129]	According to the report, 27% of respondents stated they are aware of and actively considering utilising BIM, while 22% of respondents currently use BIM. Unexpectedly, 43% of respondents claimed they were aware of BIM but weren't sure if they will implement it in their organisations anytime soon.	In order to accelerate the adoption and adaptation of BIM in India, emphasis is placed on developing tripartite centres of excellence, which unite government, business, and academic organisations.
6	Benedict D. Hozor and David J. Kelly (2012) [122]	The BIM/IPD Integration Model is a novel conceptual framework for comprehending the technologies and their interactions that: (i)identifies important advantages/deficiencies in the literature; synthesises the material with comparative analysis; and (ii) conceptualises the major benefits/deficiencies.	(i)Establish relationship between BIM and/or IPD adoption (ii)project performance measures (e.g., cost, profit, ROI, schedule, safety,

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7	Anthony Muttai, Bowling and Stan Guidera (2010). [32]	Provides a framework for advice to construction engineering professors interested in incorporating BIM technology into their curricula by analysing data and methods.	Students in all AEC-related areas may benefit from this kind of professional training if civil engineering, construction, and architectural instructors collaborate and integrate their programmes.
8	J. Vinodkumar Mahua Mukherjee, (2009). [123]	Examines the BIM application status in India. A survey has been created to gauge BIM uptake through 2009.	In many different countries, this acceptance for managing project information with capabilities for cost management and FM is well acknowledged.

IV. CONCLUSION

The most intricate component of the AEC sector is the BIM model. Practically every aspect of a building's operation can be carried out by it. BIM is helpful. [https://www.united-bim.com] BIM may be used to reinvent collaboration across everything and everyone.

BIM has the potential to bring about a variety of direct and indirect advantages for the built environment industry, such as: (i) improved information sharing throughout the entire value chain; (ii) cost and time savings; (iii) improved quality; (iv) increased accountability and transparency in decision-making; (v) increased sustainability; and (vi) improved end-user/customer satisfaction.

With the use of BIM, it is possible to improve collaboration and communication, model-based cost estimation, structural analysis, structural design, 3D modelling construction, increase productivity through prefabrication, design structural steel, detail steel structures, and create 3D, 4D, and 5D BIM services. This (xiii) improved scheduling and sequencing also includes the extraction of structural components, high-quality construction records, conflict identification, and risk reduction.

BIM has a significant impact on CI because it enables companies to prevent costly mistakes caused by human error. BIM is yet another method for bringing cutting-edge technologies to the building industry and raising project quality. Due to its incredible visualisation, simulation capabilities for diverse data sources, and capability to merge numerous stages into a single process, BIM technology has the potential to dramatically revolutionise how organisations carry out construction. Teams involved in design and construction can work more productively thanks to BIM, which also enables them to record the data they generate during the process for use in operations and maintenance. BIM data can help with project, city, and national level planning and resource allocation. This is the reason that more countries are requiring BIM.

On the basis of the literature review research, below are some inferential points summarized on adopting BIM use in the CI.

The results of BIM :The capacity to exchange accurate and useful information with many different groups of people, such as designers, managers, stakeholders, etc., is one of the key benefits of BIM as a process and platform in general. The BIM process's main objective is to force collaboration and make it easier for all project participants to cooperate and work more efficiently. Building a solid relationship between the two is made feasible through BIM.Projects could achieve sustainability with the use of BIM.

By providing architects and engineers with access to more sophisticated technology tools than ever before to properly integrate and analyse aspects like heat gain, solar, ventilation, and energy efficiency in BIM may improve facility management, BIM has, in particular, made sustainable design possible.Facilities managers may optimise their performance and foster a more data-driven culture to deliver facilities management (FM) services more efficiently and improve building performance thanks to BIM, which enables the management of knowledge throughout a building's entire life cycle.

[iv] BIM increase productivity: BIM significantly improves productivity during the project's design and construction phases. Its advantages include minimising the amount of errors produced, completing jobs faster, and discovering prefabricated material uses to reduce expenses.

[v] Construction industry change brought on by BIM

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Using BIM allows the construction team, which consists of architects, engineers, and contractors, to provide the owner with more meaningful information much earlier in the process. A contractor can often provide a very accurate construction cost estimate when the BIM documentation is about 40% complete.

[vi] BIM can increase construction productivity When compared to non-BIM projects, the ability of BIM to identify and resolve problems before construction begins minimises unplanned modifications in construction by 40% and can save as much as 10% of the total cost of the project.

[vii] BIM helps keep construction expenses down. A case investigation was carried out in a building project that made use of BIM. The results show that BIM may save costs by 52.36% and time by 50%. Because fewer people are needed and the project is completed faster, there are time and money savings that have an impact on funding.

[viii] Projects can be completed with the help of BIM, on schedule, and with effective teamwork. Owners of buildings and projects can lower risk by effectively employing BIM. With BIM, owners can expect improved project quality and easier lifecycle management.

[ix] Further, with the help of AI the BIM in construction, The AEC market is predicted to increase at a CAGR of 15.20% during the forecast period of 2023-2028, aided by the incorporation of artificial intelligence (AI) in BIM software. By 2027, the market will be worth approximately USD 7.6 billion [https://www.uniquescadd.com]. The construction market is in good shape for the balance this year and next.

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MIT UNIVERSITY'S – ABHIVRUDDHI JOURNAL
VOL.2 (01) , JUNE , 2022 pp- 75-80
ISSN(Online): 2584-1025

A review on "Sustainable Solutions for Housing Construction with Advanced Technologies in Indian Context"

Ar.Deeparani Chougule, Dr. parag Narkhede
VIT's PVP College of Architecture, Pune, India
HOD, BKPS College of Architecture, Pune, India

Abstract -The study aims at investigating the role of advanced technologies to achieve sustainable solutions in housing construction. As per the current scenario there is a huge housing demand in India which needs to be completed by 2022 under the mission of "Housing for all by 2022(MHUPA 2012)". Catering to this need, the Government of India added a technology sub mission of creating awareness and benefits of advancement in technology to be adopted for housing construction was done in 2019 through "Global Housing Technology Challenge (GHTC)". The concept of "built it fast or built it well" within the most conservative way can be achieved with the help of advanced innovative technologies. The base for research paper work is done by review of the available literature associated with advanced technologies used for housing construction like Precast or Pre fab Construction, Steel Structural System, Alternative Formwork System, Sand-witch Panel system etc. For inferences comparative analysis of selected papers are carried out. The review helps to discuss a set of guidelines for future housing proposals in Indian Context.

Keywords-Housing, Sustainable, Innovative Technologies, Government initiatives

I. INTRODUCTION

India is one of the developing country. The rapid growth in all sectors is becoming more and more prominent. Keeping this in mind this research work is about the urban development in relation with Innovative advance construction technologies and sustainability.

According to the annual report of India for 2020-2021 by "Ministry of Housing & Urban Affairs", "Urbanization is gaining momentum and cities play a crucial role in the development and act as engines of growth for the country. It is estimated that more than 50% of India's population will be living in cities by 2050." (Marina m.,Ashwini K.,Rupesh D., & Mukund J. ,May 2022)

The aim to decide and promote the use of advanced construction methodologies worldwide which were environment friendly and structurally stable. This concept has initiated by the "Ministry of Housing & Urban Affairs" in India. This mission was titled as "Global Housing Technology Challenge –India". The advanced construction technologies were of high quality, affordable, suitable for different climatic conditions, fast and fulfilling the functional aspect of houses. (Dinesh B. Bandiwadekar, Dec. 2021)

There is a grave necessity for the large scale housing projects in India to meet the social requirements, the environmental impacts of such mass construction should also be given due contemplation. This is an ongoing study and a simulation based computational framework is being developed that facilitate analyzing the impacts of various challenges and opportunities associated in realizing sustainable and affordable housing, (Ann F.,Dr. Jinu K.,& Dr. Albert T., NFiCE 2018)

This study is done for National Conference under the theme of Sustainable solutions & Emerging domains & innovation in Housing Construction.

A. Innovative Technologies

The technology adopted for construction which are safer, environment friendly, climatically suitable, speedier, superior quality, functional, flexible cost and resource effective, affordable are calld as Innovative Technologies.

B. Sustainability in Construction Industry for Housing

It is the way in which construction industry achieves technics to make it environment friendly in a various ways, like reduece waste, recycle the material, reduce carban footprint etc.

II. METHODOLOGY

For Literature review the technique of consolidating the answers for 5W's and 1H's is used. Answers to 5W's i.e. When, What, Why, Whom, Who and 1H's i.e. How were found from the selected 16 papers.

This enables to do comparative analysis of all research work done by different authors.

III. LITERATURE REVIEW

The research Papers selected for review are from Oct. 2009 to Oct. 2022 and of different types like White Paper, Working Paper, Technical Paper, Reports etc. All these papers address the Advanced Housing methodologies adopted for construction which are ecofriendly and affordable to be adopted and implemented.

TABLE I. COMPARATIVE CHART SHOWING 5W'S & 1H'S

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Sr. No.	Category of Paper	Title of the Paper	When	What	Why	Whom	Who	How
1.	Research paper	"Sustainable performance criteria for construction method selection in concrete buildings"	Oct.- 2009	Work out a suitable method for construction of given reinforced cement concrete building. Enlist the standard procedure and key drivers which will be useful for stakeholders working in construction industry.	To find out guidelines and set of instructions for the stakeholders working in construction sector. To allow a typical alternative way for construction sector making the construction environment friendly.	The surveys conducted with US construction Industry along with registered authorities working in construction industry. The sample data collected were then analyses by statistical methods.	Ying Chen, Gül E., Okudan C, David R. and Riley B.	The literature review & detailed comparative study of conventional & advanced technology was done for different sites and stakeholders. For completion of this 33 parameters for sustainability were identified and based on those the data were collected to find out conclusion and results.
2.	Research Work	"Helping CIOs Understand 'Smart City' Initiatives"	Feb.- 2010	Explaining the factors, making urban spaces more resilient through different services provided and basic physical systems for technologically modern urban areas. Responsible authorities in their hierarchy of three layers were main leaders to take the mission ahead.	To clear the concept of technologically modern urban areas to responsible authorities. To take and hand over the aim, objectives of technologically modern urban areas to responsible authorities.	Studying the recent technologically modern urban areas globally. Seven important key drivers of infrastructure components & services of existing technologically modern urban areas. To study factors of quickly growing urban areas.	Doug Washburn, Usman Sindhu, Stephanie Balaouras, Rachel A. Dines, Nicholas M. Hayes, Lauren E. Nelson.	Authors interviewed Alcatel-Lucent to study the system called as "Cisco Systems" and "IBM". This methodology enable author to get acquainted with the techniques used for developing modern urban areas.

Sr. No.	Category of Paper	Title of the Paper	When	What	Why	Whom	Who	How
3.	A Report	"Improving construction Efficiency & productivity with Modular Construction"	2010	The way to increasing the output and performance with standardized units or modules in construction work.	As per study overall productivity for construction industry were usually decreasing from 1995 to 2001 with respect to the other industries. Hence to increase performance through basic advance techniques and equipment's in construction Industry.	Identified 5 key points were –proper resource management to increase the onsite performance, use of advance technologies at design and execution stage of project, adopting new identified methods for getting high quality, speed and smart resource management, by adopting advancement in construction increasing the high end output results, study interface at different stages of project through "Building modeling Information (BIM)" software,	Experts from: "Advancing the competitiveness & efficiency of the U.S. construction Industry" and The modular building institute	Reviewing of 3 white papers by experts in advance technologies in construction field. Doing 2 day workshop with 20 experts in the advance construction field. Analyzing the data 5 key factors were identified which at end enhance the construction industry.
4.	A white paper	"India Concept House"	Dec. - 2011	Working solution for housing sector by production of cost effective, speedy, ecofriendly building elements.	Addressing the problem of housing in India a big challenge.	The demonstration 11 sites were identified in composite climate zone for study purpose where study of all key drivers impacting on the construction industry. Aims & objectives to enhance the better utilization of all resources were also studied further as mentioned in Red report focusing on the points like thermal comfort, transportation, offsite construction methods etc.	Sam Circle Venture, Kieran Timberlake	Project endeavors, supporting drawing sets & an ideal building type through program development & conceptual development along with construction system analysis was done to deal with the challenge.

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Sr. No.	Category of Paper	Title of the Paper	When	What	Why	Whom	Who	How
5.	Research Article	"Promoting precast concrete for affordable housing – An overview on promotional policies worldwide and challenges and possibilities in India"	May - 2016	Creating awareness and encouraging for use of offsite construction system for cost effective housing construction.	With the conventional system of construction, the current & future need of housing is seems difficult to fulfill. We need to use the alternative technology such as "PCC", in terms which is appropriate to achieve the goal of housing for all in India.	Studied the PCC adoption criteria's in identified developed countries and its effect in those countries.	B. Arifullah P. Sherfudeen, Nitish Kumar, Raghavan N., Radhakrishna Pillai & Satyanarayana Kalidindi	Conducted interviews with key members of organizations and firms working in PCC field. Analysis of data collected were done with the help of comparison between the different methods & techniques. Also the comparative analysis of guidelines promoting such techniques and need is done.
6.	Research paper	"Identifying and Addressing Critical Issues in the Indian Construction Industry: Perspectives of Large Building Construction Clients"	Nov.- 2017	This research work focuses on finding out the likely difficulties in Indian Construction industry and provide a forum to come out with proper guidelines.	To summarize and state again the main points of finding out the likely difficulties in Indian Construction industry.	By involving the members, organizations & groups involved in Indian construction industry to initiate "Ci3 India "mission, new initiatives which are important and environment friendly to achieve improvement in Indian Construction Industry.	Santhosh Loganathan1, Purushothaman Srinath1, Mohan Kumaraswamy, Satyanarayana Kalidindi, Koshy Varghese1	The international level meetings were held to discuss about issues faced by construction industry. These key 19 issues were enlisted, confirmed and studied. To come to conclusion 4 focus group sessions with 2 roundtable meetings of 54 experts from building construction industry.

Sr. No.	Category of Paper	Title of the Paper	When	What	Why	Whom	Who	How
7.	Research Paper	"Construction Costs in Affordable Housing in Kerala: Relative Significance of the various Elements of Costs of Affordable Housing Projects"	Sept.- 2017	The study was focused on cost of various factors and components of housing construction to make the project cost effective or affordable. The related importance, factor of cost of components which at end help to work out suggestions for new policies.	To achieve the best quality in construction of housing. To work out the strategies for making housing construction affordable. To identifying the critical check points in construction process.	The focused study sites and survey is limited to Kerala state only.	Dr. Manoj P. K.	Primary data was collected through literature review & interviews with industry expert in Kerala State. The Secondary data analysis is focused on patterns, ideal trends, housing sector etc. The building typologies considered were Villas, apartment buildings, residential housing.
8.	Research Article	"Smart Villages: Comprehensive Review of Initiatives and Practices"	July- 2018	Study of existing "smart village concepts" and digital change over in rural areas was done to understand the best practices and policies adopted. The study was also focused on "EU policies" adopted and implemented, which is helpful to decide the further guidelines for adopting same.	To understand the implications of smart development. To understand the adoption criteria's by common man. To review the technologies, methods, government policies and startups.	Study of all parameters of existing smart villages. Main focus is addressing the issues of development rules or protocols followed for completing the mission.	Veronika Zavratnik, Andrej Kos, Emilija Stojmenova Duh.	The case of Slovenian pilot practice is considered for focus study. Where analysis of findings and parameters from different regions is done. Which is base for explaining evaluation of construction practices. These statements were supported by Fab Village Concept.

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Sr. No.	Category of Paper	Title of the Paper	When	What	Why	Whom	Who	How
9.	Research Paper	"Prefabrication As A Solution To Improve Productivity Of Construction Industry, Tamilnadu, India"	Apr.- 2020	To work out the challenges faced in adoption of prefabrication technology in Tamilnadu, India.	To reduce or minimize the issues faced by construction industry key stakeholders in identifying an appropriate technology for construction in Tamilnadu, India.	The study of critical problems faced by key organizations, members and firs using prefabrication construction technology in Tamilnadu, India.	Murali, K., Sambath, K.	Through Summary of literature review was enlisted total 24 key factors, Amongst them 10 key factors were representing benefits of adoption of technology, 7 key factors indicating difficulties faced and 7 key factors were indicating guidelines of adopting the technology.
10.	Research Paper	"Sustainable Performance Criteria for Prefabrication Construction System"	Apr.-2020	To identify the potential of prefab construction technology in respect of conventional construction methods.	To enlist the key drivers playing an important role in selecting and adopting the prefabrication construction technology. To provide solution to the issues faced by construction industry for adopting the prefab technology.	Reviewing of Environment friendly construction criteria's during the construction phase of a project highlighting its aspect of social consciousness, economy and eco-friendly criteria's.	Murali, K., Sambath, K.	Comparative analysis considering the key aspects such as economy, social concerns, sustainability etc. between conventional construction technology and Prefabrication construction technology.

Sr. No.	Category of Paper	Title of the Paper	When	What	Why	Whom	Who	How
11.	Research Paper	"Quantitative Analysis of Precast and Cast in-Situ Residential High Rise Building"	Jun.-2020	The conventional & precast construction technologies were compared for cost and time required to complete the identical project.	To identify suitable construction technology for high rise housing construction. To identify suitable construction materials for high rise housing construction.	2 construction technologies were analyzed considering cost & time in Bengaluru, India. Rate analysis was done considering market rates in Bengaluru, India. Typical G+7 storied building consisting of 48 houses was considered for case study purpose.	Akshay Jagannath Rajagopal	Comparative analysis of 2 technologies was done considering the two basic points- estimation & project planning or scheduling. Estimates were done manually & scheduling was done using Primavera software.
12.	Research Article	"Application of Sustainable Prefabricated Wall technology for energy efficient social housing"	2021	Comparative study of conventional and prefabrication construction regarding economical and energy consumption points.	To review the current practices in cost effective building construction in India. To address the issues of solid waste and industrial waste management in India.	A comparative study of model house with 17 different materials like "co-fired blended ash (CBA)" an industrial waste was done. With different criteria's involved in prefabrication panel system.	Ravijanaya Chippagiri, Hindavi R. Gavali, Rahul Ralegaonkar, Mike Riley, Andy Shaw, Ana Bras	The statistical analysis of all identified 18 model houses using computer software's for two key factors- cost & energy consumed in 2 considered technologies was done.

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Sr. No.	Category of Paper	Title of the Paper	When	What	Why	Whom	Who	How
13.	Research Paper	"A Study of the Scientific and Logical Step By Step Process of Sourcing and Implementing New Technologies for Construction of Low Cost and Related Housing Initiatives in India"	Dec.-2021	To study scientifically parameters of new construction technologies for affordable housing construction. To study methodology for implementation of new technologies in detail step by step.	To make awareness about using new construction technologies in construction industry.	Detailed study of "GHTC- India" and other sub missions and missions.	C. Dinesh Bandiwadkar	Literature review of GHTC-India published by Government of India and interviews of different stakeholder involved in it
14.	Research Article	"The advancement of precast development in India : A Critical survey of challenges & benefits within the rising residential sector"	2022	To study challenges faced by Indian construction industry to adopt advancements in precast construction technology. To find out benefits of adopting new technology in growing housing sector.	To aware the importance of Precast technology in Indian construction industry	The construction technologies like cast in situ and Precast Construction were studied in detail.	D. Abhi K Rakholiya , Pravin R Minde	For literature review, comparative analysis of precast technology with conventional technology in reference to time , cost, productivity& quality

Sr. No.	Category of Paper	Title of the Paper	When	What	Why	Whom	Who	How
15.	Working Paper	"Alternate Construction Technologies for Mass Housing: Challenges to adoption in India"	Jan.-2022	To study issues faced for using advanced construction technologies in Indian construction industry for mass housing projects.	To find out the issues for using new technologies for mass housing construction in India.	The detailed study of four new construction technologies involved in construction industry.	A. Ayush Khare , Deparpita Roy, ,Triveni Nanda.	A literature review along with interviews with industry experts and stakeholders. Also discussion with government authorities, Academicians, civil society experts were done.
16.	Review Paper	"Technological & Sustainable Perception on the advancements of prefabrication in Construction Industry"	Oct.- 2022	To study the key factors those make prefabrication construction an efficient, environmentally, sustainable technology.	To enhance the existing information of Prefabrication construction technology with the data and work of 3 decades. To detail out the spectrum of different key factors which has impact on construction industry.	The review of more than 80 research articles written on prefabrication construction technology implemented or used in approximately 10 countries worldwide.	Ravijanya C. Ana Bras, Deepak Sharma, Rahul Ralegaonkar	The study of 3 decades research work from 1990's about the progress of technologies in construction world, different materials available etc. along with its implementation in construction industry.

ISSN(Online): 2584-1025

IV. Conclusion

After reviewing a wide range of Research literature the conclusion is –

It is impactful to cater the need of high housing demand due to rapid urbanization with sustainable and environment friendly innovative technologies; that need to be adopted for urban development in India.

Lots of government initiatives are taking place to promote, adapt these sustainable innovative technologies for smarter cities with built to fast concept.

Focus of stakeholders towards adopting futuristic innovations in housing construction is becoming essential day by day.

Acknowledgments

I would like to express my sincere thanks to all who have contributed in completing research work and be there as continuous support system throughout the entire process.

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MIT UNIVERSITY'S – ABHIVRUDDHI JOURNAL
VOL.2 (01) , JUNE , 2022 pp- 81-83
ISSN(Online): 2584-1025

Process Standardization for Mango Leather

Akshata Palve
Food Process and Product Technology
MIT School of Food Technology,
Pune – 412201, India
7796539833
palveakshata8@gmail.com

Dr. Prerana Shere
Food Process and Product Technology
MIT School of Food Technology,
Pune – 412201, India
8007771544
prerana.shere@mituniversity.edu.in

Dr. Sujata Ghodke
Patronage of traditional and specialty foods MIT School of Food Technology,
Pune – 412201, India
9850807262
sujata.ghodke@mituniversity.edu.in

Dr. Amit Kulthe
Agrobase Plant Operations
MIT School of Food Technology,
Pune – 412201, India
9096753818
amit.kulthe@mituniversity.edu.in

ABSTRACT
The super fruit base leather was prepared from Mango (Mangifera Indica L.) which naturally represent elevated nutritional status. The mango leather was dehydrated at 40, 50, 60, 70º C drying air temperature in cabinet dryer. The drying rate curves showed that 60º C temperature was suitable for obtaining good quality leather with a moisture content of 19.13% for 7 hours of drying time Mango pulp was found to have a moisture content of 80.63%. The proximate composition of mango leather (Protein 15.89%, crude fat 1.56%, carbohydrates 58.26%, total dietary fiber 14.06%, ash 1.98%) recorded significant increase than fruit pulp (Protein 0.61%, crude fat 0.42%, carbohydrates 14.39%, total dietary fiber 0.79%, ash 0.52%). The mineral profiling of fruit leathers demonstrated similar increasing trend due to concentration of nutrients during pulp to leather processing.

Keywords
Mango, fruit leather, dehydration

1. INTRODUCTION
Fruit puree is dehydrated to prepare a product called fruit leather. Mango, apple, and other tropical fruits are just a few examples of the many fruits that may be used to create fruit leathers. However, the composition considerably relies on the type of fruit added to the puree combination due to changes in the quantities of pectin, sugar, and acid. The formulation might occasionally include different kinds of carbohydrates as well as additives like hydrocolloids and preservatives in order to enhance the rheological qualities or preserve the fruit's original color. These fruit treats were first created as a small-scale alternative preservation technique, but recently they have become more popular due to their nutritional benefits. The processed fruit products offer less calories than traditional snacks and are a rich source of fiber as well as micronutrients (Diamante et al., 2014; Ruiz, et al., 2012; Vatthanakul et al., 2010).

Fruits are a valuable source of nutrients that are good for your health, including minerals, vitamins, antioxidants, and fiber. Fruits are a good source of energy, but the time it takes to make them and their high perishability are obstacles to increased fruit intake. Fruit eating every day helps to strengthen the immune system that keeps illnesses at bay. Among the other nations, India is the one that produces the most fruits and vegetables. Fruits are subsequently processed into various value-added products to prevent post-harvest losses (Anonymous, 2002).

The Anacardiaceae family plant, the mango (Mangifera indica L.), has a variety of beneficial compounds. Mangoferin, quercetin, catechins, anthocyanins, ellagic acid, kaempferol, methyl and propyl gallate, benzoic acid, gallic acid, and protocatechuic acid are the primary phytochemicals in mango fruit that have antioxidant effects. The primary antioxidant in mangoes, mangiferin, is well-known for its therapeutic and nutraceutical properties and is still gaining popularity, particularly for its ability to fend off degenerative diseases like cancer and heart disease. (Masibo and Qian, 2009). Similar to other polyphenolic compounds, mango polyphenols are primarily antioxidants, protecting human cells from oxidative stress, which can result in lipid peroxidation, DNA damage, and a number of degenerative diseases (Raab and Oehler, 1976).

Hidden hunger is more common among urban residents and is exacerbated by urbanization, dietary change, and sustainable food systems. Therefore, one strategy for addressing hidden hunger is diet diversity using super fruits. This study aimed to establish the nutritional significance of fruit leathers prepared from mango fruit and the comparative analysis (Pulp vs leather) to emphasize and rejuvenate the nutritional profile of fruit leathers.

2. MATERIAL AND METHOD

2.1 Materials
The good quality of mango fruit pulp, sugar, pectin was procured from local market of Pune. The Department of Food Process and Product Technology laboratory at MIT ADT University in Pune provided the processing and further working tools.

2.2 Methods

2.2.1 Preparation of fruit leathers

In mango leather, the fruit pulp was mixed with sugar and pectin. The mixture was mixed thoroughly and heated at 70ºC for 3min. Mix and heat mixture, pour into stainless steel tray, smeared with butter, and dry in cabinet dryer at 60ºC for 6 hours. The dried fortified mixed fruit leathers were prepared. The process was followed for fruit leather preparation with slight modification as reported by Vijayanand et al., (2000) as well as the fruit leather was prepared as per the method described by Patil et al., (2017) where the date and mango leather (60:40) dried in cabinet tray dryer at 65±5ºC for 12-14 hrs.

ISSN(Online): 2584-1025

2.3 Chemical analysis

2.3.1 Determination of the proximate composition of the fruit pulp and leathers

The method of A.O.A.C. (2005) was adapted for determination of ash, crude protein and crude fiber. The moisture and crude fat were determined by methods described in Ranganna (1986), while carbohydrate was calculated by difference method.

2.4 Statistical analysis

Each experiment was run in triplicate. For each treatment, the mean and standard deviations of the data were calculated. The statistically significant changes ($p < 0.05$) were found using ANOVA. The Statistical Analysis System version 9.21 was utilized for the statistical computations, and Microsoft Office Excel was used to examine the sensory assessment data. To find any significant differences between the mean values, a one-way ANOVA was performed after the means and standard deviations were calculated.

3. RESULT AND DISCUSSION

3.1 Influence of temperature on drying rate

The mango fruit leather drying curves shown in fig. 1 revealed fluctuations in moisture content with regard to time (7 h) for drying at 40, 50, 60, and 70 ºC. In all temperatures, it was found that fruit leathers moisture content dropped dramatically as they dried. As the drying air temperature increased from 40-70ºC, the drying curves exhibited steep slope indicating that the rate of moisture loss increased with increased in drying air temperature in cabinet dryer. The similar trend of results was notated by (Asabe et al., 2021). The moisture loss at 70ºC was observed to be faster compared to 40, 50, 60 ºC temperatures. However, this resulted in colour degradation of the leathers and gave chewy texture to the leathers. Hence, the experimental finding showed that 60ºC drying air temperature was suitable for obtaining good quality dried leather with a moisture content of 19.13 % and drying time of 7 hours. The drying temperature range of 50-60ºC for drying of fruit leather is supported by (Kaur and Godara 2022).

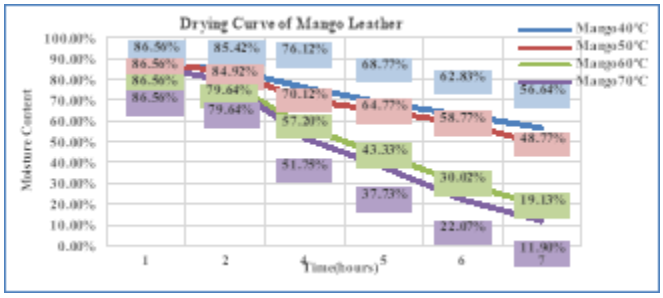

Figure. 1: Drying curve of mango leather

3.2 Comparative nutritional profiling of pulps and leathers

3.2.1 Proximate composition of raw materials

The moisture content of mango pulp was found to be 80.63%. On the other hand, mango pulp was high in carbohydrates (14.39%) and crude ash (0.52%), as depicted in table no. 1. The mango pulp contains 0.61% crude protein, 0.42% crude fat, 0.79% crude fiber. The mango pulp results are similar to those reported by Pawase et al., (2019) and Chakraborty et al., (2020) respectively. The protein-rich ingredient that is whey protein concentrate was specifically chosen to fortify mango fruit leather. According to Jangale and Ghanendra (2013), the substances mentioned above had an average protein level of 82.3%.

Table 1: Proximate composition of raw material and fortified leather

Raw materials	Moisture (%).	Carbohydrate (%)	Crude protein (%)	Crude fat (%)	Crude fiber (%)	Ash (%)
Mango pulp	80.63±0.045	14.39±0.86	0.61±0.040	0.42±0.021	0.79±0.020	0.52±0.04
Mango leather	19.13±0.02	58.26±0.015	15.89±0.40	1.56±0.015	14.06±0.015	1.98±0.01

(The values were mean ± standard deviation of three independent readings)

3.2.2 Proximate composition of leather

The proximate composition of mango leather revealed a significant increase in crude protein (15.89%), carbohydrate (58.26%), total fiber (14.06%) and crude fat (1.56%). The increase in crude protein, crude fat, carbohydrate and total fiber values is due to the addition of 12% whey protein concentrate to mango pulp. The findings are in agreement with Chauvan (2013) for mango leather that the nutritional goodness of the prepared product was improved by dehydration process which causes concentration of nutrients.

3.2.3 Comparative mineral profiling of fortified pulp and leathers

The processing of fruit pulp to leather resulted in concentration of minerals such as calcium, potassium, magnesium, iron. The calcium content in the leathers significantly increased from 30.62 to 141.01mg/100g, 176.37 to 662.12mg/100g, 20.14 to 54.16 mg/100g and 1.92 to 2.23 mg/100g in mango. This could be due to the dehydration process causing evaporation of moisture from the fruit pulp and concentration of dry matter in leathers. The trend of increase in the mineral content in fruit pulps to leather processing has been reported earlier by Karabacak et al., (2021) for pumpkin fruit leather.

Table 2: Comparative mineral profiling of pulp and leather

(The values were mean ± standard deviation of three independent readings)

ISSN(Online): 2584-1025

4. CONCLUSION

In this study the super fruit-based fruit leathers were prepared to improve the nutritional potential of super fruit leathers in terms of the concentration of nutrients, phytochemicals and antioxidant activity. Fresh mango is a high source of macro and micronutrients such as vitamins, minerals, fibers, carbohydrates and other bioactive substances. Dehydrating fruits into leather reduces post-harvest losses due to their perishable nature and extends shelf life for seasonal fruits like mango. It can be concluded that Conversion of perishable fruits to fruit leathers preserves surplus harvest and minimizes postharvest losses globally. The drying process for preparation of leather was standardized at 40, 50, 60, 70ºC for 7 hours drying time in a cabinet dryer. Air drying temperature above 60ºC affected the color and texture of leathers. Hence, 60ºC for 7 h was found to be optimum temperature (Final moisture content 19.13%) in fortified fruit leather. The drying process increased the ash, carbohydrate, protein, ash, fibre, mineral total phenols, and carotenoids contents of the fruit leathers significantly when compared to their comparable fresh fruits. The present investigation thus rejuvenates the nutritionally superior status of fortified fruit leathers as a healthy snack.

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Parameters	Calcium (mg/100g)	Potassium (mg/100g)	Magnesium (mg/100g)	Iron (mg/100g)
Mango pulp	30.62	176.37	20.14	1.92
Mango leather	141.01	662.12	54.16	2.23
SE±	0.024	0.5	0.03	0.009
CD @ 5%	0.094	0.19	0.11	0.035

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MIT UNIVERSITY'S – ABHIVRUDDHI JOURNAL
VOL.2 (01) , JUNE , 2022 PP. 84-87
ISSN(Online): 2584-1025

Student Management

Digvijay Ganesh SakoreTakali Bhima
+91-7774039249
digvijaysakore2005@gmail.com

Shravan Rupesh Takke
Mundhwa, Hadapsar
+91-8975732360
shravanrupeshtakke@gmail.com

Swapnil Tukaram Shinde
Bhekrainagar, Hadapsar
+91-7666027093
swapnilshinde7822@gmail.com

Om Mahindra Kale
Kale colony, Hadapsar
+91-84465 30031
omkale3100@gmail.com

ABSTRACT

Students form a very main part of university/college that concerns them. But the University finds it more difficult to track or save their records in one place. So, storing it physically will require more pen and paperwork and will need much more effort to manage huge data. Sometimes there will be a huge heapof files which are kept in the corner of the office and if we want to find details of a particular student then it is a time-consumingtask. So, there's a need for a system to manage this big data ona platform that can be accessed by students at anytime and anywhere so that they can be updated.

So, the student management system will provide a simple interface for storing information about students easily and if we want to find any particular student details it just needs to search for him/her by simply entering their roll number. The creation and management of accurate Up-to-Date information regarding a student's Academic career are critically important in university or college.

The student information system deals with all student records such as fee records, Filling exam forms, Accessing timetables, and many more. which will help students to get their records in one place instead of running to offices and asking them. To make these things possible there should be a user-friendly interface that will not confuse students and they can get their records with a single mouse click.

Keywords

Student management, student information, system academics, Academic career.

1. INTRODUCTION

Student Management System is a Graphical user interface designed using a java programming language with the help of a Database Which is helpful to colleges as well as students. As we know nowadays all the work is done manually Which is very time-consuming and costly. So, our Student Management system deals with various activities related to students which wewill discuss further.

Here in the student management system, there are mainly 3 actors: Admin, Faculty, and Student. Each one of these has been assigned a task/module where they perform their operations. Here Each module is secured and can be accessed by authorized persons by simply entering their Username and password given by the University which makes the system more secure and private.

2. PURPOSE

The main objective of the student management system is to allow students to edit their information, access their grade cards, and timetables, fill out their exam forms, and many more in a secure environment. And also help colleges to store students' records and retrieve them with a single click. Overall Student management system makes an easier job for admin, students, and faculty!

3. SCOPE

Without such a system i.e., a student management system it is a tedious job to manage the data of huge students in a university/college which is more secure and easy to access without any data leak or data damage so there is a need for such a system!

4. SYSTEM ARCHITECTURE

4.1 Admin Module

The first and base module of this Student management system is the admin module, this module manages students' information for viewing the total strength of students in a particular class/batch. Collecting students' fees for their particular batches and adding students(new admissions) by allocating them their chosen courses and particular stream etc.

4.2 Faculty Module

The second most important module is the faculty module which stores the academic records of a particular student such that faculty can perform the following tasks: they can add results of a

ISSN(Online): 2584-1025

particular student and also can add the timetable of the particular batch which can be seen by the students anytime anywhere. And also, the faculty module is well secure with a username and password.

4.2 STUDENT MODULE

Like Admin and faculty has to log in, same here the student will get an enrollment number which will be theirusername and a password will be his/her mobile number to log in themselves. After login, the student is redirected to a college interface where he/she can able to view and update their profiles, view their grade cards semester-wise, see their current semester timetable, apply for the examination, download the examination hall ticket, and view their running semester subjects which are allocated by their faculty.

5. OVERALL DESCRIPTION

Student Management System is an independent project which is not dependent on the availability of other resources. the system has admin and faculty modules that have sufficient rights to manage this entire system. And making the system more user-friendly and easier for the students of particular universities /colleges.

5.1 Product Functions

As we know there are three main modules in our system admin, faculty, and students so let us understand the features provided by the university to them:

The features that are available to the Administrator are:

- View Student's Details.
- Add Students.
- Collect fees.

The features that are available to the faculty module:

- Add results
- Add timetable

The features that are available to the students are: -

- Can view/Update their profile.
- Can view their timetable.
- View their Grade cards.
- Fill out their current semester examination form.
- View/download their Hall ticket for the exam.

6. TECHNOLOGY USED:

6.1 Java Programming language:

Java is a widely used object-oriented programming language that runs on millions of machines. It is a fast, reliable, and secure programming language that helps programmers todevelop their applications. java also supports a graphical user interface using which we have made our project. Applications ofjava are: used in game development, application development, web application, network application, etc.

6.2 Database Management System

A Database management system is a system used to store huge amounts of data in a secured environment, Database is used to store, update, retrieve, delete, and add data with the help of structure query language(we can also add manually).

7. DATA FLOW DIAGRAMS

7.1 Admin Data flow Diagram

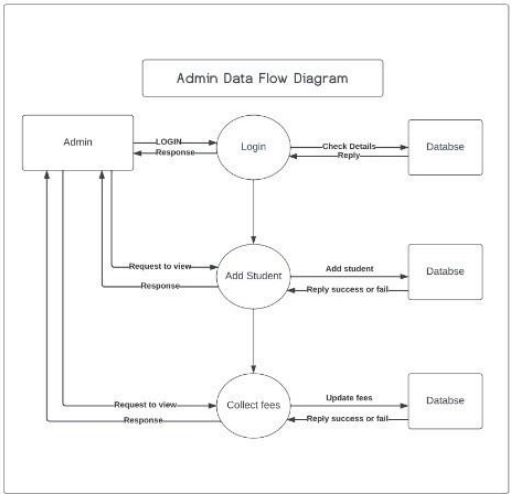
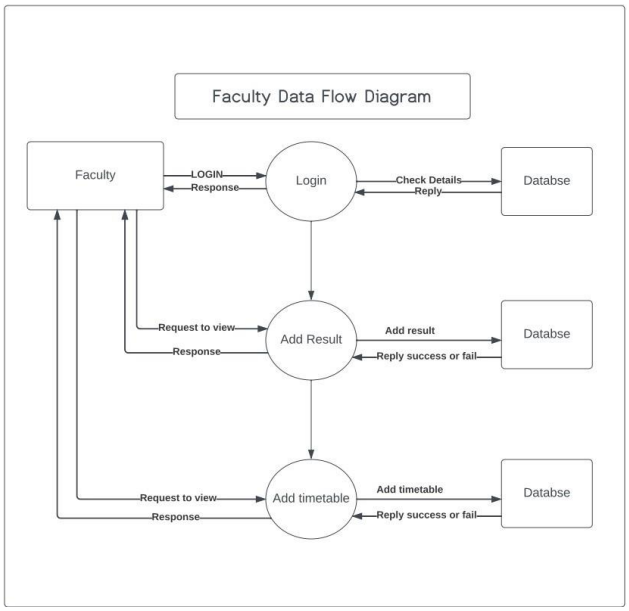


Figure1:" Admin DFD"

7.1 Faculty Data flow Diagram



ISSN(Online): 2584-1025

Figure2:" Faculty DFD"

7.3 Student Data flow diagram

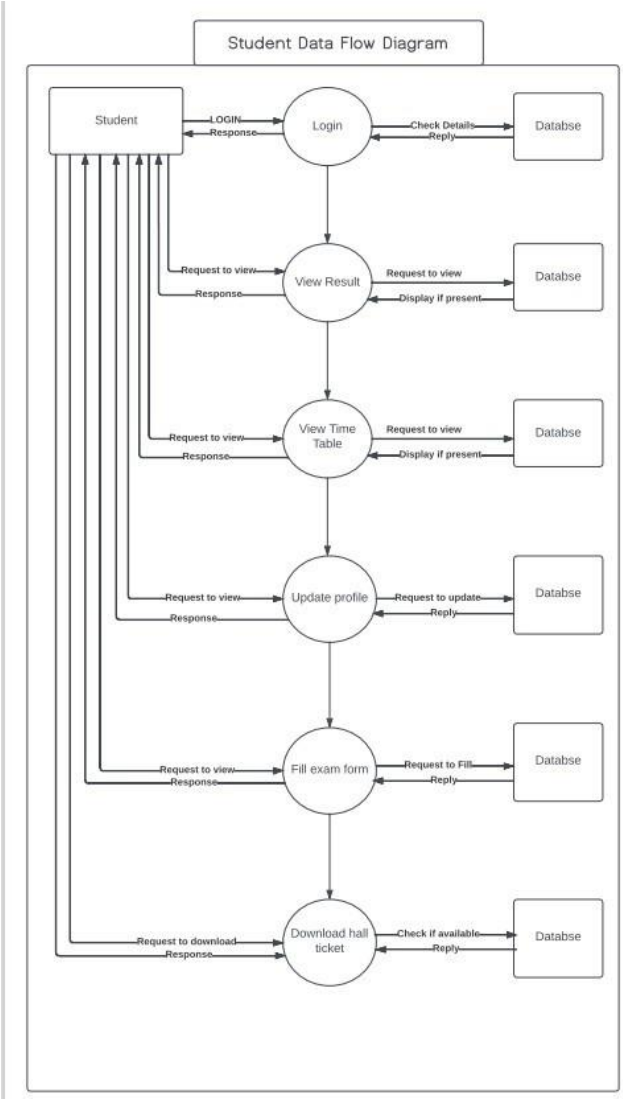


Figure 3: Student DFD

7. CONCLUSION

The Student Management system can be used by educational institutes to maintain their student's data instead of manually storing data in traditional ways which makes it very time-consuming work. All these problems are solved by this project. and also, will surely make a big change in the sector of education.

8. ACKNOWLEDGEMENT

We would like to express my sincere gratitude to my guide, Dr. Swati.D.Shirke, Coordinator of Integrated B.Tech(Data Science) for her unflagging support and continuous encouragement through our project. Without her guidance, this report would not have been possible.

We must Acknowledge all the faculties of Integrated B Tech for the ire flattering & constant support throughout making this project.

We want to express our gratitude to Dr. Ganesh Pathak and Dr. Shraddha Phansalkar for giving us exposure to the vast world of Software Engineering & Project Management by granting us the opportunity to work on this Mini Project titled – Student Management System.

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ISSN(Online): 2584-1025

Advance Research in Computer Science and Management Studies 2 (11).

MIT UNIVERSITY'S – ABHIVRUDDHI JOURNAL
VOL.2 (01) , JUNE , 2022 PP. 88-90
ISSN(Online): 2584-1025

TRUSTIFY - Article for National Conference

Vaidehi YogeshDevi
Dept. of Information Technology
MIT SOC, MIT ADT University, Rajbaugh, Loni-Kalbhor, Pune
8310353396
vaidehi2devi@gmail.com

Rupak Ghadiya
Dept. of Information Technology
MIT SOC, MIT ADT University, Rajbaugh, Loni-Kalbhor, Pune
8140154644
rupakghadiya2000@gmail.com

Yashi Pandey
Dept. of Information Technology
MIT SOC, MIT ADT University, Rajbaugh, Loni-Kalbhor, Pune
7987216275
ypandey1603@gmail.com

ABSTRACT

The use of certificates as a POE of any skill has been of widespread use in recent times at various locations. This may beat interviews for a new position; irrespective of the type of position one is trying to achieve or for a new job or a promotion. These certificates have various details (each of which shall be elaborated in the further scope of this article) which help the person on the other side of the table; trying to verify this document. Other than these, experienced people take the help of appreciation letters and letters of recommendations to move aheadthrough the hierarchy.

Keywords

POE - Proof Of Excellence;

1. INTRODUCTION

Certificates and other documents hold immense importance due to their power of being able to manipulate decisions. These certificates and documents are handed over to people through various organizations and bodies ranging from government organization to student councils.

2. THREAT

When something holds the power to makr decisions and also that it holds some responsibility, there is always a threat of duplication that surfaces through, and the reson for this fear is that with the fast moving technology, creating, editing and printing carbon copies of certificates and documents is no rocket science. Itsmerely a matter of using the right softwares and getting the detailsmentioned on the certificate right. This ease of duplication becomes a hurdle in the process of verification for an actualcertificate holder.

3. NEED

The need of this project is to be able to overcome the fear of duplicity and also be able to provide a solution that will contribute in proving the authenticity of the original certificate/document. Also another need is to provide the user (issuer) a suitable and dependent way of storing the information or details (further elaborated) of that particular document or certificate.

4. DOCUMENT SPECIFICATIONS

4.1 Issuer

The one who is declaring this document holds the term of the issuer. This issuer may be a person, group of persons, a body or a organization. This issuer may or may not hold any governmental authority. When a user visits our portal for the first time they are expected to register themselves and enter various details poving their identity. Hence, further they can avail the services.

4.2 Receiver

The one who the document has been addressed to holds the title of the reiever and his/her basic details llike the name, etc are stored in the database before the generation of the unique identity for that document.

4.3 Purpose

The purpose and other specific details of the cause of th edocument must be mentioned. Details like the event name, date, etc must be clearly mentioned. Also the level must be mentioned as its main purpose is to benefit the user.

5. TECHNOLOGY USED

The project is made using the MERN stack which stands for MongoDB, Express js, ReactJS, and Nodejs. ReactJS is an open-source front-end framework, ExpressJS is used for routing and handling middleware, NodeJS is used for creating backend servers with the help of Express js, and MongoDB is used as a database to store user information.

In this platform, the user creates an account, creates the user profile by adding required details. After creating a profile, the usercan access all the functionalities of the system and use them for thebest .

6. CONCEPTS AND METHODS

6.1 Product Perspective

The thought behind this system is inspired by the fact that when an individual tends to present any of the documents (Certificates, LOR, Appreciation Letters, etc), they must be able to prove its originality and gain its benefits. Someone one may very easily duplicate such documents and present them to gain the benefits

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must be stopped from doing so and this can be done only when such a system is in existence.

- Users will be able to validate/authenticate its document whenever they want from this platform.
- To achieve these requirements the platform will be utilising the use of technologies like Node.js (Server Implementation), React.js (Frontend Implementation), MongoDB (for non-relational dynamic content).

6.1 Product Features

- QR Code Generation
  The user can generate their own specific QR to authenticate their document using this platform so that anyone can verify it later.
- Verification of Certificate Details
  One can scan the QR code from their device to verify the document from any given location

7. MARKET COMPETITION

Table 1. Similar systems available in market and limitations

Name of the project	Features/ functionalities	Limitations
Canva	- Ready-made Certificate Template - Editable Templates	Any user in this world will be able to generate a duplicate copy of the same template
Wisenet	- Generates QR Code as per details entered - Each QR generated is unique	Portal does not store data of the QR Code generated which leaves a loophole where a different QR Code can be generated for the same details.

8. REQUIREMENT SPECIFICATION

8.1 Functional Requirements

- Generate a Unique ID/QR code
- To be able to validate the document in the future.
- To be able to store and back up all the data in an organised manner.
- Registration
  - New users can make a new account and access the website
  - Registration requires - email, password and name of the user
- Login
  - Existing users can login into the website by using their email id and password
  - Login has 2 field - email and password
  - Login also has a dedicated button for “login through Gmail” and “login through GitHub” if in case a user wants to login through their Gmail or GitHub account.
- User Profile Creation
  - After Signing up, users need to fill up their

8.2 Non-Functional Requirements

- Availability
  - The web application will be available for a wide set of users.
  - The site is specifically targeted at users who are in search of some type of developer user. This doesn’t restrict age limits, education/knowledge limits, or race and ethnicity barriers.
  - The web application is targeted to work on a global scale.
- Maintainability
  - The main technology used to maintain the structure and codebase of the site is Git which is the version control system being used here.
  - Postman Documentation tool is used for documenting APIs used for Backend Frontend communication.
  - In the hosted machine technologies like Nginx (for hosting, domain management and redirections), Let’s Encrypt (for issuing SSL certificates) and Certbot (for managing and regular updation of SSL certificates) will be used.
- Security
  - There are various security measures used and users are also requested to follow some guidelines.
  - SSL layer to the normal HTTP is implemented toensure a secured connection between client and server.
  - Users are recommended to access this website from the following web browsers Google Chrome, Mozilla Firefox, Microsoft Edge, Apple Safari, Vivaldi, or any Open Source browsers based upon Chromium and Firefox both on mobile and desktop platforms.
- Responsiveness

ISSN(Online): 2584-1025

- The responsiveness of the website will be dependent on several factors like internet speed/type, computer hardware, web browser used, also servers themselves, etc.
- Accessing this website on old web browsers and hardware could cause some problems.
- Responsiveness of the website can be improved by using updated versions of web browsers and decent system hardware.

➢ 8. DIAGRAM

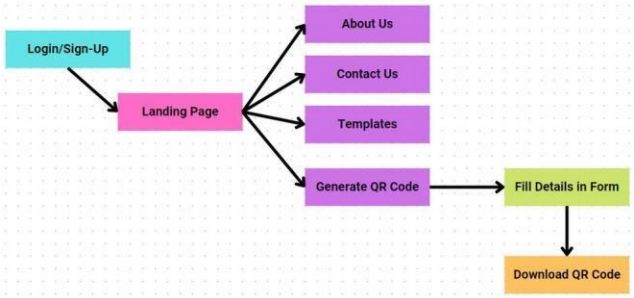

Diagram 1. System Flow

9. SOFTWARE TESTING

9.1 Types of testing used

Unit Testing
A test that confirms the functionality of a particular area of code, often at the function level, is referred to as a unit test, sometimes known as a component test. Developers typically write these kinds of tests as they work on the code (white-box technique), checking that a particular function is performing as it should. Multiple tests may be run on a single function to catch edge cases or other code branches.
In this project, unit testing has been done at the backend for authentication, the frontend of user profile creation, form validation of profile and sign-in/signup form.

Interface Testing
The web server and application server interfaces communicate with one another, and interface testing makes sure everything goes without a hitch. This involves ensuring that error messages are shown accurately and that the communication procedures are being checked.
Our programme has undergone interface testing, and the results show that all operations and communication between modules are operating as intended.

10. FUTURE SCOPE

- ➢ Premium Feature of storing data onto Blockchain
- ➢ Being able upload self templates and edit them on the system

11. CONCLUSION

"TRUSTIFY" will help the new/experienced developers across the world to explore their technical skills, connect, interact and build their dream projects with buddies across the world.

12. ACKNOWLEDGMENTS

Our thanks to our mentor and faculties for the constant support and guidance

9.2 Scenarios

Table 2: Testing Use cases

Sr. No.	Scenario	Description	Result
1	Integration of profile creation page	To integrate the profile page with the signup and login page which were made separately.	Pass
2	QR Code Generation	To be able to generate a unique QR code of each set of data	Pass
3	Validation of user data through email and password	Validating the email and password of the user if it's present in the database.	Pass
4	Taking input details for each unique certificate	Take input in 'form' format and store it into database	Pass
5	Data Retrieval from database	Being able to retrieve all the data for certificates	Fail

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MIT UNIVERSITY'S – ABHIVRUDDHI JOURNAL
VOL.2 (01) , JUNE , 2022 PP. 91-95
ISSN(Online): 2584-1025

PLANT PULSE -

An IOT device for smart farming

Richa Arora
Third Year BTech-Computer Science Engineering
Ahmednagar
Maharashtra
+918275543900
richamarora2002.rich@gmail.com

Pradyun Anthati
Third Year BTech-Computer Science Engineering
Mumbai
Maharashtra
+919867695136
pradyun.gem@gmail.com

Rahesha Yasin Mulla
Associate Professor
MIT ADT SOC
Pune
Maharashtra
+919823071906
rahesha.mulla@mituniversity.edu.in

ABSTRACT

Plants are an essential source of life for humans, providing us with the necessary oxygen, food, and other vital resources. However, we often struggle to provide plants with the essential resources they need to thrive, such as clean water, non-polluted oxygen, and adequate sunlight. This can result in plants withering away and dying, which can have significant environmental and economic impacts.

When you are on a long trip you are not able to water plants and hence the plants dry, but we have a solution for this problem. 'PLANT PULSE'. This is an Energy Efficient Gardening method which will water your plants at the date, time and days you set just by making minor changes in the python code. It enables Real time monitoring, and you can even control this device by using the 'Pi Relay' application.

Keywords

Energy Efficient Gardening; Precision Agriculture; Weather Conditions; Internet of Things; Autonomous Systems; Real Time Monitoring.

1. INTRODUCTION

Introduction: Plants are essential to our existence as they provideus with food, oxygen, and other vital resources. However, in our busy lives, we often forget to take care of our plants, leading to their untimely death. To address this issue, we have developed a cutting-edge solution called 'Plant Pulse.' This is an automated watering system that uses Internet of Things (IoT) and can be controlled by a simple Python code. The system ensures that your plants receive the right amount of water at the right time, even when you are away, through Precision Agriculture.

Importance of IoT for the Project: IoT is crucial for the Plant Pulse system as it enables remote monitoring and control of the system. With the help of IoT, the system can connect to the cloud,and the user can monitor the system's performance remotely usinga mobile application. IoT technology also enables real-time monitoring of soil moisture levels, which helps in conserving water by triggering the watering system only when needed.

Uses and Importance of the Project: Plant Pulse is an energy-efficient system that offers a revolutionary method of watering plants, promoting sustainable plant growth. The system allows plants to flourish even when the owner is away for long periods, making it ideal for people with busy schedules. The system can also be customized by making minor modifications to the Python code, allowing for the specific watering schedule tailored to the needs of the plants.

The project's importance lies in its ability to conserve water by preventing wastage while providing essential care to plants, reducing the environmental impact of watering plants. Moreover, this project can potentially revolutionize Precision Agriculture by providing farmers with an autonomous system that uses IoT to monitor and control water usage for optimal plant growth, reducing costs associated with manual watering.

In conclusion, Plant Pulse is a sustainable and innovative solution to plant care, enabling people to take care of their plants effortlessly while promoting sustainable plant growth. By harnessing the power of IoT and cutting-edge technology, Plant Pulse has the potential to transform Precision Agriculture andplant care in various fields, from homes to industrial farming.

2. LITERATURE SURVEY:

"Design and Implementation of an IoT-Based Smart Irrigation System for Precision Agriculture." by D. D. Dede, O. A. Adigun, et al. (2020)

This paper proposes an IoT-based smart irrigation system that uses sensors to measure soil moisture, temperature, and humidity levels. The system is designed to conserve water and promote sustainable agriculture practices.

"Smart Irrigation System Based on IoT for Precision Agriculture." by S. M. Shahnawazuddin, M. K. Hassan, et al. (2019)

This paper presents a smart irrigation system based on IoT technology that uses sensors to monitor soil moisture, temperature, and humidity levels. The system is designed to optimize water usage and reduce waste while promoting sustainable agriculture practices.

"A Low-Cost IoT-Based Automated Irrigation System for Precision Agriculture." by A. K. Halder, M. M. Islam, et al. (2020)

This paper proposes a low-cost IoT-based automated irrigation system that uses sensors to measure soil moisture and humidity levels. The system is designed to optimize water usage and reduce manual labour in precision agriculture.

ISSN(Online): 2584-1025

"Smart Irrigation System for Precision Agriculture Using IoT." by S. S. Kumar, S. K. Kumari, et al. (2018)

This paper presents a smart irrigation system for precision agriculture that uses IoT technology and sensors to measure soil moisture, temperature, and humidity levels.

3. PROJECT MOTIVATION:

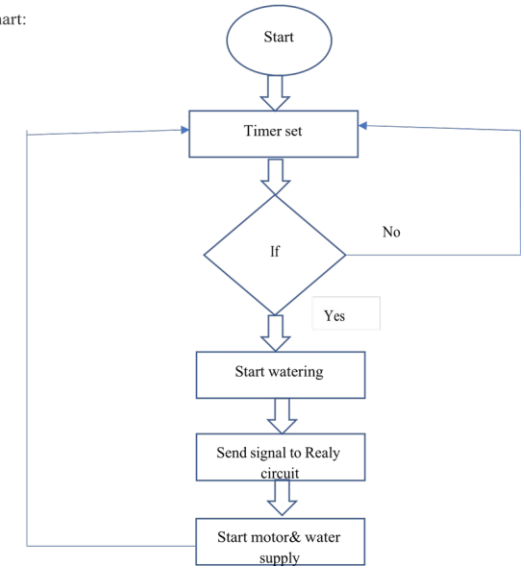
This project has given us the opportunity to explore our creativity and apply our knowledge to address a critical need in our society. As we look towards the future, our dream is to continue building upon the success of this project and make it accessible to every individual in India who can benefit from it.

Our goal is to not only achieve success as entrepreneurs, but also to make a positive impact on the lives of people by providingthem with an efficient and effective solution for plant irrigation. With the rapid advancements in technology, we believe that our idea has the potential to revolutionize the way we approach sustainable agriculture and contribute to the progress of humankind as a whole. With the advancement of the technology the idea behind this project can boost up the progress of entire mankind and hence make it easier and worth living.

3.1 PROPOSED SYSTEM:

The implementation phase of the project involves the careful execution of the design developed in the previous phase. The project aims to create an automated agricultural system that will reduce costs and revolutionize the irrigation process. The system will use Internet of Things (IoT) technology and real-time monitoring to conserve water while also providing convenient plant care. The target industry is the food and beverage industry, which is seeking cost-effective ways to improve agricultural productivity. Ultimately, the project aims to benefit the farmers who are the backbone of the agricultural economy.

Flowchart:



3.2 METHODOLOGY:

System Design: The first step in developing the smart watering system is to design the system. This includes selecting the components such as Raspberry Pi, relay, motors and other necessary hardware.

Software Development: The software development phase involves writing Python code to control the system. This includes creating the logic for motor and relay and activate the motor to water the plants.

Connectivity: The system will use Internet of Things (IoT) technology to connect the Raspberry Pi to the cloud. This will allow for remote monitoring and control of the system from a mobile application.

Motor Integration: The motor will be integrated into the system and connected to the Raspberry Pi. The motor will be activated according to the schedule.

Mobile Application Development: A mobile application will be developed to allow for remote monitoring and control of the system. The application will display real-time data from the sensors and allow the user to adjust watering schedules as needed.

Testing and Validation: The system will undergo rigorous testing and validation to ensure that it meets the required performance standards.

Deployment: Once the system has been tested and validated, it will be deployed in the field. The system will be installed in the desired location and connected to the cloud for remote monitoring and control.

Maintenance: The system will require regular maintenance to ensure that it continues to function properly. This includes monitoring the components and making necessary adjustments to the watering schedule.

By following this methodology, the smart watering system will be created, and it will help in conserving water by using real-time monitoring of soil moisture levels to trigger the watering system. Additionally, the system will help in reducing costs associated with manual watering and improve plant care.

TECHNICAL FEASIBILITY OF OUR PROJECT:

1. effortless gardening
2. cost effective
3. saves time
4. unattended watering
5. water is saved to great extent
6. accuracy in watering of different plants

3.3 ECONOMIC SUSTAINIBILITY:

Our project, the 'PLANT PULSE', is a financially viable solution due to its underlying platform - the Raspberry Pi. The Raspberry Pi is easily available at a relatively affordable price, making our solution accessible to a wider range of customers.

Moreover, our project is 100% achievable due to its straightforward implementation process. All that is required is to add a code to the Raspberry Pi and modify the device to make it compatible with our system. This makes our solution easy tointegrate into everyday life, providing a simple and effective method for automating plant irrigation.

Given the significant challenges associated with irrigation in many homes and farms, our product has the potential to provide immense benefits to the wider community. Our solution offers an efficient and sustainable alternative to traditional watering

ISSN(Online): 2584-1025

methods, minimizing water usage while promoting plant health and growth.

With our innovative technology, we aim to revolutionize the way we approach gardening and agriculture, making it more accessible, efficient, and sustainable. By providing an affordable and practical solution to the challenges associated with plant irrigation, we hope to empower individuals and communities to lead healthier and more sustainable lives.

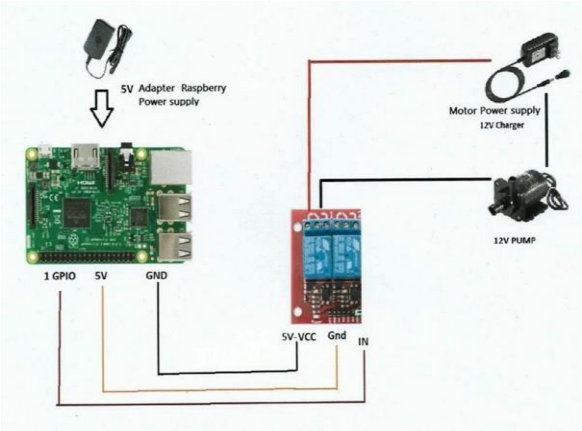


Figure 1- Circuit Diagram-Plant Pulse

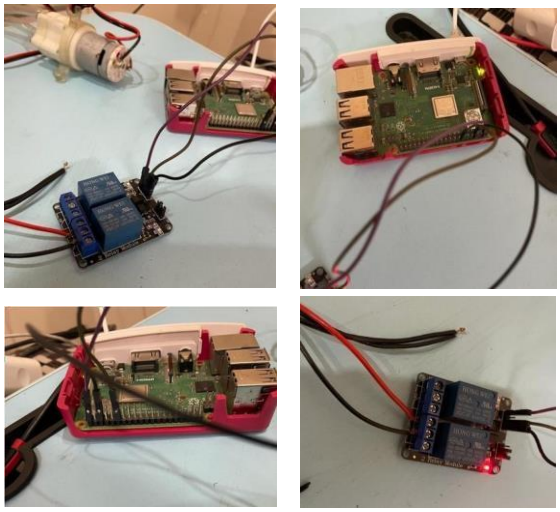


Figure 2 – Working model of our project

3.4 REQUIREMENT SPECIFICATION:

Software requirements:

- Pi Relay application - This is an application that can be installed on the Raspberry Pi to control the submersible motor that is used for watering the plants. It allows users to remotely control the watering schedule for theirplants using a mobile device or computer.
- IFTTT - This stands for "If This Then That", and is a web-based service that allows users to create applets that trigger an action based on a specific event. In this case, it can be used to trigger the watering of plants based on specific criteria, such as the weather forecastor time of day.
- Python 3.9 - This is a high-level programming language that is used to write the code that controls the Raspberry Pi and the submersible motor. It is a widely used language in the field of automation and is particularly well-suited for IoT (Internet of Things) applications.

Hardware requirements:

- Raspberry Pi 3B+ - This is a single-board computer that serves as the central processing unit for the 'PLANT PULSE' system. It is a low-cost, energy-efficient device that can run a range of operating systems and is widely used in DIY electronics projects.
- 12-volt submersible motor - This is a small motor that is used to pump water from a reservoir to the plant pot. It is submersible, which means it can be placed directly into the water source and is powered by a 12-volt power supply.
- 5-volt motor - This is a small motor that is used to control the opening and closing of the water valve. It is powered by a 5-volt power supply and is connected to the Raspberry Pi using connecting wires.
- Connecting wires - These are wires that are used to connect the various components of the 'PLANT PULSE' system, including the Raspberry Pi, motors, and sensors. They come in a range of sizes and can be used to make a variety of different connections.

4. FUTURE SCOPE

Our team is dedicated to further developing our project with a focus on optimizing its functionality through the integration of advanced sensors, specifically humidity sensors, soil sensors, and temperature sensors. We recognize the potential for this technology to positively impact the lives of citizens across India, and our goal is to make this project accessible and beneficial to allwho require it.

By leveraging the valuable data provided by these sensors, we can gain insights into the critical environmental factors that impact plant growth and yield. With this information, we can improve the efficiency of our project by developing precise algorithms to regulate watering schedules, nutrient delivery, and temperature control. This will enable us to maximize crop production while minimizing resource waste.

Our team's ambition is to create a scalable and reliable system that can be replicated in various locations throughout India, providing a sustainable solution to food insecurity. As entrepreneurs, we recognize the importance of creating a valuable product that benefits society while also achieving our personal goals of success and fulfillment

5. CONCLUSION:

This project presents the architecture and implementation of an innovative Plant Pulse system. Our solution addresses the critical challenge of ensuring regular watering intervals for plants, regardless of external weather conditions.

Our solution not only ensures the healthy growth and yield of plants but also minimizes water usage, thus contributing to

ISSN(Online): 2584-1025

environmental sustainability. Furthermore, our automated gardener can be easily adapted to a wide range of indoor and outdoor planting scenarios, making it a versatile solution for modern-day gardening.

In summary, this project showcases our innovative approach to automated gardening and provides a significant contribution to the field of smart agriculture. Our system's robust performance and scalability make it a valuable solution for various planting scenarios, enabling us to address the pressing challenges of food security and environmental sustainability.

ACKNOWLEDGMENTS

It is our honor to present the project report on 'Plant Pulse', which has been the culmination of our efforts and dedication to create a technology-driven solution to address the issue of food security in India.

We extend our heartfelt gratitude to our internal guide, Prof. Rahesha Mulla, for her unwavering support, guidance, and valuable insights throughout the project. Her expertise and mentorship have been instrumental in shaping our work and achieving our goals.

We would also like to express our sincere appreciation to Dr. Shradha Phansalkar, Head of Computer Science & Engineering, for her invaluable support and constructive feedback. Her encouragement and suggestions have been crucial in strengthening our project and ensuring its successful completion.

Furthermore, we would like to extend our special thanks to Rajneesh Kaur Sachdeov, Director of School of Computing, for providing us with state-of-the-art laboratory facilities equipped with all the necessary software platforms and continuous internet connectivity. These resources were instrumental in enabling us to conduct our research and implement our ideas effectively.

We are grateful for the opportunity to work on this project and for the assistance provided by our esteemed mentors and institution.

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ISSN(Online): 2584-1025

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