ISSN(Online): 2584-1025

MIT UNIVERSITY'S – ABHIVRUDDHI JOURNAL

VOL.3 (01) , JUNE , 2023 pp- 1-5

Formulation and standardization of millet-based protein-mineral enriched granola bar

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ABSTRACT

Malnutrition predominantly affects children and women, presenting itself in various forms such as undernutrition (characterized by wasting, stunting, and being underweight), insufficiency of vital vitamins or minerals, obesity, and leading the development of non-communicable diseases linked to dietary factors. Overcoming malnutrition can be achieved through the scientific preparation of traditional foods incorporating millets and pulses in appropriate quantities, considering the existing knowledge and preparation gap in traditional millet-based foods across generations. Recognizing this, NITI Aayog has recently unveiled a pilot program aimed at integrating millets into the Integrated Child Development Services (ICDS) and Mid-Day Meal (MDM) schemes nationwide.. The present study was undertaken to develop a protein and mineral-enriched granola bar based on millets mainly a combination of bajra, jawar, ragi crispy, amaranth puff, and moong dal. From a sweetness and health point of view, jaggery was used instead of refined sugar. The ingredients were mixed in different proportions based on response surface methodology (RSM) and the granola bars were prepared using a hot pressing technique. The optimized formulation was selected using RSM based on the protein content, overall acceptability, bowl life, and hardness. Further evaluation studies like nutrient composition and shelf life were carried out by standard analytical methods. The moisture content found to be 3.26%, while protein 10.85gm/100 gm, fat 11.80gm/100gm, carbohydrate 69.65gm/100gm, crude fibre 1.88mg/100gm.The total ash content of the bar was 2.65g/100g. The calcium and iron content on analysis was found to be 88.20mg and 5.03 mg/100gm respectively. The developed bar provided 428.20 kcal of energy per 100g, which qualified the product as a good energy-dense snack for children and women whom ed are o undernutrition. The microbial load of this bar was

ISSN(Online): 2584-1025

found to be below detectable limits during storage for 2 months. The unit cost of preparation of the granola bar was Rs.6.00/- per 25g. The developed millet-based granola bar is found to be a nutritious snack, easy to prepare, affordable, and more cost- effective than the commercial granola bar.

Keywords

Malnutrition, RSM, millets, overall acceptability

1. INTRODUCTION

A serious public health issue concerning malnutrition among children under five in India has been acknowledged. India has been identified tohave one of the highest rates of underweight childrenglobally, with a rate that is almost double that of Sub-Saharan Africa. This issue's concentration in India is evident through the observation that a significant burden is primarily borne by only five states and 50% of villages, equating to about 80% ofthe problem. The global impact of malnutrition is believed to result in approximately 2.3 million infantdeaths annually, which accounts for 41% of all infantmortality in developing nations. (Swoop et al., 2017).

Finger millet, also known as ragi or manual (Eleusine coracana L.), is a widely cultivated crop in India and worldwide. India holds the title of being the largest producer, accounting for approximately 60% of the global output. Unlike other grains, finger millet is consumed without hulling. It has a growth period of 100 to 130 days and is well-suited for acidic soils and regions with higher rainfall (600 to 1,200 mm). In terms of nutritional composition, finger millet grain contains 81.5% carbohydrates, 9.8% protein, 4.3% crude fiber, and 2.7% minerals. Notably, its crude fiber and mineral content surpass those of rice, wheat, and other millets, while its protein content is also significant. (Amir et al., 2014)

Sorghum [*Sorghum bicolor (L.) Moench*], a staplecrop originating from Africa, continues to play a

ISSN(Online): 2584-1025

crucial role in the diets of rural populations. With an annual production of between 100,000 and 180,000 tonnes and grown primarily in arid regions with an average temperature of 25°C, sorghum serves as a source of food in areas with limited resources. The grain, with a protein content ranging from 8-12%, a starch content of 65-76%, and 2% fiber, is comparable in composition to maize except for its lower oil content. The germ of sorghum, however, stands out as a nutritious source of protein (19%), ash (10%), and oil (28% of the germ). (Abah et al., 2020).

Pearl millet (Pennisetum glaucum), commonly known as Bajra, Bajri, Sajje, Kambu, Kamban, and Sajjalu in various regions of India, belongs to the Poaceae family. This cereal crop plays a versatile role in providing sustenance, forage, and food. In comparison to other cereals like wheat, rice, maize, and sorghum, pearl millet exhibits exceptional nutritional value, attributed to its deep root system, which enables it to access nutrients from the soil. It is a rich source of vital minerals such as iron, zinc, magnesium, copper, manganese, potassium, and phosphorus. Consequently, pearl millet provides ample energy with a calorific value of 361 Kcal per 100g, and it possesses a high fiber content of 1.2g per 100g. These findings are highlighted in a study conducted by Monika et al. in 2020.

2. Material and methodology

2.1 Raw Materials

Formulations for the granola bar food composed of amaranth, jaggery, and moong dal procured from the local market of Loni kalbhor. Finger millet crispy, pearl millet crispy, and sorghum crispy were procured from Susy foods, Dadar West Mumbai. Amaranth and moong dal were procured in one lot and stored in closed containers for further use in the experiment.

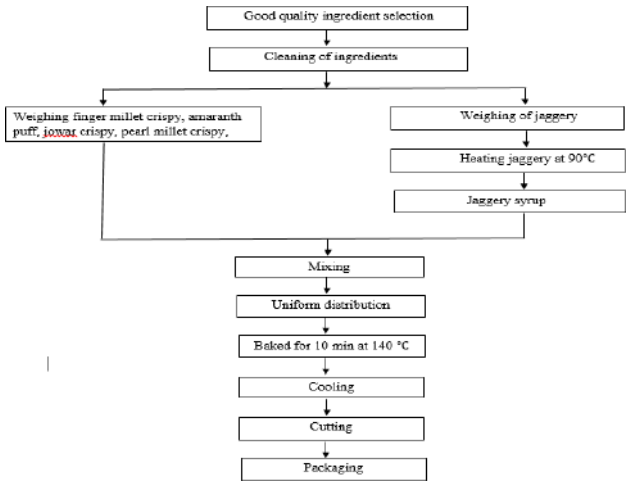
2.2 Preliminary trials

Table No-1

Raw material	S1	S2	S3
Ragi crispy	2.5	5	10
Amaranth puff	2.5	5	10
Jowar crispy	2.5	5	10
Bajra crispy	2.5	5	10
Moong dal	25	5	10
Jaggery	65	75	50

2.3 Procedure for developing granola bar

The granola bar development procedure reported by Fast and Caldwell (1990) was adopted for producing the granola bar. Various types of millets crispies are used (finger millet crispy, pearl millet crispy, and sorghum crispy) other ingredients namely amaranth puff, and fired moong dal. All these crispies are purchased from Susy food Pvt limited and checked for its purity before being used in the granola bar development. Following this method, twenty different formulations of granola bars in triplicate varying finger millet crispy, pearl millet crispy, and moong dal concentrations were developed.



3. Results and discussion

3.1 Analysis of Raw Material

ISSN(Online): 2584-1025

3.1.1 Proximate composition

A proximate composition such as moisture, ash, protein, crude fiber, carbohydrate, and fat analyzed for the selected raw material was discussed below.

Table 1 Proximate composition

Raw Materials	Moisture	Fat	Protein	Ash	Crude fiber	Carbohydrate
Bajra crispy	4.16 ± 0.76	1.64 ± 0.06	9.43 ± 0.60	1.78 ± 0.25	2.10 ± 0.36	80.89 ± 1.10
Jowar crispy	4.31 ± 0.65	1.35 ± 0.05	9.23 ± 0.92	2.38 ± 0.53	3.85 ± 0.78	78.88 ± 1.11
Ragi crispy	5.44 ± 0.60	2.36 ± 0.06	8.50 ± 1.32	1.95 ± 0.50	4.71 ± 0.25	77.04 ± 1.05
Amranth puff	4.93 ± 0.25	3.59 ± 0.18	9.25 ± 0.66	1.70 ± 0.32	5.03 ± 0.45	75.50 ± 1.10
Jaggery	6.83 ± 0.76	1.25 ± 0.25	2.50 ± 0.50	4.50 ± 0.50	1.13 ± 0.12	83.79 ± 0.20
Moong dal	7.10 ± 0.36	1.45 ± 0.40	11.33 ± 1.52	3.50 ± 0.50	3.41 ± 0.38	73.21 ± 1.09

3.2. Physico-chemical and sensory evaluation of granola bar

3.2.1. Chemical analysis of granola bar

Table 2 Physicochemical analysis of granola

Parameter	Sample 17
Moisture %	3.26 ± 1.00
Protein %	10.85 ± 1.05
Fat %	11.8 ± 0.99
Carbohydrate %	69.56 ± 1.00
Energy Kcal/100g	428.2 ± 0.90
Total ash on a dry basis %	2.65 ± 1.01
Crude fibre %	1.88 ± 0.83

3.3. Effect of storage period on the moisture content of granola bar

3.3.1. Microbial quality of granola bar during storage period

The study measured the total plate count and yeast/mold count of the granola bars during a 60-day storage period. The results indicate that the use of high-density polyethylene (HDPE) and low-density. Polyethylene (LDPE) as packaging materials prevented microbial growth in the granola bars during the 60-day storage period.

Table 3 Microbial quality of granola bar during storage period

Storage period	HDPE	LDPE
0	3.26 ± 0.04	3.26 ± 0.04
10	3.30 ± 0.05	3.34 ± 0.04
20	3.35 ± 0.05	3.40 ± 0.06
30	3.42 ± 0.02	3.44 ± 0.04
40	3.51 ± 0.03	3.54 ± 0.06
50	3.57 ± 0.02	3.61 ± 0.03
60	3.67 ± 0.02	3.70 ± 0.08

4. Conclusion:

The formulation and standardization of a millet based protein-mineral enriched granola bar made from pearl millet, sorghum, ragi crispy, amaranth puff, jaggery, and moong dal can be an effective solution to address malnutrition. The addition of amaranth puff adds a crispy texture to the granola bar, which can provide a satisfying and enjoyable eating experience, encouraging individuals to

ISSN(Online): 2584-1025

consume the supplement regularl. It is evident that the developed millet based granola bar is found to be nutridense snack, easy to prepare, affordable, and more cost effective than the commercial granola bar.

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MIT UNIVERSITY'S – ABHIVRUDDHI JOURNAL
VOL.3 (01) , JUNE , 2023 pp- 6-12
ISSN(Online): 2584-1025

"Study On Consumer Acceptance Towards Millet Based Gluten Free Products with Special Reference to Pune City"

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ABSTRACT

People's need for quick food in urban and semi-urban regions is increasing as a result of the growth of QSRs (Quick Service Restaurants) and Cloud Kitchens. Due to millennials and Generation Z's demand for satisfying rapid meals, pizza and hamburger sales have increased to account for approximately 25% of the food and beverage sector. Yet, the gluten content of the pizza base and burger buns, which ranges from 9 to 15%, is harmful to human health since it promotes the development of gluten sensitivity and damages the small intestine in a significant portion of the population. Several people aware of this situation are more likely to choose to eat items with lower gluten content or gluten-free options. Millets don't contain gluten and are a healthy source of protein. They include a lot of insoluble fibre, which aids with weight loss and lowers blood sugar and cholesterol levels. According to research, urban residents' reliance on millet-based quick breakfast blends and other food products has dramatically increased. The working middle class group is steadily becoming interested in products like millets atta, millet dosa mix, millet pancake mix, and millet noodles. To satisfy the needs of its health-conscious clientele, well-known companies like "Aashirwaad" and "MTR" have added millet-based goods to their product lines. (Bansal, 2021)

With the use of primary data, the percentage of respondence in this study who would accept gluten-free items derived from millets as replacements for gluten-based dough, particularly in their pizzas and burgers, is noted.

It was discovered through critical research that the majority of fast food consumers were under the age of 30. As the alternative product includes health advantages, which is a bigworry for most of them, they are quite happy about the philosophy of altering the main elementfrom their regularly eaten food products.

Keywords: Millets, Gluten, Health, Food

INTRODUCTION

Due to its primary objective and the fact that every human being depends on food intake, agriculture has been shown to be the most sustainable industry in the world. Food companies and delivery services made more money during the Covid virus epidemic when thesecondary and tertiary sectors were about to collapse because individuals were persuaded to purchase meals online in order to rapidly satisfy their hunger. In the past ten years, fast food consumption has also grown significantly, which has led to an increase in dietary and health

ISSN(Online): 2584-1025

problems. The presence of gluten in products that are often consumed by urban consumers is the main factor contributing to this issue.

Pizza and hamburgers are the most often requested items from various restaurants and cafes, according to statistics from popular meal delivery apps like Zomato, Swiggy, Uber Eats, and Eatsure from past years. These goods contribute 25% to the food and beverage business. The wheat used to make pizza crust and hamburger buns contains 9–15% of gluten. Consuming gluten frequently damages the bowel and interferes with metabolism. According to research, the population's gluten intolerance is growing. This can be the case as superfoods like millets aren't part of the typical diet.

Yet, 2023 is reportedly the year of millets. The highest millet grower in the world is most likely India. All 11 types of millet have great nutritional value for everyone. As a result, the Indian government is pushing farmers to produce millet crops on their farms.

OBJECTIVES

1. To draw attention to benefits of millets' for human diet.
2. To understand why millets aren't consumed by urban residents.
3. To understand how consumers behave when buying millets with additional value that are gluten-free.

SIGNIFICANCE OF MILLETS

Improves mood:

- Due to its high concentration of the amino acid tryptophan, millet might elevate one's mood. A diet high in tryptophan, according to research Trusted Source from 2014, may help lessen the signs and symptoms of anxiety and despair.
- The tryptophan in millet increases the body's serotonin level, which aids in lowering stress. A cup of millet porridge each night can promote restful sleep.

Digestion & Weight loss:

- Millet is a fibre-rich meal that promotes intestinal motility and, by increasing the density of stools, promotes waste ejection. Insoluble and soluble fibres are both present in millet.
- The fibre content improves the efflux of food or solid waste, which benefits a person's intestinal health. Because they are high in fibre, grains are beneficial for gut health.
- Probiotic bacteria, which are insoluble fibres, are present in millet. It promotes the growth of helpful bacteria in the intestines. Among many other symptoms, insoluble fibre eases bloating, gas, cramps, and incontinence.
- It has a low Glycemic index, making it help control blood sugar levels and aid in weight loss. It contains few simple carbohydrates and more complex carbohydrates than other foods.

ISSN(Online): 2584-1025

Aid for reproductive system:

- It aids in conquering ovarian, sperm, PCOD, and infertility issues. Both males and females can benefit from their assistance in treating illnesses of the reproductive system.
- This is beneficial to women who are experiencing period issues, to those who have STDs, and to males who want to increase their sperm count.
- It is high in iron, protein, antioxidants, dietary fibre, calcium, magnesium, potassium, and folate, all of which are elements that pregnant women need more of, millet is one of the nutrient-rich grains for them. Haemoglobin levels are raised by its high iron content.

Anti-ageing properties-

- L-lysine and L-proline, two amino acids, are abundant in millet. Collagen, a material that provides the tissue of the skin structure, is produced in the body with the aid of millet. Consuming millet boosts collagen levels, improving skin's suppleness and reducing wrinkle risk.

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(Mallesh, 2021) In India and other Asian and African countries, millets commonly include sorghum, pearl millet, and a range of small millets (Vetriventhan et al., 2020). The term "millets" in this paper refers to all of these crops. India is the leading producer and consumerof different types of millets, such as finger millet, pearl millet, kudo millet, foxtail millet, barnyard millet, pros millet, and little millet (www.smartfood.org[1],[2]). India is the sixth largest producer of sorghum globally

(Mohan, 2023) Although genetic factors are obviously important, it is clear that the genetics did not change during the 50-y period when diabetes rates increased by almost 10-fold in India [9]. This clearly points to the role of environmental factors having a greater role in the causation of the diabetes epidemic [10]. Indeed, the rapid socioeconomic changes in the region has led to changes in both the quantity and quality of diets consumed along with markedly reduced physical activity leading to obesity, one of the main contributors to T2D.

(Nitya Sharma a, 2023) . Considering their climate resilience and potential role in nutritionaland health security, the year 2023 has been declared as 'International Year of Millets' by the United Nations. Cereals being the major nutrient vehicle for a majority population, and proteins being the second most abundant nutrient in millets, these grains can be a suitable alternative for plant-based proteins

(Vali, 2019) Food items made with maida are converted within 10 minutes into glucose and join the bloodstream and the chemicals used to make maida are harmful to the pancreas. Normally there are only 6 to 7 grams of glucose in our blood (4-5 litres).

ISSN(Online): 2584-1025

(FSSAI, 2023) Tribal Co-operative Marketing Development Federation of India (TRIFED), the 'Nutri hub' India is honoured to be at the forefront of popularising millets, whose consumption furthers nutrition, food security and welfare of farmers. - Shri Narendra Modi Hon'ble Prime Minister of India the technology business incubator hosted by ICAR-IIMR and TRIFED is collaborating for the marketing of millets and mainstreaming tribal through livelihood opportunities. Promotion of millet value chain activities in the Van Dhan Vikas Kendra's in the tribal belt and scaling up for the national security of the tribal population, these examples vouch for the active efforts of the Indian government in the advocacy of millets in diet especially through the tribal route.

(APEDA, 2023) "The millets market is set to grow from its current market value of more than $9 billion to over $12 billion by 2025. Favourable government initiatives to proliferate the global millets market size over 2019-2025".

METHODOLOGY

A combination of primary and secondary sources are used to get the necessary information. Using a custom created questionnaire with open-ended and closed-ended questions, the data on millets intake was gathered from 120 respondents with the help of online survey method. The responses were all primarily from Pune city. Secondary materials, such as newspaper articles, research papers, and magazines, were also used to analyse how consumer attitudes regarding millets have changed over time. Table below portrays the data collected.

Table 1: Primary data recorded of participants from Pune city and converted into figures for study.

Pizza and Burger consumption	**71.7%** people are fond of pizza and burger. **28.3%** dislike pizzas and burgers.
Awareness about "gluten" and its effects	**83.3%** respondents were aware. **16.7%** respondents weren't aware.
Want to have nutritious gluten free cuisine	**95.8%** desire healthy food. **4.2%** are fine with the normal.
Believe millets make a wonderful all-purpose flour alternative for preparing pizza and burger dough.	**89.2%** Agree **10.8%** Disagree
Parameters considered while accepting gluten free products	**Nutrition** - Highly **Taste** - Highly **Price** - Likely **Appearance** – Neutrally
Age of respondents	**84.2%** Between 20-30 years **6 %** Between 10-20 years **6%** Above 40 years **3.2%** Between 30-40 years
Gender of respondents	**62.5%** Male **37.5%** Female

ISSN(Online): 2584-1025

RESULTS AND DISCUSSION

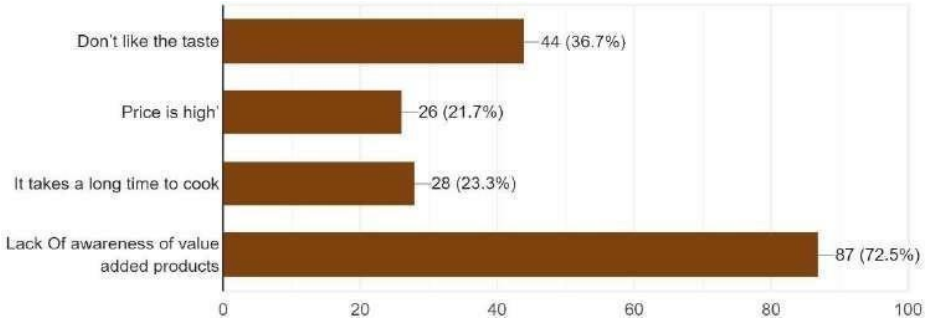
Gender: It's been seen that males consume fast food more frequently than women; this might be due to the greater proportion of men who work in the workforce. Men are more socially active than women, and since fast food is simple to prepare and enjoyable to eat with friends, most men choose to do so while they are spending time with loved ones.

Age: Those younger than them tend to like fast food the least, followed by those between the ages of 10 and 30. Fast food is far more affordable, accessible, flavourful, and fully fills hunger than fruits or other healthful choices. In other instances, marketing tactics, peer pressure, and fads also cause people to gravitate towards junk food. Our hormone of motivation, dopamine, drives the brain to repeat pleasurable behaviours. Large dopamine spikes in the brain are caused by the ideal ratio of sugar, salt, fat, artificial flavours, and sweeteners in ultra-processed food, which makes people want to keep eating it.

Awareness: Several individuals are aware of gluten's detrimental impact on human health. Yet, the explosive rise of QSRs (quick service restaurants) over the last few decades has pushed people to select food products that are simple to get in order to state their hunger. Millets are nutritious cereal crops, but older generations who once devoured them failed to carry on their eating habits. Because of this, relatively few people in the younger age group know about and consume millets on a daily basis. Currently, consumers choose packaged foodsor quick mixes over cooking since they save time while still providing nutritional advantages. Few people are aware that millet powder, which is used to make baby food, is also healthful for adults.

Availability: Very few millets-based value-added goods are readily accessible on the market. While they are rather expensive, those with lower incomes do not really favour them. Health-conscious people make sure to regularly consume millets while keeping in mind the advantages they provide for the body; yet, other people avoid them owing to their expensive cost, unappealing colour and texture, or unpleasant taste. The fig1.1 shows the major reasons behind less consumption of millets.

Fig 1.1 Reasons given by participants for not consuming millets



ISSN(Online): 2584-1025

The statistics shows that the main cause of the poor purchase and consumption of millets is a lack of knowledge about value-added goods. The processing sector makes insufficient expenditures in NPD (new product development), as well as in marketing and promoting the already-available products. One of the explanations might potentially be the lowsocial standing of tiny millet meals. (thehindu.com, 2021)

Fig 1.2 Ratio of respondents seeking healthy gluten free products

Fig 1.3 Ratio of respondents thinking millets are good for changing consumption habits of future generations.

The abovementioned pie charts i.e. fig 1.2 and 1.3 show that individuals have a highly good attitude regarding embracing the value-added millets products. In the upcoming years, it will be necessary to satiate customer demand with a greater emphasis on necessities for health. It is obvious that the majority of urban residents do not consider price to be a problem when nutrition is their top priority. Appropriate steps should be implemented to improve Pune city inhabitants' consumption and shopping habits, with a concentration on millets.

RECOMMENDATION AND CONCLUSION

Greater attention should be made on production and consumption of millets. People will be quite concerned about their health in the years to come, especially those who live in metropolitan areas. According to Prime Minister Narendra Modi, 2023 will be the year of

ISSN(Online): 2584-1025

millets in India. Farmers should be encouraged to plant millets since they can be utilised as both a food source and a raw material by the processing sector to create new goods with value additions. Brands should invest the proper amount in promoting and advertising their already-released goods. Some considerable recommendations by the respondents collected through primary data are stated below.

- The government ought to make millet or items made from millet a component of meal plans like midday meals for public schools.
- Together with rice, wheat, pulses, cooking oil, and kerosene, millet products ought to be distributed to the general people as rations through the Public Distribution System.
- Make millets readily available to individuals who truly wish to incorporate nutritious food products in their diet, and raise knowledge of millets and its advantages.
- If millet goods are made more pleasant and savoury, people are more inclined to consume it more.

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ISSN(Online): 2584-1025

MIT UNIVERSITY'S – ABHIVRUDDHI JOURNAL

VOL.3 (01) , JUNE , 2023 pp- 13-20

"STUDY OF CONSUMER ACCEPTANCE FOR WINE COCKTAIL WITH SPECIAL REFERENCE TO PUNE CITY"

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ABSTRACT:

By 2025, it is anticipated that India will consume 52.2 million litres of traditional wine. Parallel to this, the market has seen the emergence of new wine substitutes made by combining wines with fruit juices or by flavouring wines with synthetic or natural tastes. A bottled cocktail is an alcoholic beverage made from a spirit or spirits combined with additional ingredients that has at least 5% alcohol by volume and not more than 15%. Cocktails in a Bottle or Can are the newest popular items that will change the way people consume alcohol. Because only restaurants and bars provide wine cocktails, RTS cocktails have a tremendous opportunity. An in-person survey of a consumer group of young adults was undertaken to determine the possible customer acceptance and expectations for this new product (21-25). In this study, we primarily concentrate on RTS wine cocktail customer acceptability and availability in Pune City. Just those sample members who drink wine were targeted, and more questioning were conducted. We conducted an analysis of the data gathered using the JASP technique. As a result, we determined that wine cocktails were preferred to wine.

Keywords: Consumer acceptance, Consumer Perception, New product acceptability, Wine Cocktail.

OBJECTIVES:

1. To study the consumer acceptance for wine cocktail in Pune city
2. To investigate the effects on Pune city's wine and cocktail customers.
3. To examine crucial factors from the viewpoint of the consumer to aid in the creation and adoption of the wine cocktail.

ISSN(Online): 2584-1025

INTRODUCTION:

The term "development that fulfils the demands of the present without compromising the ability of future generations to meet their own requirements" refers to sustainable development; it addresses economic, social, and political actions that may have an influence on the environment. (Valentina Maria Merlino 1, 2021) As producing food requires a significant amount of resources and inputs, agriculture is important in this perspective. These elements have the potential to negatively impact both the environment and the items' own food safety, with potentially disastrous results for the environment (i.e. accumulation of pesticides, soil erosion, gas emissions). So, in order to address the worsening of these issues, new strategies and solutions are required.

Grape post-harvest losses: Due to their perishable nature, fruits and vegetables frequently experience both pre- and post-harvest losses. Due to inadequate post-harvest procedures and infrastructure, the Indian horticulture sector is predicted to lose more than 2 trillion rupees ($32.7 billion) yearly. According to a survey by Assocham, 30% of India's fresh food gets spoiled after harvesting and is therefore unsuitable for eating (Anonymous, 2013). Grape postharvest losses have been estimated by several employees to range from 8.23% to 16% nationwide. According to the current estimate of 8.23%, India is losing over 223 thousand tonnes of grapes every year. The loss is far more than anticipated if it is measured as an economic loss, rather than just a visual loss. The losses incurred during the preparation, gathering, packaging, storing, shipping, and distribution of table grapes can also be quite considerable due to the fragility and great perishability of grapes. (Sharma, 2018)

Among the 75 wineries in Maharashtra, 50 are in danger of closing down due to an estimated 50 lakh litres of unsold wine piling up in barrels and wineyard owners struggling to repay interest-bearing bank loans. Some farmers have abandoned the production of wine grapes in favour of the more sombre table grape industry.

Wine can be further processed into cocktails in order to offset these losses and strengthen the winemakers' financial position. Most individuals who don't enjoy the flavour of alcoholic beverages can still consume it and it will increase the worth of the wine. The process of making wine cocktails involves crushing and fermenting entire, dark-colored grapes with addition of flavours and spices, which might vary in taste and colour. The following are some wine cocktails' health benefits. Contains several antioxidants, Reduces harmful cholesterol, Maintains cardiac health, Regulates blood sugar, Reduces the risk of cancer, Helps treat

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common cold, Keeps memory sharp, Keeps you slim, Reduces the risk of depression, Has positive effects on the digestive system.

We can examine crucial factors from the viewpoint of the consumer to aid in the creation and adoption of the wine cocktail. Taste, appearance, aftertaste, and consistency make up these criteria. We performed a poll to learn this crucial factor and customer acceptability of wine cocktails in order to understand the consumer's point of view. We have concentrated on young adults (21-25) who drink any alcoholic beverages. On their judgement, we further filtered the data. We examined the data and obtained the necessary conclusions with the aid of the JASP software, taking into account a specific age group and their interest in the acceptance and consumption of wine cocktails. It was simple to obtain accurate replies from customers by taking into account the characteristics of our content.

METHODOLOGY:

The data was collected by a personal interview using a targeted questionnaire in the Pune City area and released in 2023. The survey was carried out in line with moral principles. All respondents gave their free and informed consent to participate in the survey. We majorly focused on young adults (21-25 years). The completion of the surveys did not result in any rewards. The questionnaire was divided into several sections, as shown in Figure 1.

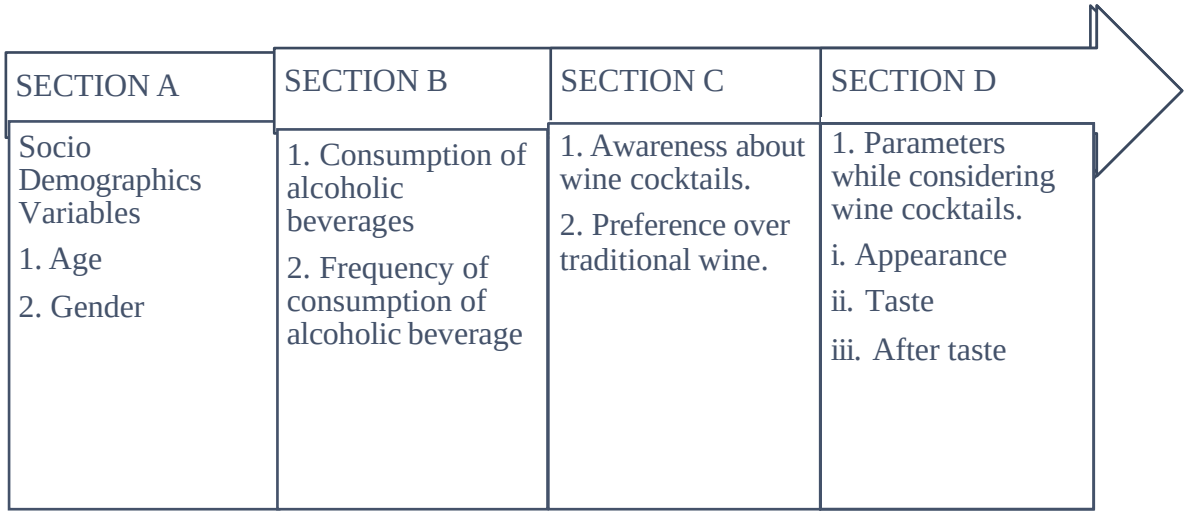

Figure 1. Questionnaire theoretical framework.

Only closed-ended questions were included in the survey's created questionnaire, which helped gather accurate data. Section D's questions were designed to help participants identify the

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attributes of a wine cocktail that could be the most crucial in order to develop a product prototype that meets customers' expectations. Three parameters were specified for this purpose, and the respondents had to rate the characteristics they would like in the product based on their preferences for each of them. The responses to the questionnaires were analysed to determine what people expected and thought about wine cocktails. The Likert scale method was used to examine the variations in consumer expectations for the sensory characteristics of wine cocktails. The analysis was performed using JASP software (JASP 0.17.1.0) package for windows. In order to distinguish various consumption orientations based on consumer experience, anticipation, and perception of a new product, Section C and D answers were chosen separately. Section C was examined using a distribution plot.

RESULTS AND DISCUSSION:

In the present study 231 participants were interviewed, of whom 145 were alcohol consumers who were also knowledgeable about wine cocktails. On the basis of these 145 samples, the data was further processed. The remaining sample was not considered. Males made up the majority of the sample (76%) compared to females (24%). This resulted from the candidates' engagement with the questionnaire. Frequency of buying alcohol can be monitored using figure 2.

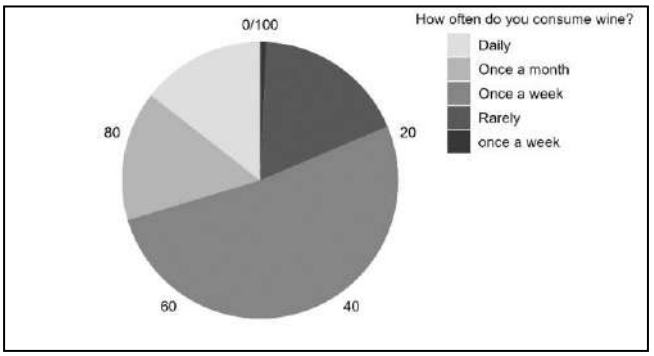

Figure 2: Consumption of alcoholic beverage

Concentrating on the whole sample who consume alcoholic beverage, we have identified that 68% of individuals were aware about wine cocktails, 23% were not at all aware about the same and 8% were not sure about their opinion. The next question was whether people would prefer wine cocktails to wine, and based on the data, we can conclude that 70% of respondents planned to try wine cocktails, 25% had zero interest in the product, and 6% weren't sure what they thought.

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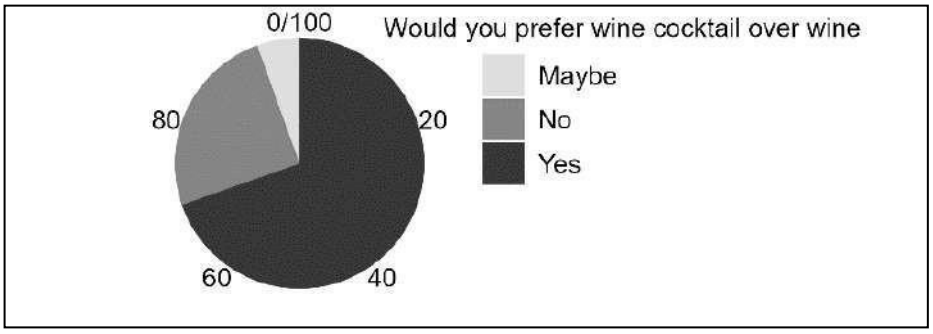

Figure 3: Preference of wine cocktail over wine

Regarding the latter consumers, the percentages of replies gathered about the reasons why they do not intend to approach this new product are displayed in Figure 3. As shown in the graph, people (25%) also responded. Instead, personal preferences for traditional beverages (such as wine, beer, and spirits) were the main driving force, followed by a lack of interest in and appeal for product innovation.

When alcoholic beverage consumption patterns were analysed, significant differences were found, particularly when beer and spirit consumption was taken into account. In particular, the new entry category was more targeted towards spirit consumption. New entries statistically varied from existing ones when the most frequent level of consumption was considered, indicating a higher tendency of consumption in the new entries. In terms of consumption frequency of alcoholic beverages, new entries statistically differed considering the most frequent consumption level, highlighting a higher propensity of consumption in the new entries.

Ultimately, the factors were taken into consideration to know the customer acceptability about new product i.e., wine cocktails. Figure 4.1,4.2,4.3 presents a brief insight regarding the characteristics especially taste, appearance and after taste.

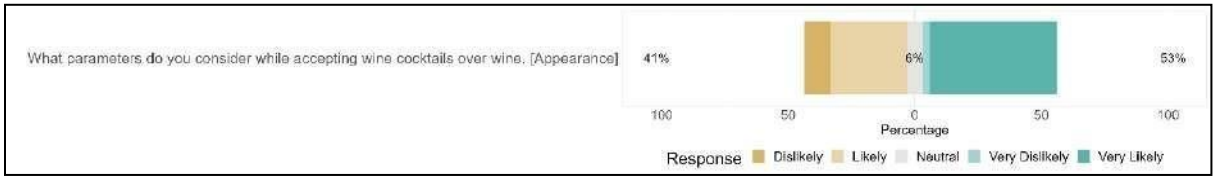

Figure 4.1: Parameters while accepting wine cocktails(appearance)

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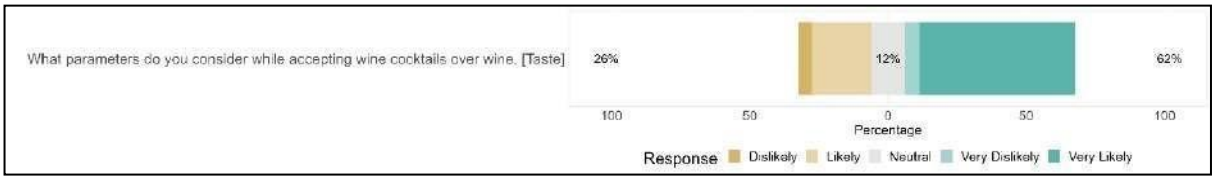

Figure 4.2: Parameters while accepting wine cocktails(taste)

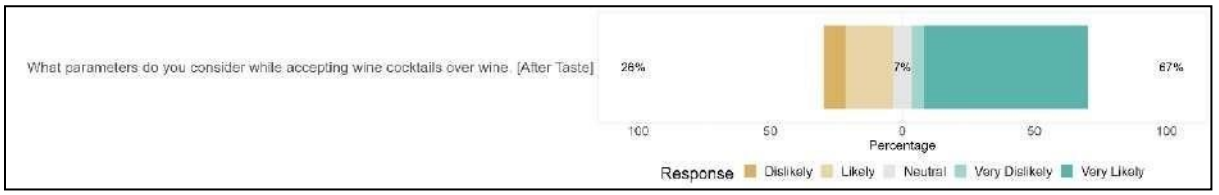

Figure 4.3: Parameters while accepting wine cocktails (after taste)

Figure 4.1 allows us to examine the product's appearance. It shows that 41% of people are unable to accept the product's appearance, while 53% are inclined to do so. As we questioned the individuals more about their unwillingness to accept the appearance, we learned that they firmly think that only the traditional wine colour belongs there.

Through figure 4.2 we can analyse the taste of the product where we can see that 62% individuals are likely to accept the product taste and 26% people don't like the taste of wine cocktails that they have tasted. We investigated it further and came to the conclusion that the wine cocktails that are currently available lack flavour. the taste of wine and other flavours is impaired.

Using figure 4.3 we can study the after taste of the product where we can see that 67% individuals are likely to accept the product after taste and 26% people do not like the after taste of wine cocktails that they have tried. We investigated it further and came to the conclusion that the wine cocktails that are now available has less after taste and is not identical to conventional wine. Instead, those who are likely to enjoy the appearance, flavour, and aftertaste of a wine cocktail choose bottled cocktails due to their convenience.

CONCLUSION

This survey helps us comprehend the views of customers regarding wine cocktails. With reference to Figure 3, we can conclude that 70% of people are eager to try wine cocktails over wine, with the bitter taste and smell of conventional wine being the key factors in their choice. The people were interested in bottled cocktails that may make consumption easier after trying

ISSN(Online): 2584-1025

wine cocktails in bars and restaurants. Figures 4.1, 4.2, and 4.3 help us to draw the conclusion that several factors influence how the wine cocktails taste. Further, by taking into account each person's previous experience, the variations in customer perception could be a marketing tool to be taken into account in the product communication strategies. Our research will assist the beverage sector in developing an effective communication strategy relating to drink attributes in order to meet and exceed customer expectations. This final point assumes additional significance in the case of new entrants who stated sensory expectations for the new product in this research that could not change in a number of wine cocktails. So, in this research, this outcome enables us to effectively emphasise the descriptors influencing the acceptance of the new entries. A successful strategy for a product's market entry might involve capillary communication of its features as well as their effects on society and the environment. By showcasing the benefits of wine cocktails, this promotional strategy could also get the attention of individuals. We are aware of the research's limitations with regard to sample size and composition. However, by extending the research into more regions and sectors to examine various consumer profiles, especially taking into account more age groups of people, this limitation may be solved. Nevertheless, based on our findings, the commercialization of wine cocktails could have a bright future and might be a useful tool for reducing food waste and loss while also enhancing the sustainability of wine chains.

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ISSN(Online): 2584-1025

MIT UNIVERSITY'S – ABHIVRUDDHI JOURNAL

VOL.3 (01) , JUNE , 2023 pp- 21-27

A study of consumer preferences towards ready to eat food in Pune

By

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Abstract

Most of the people in modern time are adopting instant cultures and behaviors. the food habits are not immune to these transitions. People are increasingly buying and using instant food products. The reasons may be listed out related to work pressures and busy life styles, most people are now choosing quick and simple methods enabling them to cook quickly. Subsequently they are preferring instant foods. The cup noodles, ready mix dal and curries, instant upma, instant idly mix, ready to cook curry powders, etc. are the examples of the ready to cook and eat products increasingly demanded by the people.

The purpose of this study is to learn about the preferences of people from Pune City for instant food products, including the variables that impact their decision to buy such products and the difficulties they encounter when consuming them.

A number of consumers from Pune city had participate in the study. The studies are undertaken on the stalls of the ready to eat food products in the consumer exhibition.

This descriptive study uses a simple random sampling technique to find consumers among Pune residents.

Secondary data is captured using books and websites. Primary data is collected from questionnaires. Statistical tools like ANOVA, frequency analysis, and independent sample t-tests are used to describe the nature of variables under study, to predict relationships among the variables and inferential analysis is used to infer the confidence the researchers have on the results.Finally, the researcher offers suggestions to the marketers of ready to cook food products.

KEYWORDS: Instant food products, Ready to cook products, Consumer Preferences, Consumer Behavior

Introduction

Food is the most sought after product which enjoys major share of consumer spending. A study by Kalidas, K., & Mahendran (Kalidas, 2017) claims that a typical Indian consumer's spent on food is more than half of the income. The consumers of world on an average are spending one third of their income on food. The ready to eat food products had occupied a considerable shelf space in stores and super markets and Malls in India. The instant mix market in India was estimated to be

ISSN(Online): 2584-1025

worth approximately Rs.350 crores during the year 2003 and at the end of 2004, it was estimated to be around Rs.700 crores.

The Indian kitchens occupying the instant meal products began to spread since 1980s. Today Every kitchen shelf in the world is having one or another instant food product.

So the study is undertaken to find out the Consumer behavior especially answering the questions, how individuals choose ready to eat products, and what are their preferences.

Review of Literature

The research undertaken by R. Keerthanan and Dr. R. Amsaveni (Amsaveni, 2022) is an attempt to determine which are the most popular instant food items and to know the reasons behind the selection of instant food products by consumers. The study is undertaken in the city of Tirupur in which 150 consumers were had participated. Judgmental sampling was used. The report findings state that, majority of the respondents prefer vegetarian food products. They check the expiry date before purchasing. Most of the respondents are from salaried class, and they have nuclear family. They spend a monthly budget of Rs. 301 to Rs. 500 on instant food products. The new clients are drawn by Advertisements giving a message that these products are reducing the cooking time considerably and they also able to prepare dishes like a famous restaurant. The study recommends that if the marketer provides complete information of the product including nutrients, quality, recipe, and required time, the sales are improved. Sample packs and discounted packs are to be used pull the new customers.

The study undertaken by J Saujanya and Yadigiri Nikitha (Nikitha, 2022)states that the life pressures of indian people are forcing them to adopt to the ready to cook products. The researchers analyzed consumer perception and satisfaction towards ready-to-eat food goods and discussed the factors those motivate consumers to consume the ready to cook products. A questionnaire is used to collect primary data, and books and magazines are utilized to collect the secondary data. Most of the respondent order food from restaurants when food is required. They look for flavor and nutrition while buying ready to cook food products, they look for TV advertisements and learn about the products. Maximum of the respondents have reported their satisfaction level towards these products as neutral. The research recommended that ready to cook products to be made easily available in retail stores, to enable point of purchase their prices should be decreased, and the taste must be improved to resemble home-cooked food.

The study undertaken by Nitya Khurana and Prachi Goyal (Goyal, 2021) claims that the Food is a vital component of all living things as it provides nutrition and support. The Consumer Behavior has experienced a significant change in the current environment. The growth in Urban population, transition towards nuclear families, changes in the employments and organizations, lack of time, quest for convenience, and changed lifestyles have forced the consumers to ready to cook food. Consumers like to save their time for cooking. Especially the young people, who are working. In most urban areas both the husband and wife are working hence they are forced to consume the ready to cook products.

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The study undertaken by Bhavya Saxena (Saxena, 2021) focuses on Consumer behavior of instant food products related to usage of media and the other variables making impact on instant food products. A survey of adults and millennial from Bhopal is undertaken for this study. The study focuses on popularity of the brands of instant food and the regularity of their purchases. The study claims that urbanization and nuclear family structures, lack of time, easy access, and changed life styles are the factors influencing the increase in sale of ready to cook products. The study has targeted women in the household. The study claims that women play a major role in purchase of the ready to eat products. The study also reveals that Consumer perceive that the instant foods are expensive than homemade food products and the quality and flavors of instant foods need to be improved to earn consumer trust. The suggestion to use media to promote sales is given in this study.

The study undertaken by E, M. A., & A, S. I. A. in 2018 (E, M. A., & A, S. I. A., 2018) stated that the Indian Instant Food production is one of large production in the World. The total food production in India will likely to double over the next 10 years and the demand for Instant Food products will also increase because of the urbanization, changes in food habits, and changes in traditions.

Statement of the problem

The eating preferences of people are changing. Most of the urban people frequently buy food in addition to the home made food. Most of the people are working and get little time to prepare food at home. Most literature claim that the nuclear households more frequently buy ready to eat food. There is significant change in the attitude of house wives also towards cooking and serving homemade food. In this context, the researchers intend to study the preferences towards ready-to-eat food products by the citizens of Pune.

Scope of The Study

The Global Ready to eat food products is expected to expand significantly. Most companies are eyeing this market strategically. The aim of the current study is to identify the variables influencing ready to eat food products and customer issues among Pune city.

Objectives of the study

- To identify the awareness level of ready-to-eat food products
- To Measure satisfaction level of the people towards ready to eat products.

Research Methodology

The researchers have undertaken exploratory research by studying available literature and descriptive study in which survey of people visiting the stall of ready to cook product in consumer exhibitions in Pune City is undertaken.

Questionnaire was administered to 100 respondents who visited stall of ready to eat foods with samples and packets of different gravies in May 2022

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Respondents responded to the questions of the questionnaire after tasting sample of the product items

Data Presentation, and Analysis

1. Demography of the respondents who are aware of the ready to eat products
   - 45 percent of respondents are aware of Ready to cook masala gravies
   - Most of them are aware of Suhaana brand followed by Mother's Recipe
   - Out of those who are aware about ready to cook masalas, 52 percent are from nuclear families and 48 percent from joint families.
   - Out of those who are aware,49 percent are self-employed and 30 percent are from service background.

2. Level of satisfaction to the taste of Ready to Eat Products

Level of Satisfaction * Characteristics Rating Tasty

Level of Satisfaction

Characteristics Rating Tasty	Mean	N	Std. Deviation
0	3.18	17	1.131
1	5.00	1	.
2	3.50	2	.707
3	3.83	6	1.169
4	3.73	30	1.143
5	4.02	44	1.045
Total	3.78	100	1.115

44 percent of Respondents for whom tasty is a very important characteristic are somewhat satisfied with the current ready to cook masalas with mean satisfaction of 4.02. This is an area of improvement.

3. Level of Satisfaction: Taste like Home food

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Level of Satisfaction * Characteristics Rating Taste like home food

Level of Satisfaction

Characteristics Rating Taste like home food	Mean	N	Std. Deviation
0	3.19	16	1.167
1	5.00	1	.
2	3.75	4	1.258
3	3.80	5	.837
4	3.62	34	1.181
5	4.13	40	.966
Total	3.78	100	1.115

40 percent of the respondents for whom taste like home food is very important have reported a mean satisfaction rating of 4.13 on the attribute of taste like home food. This is an area of improvement.

4. Level of Satisfaction: Healthy

Level of Satisfaction * Characteristics Rating Healthy

Level of Satisfaction

Characteristics Rating Healthy	Mean	N	Std. Deviation
0	3.19	16	1.167
1	5.00	1	.
2	4.20	5	.837
3	3.60	10	1.350
4	3.76	25	1.052
5	4.00	42	1.059
65	3.00	1	.
Total	3.78	100	1.115

42 percent of the respondents for whom *healthy* as an attribute is very important have reported a mean satisfaction rating of 4.00 on the attribute indicating only somewhat satisfied. This is an area of improvement.

5. Level of satisfaction: Artificial food colors

ISSN(Online): 2584-1025

Level of Satisfaction * Characteristics Rating No Artificial colour

Level of Satisfaction

Characteristics Rating No Artificial colour	Mean	N	Std. Deviation
0	3.19	16	1.167
1	5.00	1	.
2	4.00	3	1.000
3	3.60	10	1.506
4	3.79	24	.977
5	3.98	46	1.043
Total	3.78	100	1.115

Lesser levels of satisfaction reported on the attribute of no artificial color. This is an area of improvement.

6. Satisfaction Level: No Preservatives

Level of Satisfaction * Characteristics Rating No preservatives

Level of Satisfaction

Characteristics Rating No preservatives	Mean	N	Std. Deviation
0	3.19	16	1.167
1	4.33	3	1.155
2	4.33	3	.577
3	3.67	3	.577
4	3.77	26	1.210
5	3.92	49	1.057
Total	3.78	100	1.115

Lesser levels of satisfaction reported on the attribute of no preservatives. This is an area of improvement.

Findings:

Pune citizens are well aware of ready to eat products. The ready to eat products are used by both nuclear as well as joint families. The awareness is present among self-employed as well as employed citizens.

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The preferred attributes in ready to eat products are Taste, Taste like home food, healthy, no artificial colors and no preservatives.

The respondents are found to be somewhat satisfied about their preferred choices. Hence it is to be taken into notice that the ready to eat food producers have to improve in the preferred attributes of the ready to eat products to have patronage from Pune Citizens.

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ISSN(Online): 2584-1025

MIT UNIVERSITY'S – ABHIVRUDDHI JOURNAL

VOL.3 (01) , JUNE , 2023 pp- 28-35

The Study On Services Offered by Forensic Accounting Sector

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Abstract: The objective of this study is to analyse the existing literature on the services offered by forensic accounting sector to Indian corporate, banks, insurance etc. and identifying the gaps in literature. This study provides an overview of the existing study on services offered under forensic accounting done by researchers from all over the world plus with specific reference to India. This study is helpful for researchers who wants to do further research in this domain. This is also helpful to academician, consultants, professionals, forensic accounting practitioners, corporate risk managers and regulators. **Methodology:** This study analysed 27 research articles which have been conducted in the forensic accounting domain. The sample has been selected from different online database like Google Scholar, UGC Care & Scopus Indexed Journals etc. from the period 2011 to 2021. This paper will explore services under forensic accounting domain which are unexplored. The overview of these services will give new perspective to Indian corporate world for prevention of fraud in early stage through forensic accounting. **The result of the study** is showed that, if organization will use forensic accounting services as one of the internal control measure, it may reduce the fraud at some extent.

Keywords: Forensic Accounting, Corporate Governance, Fraud, Internal Control Measure, Fraud Risk Assessment.

ISSN(Online): 2584-1025

I. INTRODUCTION

The typical work of accountant is to do closing monthly balance sheet, P&L, reconciliation and process few payment cheques. Whereas forensic accountant looks beyond the ledger and tries to find out corporate wrong doings. A forensic accountant should have investigative & analytical skills, knowledge of accounting & law, as they are frequently called as an expert witness during trials, good communication skill and he should be techno savvy, as technology plays a major role while investigating fraud. Forensic accountant need to look beyond the numbers. Many cases of financial statement misrepresentation have been reported, from big corporates like Enron, WorldCom, Adelphia, Xerox, Qwest, and many more.

In Indian context we can name few like frauds at Satyam Computers, Karvy Stock Broking Ltd., Punjab & Maharashtra Co-Op Bank (PMC), PNB (Kala Ghoda Branch) and recent IL&FS, ABG Shipyard scam which shook Indian Economy recently. These corporate frauds bought forensic accounting profession into limelight.

Due to increase in new techniques of fraud, organization started to realise, they need to hire an expert who will do inspection or audit in unbiased and independent way and one of that independent expert is forensic accountant. Forensic accountant's services are required by all sectors like bank, corporates, regulators like SEBI, RBI and even law officials while filing fraud cases in court.

Frauds could be categorized as below:

1) **Bank frauds**: In India, there is a large number of bank frauds. It is increasing over time in all of the major operational areas of banking. There are various areas in banking such as deposits, loans, inter-branch transactions, accounting, and so on. (*STUDY MATERIAL PROFESSIONAL PROGRAMME FORENSIC AUDIT*, n.d.)

2) **Corporate frauds**: Corporate fraud by leading Indian businesses is shaking the Indian economy on a regular basis. Satyam Computers shocked the national financial world in 2009, when Satyam's Founder B. Ramalingan Raju declared he had exaggerated profit and inflated the company's Balance Sheet by more than one billion dollars, to the PNB Fraud in 2017 and the recent 23K-Cr fraud at ABG Shipyard in 2022. Corporate fraud by leading Indian businesses is shaking the Indian economy on a regular basis. Satyam Computers shocked the national financial world in 2009, when Satyam's Founder B. Ramalingan Raju declared he had exaggerated profit and inflated the company's Balance Sheet by more than one billion dollars, to the PNB Fraud in 2017 and the recent 23K-Cr fraud at BharatPe & ABG Shipyard in 2022. Fraud isevident in corporates. This must be strictly monitored in order to guarantee economic stability and the growth of the emerging economy. (*STUDY MATERIAL PROFESSIONAL PROGRAMME FORENSIC AUDIT*, n.d.)

3) **Insurance frauds**: In the insurance industry, there are various types of fraud. For example, health insurance, claim fraud, bogus claims, insurance speculation, application fraud, and so on. (*STUDY MATERIAL PROFESSIONAL PROGRAMME FORENSIC AUDIT*, n.d.)

4) **Cyber frauds**: Cyber frauds are internet-based scams that target the illicit use of digital instruments such as credit cards, ATM cards, and home-based cyber equipment, among other things. (*STUDY MATERIAL PROFESSIONAL PROGRAMME FORENSIC AUDIT*, n.d.)

5) **Securities frauds**: Frauds in the securities market, in addition to corporate fraud, harm a large number of people. When it comes to securities fraud, the investor community cannot forget the under truncate Rs.4000 crore Harshad Metha scandal and the above Rs.1000 crore Ketan Parekh scams, both of which defrauded investors by causing them to lose their money in the main markets. Furthermore, insider trading is often regarded as securities fraud. (*STUDY MATERIAL PROFESSIONAL PROGRAMME FORENSIC AUDIT*, n.d.)

If we explore further in corporate fraud then, there are a number of ways in which a companies can commit fraud – (*STUDY MATERIAL PROFESSIONAL PROGRAMME FORENSIC AUDIT*, n.d.)

- A authorised person can approve his personal purchases. Recent example is BharatPe's fraud.
- Can create a record of dummy or Ghost employee. Means who is on payroll but not doing any work or

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after the death of employee, data is not removed purposely.

- Embezzling Money or stealing of cash before it is being recorded.
- Companies avoid to pay taxes or pay less tax by using a legal method.
- There may be theft of asset. Even using organization's asset for personal use is also a asset theft.
- Prepare a false Financial statement by -

- Delaying depreciation acknowledgement by prolonging the depreciation period.
- Transferring debt to specific companies.
- Speeding up the recognition of revenues.
- Capitalize the expenditure.

II. OBJECTIVE OF STUDY

- To explore services offered under forensic accounting domain.
- To find out whether inclusion of forensic accounting services as an internal control will prevent the fraud at early stage and strength the corporate governance.

III. METHODOLOGY

For this research data collection is through secondary sources available through research journals. books, magazine, newspaper articles from India Today, Business Times, Economics Times etc., Past Survey and Case studies of previous frauds.

IV. LITERATURE REVIEW

Forensic accounting is not a new concept for the developed countries like USA but in the current situation it is just gaining popularity in India as frauds are increasing day by day. It started gaining momentum from around 2013-14. Especially after the Satyam Fraud shook the entire country in 2009. Still Small & Medium Enterprise (SME) sector which is very prone to fraud aren't aware of the forensic accounting services available. So indeed it is very much essential to explore services offered by forensic accounting. Also to study the effect if it will use as one of the internal control measure.

1. Areas where Forensic Accountant give services:

Fraud Risk Assessment

Forensic Accountant are a FRAUD STOPPERS and have a dedicated Fraud Risk Assessment Team, who are unique in the sense that they come from both the field of Auditing and Forensic Accounting. The professionals who work on fraud risk assessments have been a part of implementation of many forensic accounting standards, like United States' Public Company Accounting Overseas Board (PCAOB) standards. FRAUD STOPPERS are now a trusted name when it comes to Fraud Risk Assessment and Forensic Accounting. Fraud Risk Assessment is an ongoing process which helps to identify the inherent risks and helps to mitigate those threats. These services, which fall under the forensic accounting umbrella, are required by the corporate kings of our county.(INDIAFORENSIC.COM)(*STUDY MATERIAL PROFESSIONAL PROGRAMME FORENSIC AUDIT*, n.d.)

- **Due Diligence**

Due diligence is a comprehensive investigation of a company or individual in order to determine the risks associated with providing resources and capital.

Forensic accountants can help companies to assess opportunities and threats in foreign markets. They will carry out research into relevant factors such as: foreign market entry strategies for companies, types of joint-venture partner, financial guidelines for investing overseas, country-specific business customs, accounting requirements for foreign currency transactions. (INDIAFORENSIC.COM)(*STUDY MATERIAL PROFESSIONAL PROGRAMME FORENSIC AUDIT*, n.d.)

- **Information Security Risk Assessment**

With the emergence of cyber-crimes, Information Security assessments have emerged as an essential aspect of forensics practice and services. An information security assessment is a critical requirement of risk management in any organization to assess the organization's current level of risk, threats and vulnerabilities. Even being a new service area, it has seen a lot of traction due to the introduction of Sarbanes – Oxley act in America and the impending regulations under the same act in Europe with general data protection legislation. The information security assessments are largely conducted by technology forensic accountants. (INDIAFORENSIC.COM)(*STUDY MATERIAL PROFESSIONAL PROGRAMME FORENSIC AUDIT*, n.d.)

- **Asset Tracing**

The Stamp Paper Scam involving Abdul Karim Telgi was the greatest scandal, involving over 30,000 crores of rupees. Abdul Karim Telgi had a

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couple billions of rupees in assets before he was jailed. The largest scam going on in India is the generation of assets through bank transactions. If we look into the records of bank transactions pertaining to the years after 2014 we can find a huge number of suspicious transactions, which do not match with actual asset purchased and made under Benami accounts. These are just few examples and if someone starts looking into records, he would be amazed to find out the magnitude of scam and get convinced about its existence. Forensic accountant's job is to trace & identify client's assets which are illegally in possession of third parties. (INDIAFORENSIC.COM)(*STUDY MATERIAL PROFESSIONAL PROGRAMME FORENSIC AUDIT*, n.d.)

Vendor Monitoring

It is very much essential to check authenticity and reliability of vendor or borrower in all types of industries from manufacturing to Information Technology. Banking officials should verify this before the process of credit approval. As there are lots of cases where companies duped bank in working capital loan. (INDIAFORENSIC.COM)(*STUDY MATERIAL PROFESSIONAL PROGRAMME FORENSIC AUDIT*, n.d.)

Money laundering compliance programme

Money laundering is a serious crime which is directly related to criminal activities. Illegal arms sales, smuggling, drug trafficking, prostitution gangs, extortion, market manipulation, bribing, and computer fraud schemes are just a few examples of criminal activity. Profits from such unlawful operations provide an incentive to "rationalise" the ill-gotten gains by laundering the money. (INDIAFORENSIC.COM)(*STUDY MATERIAL PROFESSIONAL PROGRAMME FORENSIC AUDIT*, n.d.)

- **Litigation Support**

Forensic accountant also proves litigation support. He provides technical questions of accounting & audit, taxation, law. In case of fraud he also calculates quantification of losses, business valuation, insurance claims and many other situations. (INDIAFORENSIC.COM)(*STUDY MATERIAL PROFESSIONAL PROGRAMME FORENSIC AUDIT*, n.d.)

2. Preventive Role of Forensic Accounting

Forensic accounting is an innovative branch of accounting which involves the investigation of financial crimes. Forensic accountants handle subject matters like valuing companies, discovering frauds, criminal acts and any other illegal activities for the organization and related parties.(*STUDY MATERIAL PROFESSIONAL PROGRAMME FORENSIC AUDIT*, n.d.)

Till date in Indian Context Forensic Accounting is used as a detective method after fraud took place. But Forensic Accounting should be look like as a tool or activity for prevention of fraud. Major reasons for fraud occurrence is immaturity of corporate governance and not using Forensic Accounting as a preventive tool within the organisation (Ali Rehman, Fathyah Hashim,2020; Singleton, T. W. & Singleton, A.J.2010). Control activities should be undertaken within the company such as planning, regular assessment of all types of transactions so red flags will raised in their early stage, close monitoring of loans /advances. Corporate governance should be nurtured and complimented internally within the organisation. Similarly, Forensic Accounting should be included as an in-house activity and included in the organizations management policy. It is well known fact proved through many researches that frauds are majorly conducted by the persons who are working or a part of the internal organisation and they can have carried out frauds because of weak internal control system and it means immature corporate governance. If the Control mechanisms will have enhanced, it will reduce the risk of fraud and will increase the Corporate Governance maturity. To achieve this Forensic Accounting should be included as an in-house activity by the organisation to eliminate the risk of fraud which may be the obstacle for the growth and sustainability.

Because of continuous increase in frauds, there is constant pressure on accounting and auditing profession to identify the alternative ways to detect and mitigate frauds. This alternative way can be defined as Forensic Accounting (Bhasin,2013; Malusare (2013) (Bhasin, 2013b)(Bhasin, 2013a). Forensic Accounting can be seen as a cost saving measures when compared with the amount of the fraud and amount spent for legal & litigations in addition of Preventive measure (F Vinluan,2015). Forensic Accounting's existence is necessitated because of the increasing organizational frauds which are not detected through conventional audit. Frauds are still occurring even with the availability of policies, code of corporate governance and bodies (Bhasin,2013). Forensic Accounting as a preventive tool can be represented as identification of fraud before its occurrence. In comparison with

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the preventive role of Forensic Accounting, detective role is only limited to the detection of fraud (Singleton, T. W. & Singleton, A.J.2010). Detection of fraud can only happen when fraud actually happened (Rehman, A., & Hashim, F. (2018). In current business environment, role of Forensic Accounting is normally perceived as detective role only (MJ Nigrini, 2012; Adrian, Lawrence & Cristal, 2009).

In 2013 & 2016, Madan Lal Bhasin has a theoretically contributed on Forensic Accounting & Corporate Governance. He portrayed 'Global Regulatory Action for Corporate Frauds, Corporate Governance and Accounting Reforms Scenario' in which he researched various accounting reforms undertaken by regulatory bodies to improve the corporate governance and to prevent the corporate frauds. In the Indian context, he also investigated whether the abilities required of FCAs in developed nations differ greatly from the expectations of clients and accountants in India.

In 2017, To strengthen the Corporate Governance system, Madan Lal Bhasin studied the requisite skills, education, and training requirements for CFAs.

Another major contributor to the Forensic Accounting & Corporate Governance study is Ali Rehman , Fathyah Hashim.

In 2018, His research adds to the body of knowledge and contributes to the previous literature collection, laying the foundation for future research and gaining new knowledge on issues connected to forensic accounting and corporate governance.

In 2018 Indonesian researcher Imang Dapit Pamungkas, the goal of this study was to look at the risk factor of the fraud diamond model in relation to accounting fraud, as well as corporate governance as a moderating component. Using the fraud diamond theory, this study will look at how excellent corporate governance can avoid accounting fraud. They used 12 fraud companies and 32 non-fraud companies that were listed on the Indonesia stock exchange for this study.

In Dec 2020, Ali Rehman , Fathyah Hashim published an article on how to integrate related literature and empirical research in order to enhance the claimed capabilities of forensic accounting on corporate governance maturity, particularly for publicly traded businesses. They used data from the KPMG study from 2014 and the Observer from 2017. "'Fraud Risk Assessment' (FRA) is a control," they conclude, "and due to its non-implementation, many parts of fraud and related activities go un-checked, increasing the likelihood of cheating and severe mismanagement, which can have a detrimental impact on the accomplishment of Corporate Governance Maturity."

In 2020, Ali Rehman , Fathyah Hashim researched on another topic that, There is a link between fraud risk assessment and excellent corporate governance among companies registered on the Muscat Stock Exchange in Oman.

In 2020, Ali Rehman , Fathyah Hashim also researched measuring the impact of forensic accounting's (FA) on Omani public listed businesses' sustainable corporate governance (SCG).

Deloitte India's 'India Corporate Fraud Perception survey, IV-2020, (Figure – 1,2 & 3)

As per Deloitte survey 80.3% says, fraud would rise in the future, especially in the cybercrime due to large-scale remote working arrangement and business change model. Whereas, 37.80% says, fraud will rise due to large-scale remote working arrangement.

These frauds will rise due to 2 main reasons –

1. Inability to understand vulnerabilities and
2. Dependency on static data for fraud risk assessment.

Procurement (19.35%) and Information Technology (16.94%) are most vulnerable to fraud risk. 48.5% believed techniques of fraud prevention is the key for success of fraud risk management. Approximately 35% that future frauds would get detected by using data analytics tools. In addition to this around 50% people believe that 'Employee Behavioural Analysis Tool', Artificial Intelligence (AI) and Machine Learning (ML) tools will prevent frauds partially or completely.

Figure 1- Source: ©2020 Deloitte ToucheTohmatsu India LLP

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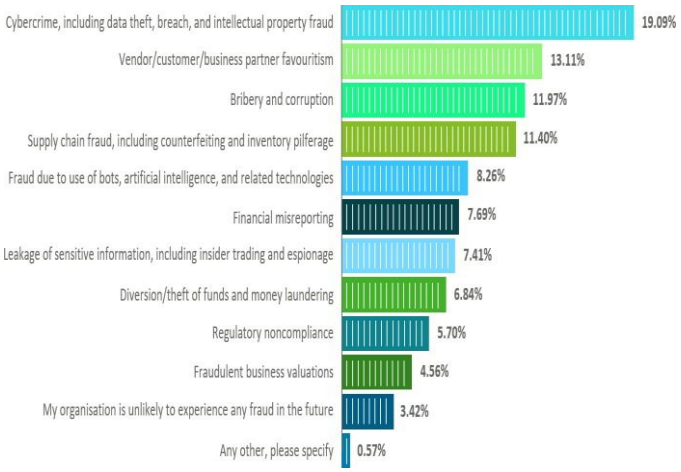


Figure 2- Source: ©2020 Deloitte ToucheTohmatsu India LLP

Is organisation's existing fraud risk management framework is adequate?

Figure 3- Source: ©2020 Deloitte ToucheTohmatsu India LLP

V. CONCLUSION

A branch of Forensic Accounting in India is still in the beginning stage which displays sign of future potential and growing area of need in all types of corporate structure of India.

In 2002, the Sarbanes-Oxley Act (SOX) was enacted as a result of the Enron scandal and collapse of the Satyam Computers amended the Company Act in 2013. Similarly, Frauds at security market especially Harshad Mehta, Ketan Parekh and Karvy Stock Broking Ltd gave birth to National Stock Exchange (NSE) in 1992, SEBI Act,1992 was amended in 1995. Amended act gave SEBI more authority to access the records of any bank and inspect the books of Public Listed Companies. Harshad Mehta scam became an eye-opening event for Indian financial sector and the beginning for better Corporate Governance policies in India.

After timely amendments in laws still frauds are increasing day by day especially after the pandemic situation research in this domain is very much essential. India is marching towards the fraud free corporates & Financial institutions but, still companies are not ready for extra expenditure on forensic accounting services.

So it is very necessary to do research on how inclusion of Forensic Accounting in a system can improve Corporate Governance of the organization as well as will decrease the cases of frauds.

If organization will consider Forensic Accounting as a part of governance management system, just like internal & external audit, frauds can be avoided before the occurrence.

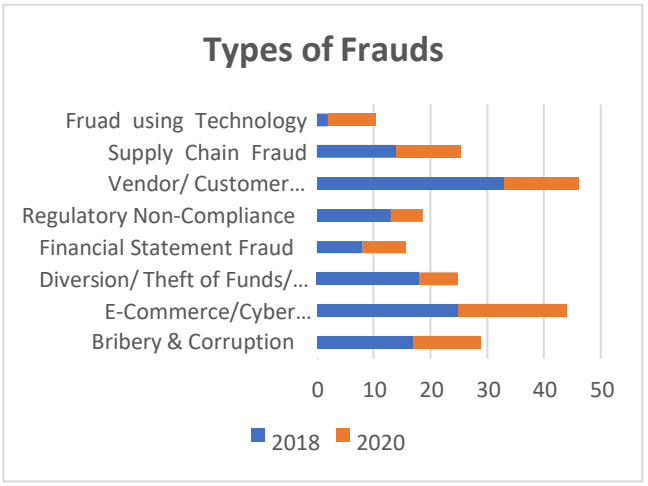
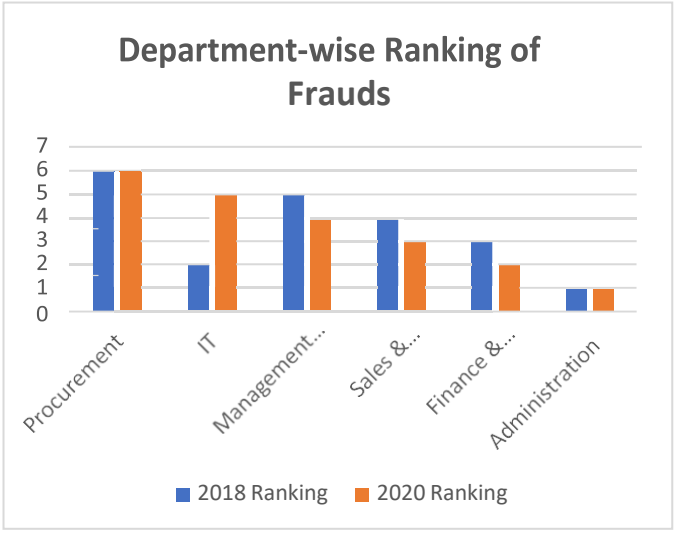


Figure 4 – Source: Compiled by Researcher

From figure-4 it is evident that fraud using technology are increased tremendously.

As per figure 5 chart, Procurement department remains at the top where maximum frauds happen. Whereas, frauds in IT department increased more than double.

Figure 5 – Source: Compiled by Researcher



As we are marching in 2022, so the skill set required almost after 8 to 10 years' time gap are different. There were introduction of new techniques and software like AI & ML technology. Especially after pandemic it is predicted by different sources that frauds will be increased

ISSN(Online): 2584-1025

majority in the cybercrime. For this forensic accountant must be aware with current technology. So there is a need to do fresh research on this topic in the current time period as from 2011 to 2022 there are lot of amendments in rules & regulation in Indian law. The major which is related to Forensic Accounting is 'The Company Act, 2013' which amended after India's first major corporate fraud i.e. Satyam Computers.

Right Fit uses its expertise in the area of forensic accounting & investigations, to develop a fraud risk assessment report. Through discussion with the client and analysis of the client's working environment and industry, they are able to understand what are the possible areas where fraud is likely to happen. The purpose of this exercise is to identify risks related to management override, gross misstatement, collusion between employees and outsiders for illegal personal gain, as well as operational weaknesses that may be susceptible to fraud. Based on the risk assessments carried out by Right Fit; suitable strategies are formulated that help minimize frauds so that liability pertaining to fraudulent accounts is contained and affirmed in timely manner.

As per 'IndiaForensic', Software businesses have created software for internal auditors that complies with SOX requirements. On a same line, in future they may develop a software using a set of pre-defined standards for spotting fraud's red flag and to design such software, software companies will prefer the functional consultants with Forensic Accounting Background.

This study proves, the Corporate Governance maturity is the internal system of the organization to fulfil their goals & objectives. Forensic accounting's proactive role improves corporate governance maturity. which gives satisfaction to shareholders and increases their faith in the organization. It also protects the rights of the shareholders. Forensic Accounting as a preventive tool within the organisation is a control activity within the company such as planning, regular assessment of all types of transactions so red flags will raised in their early stage of fraud.
It is now proved that frauds are majorly conducted by the persons who are working or a part of the internal organisation and they can have carried out frauds because of weak internal control system, which means immature corporate governance. If the Control mechanisms will have enhanced, it will reduce the risk of fraud and will strengthen the Corporate Governance maturity. To achieve this Forensic Accounting should be included as an in-house activity by the organisation to eliminate the risk of fraud which may be the obstacle for the growth and sustainability.

If organization will follow measures like appointment of independent directors, regular scrutiny of high value transactions, consideration of whistle blower's complaints, appointment of credible expert like forensic auditor etc. which are shown in the Figure 4, will reduce the chances of fraud.

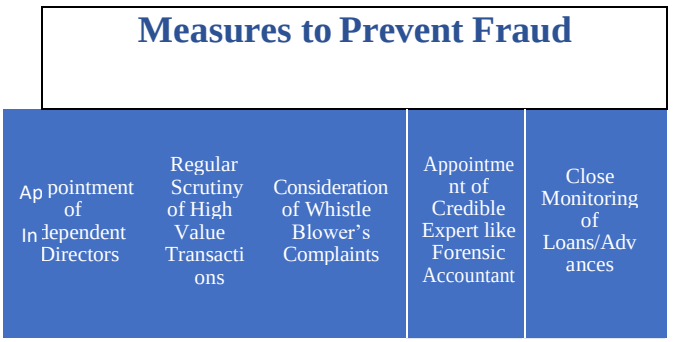


Figure 6 – Chart by Researcher

If organization will consider Forensic Accounting as a part of governance management system, just like internal & external audit, frauds can be avoided before the occurrence.

This study highlights the fact that Forensic Accounting can be used as a preventive tool and also as governance management control. Currently Forensic Accounting is used only as a detective tool after the fraud happened. This research supplements the available literature in India. This research paves the way for future research in the fields of Forensic Accounting, Fraud Risk Assessment and Corporate Governance.

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ISSN(Online): 2584-1025

MIT UNIVERSITY'S – ABHIVRUDDHI JOURNAL

VOL.3 (01) , JUNE , 2023 pp-36-40

Development of Mapping and Surveying Drone

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***Abstract*— Traditional surveying and mapping methods for obtaining ground data are often inefficient, inaccurate, expensive, and risk damaging or losing equipment. Enter drones, and unmanned aerial vehicles (UAVs), which address these issues by providing innovative mapping capabilities. GIS professionals can use drones to perform topographic surveys with accuracy, matching traditional methods, but with reduced efficiency and cost. The use of drones reduces the workload of on-site experts and improves the efficiency of on-site investigations. The project aims to develop a mapping and surveying drone capable of capturing terrestrial images that can be converted into a 3D representation, collecting important parameters such as distance, area, and volume.**

Essentially, traditional surveying and mapping methods have limitations such as inaccuracy, high cost, and high risk, while drones used for surveying and mapping have multiple advantages including faster surveys and more efficiency, reduced costs, and relief of the experts' workload. The main objective of the project is to design a drone capable of capturing terrain images and converting them into a 3D representation, making surveying more efficient and precise, potentially revolutionizing surveying methods.

Keywords—Drone, Prototype, Mapping, Photogrammetry, 3D Model

I. INTRODUCTION

Land mapping in India has suffered from a variety of issues, with a primary cause being inefficiency, inaccuracy, and high costs. The traditional method of land mapping is a lengthy and tiresome process, requiring extensive human effort to manually measure distances and collect data. As a result, this method is prone to human error and inaccuracies, which often results in disputes over land ownership and boundaries. Furthermore, traditional mapping techniques often rely on outdated equipment and technology, rendering them less reliable and less precise. This obsoleteness can lead to further complications and disputes, as the data gathered, may not be reflective of the current state of the land. The financial burden of traditional mapping techniques is also a significant issue, making them inaccessible to rural communities and small-scale farmers. The inaccessibility to accurate land mapping data poses a considerable obstacle to economic development, leading to social inequality.

In summary, traditional land mapping techniques in India have faced numerous challenges, limiting their effectiveness and accuracy. The solution to these challenges may be in the adoption of modern technologies such as drone mapping, which can provide a more precise, faster, and cost-effective method of mapping land, benefitting individuals and society as a whole. [1,2]

II. BASIC CONCEPTS

A. Drone Mapping

Drones are flying robots, ranging from unmanned aerial vehicles (UAVs) that fly for miles to small drones that fly in confined spaces. They are aerial vehicles without a human operator, which can fly remotely or autonomously, carry lethal or non-lethal payloads, and are considered drones.

Drone mapping is an aerial survey which is conducted by the means of a drone and specialized cameras, which can include RGB (for photogrammetry purposes), multispectral, thermal, or LiDAR sensors. Drone mapping is a process that involves surveying an area of land using an unmanned aerial vehicle (UAV). This method is used by many industries that require surveyors to provide maps of areas of land. The process involves flying the drone over an area of land and taking hundreds of pictures. These images are then stitched together using computer software to create a model of the site. The drone mapping process allows surveyors to collect highly-accurate data quickly and safely. In fact, drone mapping collects data over 90% faster than manual methods. The collected data can be processed through several available drone mapping software to create 3D models, 2D maps, and digital elevation models. These assets are used to extract information that is required by the user such as highly-accurate measurements and volumetric calculations.

Drone mapping has several advantages over traditional mapping methods. It is faster, cheaper, and safer. Drones can scan large swathes of terrain in a fraction of the time it takes to manually measure on the ground, especially in areas with difficult terrain. This reduces operational costs and risks, as investigators do not necessarily need to be onsite or in hazardous areas to obtain data. Combined with traditional surveying methods, drone mapping can also produce extremely detailed and highly accurate point files down to millimeters. In summary, drone mapping is a highly efficient and effective way to survey and map areas of land, providing valuable data for a range of industries. [3]

B. Photogrammetry

Photogrammetry is a method that permits the creation of 3D models from 2D photographs. It is utilized in a broad range of applications, including architecture, archaeology, and geology. The method comprises capturing a series of photographs from different

ISSN(Online): 2584-1025

viewpoints and then employing specialized software to generate a 3D model from the images.

The process of photogrammetry can be quite intricate, involving multiple diverse steps and calculations. The first step is to capture a series of photographs of the object or scene to be modeled. These photographs must be taken from varying angles and distances to capture all the necessary details. Once the photographs have been captured, they must be processed using specialized software. This software employs algorithms to match up the diverse images and calculate the positions and orientations of the cameras that captured the photos. This information is employed to create a 3D point cloud, which represents the surface of the object or scene. The point cloud can then be employed to create a 3D model using further processing steps. These steps may include smoothing the surface, filling in any gaps or holes in the data, and adding textures or colors to the model. The resulting 3D model can be used for a diverse range of purposes, such as visualization, measurement, and analysis. [4-5]

For example, an architect may use a photogrammetric model to plan a building renovation, while a geologist may utilize a model to examine the topography of a landscape.

Photogrammetry is a powerful tool for creating detailed 3D models from photographs. Nevertheless, it can be a complex and time-consuming process, requiring specialized equipment and software. Additionally, the accuracy of photogrammetric models depends on many factors, including the quality of the photographs, the precision of the camera positions, and the processing algorithms employed. Despite these challenges, photogrammetry is a valuable method that has transformed the way we create and study 3D models.

III. Drone Physical Parameters

Drones are all the rage nowadays, being widely used across various industries such as photography, agriculture, and surveillance. Nevertheless, operating a drone without considering its physical parameters like weight, thrust, and power consumption can prove to be very dangerous. These are just a few of the physical parameters that affect a drone's flight characteristics, like speed, agility, and endurance. Grasping these parameters allows drone operators to pinpoint the perfect battery size, propeller type, and motor power required to attain their desired flight objectives.

According to the required needs for the functioning of the drone, the values were calculated to be as follows: -

Sr. No.	Parameter	Value
1	Minimum Thrust per Motor	0.3 kg
2	Average Current Drawn	18 A
3	Average Flight Time	16.7 min

Table 1. Calculated values for the drone

IV. Conversion of 2D Photographs into 3D Models

Photogrammetry is the process of creating 3D models from 2D images. It consists of the following steps: -

1) Collect a series of photographs of the object or scene from different angles and positions.
2) Prepare the images by formatting, aligning, cropping or resizing, adjusting brightness and contrast, and removing distortions.
3) Import the images into photogrammetry software and identify common points in the images manually or through automated software.
4) Generate a point cloud, which is a collection of 3D points representing the object or scene.
5) Use the point cloud to create a mesh, a 3D surface approximating the shape of the object or scene.
6) Apply texture mapping to the mesh by projecting the images onto its surface to create a realistic 3D model.

A. Capturing Images

The key to successfully creating great 3D models through photogrammetry is to capture high-quality images that provide good coverage of the object or scene from multiple angles, with consistent camera settings and lighting conditions. For this we must note these points before capturing images:

1) Use a high-resolution camera: A high-resolution camera is essential for capturing sharp and detailed images that can be used to create an accurate 3D model.
2) Ensure good lighting: Good lighting is important for capturing clear images with proper contrast and color.
3) Capture the scene from multiple angles: Capturing the scene from multiple angles will help ensure that you have good coverage of the object or scene, and will provide more data points for the photogrammetry software to work with.
4) Use a stable camera platform: Using a stable camera platform, such as a tripod or steady surface, will help ensure that your images are sharp and in focus.
5) Use a consistent camera setup: Consistency is important when taking photographs for photogrammetry. Use the same camera settings, including aperture, shutter speed, and ISO, for all of your images.
6) Overlap each image: Overlapping each image by about 60-80% will help the software to identify common points in the images more accurately and create a more detailed 3D model.
7) Avoid blurry images: Blurry images can cause problems for the photogrammetry software and result in a less accurate 3D model. Make sure your images are sharp and in focus.

Fig.1 Reference Photograph of the area

B. Generation of Point Cloud Data

Point cloud data is a 3D representation of an object or scene, consisting of a collection of points that describe its surface. Generating point cloud data in photogrammetry involves identifying common points in multiple images and using these points to triangulate the object or scene's position in space. [6-7]

Point clouds are collections of XYZ coordinates that precisely locate every point within a 3D model. They act as the base for creating more intricate models such as mesh or surface models and have a broad range of applications such as analysis, measurement, and more. Because of the vastness and complexity of point clouds,

ISSN(Online): 2584-1025

specialized software is necessary to manage and process them. With the help of this software, users can accurately manipulate and utilize the data contained within point clouds. In summary, point clouds provide a detailed representation of 3D models, and by using specialized software, they can be leveraged for a wide range of purposes. The generation of point cloud data in photogrammetry is based on triangulation.

Triangulation is a mathematical process that photogrammetry uses to generate point cloud data. This process determines the 3D position of a point in space by analysing its relationship with other known points. In photogrammetry, triangulation is used to calculate the position of common points in multiple images. By triangulating these common points, photogrammetry can create accurate and detailed 3D models of real-world objects. Therefore, triangulation is a critical component of photogrammetry that enables the creation of precise and reliable 3D models.

The software (In this case software used is 3DF Zephyr) identifies these common points by either manual identification or through automated feature detection algorithms. Once the common points

have been identified, the software uses the geometry of the camera lenses and the relative positions of the cameras to triangulate the position of each point in 3D space. By using appearance data from multiple images, the software generates a dense point cloud that accurately represents the surface of the object or scene. [8-10]

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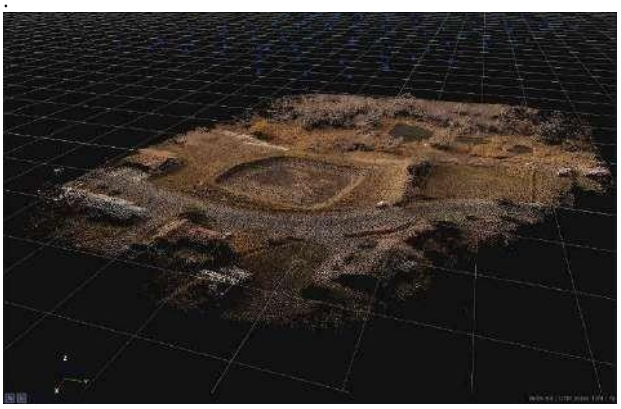

Fig.2 Point cloud data

C. Mesh Creation

In photogrammetry, a mesh refers to a 3D surface model of an object or scene that is created by connecting the points in a point cloud to form a continuous surface.

Mesh creation is an essential aspect of photogrammetry that involves creating a 3D surface model of an object or scene. In the process, a mesh is formed by connecting the points in a point cloud to create a seamless surface. The mesh is made up of a network of triangles that define the surface geometry of the object or scene being scanned. The mesh creation process comprises several steps, including cleaning and processing the point cloud data to eliminate any noise or outliers. The next step involves connecting the points to form a triangular mesh that is then refined and smoothed to create a more accurate representation of the object's surface. While mesh creation can be done manually, specialized software often automates the process. The software provides users with various parameters to adjust the quality and density of the mesh to their desired output. In summary, mesh creation plays a vital role in photogrammetry, converting raw point cloud data into a more usable and visually pleasing 3D model.

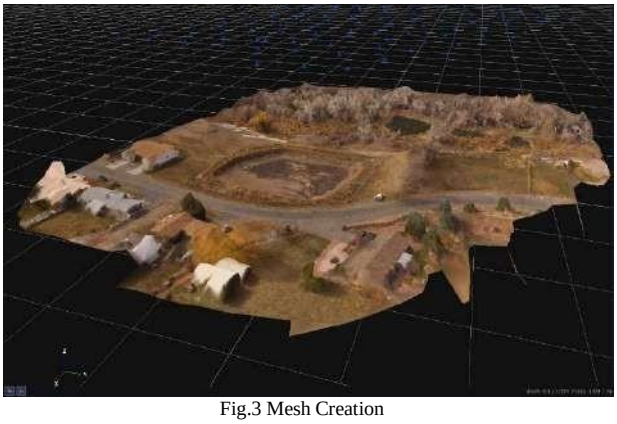

Fig.3 Mesh Creation

D. Texture Mapping

Texture mapping is the process of adding color and texture to a 3D mesh created from photogrammetry.

Texture mapping in photogrammetry involves projecting 2D images onto a 3D mesh model to create a texture map. The process starts by aligning the 2D images with the 3D model through camera calibration, which determines the camera parameters like focal length, lens distortion, and relative position. Then, texture projection is applied to project the images onto the 3D model by determining the position and orientation of the cameras at the time of image capture. After texture projection, a seamless texture map is generated by blending the 2D images together and removing any seams or artifacts.

This results in a single texture map that can be applied to the 3D model to create a realistic and visually appealing representation of the object or scene. Texture mapping is a vital step in photogrammetry as it enhances the visual quality and realism of the 3D model. Specialized software is often used to automate the texture mapping process and enable the user to adjust parameters to control the texture map's quality and resolution. [11-13]

Fig.4 Texture Mapping

V. CREATION OF A PROTOTYPE

Prototyping is an essential step in the product development process that enables designers and engineers to test their ideas before committing to costly and time-consuming production processes. By creating a physical model of a proposed product, they can identify areas where the design needs refinement and improvement. Creating a prototype allows designers to observe and interact with the product in a way that is not possible through mere digital simulations or descriptions. This hands-on experience provides valuable insights into the strengths and weaknesses of the design, which can then be used to refine the product further. For

ISSN(Online): 2584-1025

example, a prototype can reveal issues related to ergonomics, aesthetics, or functionality, which can be addressed in subsequent iterations. Moreover, the prototyping process can also help designers to communicate their ideas more effectively to stakeholders and investors. By providing a tangible representation of the proposed product, it becomes easier to demonstrate its potential value and appeal. [14-15]

A. Materials required

When it comes to the performance and durability of drones, material selection is a critical factor. There are a multitude of reasons why this is the case. Firstly, drones are not bound to a specific environment, which means that they have to be able to handle a broad range of weather conditions and other environmental factors. Secondly, lightweight materials are crucial to maximize flight range and duration, making it necessary for the materials used to have specific characteristics. Lastly, drones are employed for a vast array of purposes, such as agriculture, surveying, and aerial photography, and the quality of the data they gather is reliant on the material properties of their components.

When selecting materials for drones, various factors must be considered. These include weight, strength, stiffness, durability, and corrosion resistance, among others. Carbon fiber, aluminum, titanium, and various types of plastics and composites are some of the commonly used materials in drone construction. [19,20]

Carbon fiber is a top choice for drone frames and components due to its strength, stiffness, and lightweight properties, which make it ideal for flying. Aluminum and titanium are also preferred materials because of their high strength-to-weight ratios and corrosion resistance. Plastics and composites are often utilized due to their ease of manufacturing, affordability, and their ability to be molded into complex shapes, which makes them a great choice for components that require intricate designs.

The materials selected for the creation of the prototype:

1. Drone Frame: - Carbon Fibre
2. Propeller Arm: - Carbon Fibre
3. Propellers: - ABS Plastic

B. Electronic Components

Drones rely heavily on electronic components to function properly. These components are responsible for controlling the flight, capturing data, and communicating with the operator. Without them, drones would be rendered useless. The most crucial electronic components include the flight controller, GPS module, motors, and camera. The flight controller acts as the brain, receiving commands from the operator and transmitting them to the motors. The GPS module provides location data, while the motors control movement. Finally, the camera captures high-quality imagery and video, enabling a broad range of applications, such as aerial photography, surveying, and inspections. [16- 18]

The electronic components used are: -

1. Flight Controller: - Flight Controller is a circuit board with a set of sensors that detect the movement of the drone as well as user commands. Using this data, he can control the speed of the motors to make the craft move as directed. It supports 8 RC channels and 4 serial ports. Therefore, this prototype uses a PIXHAWK PX4 2.4.8 Flight Controller which is a high-performance autopilot on-board module for fixed-wing, multi-rotor, helicopter, or any other robotic platform that can move.
2. Electronic Speed Control (ESC): - The electronic speed controller (ESC) is an important part of the drone flight control system. They regulate the speed of the motors for stable flight, precise motion control and efficient power management. As mentioned earlier, the prototype draws an average of 18 A, so a higher ESC is required and the next available standard was a 30 A ESC.
3. Geo Positioning System (GPS): - Drone GPS modules provide position data for accurate and reliable navigation, precise positioning, and autonomous flight capabilities. Therefore, the prototype uses a new generation of Ublox NEO-M8N GPS, which has low power consumption and high accuracy. The final accuracy reaches 0.6 meters, which is actually close to 0.9 meters, which is larger than the previous generation NEO-7N 1.4 -1.6 American precision.
4. Motors: - Motors provide the necessary lift and propulsion for a drone to fly, enabling it to move and maintain stable flight in the air. The prototype has a 1000kv motor at its disposal.
5. Camera: - For photogrammetric purposes, cameras are an essential element. For the current application, the GoPro camera was chosen because of its light weight of around 150-200 grams, pits ability to record and capture in 4K, and its excellent image stabilization allowing for sharp images even when the prototype moved and wobbled.

Fig.5 Prototype Image

VI. CONCLUSION

The paper provides a compelling argument for using drones instead of traditional methods for land mapping. The traditional method of land mapping is time-consuming, labor-intensive, and inefficient, as it requires extensive human effort to manually measure distances and collect data. In contrast, drones are faster, cheaper, and safer, and can scan large patches of land in a very short amount of time, making them ideal for mapping large areas quickly and efficiently. This is especially useful in areas with difficult terrains, such as mountainous regions, where it can be challenging for humans to measure distances manually.

The paper also discusses how drones can be used for land mapping through the means of photogrammetry which is a technique that uses photographs to create 3D models of an area. The process involves taking a series of overlapping photographs of the area and using specialized software to create a 3D model from these images some of the steps involved in creating the 3D model, being; capturing images, creation of point cloud data, mesh generation, etc.

The paper also describes the creation of a prototype drone for land mapping purposes. The physical parameters and electronic components of the prototype are also discussed, providing a blueprint for the construction of similar drones.

ISSN(Online): 2584-1025

Overall, the paper highlights the advantages of using drones for land mapping purposes, including increased efficiency, cost-effectiveness, and safety. It also explains the process of using photogrammetry to create 3D models and provides a detailed description of the prototype drone.

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MIT UNIVERSITY'S – ABHIVRUDDHI
JOURNAL VOL.3 (01) ,JUNE , 2023 pp- 41-43

ISSN(Online): 2584-1025

Control of Bipod Robot and its stability

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Abstract—**The ideology of biped robotics has a very wide range of application making it a very crucial one. In order to achieve this, the most important factor to take into consideration is its stability. The stability affects the aesthetic structure as well as the systematic functioning of it. The sophisticated robot can also be programmed the alter the speed of motion, direction change and obstacle detection and motion for inclination. Issues can be resolved by the utilizing the concept of Zero Moment Point (ZMP). It is defined as the point at which all of the system's moment and inertia cancel out, or when there is no net moment. Also, the influence of center of mass (CoM) trajectory on biped robot stability was studied in this research. The biped walking robot that receives ankle rotation assistance may have an additional non-performing degree of freedom situated between the toe of the foot and the surface of contact. The biped models under consideration are the revolute and the prismatic one and using the knowledge of kinematics, an inference is drawn in which the superior model will be considered.**

Keywords— crucial, stability, aesthetic, trajectory, revolute, kinematics, moment, inertia.

I. INTRODUCTION

The invention and development of legged motion resulted in a technological revolution in transportation; the most important concept of this motion was bipedalism, which was inspired by humans. Modern bipedal robots are developing to the area of interest in which it could be applicable to substitute mankind in a vast range of jobs performed in surroundings composed only for mankind (such as the usual commercial and factory workplace). Leg movement is distinguished by the availability of numerous collection of surface touch points that result in similar postures. This feature is extremely effective in unusual landscapes because the humanoid body position is less restrained by obstructions (if one collection of surface contact areas is not possible due to an obstacle, after which alternate solution sets are generally possible), as contrasted to wheeled locomotion, which has fixed points of contact that cannot overcome the hindrances. Bipedal robot integrate the adaptability of human movement with a minimal amount of surface touch area (which simplifies the designing of propulsion algorithms) at the price of increased motion

stability challenges.

Biped robots are often investigated with the goal of imitating human-like movement skills while also taking animal biped locomotion [1-3] into account. Human movement is divided into two instances: such as the swing instance as well as double foot supporting instance. Throughout the swinging stage, one foot, known as the balance assistance foot, remains grounded on the surface. Meanwhile, the other leg, known as the balancing leg, swings forward at a speed that is sufficient to keep the user from toppling over. Movement on two feet has a number of challenges, prominent among them being stability.

Static stability necessitates such the bipedal robot must be steady in any static arrangement, and its measurement is solely dependent of the information of position. The related idea is dynamic stability, that demands that the bipedal robot not collapse on the walking surface when displacing without regard for stability at any point of the trajectory. [4,5] Velocity data is also used to calculate dynamic stability.

II. 3-D LIPM AND ZMP

The Linear Inverted Pendulum Model (LIPM) is used to potray the estimated displacement of the bipedal walking robot while stably assisting its structure on its one foot. A 3 - D linear inverted pendulum is such a system in which the inverted pendulum that travels in one plane alone. The physics model may be expressed as follows if the restricted plane is considred as a landscape plane.[6]

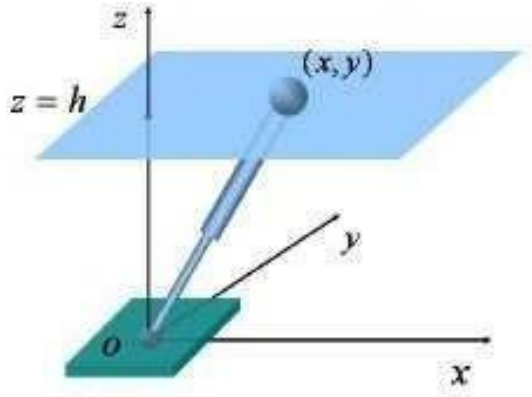

Fig. 1 3-D LIPM

$$\ddot{x} = \frac{g}{h}x + \frac{1}{mh}T_y \quad (1)$$

$$\ddot{y} = \frac{g}{h}y - \frac{1}{mh}T_x \quad (2)$$

Here the gravitational acceleration is considered to be g , the provided vertical height is h, the inverted pendulum has a mass of m, (x, y) as well as (¨x, ¨y) are considered as the location as well as the pendulum's acceleration within the restricted plane, also the _x, _y are x-axis and the y-axis torque respectively.

Another key notion in biped walking is the ZMP. It is designated as the place lying on surface of the earth in which the moments cumulation (which can be considered as the inertia as well as the gravitational force) is a net zero [7].

ISSN(Online): 2584-1025

Bipedal robot may walk in a steady way during which the ZMP lies in the limitation of the elliptic curve of the touchdown area within the leg and the surface of contact; the biped's feet will thoroughly contact the ground. It is especially important for humanoid bipod robots that have touch sensors positioned beneath their feet to be able to adjust their balance by using the input received from such sensor.

Calculating the ZMP in a three-dimensional LIP can be done by,

$$p_x = -\frac{1}{mg}\tau_y \quad (3)$$

$$p_y = \frac{1}{mg}\tau_x \quad (4)$$

where (px, py) are considered as the point of the ZMP. We can rewrite (1) and (2) as,

$$\ddot{x} = \frac{g}{h}(x - p_x) \quad (5)$$

$$\ddot{y} = \frac{g}{h}(y - p_y) \quad (6)$$

To accomplish full walking, the double-support phase might be scheduled in a lower-level planning based on ZMP decisions. Our simple bipedal walking model is as follows:

1) Consider the biped to be a linear inverted pendulum stably assisted with its anyone foot. The robot's combined mass is spread over the Center of Mass, and travels horizontally at a static and fixed height. Inertia's effects are disregarded.

2) The walking process is exclusively made up of single-support periods. Each of the robot's legs serves the stably assisting foot in each motion turn. In theory, one single- assisted moment might quickly move to the adjacent.

3) During the single-assistance moment, we employ a singular ZMP result rather than a ZMP trajectory.

III. CENTER OF MASS (COM)

The information included in the center of mass states plays a crucial part with the management and steadiness of biped robots. The interference, expressed as the modelling fault as well as the acceleration fault, might have a negative impact on the optimization mechanisms. CoM conditions are employed in the standard of steadiness, either directly or indirectly through inertial and gravitational forces.[8-11]

Managing the biped CoM dynamics necessitates knowledge of the CoM states as well as the ZMP trajectory. The ZMP may be determined by utilizing constraint optimization to estimate the reaction forces and their placement.[12] The restrictions are caused by the leg coming into contact, friction, and the support polygon.[13] Process and measurement models are used to estimate CoM states. The perturbation might have a substantial impact on the system.[14] It may be approximated by representing it in the system model as an enhanced step disturbance state.

The position and the displacement speed states of the CoM are estimated.

To estimate the disturbance, the enhanced state approach is applied. Position and force measurements are included in the measuring model. Using accelerometer sensor and feet accelerometer sensor, the interference observation recored is utilized to measure the exterior factors. The ZMP interference observation divides the ZMP fault into the location as well as the acceleration fault focused on band of frequency, but it ignores the CoM states. [15]

The process dynamics of the prediction are formed using the LIPM dynamics as building blocks.

$$\ddot{c}_x = \frac{g}{z_c}(c_x - p_y) \quad (7)$$

$$\ddot{c}_y = \frac{g}{z_c}(c_y - p_x) \quad (8)$$

where c Z is the CoM's constant height. For the sake of simplicity, the subscripts x and y shall be ignored from now on. The following analysis applies to both the x and y dimension.

In an ideal setting, the force "p f" calculates the same p as the force "p".

$$p - c - \frac{z_c}{g}\ddot{c} \quad (9)$$

IV. BIPED MODELS

Both of the kinematic structures under consideration feature two feet also a rigid associating waist. Considering that the disposition of the biped examined within the study is limitedto the sagittal surface, the feet that require that they displace within this surface, and therefore each of these have a smooth surface structure.

The initial structure's kinematics, in which each and every linkages are of the revolving type. Each leg contains three joints (all of which are systematically functioned) that correspond to the humanoid foot: the hip joint, the knee joint, and the ankle joint. A prismatic joint replaces the knee joint in the second construction. [16-18]

The modelling of each structure takes use of a significant notion that they are both sequential chain of kinematic, and therefore typical approaches for the kinematics as well as dynamical structuring of the sequential operators (6-dof sequential operators for each and every structure) may be applied. This process associates the manipulator's base with the assisting foot as well as the manipulator's end-effector with the balancing foot.

The influence as well as the surface response forces are represented as the exterior factors affecting on themanipulator's tip, i.e., the stability assisting foot.

The three joints of the 6R structure have and application to locate and organize the feet, but within the RPRRPR

ISSN(Online): 2584-1025

arrangement, the joint of the knee is solely utilized to place the legs, along with the joint of the ankle primarily employed for leg organization.

As a result, describing an associative disposition for the arrangement of the RPRRPR is less complicated than for structure 6R. [19-21].

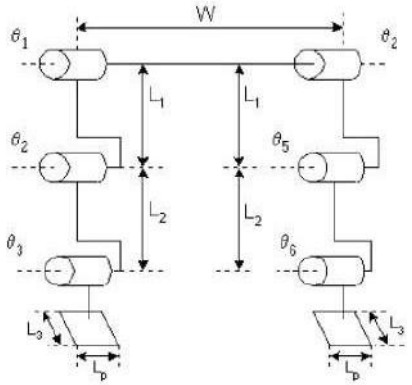

Fig. 1 Revolute Structure (6R)

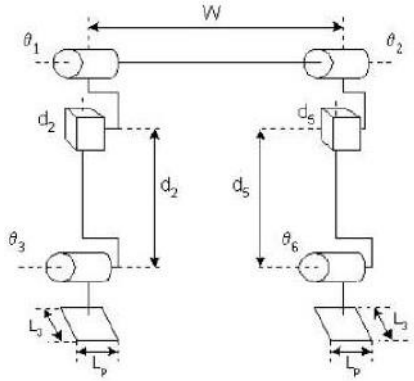

Fig. 2 Prismatic Structure (RRPRRP)

V. CONCLUSION

In this paper, we describe a novel approach for biped walking planning. We discussed the LIP model, the ZMP notion, and a simpler walking method. The control approach of managing the CoM trajectory to achieve a stable walking pattern was explored. Walking pattern generating system based on the notion of changing CoG ahead of time to respond to changes in road conditions as humans walk. Both of the structures that are shown cannot stand on their own because they are statically unstable, despite the fact that they are mechanically straightforward. In order to prevent the robot from toppling over, any maneuvers that are performed when it has just one foot grounded on the surface need to be performed quickly. Because of the rapid pace at which the robot moves, the actuators need to be powerful enough to provide significant torques and forces despite the rapid pace at which they operate. Also, the mobility description for the RPRRPR design is less restricted, with smaller amplitudes of hip and ankle joint motions than the 6R structure. As a result, the prismatic structure is selected for implementation.

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ISSN(Online): 2584-1025

MIT UNIVERSITY'S – ABHIVRUDDHI JOURNAL
VOL.3 (01) , JUNE , 2023 pp- 44-50

Study on Application of AI controllers for speed control of motors

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***Abstract*—Building high-performance motor drives is vital for industrial uses. A high-performance motor drive system must be quick in terms of dynamic speed order monitoring and load regulating. The motor controllers can provide system protection by regulating or limiting torque, protecting against overloads, and safeguarding against mistakes. Many motor controllers include logic for managing applications as well as additional features like data recording and data collecting. The purpose is to study various tuning techniques for motor speed controllers using Artificial intelligence. The controllers such as proportional integral (PI) controller and proportional integral derivative (PID) controller have been considered here. Most frequently used Artificial intelligence (AI) methods such as Artificial Neural Networks (ANN), Fuzzy logic controller (FLC), Genetic Algorithm (GA), Bat Algorithm, Adaptive Tabu Search (ATS), Ant Colony Optimization (ACO), Ziegler and Nichols (ZN) Algorithm areconsidered by their decision-making capability. In the proposed work the rigorous literature review is done for analyzing the performance of AI based controllers. This will help other researchers to understand various aspects of the said controllers, particularly technology involved. In depth review and application of AI controllers are highlighted usingvarious charts and graphs for easy understanding.**

Keywords—AI motor controllers, Fuzzy Logic, PID controller, PI controller, Genetic algorithm, PSO algorithm, Ziegler and Nichols algorithm, Bat algorithm, Adaptive Tabu search algorithm.

I. INTRODUCTION

In our day today activities, we use electrical motor in the various machines, appliances, electric vehicles, large scale industries, medical sector, electric traction, robotics, air-crafts, military equipment, hard disk drive, etc. To get the efficient output from the motor shaft, the speed regulation of the motor must be reliable and robust at various conditions. For speed control of the motors Lately, numerous contemporary management methods have been put forth to regulate the motor's speed. The traditional PID controller, has a straightforward algorithm, that is simple to modify, operates steadily, and is more reliable. The majority of time, conventional PI and PID controllers are used to regulate motor speed. [1,2]. However, the majority of commercial processes use nonlinearities, parameter variations, and unsettled parameters. Due to the difficulty of tuning traditional controllers values under these circumstances, the total system's robustness is reduced.[3]. The effectiveness of the motor is diminishing in the case of the traditional PI controller as a result of rollover. Due tothe saturation effect, rollover is an issue that occurs in traditional PI controllers. Saturation occurs when the processor receives steady input or when there is a significant amount of erroneous input.[4]. Therefore, for the entire system to operate reliably, an advanced control algorithm is required to regulate the motors' speed. These intelligent techniques, however, are more complicated and challenging to execute. [5].

To identify the most applied AI technique for speed control of the motor 40 research papers are studied related to application of AI controllers. Due to straightforward structure, conventional motor controllers or deterministic motor control techniques like PID (Proportional Integral Derivative) controllers are still extensively used. However, in order to use the previously stated controller to its full potential, the system's controller parameters must be precise and accurate (such as tuned Proportional, Integral, Derivative values, back electromotive force constant, armature and field coil impedance and inductance etc.) [6]. Additionally, the reason why traditional controllers, like the PI controller, have limited capability is because their overshoot from the set point is too high. Additionally, sudden changes in load torque and their sensitivity to controller gains Ki and Kp can cause delays in obtaining constant and weak responses. [7]. For the majority of complicated nonlinear systems with indeterminate mathematical analysis, appropriate control strategies can be developed by applying artificial intelligence methods. Smart controllers are preferred because they can be created for any mechanism without the need for a quantitative model, increasing the controller's effectiveness and dependability [8]. Controlling the speed of the motor as per the load requirements is quite a difficult task, but with the use of the right motor controller, getting desired speed requirements becomes easy.

The paper is ordered as following; types of conventional motor controllers in section II. The artificial intelligent controllers are described in section III. The observation and discussion of the study are presented in section IV. Finally, the summary is given in section V.

II. TYPES OF CONTROLLERS

A. Proportional Integral Controller:

The PI controller is currently widely used in commercial applications due to its simple setup, straightforward presentation, and affordable price. The block layout for a proportional-integral (PI) control system is shown in Fig. 1.

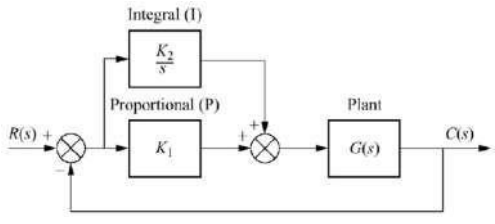

Fig. 1. Block diagram of Proportional Integral controller[7]

ISSN(Online): 2584-1025

The PI controller receives the speed error EN between the motor's real speed N and the standard speed NR, and its proportionate end integral gains are K1 and K2 [9].

$$T = Kp\ e(t) + Ki \int e(t)\ dt \qquad (1)$$

By using the gain Kp, the Proportional controller generates an output that is proportionate to the present error value. When the regulated system is highly complex and unpredictable, the PI controller fails. Integral action must be done in order to maintain the system's functioning. By using proportional action and delayed reaction, this integral mode is used to build steady state defect [9-10]. Almost any operation that could imagine has been controlled by PI-controllers, from aircraft to mobility management, from sluggish to rapid systems [10-11].

B. Proportional Integral Derivative Controller:

PID controllers are employed in a variety of commercial environments. PID controllers are used in closed loop functions in about 95% of the field. Proportional- Integral-Derivative, or PID, is a term. The combination of these three functions results in the production of a control signal [12]. To prevent overshoot and oscillations in the system's output response, the derivative gain component is additionally added to the PI controller within the PID controller. The result is formed by adding three terms— proportional, integral, and derivative terms. The controller provides high stability, no oscillations, quick response times, and 0% steady errors [13,14]. The following equation indicates the basic structure of a PID Control system:

$$y(t)=k_p\ e(t)+k_i \int e(t)+ k_d \frac{de(t)}{dt} \qquad (2)$$

In which u(t) is the control variable, Kp is the proportionate gain, Ki is the integral gain, and Kd is the derivative gain, e(t) is the program error (change in between standard input and the process output) [14]. Although k_p , or the proportional constant, accounts for the error's current value, k_d or the derivative constant, accounts for the error's future value by taking into account its present rate of change. As an integral constant, k_i accounts for the error's past value [15-16]. Fig 2 shows the block diagram of the proportional integral derivative controller.

1) Proportional part: If a deviation is generated, the supervisor will attempt to decrease it using a proportionality link that reflects the deviation signal.

2) Integral component: primarily used to reduce static mistake and increase system reliability.

3) Differential part: can show the deviance signal's change tendency (change rate) and initiate a better preventive adjustment signal before the value of the deviation signal becomes excessive, accelerating system operation and cutting down on modifying time [17].

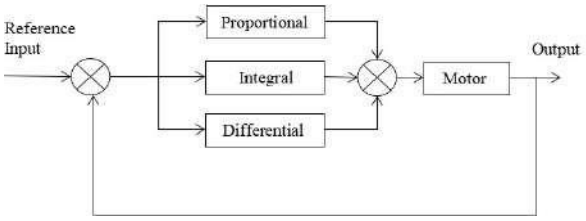

Fig. 2. Block diagram of PID controller [15]

III. ARTIFICIAL INTELLIGENT CONTROL TECHNIQUES

A. Artificial Neural Network:

In a traditional system, an ANN replaces a PI or PID control system. This can be used to export the motor's power, flux, or flux inclination at any moment in the past time or present time [18,19]. Here, the benefits of AI are quickly addressed. Examples include ANNs and fuzzy neural networks. An observed multi-stacked stream forward ANN can be trained using back-propagation (BPA) instruction to estimate the rotor location and rotor inclination. The square of the variance between the expected and real ANN output is reduced by using the back propogation. The real-time programs can make use of the trained ANN [20,21]. An ANN of this type includes concealed levels, an input, and an output. Though it should be noted as a rule that in electronic real apps, the depiction of concealed levels to be used is not recorded in preparation; this must be settled by experimentation. Additionally, the number of concealed elements in the hidden levels is also unknown beforehand and must once again be determined through experimentation and trial and error. The maestro levels for neural networks are shown in Figure 2 [22].

B. Genetic Algorithm:

GA is a technique of random worldwide responsive search algorithm. that is based on the workings of natural selection. In comparison to other optimization approaches, GA has recently come to be acknowledged as an effective and efficient tool for solving optimization issues [23]. Each chromosome in the initial population of the GA represents a different solution to the issue, and a optimization algorithm evaluates its effectiveness. GA's three main stages are evolution, crossing, and classification. These three basic techniques allow for the growth of new individuals who may surpass their forebears. After many iterations, the programme stops when it encounters the characters who best reflect the solution to the issue [24,25]. These more recent characters fare better than their forebears. Each chromosome in the initial population of the GA represents a different solution to the issue. It's employed to enhance the general efficiency of the system as well as other parameters like overshoot, rise time, and settling time. The choice of the goal feature (fitness) constitutes the most important stage [26,27]. Figure 3 displays the Genetic Algorithm Architecture.

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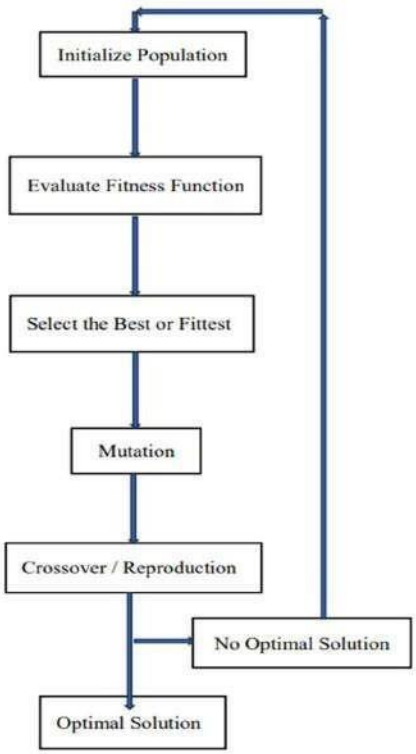

Fig. 3. Genetic Algorithm Flowchart[27]

C. Fuzzy Logic Controller:

The block diagram of the dc motor control system with a basic FLC is shown in Fig. 4. The basic FLC consists of the following four blocks:

- This fuzzy logic generator transforms the incoming data (error and error rate) into appropriate language values.
- The rationale employed in decision-making to choose the best course of action for control.
- The rationale employed in decision-making to choose the best course of action for control.
- Defuzzifier that generates an inferred fuzzy control action's membership function as a non-fuzzy control action [28,29].

Using the Center-of-gravity approach, defuzzification is carried out, and the inferred (numerical) value of the

$$u = \frac{\sum mi\ Ti}{\sum Ti}$$

where Ti is the corresponding degree of fulfilment and mi are the singletons.The regulated voltage supply, which transforms the incoming signal into an equal voltage to control the motor speed, is fed its output from the Fuzzy controller as its input [30,31]. The action of the flexible system frequency reaction is first studied to make it easier to incorporate knowledge and expertise into fuzzy control algorithms [32].

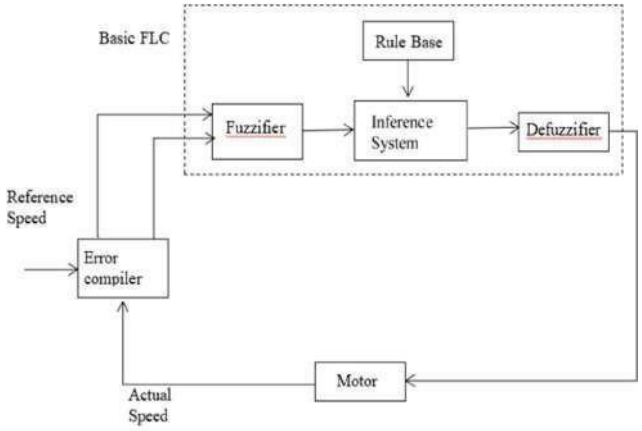

Fig. 4. Basic Function of Fuzzy Logic Controller [32]

D. Ziegler Nichols Method:

There are many approaches to adjust a PID and PI cycle. The most efficient techniques typically involve the creation of some type of system design, then P, I, and D are chosen according to the features of the dynamical system. especially if the circuits' response times are several minutes or greater, manual tuning techniques may not be adequate [33]. Ziegler and Nichols provided the finest PID controller tuning approach, which is now regarded as industry standard procedure in the field of control systems. Both methods make previous assertions about the system model, but they don't demand that these models be known in particular. Plant step reactions serve as the foundation for the Ziegler-Nichols equations used to define the controllers [34]. Tuning a controller means adjusting the gain setting to the correct amount. Any system's efficiency can be increased with the correct controller setting. If the gain settings of a controller are set at an incorrect number, the control signal deteriorates and becomes unreliable. As a result, appropriate controller tuning is required to obtain the intended result [34].

E. Adaptive Tabu Search:

The updated form of the Tabu Search is called the adaptive tabu search, or ATS. The ATS was introduced in 2004 and is based on an iterative neighbourhood search strategy. The ATS search process starts with a few early answers that are randomly selected and fall into a neighbourhood search space. Every answer in the local search area will be assessed using the objective function [35]. The answer providing the lowest goal cost is retained in the tabu list and set as the new starting point of the following search round (TL). The process flow of ATS is shown in Fig. 5.

The basis of ATS is a live neighbourhood search methodology for nonlinear and complex issues. The adjustable radius (AR) and backtracking are ATS methods (BT). AR technique is heavily used in the ATS search process to hasten it. The BT device can also be used to getout from under nearby obstacles [36,37]. One crucial component of this technique is the Tabu collection, which is used to keep track of resolution behavior and take a different course that can avoid a minimum error hazard. The ATS technique also includes two extra methods to improve convergence: retracing and responsive search range.

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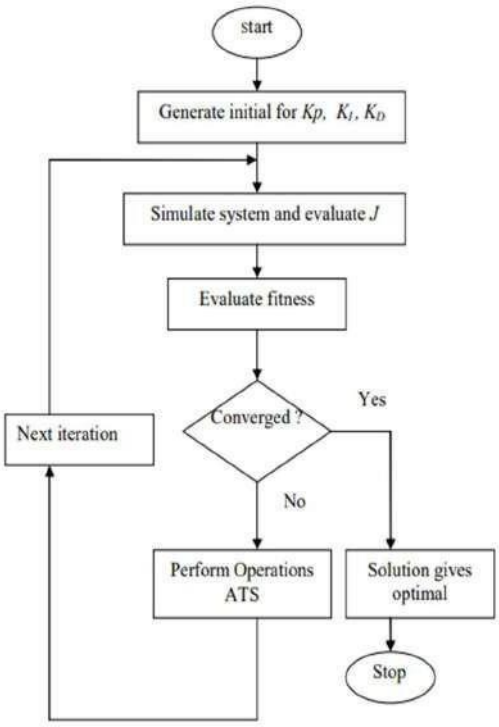

Fig. 5. Flowchart of Adaptive Tabu Search [37]

F. Bat Algorithm :

The echolocation technique used by bats is known as the bat algorithm. These bats use echolocation to produce a very high sound pulse and pay attention to the echo that is reflected back from nearby items. Species differences affect the transmission band-width of these organisms. Frequency, volume, and pulse release rate are all components of each sound pulse [38]. While the remainder use fixed-frequency signals, the majority of bats use signals with adjusting frequencies. These animals operate in the 25 kHz to 150 kHz frequency band. The following factors form the basis of the bat algorithm: echolocation, which all bats use, and the ability to tell a target from an obstacle. Bats travel at arbitrary speeds, in random places, and with varying frequencies, decibel levels, and pulse emission rates [39- 44].

G. Ant Colony Optimization :

The theory behind Ant Colony Optimization is that ants can locate the quickest route from their home to a food location. In 1992, Marco Dorigo created the very first Ant Colony Optimization device. Both the cubic distribution issue and the roaming marketer challenge were addressed using ACO. Due to their innovative idea, ant strategies have received extensive study over the recent few years, and their uses have been expanded to include inflation issues, network invasion, information extraction, etc [40]. ACO has several benefits over other optimization methods, including appropriated computation, a positive responses mechanism, optimistic scanning, and improved extensibility. Its drawbacks include a bottleneck and a lengthy scanning duration. However, the symmetry can somewhat compensate for these drawbacks [45-49].

IV. Discussion

From the study of the mentioned AI controllers it isobserved that all the Artificial controllers are robust and perform with high accuracy for the speed control of the motors. The AI control techniques and their hybridization with conventional controllers and the application for different motors are mentioned in the TABLE I.

TABLE I. Application of AI controllers for speed control

Sr. No.	*Name of the Technique*	*PID*	*PI*	*AC motor*	*DC motor*
1	Genetic Algorithm	4	2	2	5
2	Particle swarm optimization	3	0	0	3
3	Adaptive Tabu Search	2	0	0	3
4	Ziegler and Nichols	3	2	0	4
5	Bat Algorithm	1	1	0	2
6	Ant Colony Algorithm	2	0	0	3
7	Artificial Neural Network	2	1	4	3
8	Fuzzy Logic	5	8	7	10

A. AI Application on PID Controller:

The application of AI techniques for controlling speed of the motors have shown in the pie charts and bar graph below. From the pie chart Fig 6, it is observed that, most ofthe research has been done on the Fuzzy Logic PID Controller and Artificial neural network controller. Implementation on these AI techniques is much easier than the rest of the mentioned AI techniques.

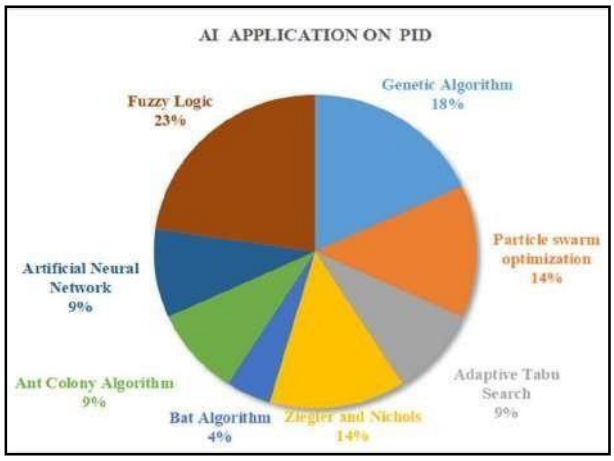

Fig. 6. AI applications on PID controller

Due to which more research is done on the Fuzzy logic PID controller and Artificial neural network PIDcontroller.
The new hybrid AI methodologies are compared with conventional Ziegler & Nichols tuning method. And by

ISSN(Online): 2584-1025

the comparison table it is shown that new hybrid AI techniques are much efficient and widely used in speed control of motor application.

B. AI Application on PI Controller:

By studying research on various AI techniques, it is observed that, most of the research has been done on the Fuzzy Logic PI Controller and genetic algorithm based controller. Implementation of these AI techniques is much easier than the rest of the mentioned AI techniques. Due to which more research is done on the Fuzzy logic and Artificial neural network techniques. The new hybrid AI methodologies are compared with conventional PI controller. And by the comparison, it is shown that new hybrid AI techniques are much efficient and results zero steady state error. The AI techniques like Firefly Algorithm, Bat Algorithm, Ant colony Algorithm are used less because of their complex structure as well as complication in implementation. Tuning of PI controller by these AI techniques is not as simple as PID controller because of the output parameters. Therefore there are less papers available on Bat algorithm, Firefly and Ant colony algorithm. The application of AI techniques and research papers availability is shown by the pie chart diagram in Fig. 7.

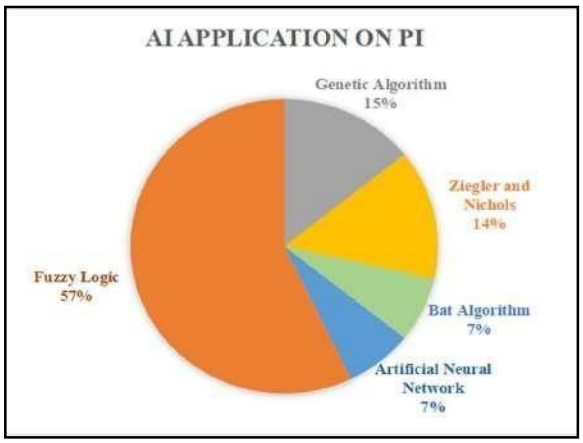

Fig. 7. AI applications on PI controller

All the AI methodologies are applicable on different motors as shown in Fig. 8. The bar chart shows that mainly most of the research of AI speed control techniques are done on the DC motors because of its robustness and ease of implementation. The AI methodologies discussed are mostly applied on the DC motors. The use of DC motors is much wider in various small day today applications. The use of AC motors is mainly applicable for industries and heavy duty operations. Therefore, the speed controlmethodologies are mostly experimented on DC motors.

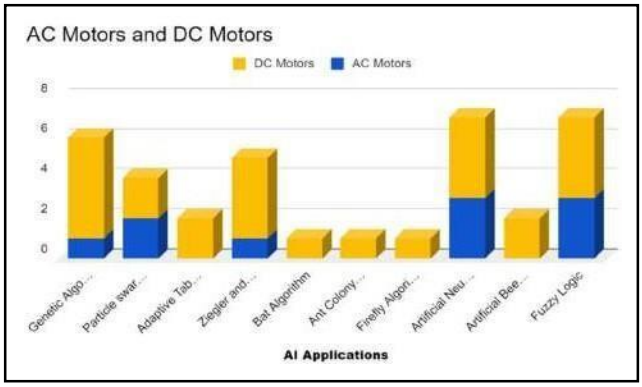

Fig. 8. AI applications on AC Motors and DC Motors

In TABLE II. letter 'Y' indicates consideration of that particular methodology.

On the basis of study of the research papers available on AI techniques for speed control of motors. The research done is classified by the year of research published with the author's name and on which specific AI technique the experiment is done with particular motor used forexperiment is mentioned. As per the information gathered in the table, it is observed that the research done on Fuzzy logic and genetic algorithm on DC motor is more than the research done on rest of the AI techniques and on AC motors. In case of the research on tuning method for PID controllers, the most conventional Ziegler & Nichols technique is utilized for the comparison purpose. All other AI techniques results significant rather than the conventional control technique. In some of the researches AI tuning techniques are directly applied on the motor input parameters.

TABLE II. APPLICATION OF AI TECHNIQUES ON MOTOR CONTROLLERS FOR SPEED CONTROL

Public-ation year	***Author***	***AI Control Techniques***								***Controllers***		***Motors***	
		GA	***PSO***	***ATS***	***ZN***	***Bat Algorithm***	***ACA***	***ANN***	***Fuzzy Logic***	***PID***	***PI***	***AC motor***	***DC motor***
2009	Yang. Yi							Y				Y	
2009	K. Ang, G. Chong									Y			Y
2010	Changliang Xia						Y		Y				Y
2010	Atef Saleh Othman									Y			Y
2010	Adel A. A. El-Gammal		Y							Y			Y
2011	Hassan. M. Kamel								Y		Y	Y	
2011	Mohanasundaram K.								Y		Y	Y	
2012	E. Daryabeigi									Y			Y
2012	J. L. F. Daya								Y		Y	Y	
2012	Tan Chee Siong								Y		Y		Y
2013	Rohit G. Kanojiya				Y					Y	Y		Y
2013	H. Aloui								Y			Y	
2013	Walaa M. Elsrogy							Y	Y	Y			Y

ISSN(Online): 2584-1025

2013	Yogesh Mohan								Y		Y		Y
2014	Dhivya.N.M							Y				Y	
2014	S. Mishra							Y			Y	Y	
2014	Amir Ahmed	Y							Y				Y
2014	Ch. Bhanu Prakash	Y								Y			Y
2015	Pranoti K. Khanke								Y		Y		Y
2015	Olivier Munyaneza								Y	Y			
2015	K. Premkumar		Y			Y			Y	Y			Y
2016	Sajid Ali Bhatti				Y						Y		Y
2016	Essamudin A. Ebrahim						Y			Y			Y
2017	Sushma J Patil								Y		Y	Y	
2017	Ansar Rizal							Y					Y
2017	Meena D. K.	Y			Y					Y			Y
2017	Yasser Ali Almatheel								Y	Y			Y
2017	P. Suganthi								Y	Y			Y
2017	Thanet Ketthong			Y						Y			Y
2018	Abasin Ulasyar									Y			Y
2018	S.Sakunthala							Y	Y			Y	
2018	Gamze Demir	Y									Y	Y	
2019	Archana Mamadapur							Y		Y			Y
2019	Vishal Verma									Y	Y		Y
2019	Era Purwanto	Y										Y	
2019	Amer Mohammad Jarjees			Y					Y				Y
2019	Manoon Boonpramuk1	Y		Y	Y					Y			Y
2020	S. Balamurugan									Y			Y
2020	Kiran Gadekar									Y	Y		Y
2020	Paliwal D.					Y					Y		Y
2022	Sandeep Yadav	Y	Y				Y			Y			Y

CONCLUSION

In this study, research papers on 'AI techniques for speed control of the motors' are considered for the identificationof robust and easily applicable methodology for speed control of the motors. On the basis of the study we can say that, most applied AI techniques for the speed control of the motors are fuzzy logic and Genetic Algorithm. From the all studied research papers, for PID controller there are 23 percent papers available on fuzzy logic and 18 percent on genetic algorithm. Which are major among all the AI techniques. For PI controller, 57 and 15 percent papers are available on fuzzy logic and genetic algorithm respectively. The aforementioned AI techniques are mostly applied on the PID controller than the PI controller. As well as the implementation is mainly done on the DC motors rather than the AC motors. In future, more combinations of theseAI techniques can be used to control speed of the motors in much efficient way.

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ISSN(Online): 2584-1025

MIT UNIVERSITY'S – ABHIVRUDDHI JOURNAL

VOL.3 (01) , JUNE , 2023 pp- 51- 57

A Review on Involvement of AI, RPA and IoT in Human Resource Management

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***Abstract*— By definition, Human Resource Management(HRM) is the strategic approach to effectively and efficiently managing people in a company or organization. HRM involvestasks like recruitment, training, and development, managing company culture, managing employee benefits, salary processes, attendance records, data maintenance, exit formalities, etc. From the start of HRM, the work was mainly paperwork, which is being digitized in this digital era. In this paper, technologies like AI (Artificial Intelligence), RPA (Robot Process Automation), and IoT(Internet of Things) are reviewed. These technologies help HRM departments and HR (Human Resources) individuals in several ways to improve the services involved in it. The primary purpose of the present research is to investigate the ways in which HR practices are being influenced by technological advancements. Taking into account earlier study investigations and evaluating both the prospective benefits and drawbacks of utilizing these systems, one arrives at the conclusion that this technology is very recent.**

Keywords— Human Resource Management, Artificial Intelligence, Automation, Robotic Process Automation, Internet of Things.

I. INTRODUCTION

The oversight of the human resources department is a role in organisations that strives to maximise the performance of employees in helping to achieve the corporate objectives of the company they work for. This role is frequently referred to as human resource management (HRM) or just HR for short. Human resources is largely concerned with the management of people inside organisations, with a particular emphasis on policies and procedures. In most businesses, the Human Resources (HR) department or unit is responsible for a variety of tasks, some of the most common of which include employee recruiting, training and development, performance evaluation, and awards. Industrial relations also fall within the purview of HR. l [1].

Human resource management (HRM) maximises employee performance to meet the company's strategic goals. HRM in changing organizations, 2009. HR is primarily focused on policies and mechanisms that govern how people are handled within firms. HR departments and units are often in charge of a variety of tasks, such as hiring new employees, providing them with training and development, evaluating their performance, and providing awards. Industrial relations or the balance of organizational practices with rules resulting from collective bargaining and governmental laws is another area of HR that is of interest. The goal of human resource management, also known as HR or just HR, is to maximize employee performance in support of the strategic goals of the company. 2009 study on HRM in evolving organizational situations. HR is primarily focused on policies and mechanisms that govern how people are handled within firms [2]. HR departments and units are often in charge of a variety of tasks, such as hiring new employees, providing them with training and development, evaluating their performance, and providing awards. [3].

However, there has been relatively little research done on its effectiveness, and the majority of the research that has been done thus far has not examined the degree to which these new platforms assist businesses in achieving their HR goals of attracting, motivating, and retaining workers. The fact that current systems have a variety of problems, such as the fact that they primarily rely on one-way communication, are impersonal and passive, rarely permit an interpersonal connection, and usually create an unnatural barrier between people and organizations, is one reason for this. Another reason for this is that technological advancements have made it possible for individuals to communicate with each other in multiple ways. [4].

II. ROLE OF HR

Documentation, hiring, screening, training, relations with employees, and remuneration are all topics included in normal HR programs. Despite the fact that each of these programs comprises a variety of HR-related activities, these activities can be categorized into three basic categories: transnational, conventional, and revolutionary. HR personnel makes sure that the company employee is having high productivity so they can help companies to achieve their goals. And in this process employees get the benefits that companies have set aside for them. HR personnel deals with onboarding when more workforce is needed while doing so, they have to evaluate and assess the right candidate for the vacant position. In a bad time of a company where management decides to lay off some workforce for cost-cutting or whatever the reason might be HR personnel has to deal with the procedure of letting go of employees [5].

Large-scale management of organizational leadership and culture falls under the purview of HR. HR frequently oversees health, safety, and security in addition to making sure that local labour and employment laws are followed. When workers seek and are able to legally hold a collective bargaining agreement, HR frequently serves as the company's main point of contact with the employee representatives. In order to advance its objectives, HR thus participates in lobbying actions with governmental organizations, usually through representatives. The field may also deal with mobility, especially in relation to expatriates, and it frequently takes part in merger and

ISSN(Online): 2584-1025

acquisition activity. HR is typically viewed as a business support role that reduces risks and expenses [6].

III. AI IN HUMAN RESOURCE MANAGEMENT

In order to successfully transition HR operations into the digital age, AI is absolutely necessary. Certain activities, such as training, development, and organisation, will be increasingly vital to adapt to these changes that have occurred internally with certain activities and workers, particularly owners' simple skills and regular work. This is because certain activities and employees may be dispensed with, such as certain activities and employees. There is no question that the rising usage of technology and information within the organisation has dramatically altered the kinds of business you need to be successful in as well as the abilities you need to have. The application of artificial intelligence (AI) in the field of human resources can be helpful in a number of areas, including the recruitment and retention of employees, the reduction of the workload of shared service centres and help desks by addressing typical enquiries, and the reduction of the amount of time that HR specialists spend on administrative tasks. [7-10].

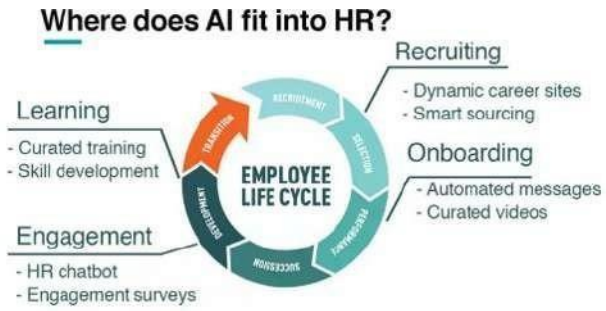

Fig:- 1 [7]

Between 2000 and 2018 on numerous HR subjects using AI, they discovered that until roughly 2006 or 2007, very little research had been done in HRM. These themes included management, team estimation, training, turnover, employability, etc. The use of AI in management proceeded around the first half of 2010, and from then on, the research centered on its use in hiring [11].

An AI system can help with administrative tasks including providing IDs, granting access requests, and organizing first meetings for new hires. It can also verify documentation, manage orientation programs, manage orientation sessions, and manage orientation meetings. Training and development is another area where AI will have a profound effect on HR. In all industries, improving one's skills is a key strategy for remaining competitive. Enhancing your employees' skill sets through training and development is a terrific idea. AI tools can be used to construct training and development plans that are unique to each individual. Consider providing different employees with varying levels of training modules based on their skill levels, employment status, and requirements. Additionally, these AI systems can make it easier to discover resources internally by connecting new projects with employees who have enhanced their abilities or completed a required course. The degree of engagement that a person has in their work can be significantly improved through the use of recognition and incentives. A motivated employee is one that is not only more productive but also more self-reliant in their work. When it involves incentives and honour, there are a few factors that are necessary, and they include the following: the benefits need to be promptly, they need to be comprehensive, and they need to be consistently.

Zomato is a meal delivery business that works with other delivery companies to offer them with an artificial intelligence system that encourages them to make more deliveries. The system rewards delivery partners with financial incentives after they have completed a predetermined threshold of deliveries.A sizeable portion of each workday is devoted by HR staff members to fielding inquiries. When performance reviews are carried out, a great number of additional questions pertaining to the completion of assessment forms, the submission of work, and the filing of complaints are posed. [12]

These fundamental questions can be answered by AI tools, which may result in a reduction in the volume of messages sent via chat and email that a person must process each day. In addition, AI may assist with the administrative chores of a corporation. Some examples of these are the handling of employee paperwork, the generation and updating of organisational terms and conditions, the updating of employee information in the internal database, and the verification of legal compliance. Depending on the kinds of adaptations that are required, AI may be able to take over some, most, or all of these jobs. AI tools have the potential to assist in decision- making, but not entirely, through the use of methods such as conducting surveys, gathering feedback, and a variety of business-related statistics, such as performance, engagement, and potential areas for improvement. Individuals working in HR are able to base their decisions on the information offered by AI tools. [13-14].

There are many different applications for AI in HRM, some of which include recruitment, personnel acquisition, performance evaluation, and compensation. There are several establishments that use artificial intelligence to screen the thousands of applications they receive, which makes the hiring process far easier and more cost-effective forenterprises. Additionally, it is especially beneficial when picking the most qualified individual to fill a post. An advantage over the competition can be achieved by a business in a service-based economy, in which people are the most valuable resource a company possesses, by using decision assistance to select the best employees. Artificial intelligence (AI) systems are able to "predict" and "learn" statistically by drawing curves that indicate prospective outcomes and then make decisions that are optimized for a range of parameters. As a result, it is possible that AI will eventually develop a system that "predicts" a candidate's performance on the job based on all pertinent demographic data, employment history, and interview questions. When looking for new personnel, it is no longer essential to spend countless man-hours searching through tens of thousands of applications and online job profiles. [15-16]

A firm that offers services related to AI recruiting has stated that the amount of time required for the hiring process may be

ISSN(Online): 2584-1025

cut down to nine days using the AI candidate sourcing algorithm that it has developed. Previously, the procedure required 34 days. The efficiency of candidate sourcing and onboarding have both seen considerable improvements as a result of the implementation of a non-biased strategy that removes the need for assumptions throughout the sourcing process and discovers individuals who are technicallyqualified for the post. The application of AI also enables the automation of the candidate screening process. This advanced method makes it possible to collect significantly more data from online sources, such as social media accounts, online career records from the past, and school credentials, which in turn improves the ranking system of prospects from which recruiters can choose. [17].

Companies that want to save money on hiring expenses, improve access to talent, shorten response times, and enhance candidates' impressions of the organisation may choose to implement an electronic recruiting platform. Proponents of this strategy assert that automatic matching between job offers and suitable candidate profiles offers a number of benefits, including reduced effort (in terms of cost and time) and the elimination of the requirement that HR professionals have knowledge pertaining to However, despite the fact that the shift towards the use of information technology for electronic recruitment has altered the process of employee hiring and retention, there are a number of obstacles that prevent it from being fully effective. [18].

Over the years due to the digitalization of job information, including information from candidates to employer and employer to candidates is easily available it has resulted in a reduction of cost and inconvenience of matching jobs. With this applications from interested candidates have increased exponentially. To be able to deal with the assessment of a lot of data could be expensive and inefficient for humans but, AI has been proven more efficient over past decades than humans. fairness can become a determinant of AI adaption. this paper consists of 21 interviews from different backgrounds and ages. It demonstrates that the pre-selection of promising talents is where the use of AI in recruiting is most widely acknowledged.

There are some factors that contribute to fairness that are The level of perceived fairness increases with the degree of diversity, ethical aspects considered, the degree to which people think AI makes fair decisions and reduces discrimination, and the degree to which decisions made using AI are understandable increases or decreases the degree of fairness of AI in hiring. HR leaders and practitioners need to have a comprehensive understanding of how decisions are made. Making sure that employees trust the new technology will depend on this openness For instance, according to a Deloitte survey of senior executives, 72% of them believe that AI in hiring is essential, but just 31% believe that their companies are set up to take advantage of the potential [19].

The term "artificial intelligence" refers to a technology that, in some contexts, can perform as well as or even better than the brain of a human being. When the efficiency of automation the process for hiring was compared to that of conventional recruiting processes, businesses took note of the former and took steps to implement it. Now that growth is being pursued, the recruiting sector is integrating intelligent techniques to recruit, specifically through the use of artificial intelligence. Because it enables the recruiter to align all unstructured candidate biodata, develop profiles into uniformity, and discover and match skill sets required for the sector, artificial intelligence technology is of significant assistance in the recruitment process. [20].

Specialised artificial intelligence (AI) systems are evolving at an impressive pace in a variety of industries, including health care, automobile manufacturing, online communities, advertising, and sales. While overall-purpose AI continues to be some way off in every field of human endeavour, AI as a whole is nevertheless in its infancy. Concerns relating to the administration of the workforce have led to a lot fewer headway. We offer the following causes for this phenomenon: the complexities of HR, the limited data available from the HR department, equitable and legal constraints, and the responses of employees to AI administration. [21].

Candidates who participate in AI-enabled recruiting may be influenced in their decision-making by a variety of factors, including online communities, intrinsic perks, equal opportunity, and trendy on the side of potential employment. 89% of people who are looking for work say that their mobile devices are the most important resource they have while doing so, and 45% of those people indicate that they use their mobile devices to look for work at least once each day. However, just 16% of applications are submitted via mobile devices.

Push notifications will encourage candidates to engage and complete AI-enabled job application processes on their mobile devices in order to increase that number and AI- enabled advertising. Job seekers could easily anticipate the intrinsic advantages of participating in a social media job application process using artificial intelligence (AI) without regard to any practical consequences, such as landing a job through an AI-enabled hiring procedure. Candidates will be more engaged and more likely to finish a digital, AI-enabled job application process if they perceive it as intrinsically satisfying. The issue is that HR sees AI-enabled recruiters as a threat to their jobs, yet instead of being a threat, AI-enabled recruiters will allow HR to pivot into their higher-value activities. When enterprises carry out recruiting AI was used for evaluating applications. The enhanced efficiency brought about by AI in recruiting was clear, however, opinions on the accuracy of applicant evaluations were divided. More than 50% of those surveyed who had not yet used technology or who planned to do so in future either disagreed with an evaluation of the application or had no opinion on it, there was a lack of trust shown in AI’s capabilities for evaluation [22].

IV. RPA IN HUMAN RESOURCE MANAGEMENT

Transactional activities are daily activities that largely concern record keeping. Examples include entering payroll data, monitoring changes to an employee's status, and overseeing benefits administration. Traditional HR programs including planning, hiring, selecting, training, compensating, and managing performance. These activities may have strategic value for the organization if the results or outputs align with the organization's strategic objectives. Organizational or cultural change, structural realignment,

ISSN(Online): 2584-1025

strategic reorientation, and increased creativity are examples of transformational actions that offer value to the organization. [15].

Robotic process automation is being used to transform HR procedures in small and medium-sized businesses (SMEs) enhancing competitiveness in the digital era. An evaluation of the HRM department's present manual, paper-based processes are required to assess whether or not RPA can be used to improve them. Adding automation to operations is a significant barrier for many SMEs. The order in which RPA could be used to automate various processes and sub- processes, as well as which ones to automate first, can proveto be a significant problem for HR departments of SMEs. RPA deployment is dependent on the RPA platform being utilized; therefore it might be challenging to select the best RPA platform for the HR department. The type of papers being analyzed whether they are scanned or created, with or without graphics, etc. must be taken into account while establishing an RPA-based solution for documentation. Processing data that has been wrongly extracted might frequently take a long time. RPA can be regarded as a feasible option for streamlining HR procedures, which can quickly increase a business's overall value even though some HR processes still need human intervention to fix extraction problems [15].

A pilot implementation of RPA in an enterprise is carried out to gather information about how RPA can be implemented in an enterprise and how it affects employee productivity although it remained in the initial phase and could not be implemented in live operations. But this study has presented some benefits like when human resources are overused or when the HR department is unable to manage onboarding or training on time, the organization may leverage this robotic capability. The very repetitive jobs, which are still carried out by humans and may lead to burnout and other workplace problems, provide another enormous area of opportunity. This might be done by robots, and since work-life balance is popular right now, it might be advertised as a perk for employees [16].

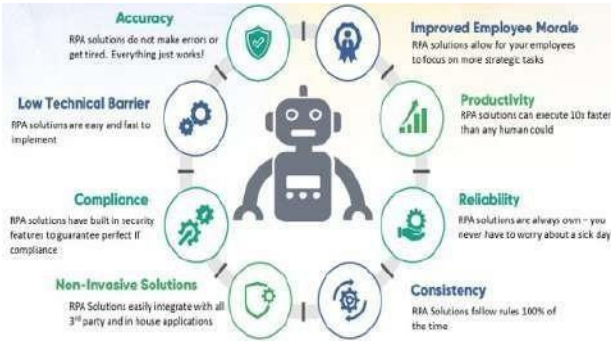

Fig:2 RPA benefits [14].

The use of RPA in HR procedures has enormous potential. It can facilitate the automation of numerous common HR operations, including the onboarding and offboarding of employees, updating employee information, the procedure for timesheet submission, and many other similar duties. this study gives a structured approach in implementing RPA which involves 6 stages. Stage 1 involves assessing the RPA product, identifying processes that should be automated, and creating a business case for RPA implementation. The second stage involves resource allocation and approval. The third step entails creating the RPA structure and putting together the team to implement it, with an emphasis on developing internal capabilities and self-sufficiency as soon as is practical. It also involves team training for all participants. The fourth stage involves testing the four automated processes, communicating the test results to management, emphasizing the advantages of RPA, and addressing concerns about job loss. In stage 5, six more processes are automated, offering all employees advanced training. Stage 6 is concerned with ongoing development [17]. Chronologically growth from year 1998 to th recent year is shown in Table-1.

V. IOT IN HUMAN RESOURCE MANAGEMENT

In recent years, IoT is revolutionizing the industry by connecting everything to the internet and the HR department is no exception to it. IoT wearable devices are helping enterprises to gather data about their employees about their physical health, mental health, and productivity, IoT sensors also help in the training and evaluation of an employee.

The application of IoT in HRM necessitates changes to HR technology (hardware, software, and data), HR activities including flexible work schedules, performance improvement, and customised work environments, as well as HR actors (tasks and qualifications) With the aid of employee self- service (ESS) technology, staff members can manage their own data without the assistance of HR specialists and registerfor training with the goal of increasing productivity. Electronic performance monitoring may change a number of HR processes, including evaluation, recruitment, and training. There are currently electronic records of prescription administration, call and internet monitoring, and other typical EPM forms in use. However, it is becoming more and more common to state that technology like body heat sensor desk hardware and microchip wrist implants may be the future of job monitoring [23].

The usage of wearable IoT in the workplace; these devices collect information on employees' food, sleep, pulse location, and other habits. This information helps companies and people increase productivity at work. It also helps companies keep track of employees' health in real-time .With the use of IoT wearables, there are some concerns present, even though wearables are useful for tracking attendance. It also calls into question the privacy of the workforce. HR should have a company policy about IoT, or there should be laws.

Learning management systems can deliver training in real time if sensors identify employee qualification gaps. Real- time delivery of the relevant training measures is required. Delays and interruptions are reduced if a device can measure typing speed of an employee and that employee is better at typing than receiving calls for example then [19]. This study tries to systematize the academic contributions made thus far and to make clear the uniqueness of Big Data, its implications and difficulties for HRM practice, and the primary contributors within HR practice systems. Big Data will contribute to a more diverse talent pool from which to recruit potential future employees [24]. No matter where an employee is located, IoT devices like smartphones can be utilized to solicit their innovative thoughts and proposals. Employers are using fitness trackers to monitor employee

ISSN(Online): 2584-1025

health, which might provide a company with important employee data that could be utilized to create customized policies. For the objective of increasing efficiency, location trackers monitor the employees' movements and locations. The Microsoft HoloLens and other virtual reality and augmented reality tools aid in the evaluation of applicants by placing interviewees in a simulated setting to gauge how they would behave there.

VI. CASE STUDY

There were two different case studies in the articles that were examined. The first case study focuses on the application of RPA to a business process. This particular case study was carried out on a business process outsourcing (BPO) provider company in Bogotá, Colombia. As a result of the fact that RPA was identified by a number of analysts as one of the new technologies that not only threatens conventional process outsourcing but also presents an opportunity for this sector, this BPO company initially began by testing and prototyping this automation technology on a number of its customer's business procedures. The use case was tested on a procedure involving the creation of a payment receipt. Participants in this operation were split into two groups: those with RPA and those without RPA. One group was responsible for carrying out the operation. In the group that did not utilise robotic process automation (RPA), there were both front- and back-office agents; in the group that did use RPA, however, there were only front-office agents because the robot took care of the back-office tasks. The length of time spent on each case and an agent's overall productivity were the metrics that were utilised in the process of analysing the results. These metrics were calculated for each agent by tallying the number of cases they worked on throughout the time period being evaluated. The conclusion reached after conducting the test for a week.

When productivity was determined by the number of cases that were worked on by each agent, the group that utilised RPA was able to work on 21% more cases than the group that utilised traditional methods. On the other hand, it was discovered that the RPA group experienced a mean case duration that was just 9 seconds less than the control group experienced. The fundamental reason for this is that some people with a lot of expertise might finish mundane back- office tasks very rapidly, even more swiftly than software robots that simulate human behaviour. [25-28]

The second case study is an interview-based investigation of the application of AI in the field of human resources (HR). The research consisted of a series of surveys that included both open-ended and closed-ended questions. The research addresses ten different questions. According to the findings of the research, interviewees would rather speak with real people than a computer throughout the interviewing process. When questioned about the influence that AI will have on their job, 32% of respondents said it will have a significant impact, 37% said it will have some impact, 20% said it will have little impact, and 10.8% said it will have no impact at all. A total of 72 percent of respondents believe that AI will make recruiting cheaper in the future, while the remaining respondents do not believe it will make any impact. When asked whether they believe AI will totally replace HR positions, 33.8 percent of respondents responded that it will, while 53.8 percent of respondents felt that it will not completely replace HR jobs.

12.4 percent of people were unsure. About 55.4% of respondents indicated that they had trust difficulties regarding the application of AI, whereas 40% of respondents stated that they do not have any trust issues.

TABLE I. CHART FOR YERARWISE TECHNOLOGY USED AND WORK DISTRIBUTION

Ref. No.	**Year**	**Technologies used**				**Work contribution**
		AI	**RPA**	**IoT**	**HRM**	
[1]	1998				√	This paper presents a definition and work of HR individuals.
[2]	2009				√	Discussion on the role of HR individuals.
[3]	2021		√			This study collected data on how robotic process automation (RPA) is being utilised to improve human resource (HR) procedures in medium-sized organisations (SMEs) and increase technological competitive.
[4]	2019				√	Discussion about various technology and their impact on HRM.
[5]	2019				√	The authors have described HR activities.
[6]	2019	√				AI technology helps recruiters align unorganised applicant biodata, generate standardised the profiles, and find and connect industrial competencies, which greatly impacts the recruitment procedure.
[7]	2020	√				The use of AI in human resource activities can aid in a number of areas, including recruiting and retention, lowering the workload of shared service centres and help desks by handling common inquiries, and reducing time spent on administrative chores by HR experts.
[8]	2019				√	Papers show research done from 2000 to 2018. It shows in which area of HRM have research taken place over the year.

ISSN(Online): 2584-1025

[9]		√				Gives a brief description of Ai's involvement in every aspect of HRM.
[10]	2018					This study presents problems that the implementation of AI can face one of them being that employees trust on the new technology.
[11]	2019	√				It is a study of 21 interviews where AI is used to increase the degree of fairness.
[12]	2015	√				AI technology enables recruiters align unorganized applicant bio-data, create standard the profiles, and find and match industry-specific skill sets.
[13]	2019	√				HR procedures, ethics and legal constraints on advertising, and staff responses to AI management might slow growth.
[14]	2020	√				Although it was obvious that AI had increased productivity, there were differing views on how accurate application evaluations were among more than 50 per cent of surveyed individuals who planned to use or not used the technology.
[15]	2021		√			This article outlines early findings from a university-SME partnership on RPA use in HR activities. Many SMEs struggle to automate.
[16]	2019		√			This study provides a pilot implementation of RPA although it remained in initial phase it has produced some benefits.
[17]	2020		√			The study gives a structured approach to implementing RPA. It is 6 stage approach that identifies the process, resource allocation, training and maintenance.
[18]	2017		√			This study presents a study on the implementation of RPA in BPO service provider.
[19]	2018			√		This paper discusses the usage of IoT wearables and their benefits.
[20]	2020			√		Papers present a framework for IoT usage and issues with the usage of IoT wearables.
[21]	2022			√		IoT devices and how they help in the learning management system by providing real-time data.

VII. CONCLUSION

In conclusion, there need to be more quantitative research needs to be presented for further advancement of technologies in HRM. It will help to measure the benefits of mentioned technologies. AI helps in recruiting, data Maintenance, and benefits distribution. In recruiting it helps sort candidates according to job role also in interviews it could eliminate bias giving a candidate a fair chance. AI has difficulty in implementation as there are trust issues for humans as it is a very new technology. RPA helps employees to reduce their repetitive and time-consuming tasks. But RPA increases the productivity of enterprises. RPA is considered a job-snatching technology by employees. Employees will need training before getting used to the RPA.

IoT devices keep track of real-time data which helps enterprises to track their employees' data. This data will help in the policy-making of enterprises. IoT devices collect data all time and the privacy of employees.

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ISSN(Online): 2584-1025

MIT UNIVERSITY'S –ABHIVRUDDHI

JOURNAL VOL.3 (01),JUNE , 2023 pp- 58-61

HESS with Control Algorithms in Dual-Chemistry Battery Pack for Light Electric Vehicles

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***Abstract*— Electric vehicles with excellent sources of energy will proliferate in the near future. An overview of hybrid electric vehicles (HEVs) is covered in this review article, with afocus on battery cell technologies, topological HESS configurations, and control algorithms. The main objective is to improve the effectiveness and efficiency of the battery system under safe working conditions. A study found that some researchers have improved driving cycles, range, and vehicle efficiency using battery-UC HESS. The use of a second storage system has been found to increase the main storage system's lifespan (battery). Ultra-capacitors' quick charging and discharging capabilities made it feasible to store the regenerative braking capacity in the right way. The development of superior optimization techniques will lead to improved energy management within the HESS. Using a variety of modular hybrid battery managers, the HESS design links the different battery chemistries (HBMs). Power-mix algorithm for dual-chemistry HESS is one of this work's most important advances. These goals can be accomplished through a variety of means, some of which include the hybrid predictive power optimisation (PPO) control approach, the adaptable FLC plan of action, the grey wolf optimisation methodology, and the pontryagin's minimal principle.**

Keywords — ***HEV, HESS, Predictive Power Optimization (PPO), FLC, Energy storage, HBM, Grey Wolf Optimization, Pontryagin's Minimum Principle.***

I. INTRODUCTION

The problems associated with the energy crisis and environmental contamination have become much more severe in the twenty-first century [1]. Climate change and global warming are what pose the biggest danger to the environment. The use of fossil fuels as a source of energy has led to a rapid rise in greenhouse gases (GHG) and a rapid depletion of natural resources. The excessive use of fossil fuels has irrevocably harmed the ecosystem. The energy sector is one of the main drivers of the rise in greenhouse emissions. Due to greater environmental awareness and stricter emission laws, environmentally friendly electricity generation has become more essentialIt is absolutely necessary to make the switch to energy sources that are greener and more sustainable. [2].

The basis for electrifying cars is the development of energy storage technologies. The lithium-ion battery is significant energy storage devices right now [3]. An apparatus that transforms molecular energy into electrical energy is a battery. The creation of Lithium ion batteries, each with a distinct chemical composition, was motivated by various factors. LFP, NMC,LTO and others are a few of numerous Li-ion battery varieties used in the evs [4].

II. TYPES OF CONTROL ALGORITHMS

A. Basic of hybrid energy storage system:

While control procedures are being developed, a depiction of two distinct battery packs in the form of a schematic showing how they will be connected in parallel by way of a DC-DC converter. For example, if we examine any two distinct battery packs to be Li iron Phosphate and Li nickel manganese cobalt oxide, we can see that there are significant differences between the two., and In order to hybridise, it's necessary to find an acceptable compromise between all of the characteristics; for example, "LFP" and "NMC." [5].

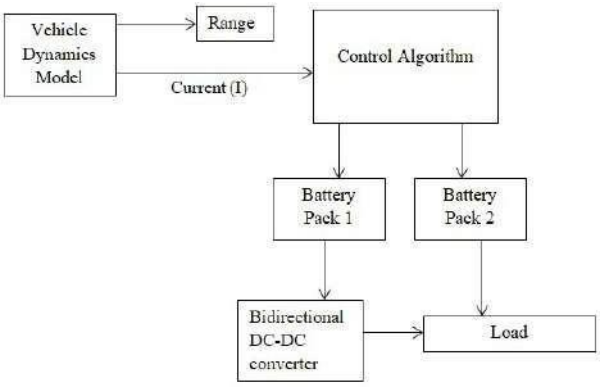

Fig 1.1 Schematic diagram of HESS

B. Control strategies :

Currently, strategies based on optimization have been researched to handle complex management objectives, such as lifetime and cost-effectiveness. These techniques are built on improving performance and reducing cost function [6].

III. ENERGY MANAGEMENT STRATEGIES

In the papers [7], numerous EMSs for FC-based hybrid energy systems have been described. These techniques can be broken down into four distinct categories: rule-based, control-based, filter-based, and optimization-based strategies respectively. [8].

A. Pontryagin's minimum principle

This regulating technique is the utmost fit for handling a vehicle's energy because of the EMS-base Pontryagin's minimal principle capabilities. It also gives the finest

ISSN(Online): 2584-1025

circumstances for promptly addressing issues, which makes it the best choice overall. This strategy aims to maximise the number of battery cycles while simultaneously minimising the amount of energy used. Control Utilising Adaptive and Fuzzy Logic.

Adaptive fuzzy energy management algorithms have been put into action in order to analyse the power separation that occurs between the Supercapacitor, the Fuel Cell, and the battery unit. As a result of the complexities of the hands-on controller issues, a fuzzy controller is required. [9-10].

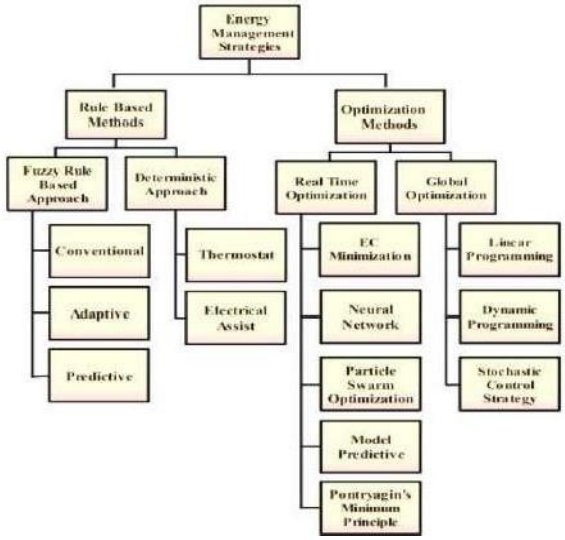

Fig. 2 Classification of EMS [9]

The evolution of the EMS is based on the consideration of these three factors.

(1) Operating cycle's energy requirement should always being met. Although its propulsion system and the operating environment may vary, electric vehicles must be prepared to function like conventional vehicles. As a consequence, it will always be crucial to show a pattern of operating circumstances in simulations and the real experiment.

(2) Operating conditions have a considerable impact Th on the battery in terms of how long it will last, how efficiently it will perform, how healthy it will be overall,

(3) It is important to keep in mind that the primary source of power for the EV must come from the batteries. Because of the nature of batteries, the whole amount of power essential to energising the entirety of the drive cycle must originate from batteries; any more power must originate from either super-capacitors, fuel cells, or both. Batteries are the only acceptable source of power. [11-13].

B. Grey Wolf Optimization Technique

Based on Gray Wolf Optimizer, an energy management approach is created for a fuel cell and super-capacitor hybrid energy storage system. The algorithm resembles qualities that are similar to the behavior of the grey wolf, from which it derives its name.

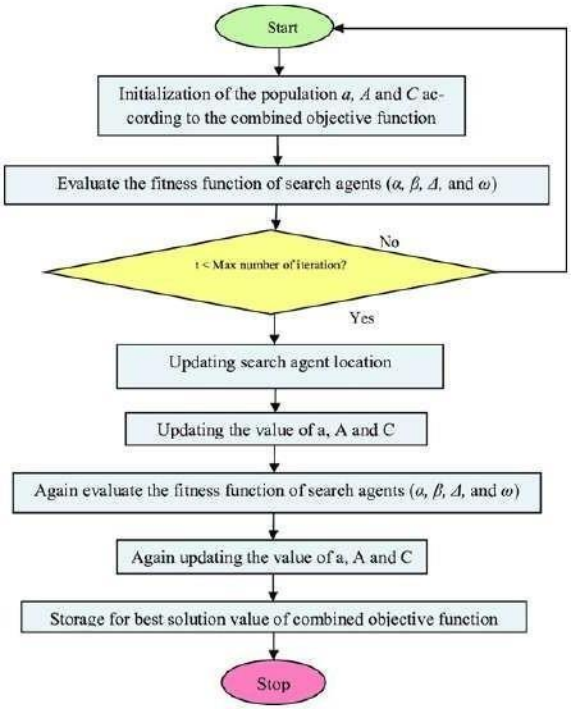

Fig. 3 Grey Wolf Optimization algorithm [12]

In this investigation, the Grey Wolf Optimizer algorithm was put through its paces by utilising a multi-sources, single-area power network that included hydro power plants, gas turbine power plants, and reheat thermal power plants, all of which were outfitted with mechanical hydraulic regulators. This network was used to test the algorithm's ability to optimise power distribution across the network. The research was carried out by utilising a power network that served only a single area. [14-17]

C. EMS based Particle Swarm Optimisation (PSO)

A stretegy using meta-heuristic population-based approach was chosen to tackle the problem. PSO, a well- known population-based optimization technique, was first presented by Kennedy and Eberhart. The steps are given below as:

Step 1: Initialization of variables like velocity, search region boundaries, acceleration coefficients, iterations, and swarm size. The placements of the particles are first established inside the searching region in a completely randomized fashion..

Step 2: The objective function's value has been determined at that particular time.

Step 3: The best position of the particle, referred to as pbest, and the best position in the world, referred to as gbest, are both determined in the third step.

Step 4: The speed and location of the swarm particle are reformed in the fourth step of the process.

Step 5: The algorithm is complete once Step 5 has been completed, when OF is minimal.

ISSN(Online): 2584-1025

Step 6: It is decided what desirable characteristics the components should have.

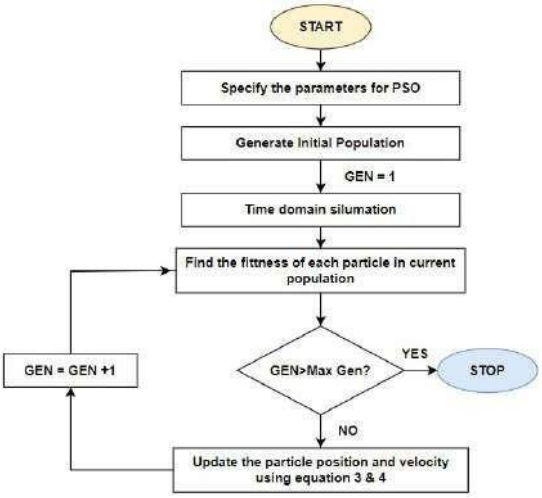

Fig.4. Flowchart of PSO Algorithm [13]

IV. THE ARCHITECTURE OF HESS

The reaction time of the slow unit, which is longer than one minute, needs to be synchronised with the reaction time of the fast energy storage unit, which has a response time of less than one minute to increase income (or decrease total price) from HESS. (reaction time less than one minute). An optimal control approach has been developed for this purpose.[18-22]

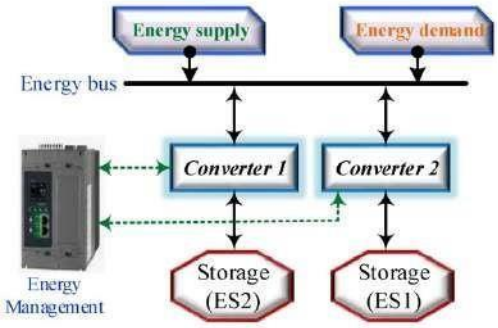

Fig. 5. The architecture of HESS [13].

A. Control strategy for battery UC HESS

To enable precise control of power flow in both battery and the super-capacitors, this architecture was selected. If the motor is only being powered by the batteries, losses can be minimized by connecting the batteries straight to the motor inverter.

Considering the low voltage at which supercapacitors discharge, they are not immediately connected in the arrangement. [23-22].

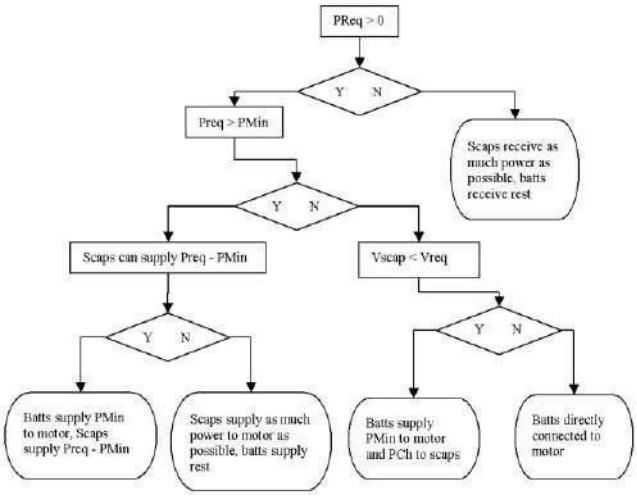

Fig.6. Flowchart of control strategy for a requested power PReq from the energy storage system [14]

B. dynamic programming in hybrid energy storage system

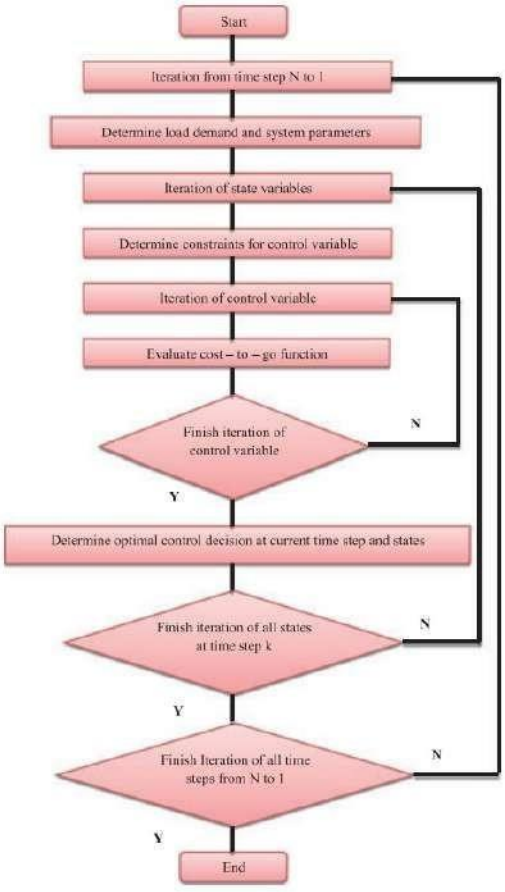

Fig. 7. Flowchart of dynamic programming [14].

TABLE I. EVALUATION OF DIFFERENT EMS METHODS

ISSN(Online): 2584-1025

Methods	CoS	CT	ToS	RoPK
FL	×	Small	Global	Yes
PSO	×	Medium	Global	×
PMP	×	Small	Local	Yes
GWO	×	Medium	Global	×
DP	Yes	Medium	Global	Yes
MPC	×	Small	Global	×
NN	Yes	Small	Global	Yes

Here terms are described as follows:

CoS	Complexity of Structure
CT	Computation Time
ToS	Type of Solution
RoPK	Requirement of the Prior Knowledge PSO Particle Swarm Optimization

V. SUMMARY

This study educates us on a wide range of control strategies applicable to a variety of models, as well as their significance and possible future directions for research into control strategy. When common and well-known driving patterns are considered, an optimization technique has the potential to considerably increase the lifespan of the hybrid's power storage device. They aren't making any attempt to correct the sporadic working habits that they have been observing. Although fuzzy-based methods that are very effective for various drive cycles are available, optimal control approaches typically have a significant impact on better battery life. This is the case despite the fact that these alternatives are available. In addition to this, the GWO in the ESS that is integrated with the fuel cell helps to minimize the fluctuations in current and provides protection against the unstable state of charge that the battery may occasionally assume. Both of these benefits come about as a result of the combination of these two components.

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ISSN(Online): 2584-1025

JOURNAL VOL.3 (01) , JUNE , 2023 pp- 62-68

Autonomous Indoor Mapping Robot using ROS

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***Abstract*—The concept of mobile robots has always been the prime topic of interest among the community of the roboticist However, the idea of engineering a mobile robots robot that can display indoor mapping and navigation, The current robots that we find are made for only a particular task orientation and are not user friendly as well as they also lack the ability of flexibility in the development of the robot, The purpose of this research thus involves developing and fabrication of the highly user-friendly and open source flexible interface of ROS(Robotic Operating System) which can integrate a wide range of sensors and can perform various operation as well as functions very efficiently and it takes the shortest time to cover (i.e.) Path planning, In the indoor environment, It also is the combination of A* algorithm into the robot automation firmware using obstacle avoidance, and thus every decision is unique and optimized. The experimental and simulation results are validated here to show the effectiveness of the A* algorithm.**

Keywords—UGVs, ROS (Robotic Operating System), Path planning, mobile robot navigation, obstacle avoidance, indoor mapping, A* algorithm

I. INTRODUCTION

Robotics constitutes a significant subfield within the discipline of mechatronics engineering. Robotics encompasses various aspects, including the strategic formulation, conceptualization, physical realisation, functional execution, and practical use of robotic systems. A robot is a machine, specifically one that can be programmed by a computer to execute a set of intricate activities autonomously. In the manufacturing sector, robots are commonly employed for various tasks such as the creation, finishing, transfer, and assembly of components. Various forms of robots exist, including drones. The six most prevalent categories of robots are autonomous mobile robots (AMRs) [1], automated guided vehicles (AGVs) [2], articulated robots, humanoids, industrial robots, and hybrids. Robotics is an engineering discipline concerned with the development, design, and operation of robots for the purpose of automation.

It is also associated with the study and implementation of robotics, encompassing the construction of robots through the integration of diverse technologies and their utilisation in our daily activities. The field of robotics presents significant prospects for future advancements. Robotic systems find extensive utilisation across diverse domains, serving a multitude of objectives. Presently, their deployment is particularly prominent in hazardous settings, encompassing tasks such as inspecting radioactive substances, detecting and neutralising explosive devices, as well as facilitating manufacturing operations. Additionally, robots are employed in environments that are inhospitable to human presence, such as outer space, underwater realms, extreme heat conditions, and the management and confinement of perilous materials and radiation. Robots possess the capacity to assume various physical manifestations, with certain models specifically designed to closely resemble the human form. This facilitates the integration of robots in specific tasks that typically involve human-like replication. These robots endeavour to imitate many human activities [2].

A. Challenges and Motivation

With the due research done, we came to know there is not much evidence of using the A* algorithm in the robot with ROS and implementing that in the mobile robot navigation the main objective is to optimize path length and navigational time and find the shortest distance, This was a challenging task to implement (Robotic operating system) with the A* algorithm because the method was unknown and we had to find many different innovative ways to accomplish the task and we are successful in making that, There are various parameter for the A* algorithm to inculcate in our research.

The 1st section contains information on robotics, its uses, and its application, the 2nd section contains and information about the navigation and mapping of the mobile robot including the self-localization and mapping. The 3rd section of the research paper consists of the path planning of the robot using the A* algorithm and integrated with the ROS (Robotic Operating System) and the detailed information on the robot construction with the software used in the simulation it also consists which path planning algorithm (A* algorithm) used in the indoor environment. 4th section consists of the simulation and analysis of the robot in the different indoor environments in using A* path planning and ROS architecture with different parameters are taken into consideration having graphical and statistical data. 5th section consists of the simulation results during the simulation of the robot in the indoor environment using ROS and the A* algorithm. 6th section consists of all the research papers that we have gone through and had some useful insights during our research.

ISSN(Online): 2584-1025

II. MOBILE ROBOT NAVIGATION

The field of autonomous mobile robotics places significant emphasis on control systems and navigation as primary areas of concern. The system has components for hardware circuit design, control software, and upper computer software. The velocity and current control of DC motors have been observed in lesser computer systems. The navigation pack holds significant importance and possesses considerable power inside the framework of the ROS (Robotic Operating architecture) architecture. The navigation system employed in the autonomous car [3]. As depicted in Figure 1, the comprehensive structure of the navigation and Path planning involves determining the most efficient route considering the surrounding environment and the presence of obstacles that the robot must navigate. There are two primary categories of obstacles: static obstacles, which remain stationary, and dynamic obstacles, which are subject to movement. Upper computer interaction primarily facilitates human interaction, machine interaction, remote control, and data communication. The navigation stack operates at a basic conceptual level by receiving input from the odometry and sensor streams.

In order to ensure accurate navigation, several prerequisites must be met for the mobile base to receive appropriate velocity commands. Firstly, the robot must be utilising the ROS software framework. Additionally, the tf transform tree must be properly established. Furthermore, the publisher data should be transmitting the correct messages. Lastly, the ROS configuration should be tailored to accommodate the shape and dynamics of the robot, enabling it to operate at an optimal level. The hardware requirements of the navigation stack are specifically designed for wheeled robots with differential drives. It implies that the mobile base may be controlled by transmitting velocity signals. Additionally, the navigation stack necessitates the presence of a planar laser, which should be positioned on the mobile base. The laser in question is utilised for the purposes of map construction and localization. The navigation stack was originally devised for implementation on a square robot, therefore yielding optimal performance on robots of all shapes and sizes. However, while employing this navigation stack on larger rectangular robots within confined areas such as entrances, certain limitations may arise [3].

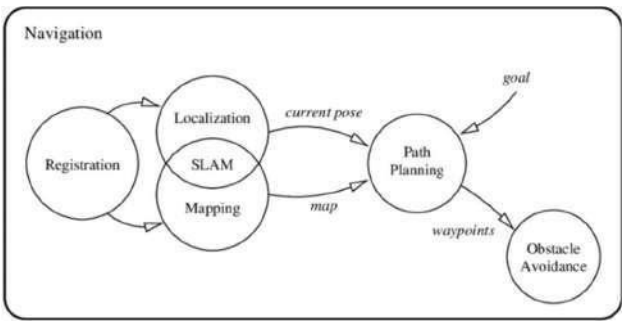


Fig 1 Navigation Stack

A. *Self-localization*

The expeditious execution of a comprehensive methodology for a robotic system to achieve self-localization within an indoor setting that may be represented as a basic polygon. As depicted in Figure 2, the robot's sole source of information consists of a polygon map and sensor data obtained from a range detecting device. It is assumed that in this manner, the robot possesses access to its localised visibility polygon. The iterative approach we employ involves consistently moving towards the nearest point where the robot can ascertain the elimination of at least one potential location in which it may be situated [4].

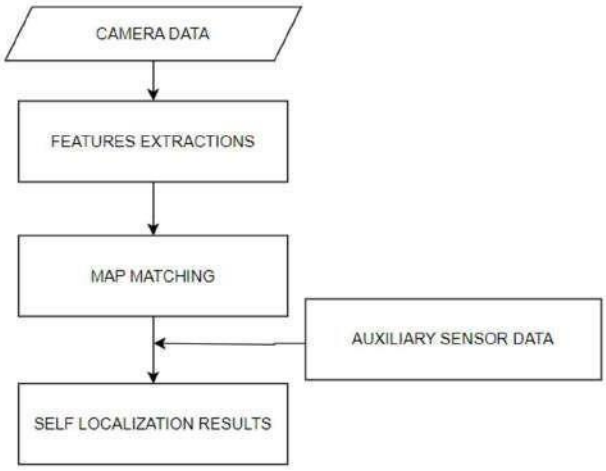


Fig 2 Self Localization

B. *Map Building and Map Interpretation*

The process of mapping the mobile robot is a fundamental aspect of achieving effective navigation in the field of mobile platform technology. Figure 3 illustrates that localization is a fundamental and crucial undertaking for attaining a high degree of autonomy in robot navigation and ensuring resilience in vehicle positioning. The field of robotic mapping and map interpretation is closely associated with cartography, employing techniques and computational methods to construct trajectory maps that accurately represent reality and effectively convey spatial information. [4].

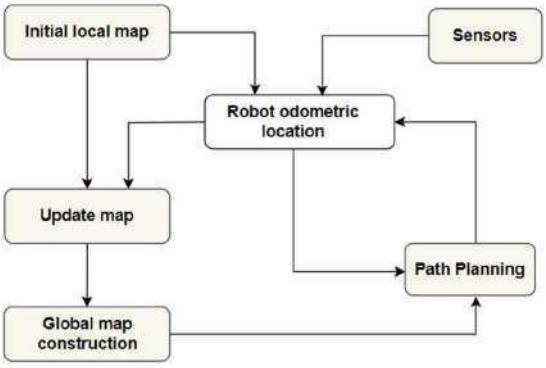


Fig 3 Robot Mapping

III. PATH PLANNING OF MOBILE ROBOTS USING A* AND ROS

Path planning, also called motion planning, is a computational problem that involves determining a set of feasible configurations to move an object between two locations. The objective of a path-planning algorithm is to determine a geometric trajectory that links the robot's present position to the desired destination, utilising a given map. Moreover, mobile robots working in unorganised settings or service and companion machines often lack comprehensive or complete prior understanding of the setting. Additionally, the context in which these robots operate is not static, meaning that while in motion, the robot may come across other robots, human beings, or companion animals.

ISSN(Online): 2584-1025

Consequently, its performance of tasks is frequently influenced by unpredictability. Local obstacle handling, which includes obstacle detection and avoidance, is also required to achieve collision-free path planning. Robots may now detour around barriers utilizing modern approaches by quantitative measurement of the dimensions of obstacles [5]. In order to simulate the robot, the proposed algorithms were implemented in the Robot Operation System (ROS) as shownin the (Fig.4) the An free to use, meta-operating system designed for robotic platforms. The operating system, or OS, offers a range of services that are typically anticipated, such as hardware conceptualization, control over low-level devices, implementation of frequently utilised functionalities, inter-process communication through message-passing, and managing packages. More importantly, ROS (Robotic Operating System) has plenty of open-source packages including sensor drivers, navigation tools, environment mapping tools, path planning tools, communication and visualization tools, and many others that ultimately rigidifies the robot software network. The robot has a 360 Lidar module which can sense and give proper instructions to the micro-controller of that of the obstacle within the alarming range of the robot it also has a Bluetooth module for the communication of the instructions that the robot needs to accomplish and it has the encoder. The unmanned vehicle autopilot software suite in the Gazebo environment [5], the robot receives its position from the LiDAR module that connects to ROS(robotic operating system) for continuous movement along its x, y axes. In a SITL simulation, the desired path runs on the computer (either on the same computer or another computer on the same network). Sensor data is observed on the computer from the vehicle dynamics model in the simulator during SITL operations [6].

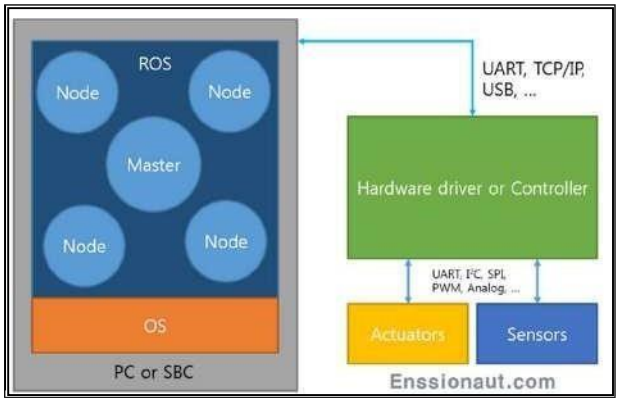


Fig 4 ROS-Robot Framework

A. Robot Construction

Mobile robots are required to know their locations within the environment as well as their surroundings so that they can perform assigned tasks. These issues are investigated within the context of localization and mapping, a phenomenon in robotics that analyses the world around a mobile robot. As shown in (Fig.5) The method is implemented in software that runs on the(robotic operating system) ROS platform. by using the stereo depth sensor on the robot, a point cloud about the obstacles is obtained for simulation and its applications the robot is equipped with various sensors for obstacle identification. the robot is equipped with 360 LiDAR shown in (Fig.6). This method involves the utilisation of remote sensing techniques, wherein the surrounding environment is subjected to scanning through the emission of a pulsed laser beam. Subsequently, the time taken for the reflected signal from the object to reach the detector is measured. Lidar sensors possess the ability to identify obstacles throughout a broad range of visual perception, rendering them highly suitable for integration into a comprehensive sense and avoid framework. Additionally, ultrasonic sonic sensors and a depth camera are also used to determine the presence of obstacles and its data will be used to plan the optimal path. A number of filter operations are used to convert this data. The robot receives the user's intended destination information, which is used in conjunction with the drone's position and map information to construct the intended flight path [6].

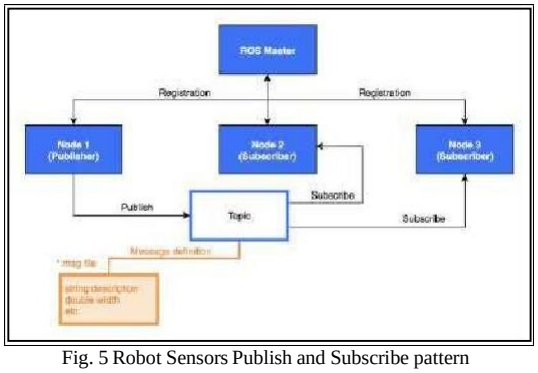


Fig. 5 Robot Sensors Publish and Subscribe pattern

Fig 6 Robot Design

B. ROS (robotic operating system)

The Robot Operating System (ROS) comprises a collection of software libraries and tools that facilitate the development of robot applications. ROS is an open-source, meta-operating system designed for robots, encompassing a wide range of components like as drivers, state-of-the-art algorithms, and a robust development community. The operating system offersa range of services and resources, which encompass hardware abstraction as illustrated in the block diagram (Figure 7), implementation of frequently utilised functionalities, inter-process communication through message-passing, and package management. Additionally, it provides a diverse array of tools and libraries for the acquisition, construction, composition, and execution of code across many computational devices. The Robot Operating System (ROS) incorporates various modes of communication, encompassing

ISSN(Online): 2584-1025

synchronous Remote Procedure Call (RPC)-style communication through its service offerings, asynchronous streaming of data via topics, and data storage on a Parameter Server. The major objective of the Robot Operating System (ROS) is to facilitate the reuse of code in the field of robotics research and development. The Robot Operating System (ROS) is a distributed framework consisting of a collection of processes referred to as Nodes. These Nodes allow for the creation of executables that can be created independently and have loose coupling during runtime. The aforementioned processes can be categorised into Packages and Stacks, facilitating their seamless sharing and distribution. Currently, the ROS framework is exclusively accessible on operating systems that are Unix-based. The software designed for the Robot Operating System (ROS) is consistently subjected to testing on Ubuntu and Mac OS X operating systems. However, it is worth noting that the ROS community has actively contributed to extending support for more Linux platforms like as Fedora, Gentoo, Arch Linux, and others. [6].

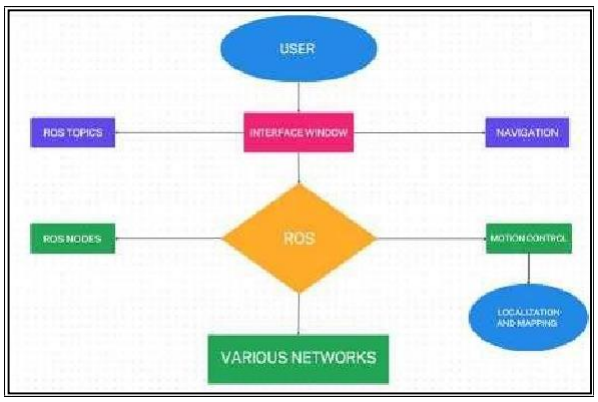


Fig 7 ROS Interface and Architecture

1) *Packages:* Packages play a crucial role in the organisation and structuring of software within the Robot Operating System (ROS). A package encompasses ROS runtime processes (referred to as nodes), a library that is dependent on ROS, datasets, configuration files, or any other components that are effectively organised in conjunction. Packages are the most desirable build item and release item present in ROS framework.

2) *Nodes*: ROS nodes are essentially just processes that are communicating with the robot through the use of ROS application programming interfaces (APIs). It's possible for a robot to have a lot of nodes to help it with its computations. ROS client libraries, such as roscpp and raspy, which will be covered in the next sections, allowus to establish ROS nodes. In the following parts, we will discuss:.

3) *Topics:* ROS topics are one of the ways in which two ROS Department of Mechanical Engineering nodes can communicate with one another and exchange ROS messages with one another. ROS messages are used to communicate between participants on designated buses known as topics.

In the search for the optimal course, the academic literature presents a great deal of different approaches. Every obstacle in the planning process requires a series of decisions that must be carried out in sequence throughout the course of time. In addition, it is absolutely necessary to specify in the planning formulation how the state shifts as activities are carried out. Each step of the path-planning procedure takes into account both the initial state and the destination state [7]. In many cases, there are two distinct categories of planning issues. The first factor to consider is whether or not the goal can actually be accomplished. To do this, you must devise a plan that, regardless of how effectively it works, will bring the robot to the desired destination. The second objective is to devise aplan that is both practicable and effective in enhancing performance in a particular manner. On the other hand, the effectiveness of these algorithms was evaluated according to the following ideal criteria: time required for computation and distance travelled [8].

In this work, we have used A* algorithm below is the general working and the basics of the A* algorithm and this is one of the best path planning algorithms that produced very satisfactory results.

a) A Search Algorithm:* There is a well-known and fundamental heuristic method called a star search (A*, A-star, or A* search [8]. Methodically, (Fig.8) the algorithm that the A* uses for its optimization. It is attempted to minimize the function, formalized as f(n) = g(n) + h(n) taking into account the links between nodes and edges. In mathematical terms, g(n) is the cost of the beginning point or node, while h(n) is the cost of the remaining journey. h(n) hereby constitutes the heuristic base of the algorithm [8].

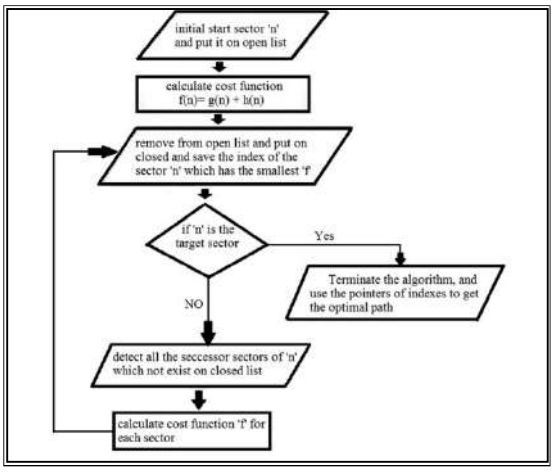


Fig. 8 The A* Algorithm flow chart

TABLE I. A* ALGORITHM PARAMETERS IN SIMULATION

Sr No	ALGORITHM PARAMETERS	
1	*a* - Safety Distance	0.8m
2	β - Safety Distance	0.7m
3	Velocity safety Distance	1.2m
4	Critical Safety Distance	0.07m
5	Max velocity	0.4m/s
6	Octomap resolution	0.1m
7	Spherical matrix resolution	6 degrees

ISSN(Online): 2584-1025

The simulation that is performed in the indoor environment parameter used for the A* parameter is shown in (Table No 1). The UGV parameters of the performed simulation are shown in (Table No 2), The results of the simulation of the Special Case 1 are shown in (Table No 3), The results of the simulation of the Special Case 2 are shown in (table No 4).

TABLE 2 UGV PARAMETERS FOR THE SIMULATION

Sr No	UGV PARAMETERS	
1	Mass	2kg
2	Radius	35 cm
3	Inertia, ixx	0.0348
5	Inertia, iyy	0.0459

IV. SIMULATION AND ANALYSIS

After getting a broad grasp of how these algorithms function theoretically, it's crucial to put them to the test on a real robot to determine their effectiveness and usefulness. As shown in (Fig.9) the top view of the navigation and mapping sensors ROS (robotic operating system) includes a real-time physics simulator environment called Gazebo[9], allowing a robot model to be thoroughly evaluated before a prototype is built. In addition, the robot model is integrated into the Gazebo using a technique known as 'Software in the Loop,' or SITL[10], which feeds real-life robot data to the physical environment for simulation.

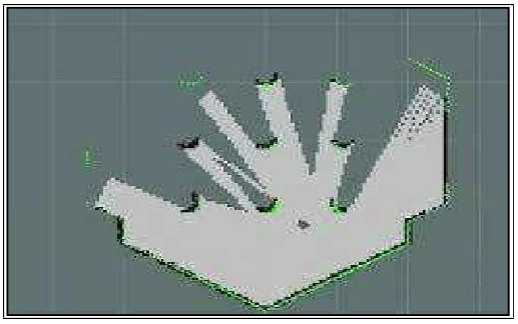
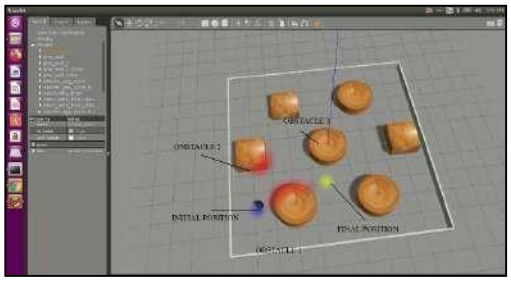
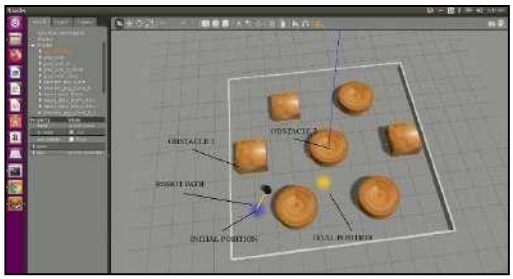


Fig 9 Robot sensors Navigation and Mapping

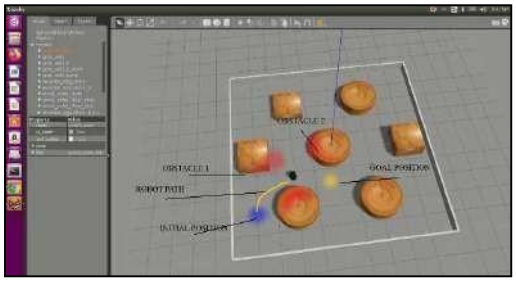


(a)

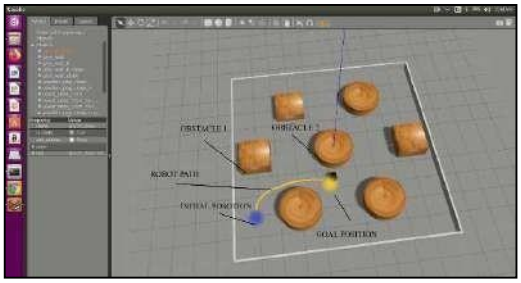
Special Case 1: The robot in the room with the Gazebo closed environment and with some static obstacles and the robot is situated in a particular position here the robot navigates through the obstacles and intelligent path planning is used to navigate the robot to find the most efficient path which has less cost in covering the distance, The (Fig.10) depicts the navigation mapping and the path taken by the robot. Here we give the robot a particular target position and the robot first determines the initial position of the robot in the room and analyses the target position given to the robot through which it navigates and reaches its given destination in the most efficient way possible to reach the point of target. (Table.3) gives the coordinates of the initial position and goal position of the robot with its navigational time taken by the robot and the path length achieved by the robot. The graphical representation of the statical data of particular case 1 is shown in (Graph.1) performed in the indoor test environment.



(b)



(c)



(d)

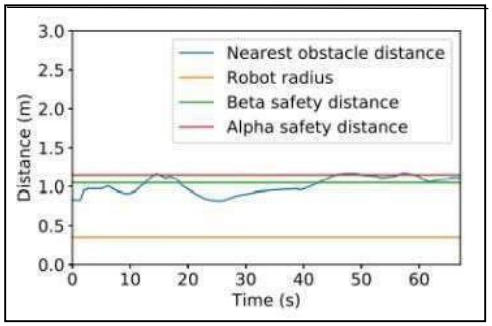
Fig 10 Test scenarios created in Gazebo simulator

Fig (a) The robot initiates the action by analyzing the initial position of the robot. Fig.(b) The robot starts the path planning and acts according to the set path planned by the software. Fig.(c) The robot is in the given path and detects the object and avoids the object and moves around. Fig. (d) The robot reachesthe final destination.

TABLE NO 3-PATH LENGTH AND NAVIGATIONAL TIME USING A*ALGORITHM

Sn No:	Initial position (x, y)	goal position (x, y)	Navigational time (s)	Average path Length (m)
1	-10; -10	-2.1; -1.35	1.72	8.5950
2	-10; -10	-2.3; -1.96	1.70	9.5950
3	-10; -10	-2.2; -1.21	1.69	8.1056
4	-10; -10	-2.2; -1.36	1.66	8.2369
5	-10; -10	-2.0; -1.54	1.74	9.1256
		Σ	1.702	8.73162

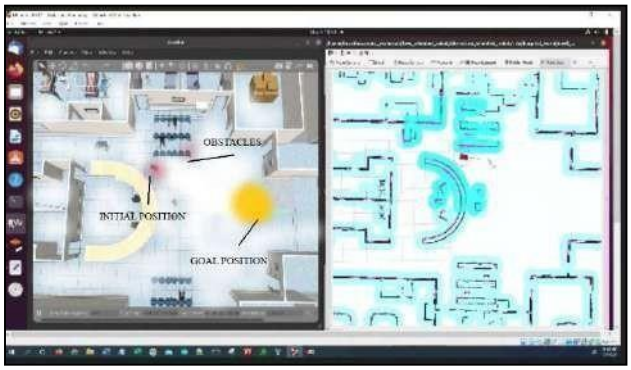
ISSN(Online): 2584-1025



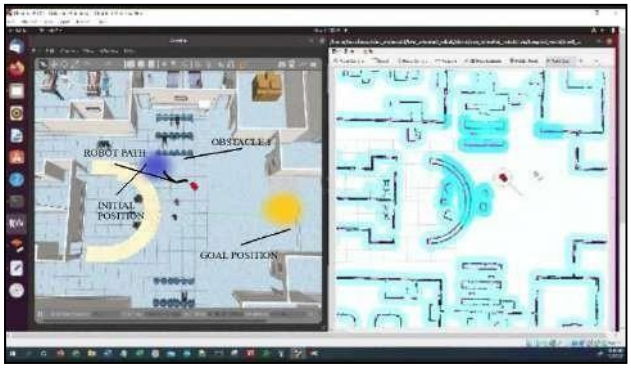
Graph 1 of Path Planning using A* algorithm in case1

TABLE NO 4 PATH LENGTH AND NAVIGATIONAL TIME USING A* ALGORITHM

Sr No:	Initial Position (x, y)	Goal Position (x, y)	Navigational time (s)	Average path Length (m)
1	-5, 10	-3; -2.5	2.73	15.5873
2	-5, 10	-2.9; -2.5	2.78	15.6669
3	-5, 10	-3; -2.72	2.69	15.6988
4	-5, 10	-3; -2.61	1.88	15.6524
5	-5, 10	-3; -2.65	2.88	15.2546
		Σ	2.592	15.5720

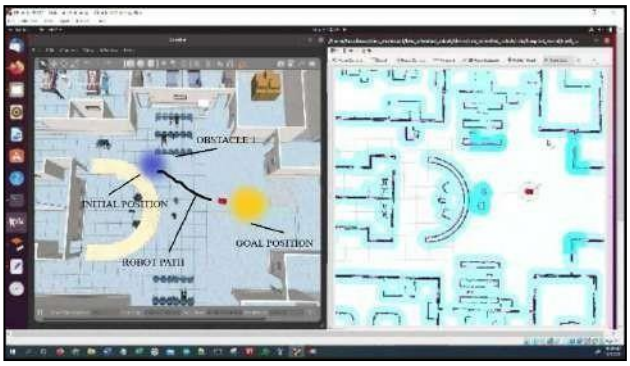


(a)



(b)

Special Case 2: As shown below (Fig.11) that the robot performs path planning with many obstacles as well as obstacle avoidance, In this simulation environment the robot is placed between many obstacles that are stationary as well as some of them are dynamic obstacles the robots need to analyze the data from the sensors and make the necessary decision and decide the most efficient path through the obstacles it helps the robot to reach its target decision in the best possible way. (Graph.2) below depicts the statistical information of case 2 of the indoor mapping environment performed by the robot. (Table.4) shows the results of the simulation performed by the robot in case 2.



(c)

Fig 11 Test scenario 2 created in Gazebo simulator

Fig (a) The robot initiates the action by analyzing the initial position of the robot. Fig (b) The robot starts the path planning and acts according to the set path planned by the software. Fig (c) The robot is in the given path and detects the object and avoids the object and moves around. These are some of the navigation codes used in the ROS environment to plan the path to be executed to reach from given position of the robot to the target destination. These codes include various parameters that the robot has to behave accordingly.

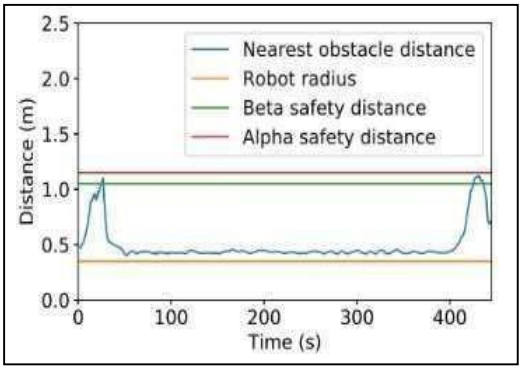


Fig. 12 Path planning using A* algorithm in Case-2

CONCLUSION

The experiments reveal that the A* algorithm takes the shortest path, however, it uses significantly more computing power than the other algorithms. The proposed research was in the view to develop a autonomous mobile robot system that is capable enough to smartly navigate to the given goal position, and efficiently follow the path provided by an optimized path planning algorithm. This study included that the A* algorithm is more efficient and better in performance with the robot in the Gazebo Simulator using the ROS (robotic operating system) framework, and it was discovered that the A* algorithm produced better results and computes the path more quickly in the particular environment in which the robot was situated in the Gazebo environment.

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ISSN(Online): 2584-1025

MIT UNIVERSITY'S – ABHIVRUDDHI

JOURNAL VOL.3 (01) , JUNE , 2023 pp- 69-72

Design and development of 5-dof robotic arm with a mechanical gripper

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***Abstract*— The objective of this study is to conceiveand construct a robotic arm possessing five degrees of freedom (DOF). This endeavor may be divided into three distinct phases: the design phase, which entails conceptualizing the arm's structure; the control logic phase, which involves formulating the algorithms necessary for governing the arm's movements; and the hardware mechanism phase, which encompasses the selection and implementation of the components responsible for controlling the motion of the arm's links and joints. In order to regulate the movement, a mobile application has been created, utilizing the Bluetooth module HC-05 for transmission, which provides a range of roughly 10 meters. The code has been implemented in the C++ programming language, allowing for either automated or manual control of the motion through the mobile application. The Arduino Mega microcontroller is employed for the purpose of establishing a connection between the wireless controller and the robotic arm. The utilization of 3D printing technology is employed in the advancement of a robotic arm. The prototype that has been built is anticipated to address the issue of manual object choosing and positioning.**

Keywords*— *Bluetooth, Microcontroller, 3D printing, Wireless Controller

I. INTRODUCTION

The industrial sector is expanding quickly. As a result, industrial automation is crucial in today's environment. Pick and place mechanisms are necessary for all automated operations to transfer and rotate goods on production tables or conveyors. Robotic arms, however, are fixed at one point and are unable to travel to other areas, unlike a human worker who may pick up a product or material, carry it to a separate workstation for a different operation, and then deposit it on another. [1] The robotic arm is a sophisticated mechanical device that replicates the motions and uses of the human arm. It is frequently utilized in manufacturing and other fields where the accurate and precise performance of repetitive tasks is required. In comparison to human employees, the robotic arm offers several benefits, such as the capacity to operate constantly, a decrease in human mistake rates, and an increase in productivity. The use for which a robotic arm is intended determines its design. The end-effector, the arm, and the base are the three basic parts that make up the majority of robotic arms. The arm's end- effector is the portion that engages with the outside world and carries out the necessary function. The end-movement effectors and location are controlled by the arm, while the arm is supported by and stabilized by the base. A robotic arm is built using a variety of materials, including steel, titanium, and aluminum. Electric motors, pneumatic actuators, hydraulic actuators, or a mix of these are frequently used to power the arm's joints. The robotic arm's control system is made up of sensors, actuators, and a CPU that interprets input signals from the user or the environment into the proper actions. [2]

Functionality-The end-effector and control system programming are what determine how well a robotic arm works. Many applications, including welding, painting, and pick-and-place tasks, can be accommodated by the end design. effector's Programming methods like teach-pendant programming and off-line programming can be used to operate the robotic arm. The robotic arm's movements, such as moving, grabbing, and releasing things, are conducted in a certain order according to programming. [3] Types and Applications: Based on their construction, motion range, and payload capacity, robotic arms may be divided into many varieties. Robotic arms of the articulated, Cartesian, cylindrical, polar, and scara varieties are the most prevalent. Each kind is ideal for particular uses and has benefits and disadvantages of its own. [4] Articulated robotic: Since they feature a jointed construction and a high degree of freedom, articulated robotic arms are ideal for applications that call for flexibility and mobility. They are frequently employed in material handling, painting, and welding.

-Cartesian robotic arms can be used for tasks that call for accurate, repeated motions and have a rectangular workspace. They are regularly utilized in packing, assembly, and pick-and-place processes.

Robotic arms with circular workspaces are appropriate for uses that call for a large payload capacity. They are frequently employed in demanding material handling and assembly tasks. Polar robotic arms are appropriate for applications requiring a high level of accuracy and precision because they use a polar coordinate system. They are frequently employed in medical procedures including imaging and surgery. Scara robotic- While they have a smaller range of motion, scara robotic arms have a similar construction to articulated robotic arms. They are appropriate for tasks like pick-and-place operations and assembly that need great speed and accuracy. [5]

However there are challenges: The high cost of development, the complexity of the programming, and the safety issues surrounding the interaction of the robotic arm with people have all been difficulties for the development of

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robotic arms. Recent technological developments, such as the creation of collaborative robots that can operate securely with people, have nonetheless solved some of these issues. Future advancements in the field of robotic arms include the development of self-learning robotic arms that can adapt to different environments and tasks without the need for programming. [6] An embedded system is a collection of computer hardware, software, and maybe other mechanical or non-computer pieces that are used to carry out a particular task. An embedded system is a microcontroller-based, software-driven, dependable, real-time control system that is marketed into a competitive and price-conscious market, autonomous, or human or network interactive, working on a variety of physical variables and in a variety of situations.[7] A standard commercial or scientific application, a PC or UNIX software system, or a computer. the system used largely for processing are not examples of embedded systems. Systems that are both high-end and low-end embedded [8].

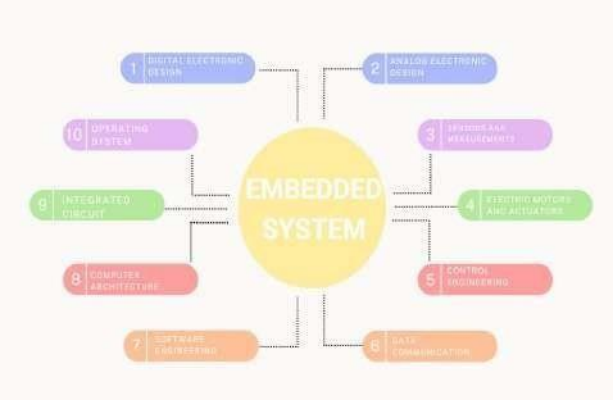

Fig-1 Embedded System Framework

II. DESIGN

For designing the robotic arm we will use AutoCAD Fusion 360

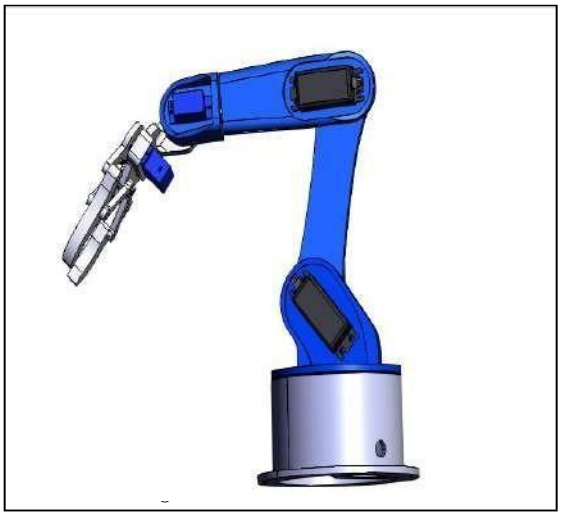

Fig 3- Exploded 3D view of the robotic arm

Calculation- One of the six actuators on the arm opens and closes the gripper in the kinematic model, which does not count as a degree of freedom. The total degree of freedom for the entire system is five, with one degree of freedom for each of the five spinning actuators. The relation: represents the Gruebler-Kutzbach equation, which mathematicallyexpresses the DOF of the arm. [9,10]

$$A = 3 * (b - 1) - 2 * M1 - M2 \quad (1)$$

where M1 is the number of joints with one DOF and M2 is the number of joints with more than one DOF, A is the

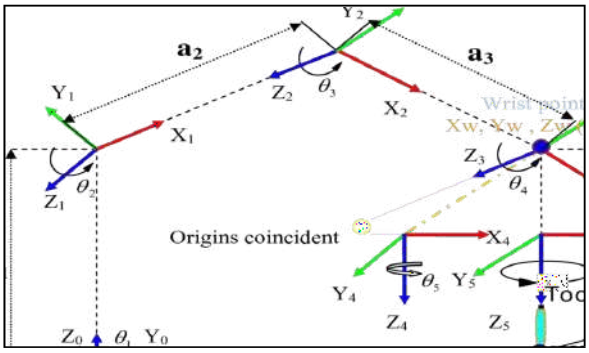

Fig 3- Axis and joint movement representation [10]

system's DOF, n is the number of links (including the base frame), and b is the number of links.

The joints (1, 2, 3, 4, and 5) and links (Z1, Z2, Z3, Z4, Z5, and Z6) of the arm are visible. As there are no joints with two DOF in the system, the M2 value is 0.

Therefore:

$$A = 3 * (b - 1) - 2 * M1 - M2 = 3 * 5 - 10 \Rightarrow (6)\ A = 5 \text{ DOF [11]} \quad (2)$$

III. METHODOLOGY

Figure 4A and figure 4B represent the actual robotic arm model created with the help of 3D printing. For a clear understanding of the links, both lateral and font view is represented.

ISSN(Online): 2584-1025

Fig 4A - Robotic arm model lateral view

Fig 5- Robotic arm model front view

A. Hardware Connection

Circuit board- A customized circuit board was designed to fulfill our design requirement consideration, it provides the connection to the servomotor, steeper motor, and drivers The circuit connection is shown in the following pattern[11,12]

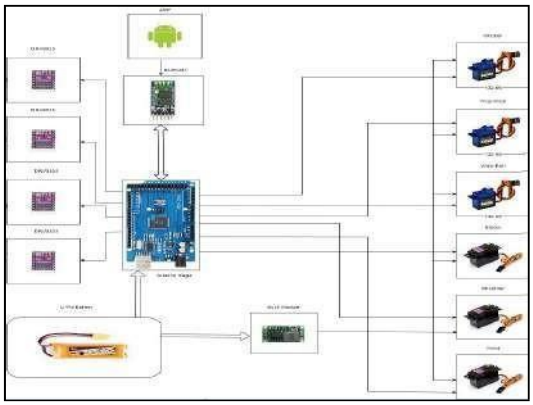

Fig 6- Electric circuit diagram connection

B. CODE

This section covers the programming for the robotic arm. The application used is called the Arduino IDE (Integrated Development Environment). The programming languages C and C + + are supported by the software. Programmers have access to a variety of input and output methods using the software libraries provided by the Arduino IDE. One way to include a library that is used to identify mathematical equations while programming is by adding # includes math.h> to the command line of the Arduino IDE,[13-16] for example. We created four programmers that show how the arm sensor works with various contemporary industrial forms of production by looking back at prior research.[17]

```
servo02.attach(3);
servo03.attach(4);
servo04.attach(5);
servo05.attach(6);
servo06.attach(7);

// Define baud rate of the Serial3 module
Serial3.begin(9600);
Serial3.setTimeout(5);
delay(20);
```

Fig 7- Sample Code for Arduino in C

Arduino Mega – Arduino—The open-source Arduino board, a microcontroller board, is built on an Atmega 2560 CPU. The expanding environment of this board executes the processing or wiring language. These boards have revived the automation industry because of their user-friendly platforms, which enable anybody with little to no technical experience to start by learning the skills required to operate and program the Arduino board. These boards may be usedto expand many interactive things or connected to computer applications like Max MSP, Processing, and Flash.

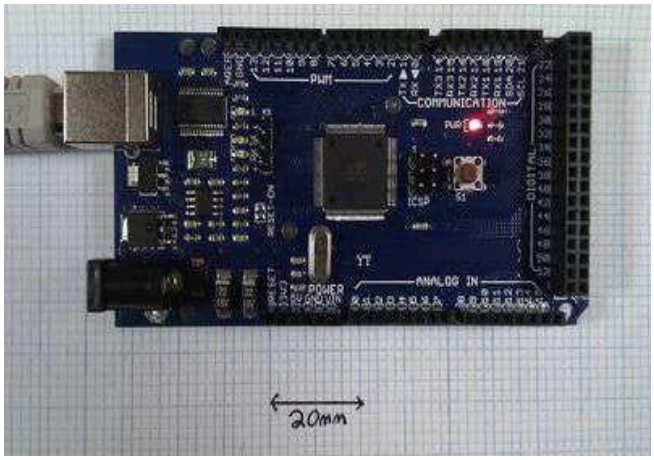

Fig 8- Arduino Microcontroller [15]

Mobile Application- For the mobile application we have used the MIT APP inventor, coding with the backend using the interface is quite convenient with the coding block, the coding for the app is done in C++. [18-22]

The application allows the movement of the robotic arm the mobile application is connected via Bluetooth connection and has a range of 10m. After coding the interface we convert our files into downloadable apk which can be downloaded and shared with multiple mobile phones.

ISSN(Online): 2584-1025

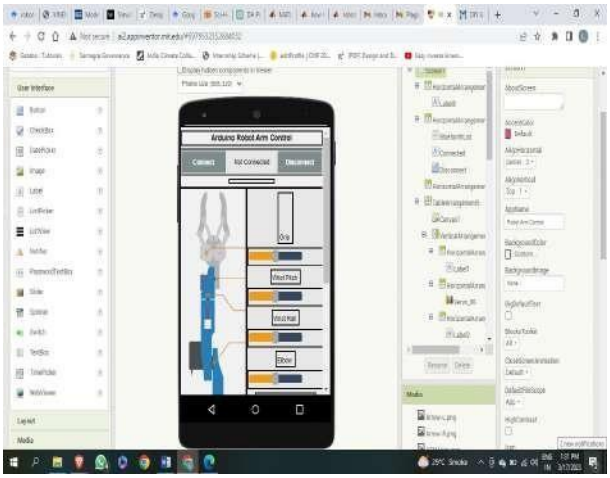

Fig 9A- Mobile Application Frontend

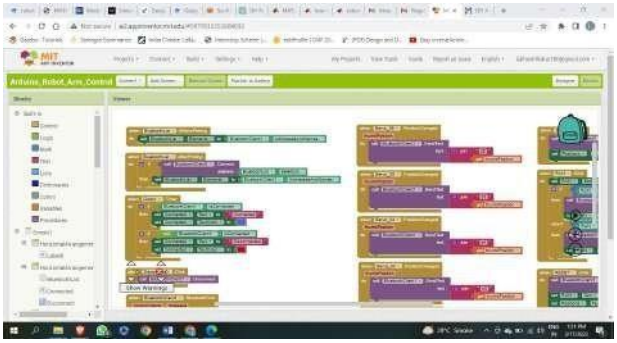

Fig 9B- Mobile Application Backend code with blocks

CONCLUSION

The investigators have successfully designed and built a robotic arm that possesses five degrees of freedom (DOF). The robotic arm's ability to manipulate and relocate objects is made possible by the presence of a mechanical gripper on the end of the arm. Utilizing an Arduino microcontroller makes it easier to manage motors and motor drivers in a system. This is because of the versatility of the Arduino platform. According to the results of the tests that were carried out, our robotic arm has proved that it is capable of moving in five different degrees of freedom (DOF). It is possible to save the coordinates of the robotic arm and then use them later for the purpose of automating processes. By utilising a mobile application, the management of position control may be made available on any mobile device that is equipped with Bluetooth capabilities. This accessibility can be achieved by using any mobile device.

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ISSN(Online): 2584-1025

MIT UNIVERSITY'S – ABHIVRUDDHI
JOURNAL VOL.3 (01) , JUNE , 2023 pp- 73-76

Development of dual purpose treadmill bicycle model

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Abstract— **The work for this project involves modifying a treadmill such that it better meets the needs of users. The human beings who enjoy running outside are the target audience for the treadmill bicycle. The combination of a treadmill with a bicycle frame result in a significant innovation that has been dubbed the "TREADMILL BICYCLE." This bicycle features electronic components and operates flawlessly when propelled forward by human momentum. The rider walks on a treadmill, which causes the belt to rub against the bike's rear wheel, which in turn causes the bike to go ahead. Running and cycling are two of the best forms of exercise, and the treadmill bicycle combines the two for a low-impact, high-performance work out that can be done outside. This equipment is created specifically for runners as the ultimate treadmill device. In our opinion, it is the most suitable piece of equipment for fit runners. It provides an experience that is more analogous to running than any other form of exercise that is currently on the market.**

Keywords— Treadmill, Walking Belt, Wheels, Rollers, Bearing, Flywheel, Sprocket

I. INTRODUCTION

The treadmill bicycle is a completely novel kind of exercise that was developed especially for people who go for runs. Running, hiking, or walking on a treadmill is practically the same thing as doing it on a treadmill. Think back to the last time you rode a bicycle across challenging terrain, whether it was through train tracks, potholes, or speed bumps. It's possible that when negotiating the challenge, you stepped on the pedals to give yourself a little more stability. [1]

The user is responsible for maintaining a balanced stanceat all times while riding the treadmill bicycle.[1] Because of the cooperation of a DC motor and a great many additional components, you are now able to walk considerably more quickly. Because it does not require the use of any fuel, it has become a popular method for people who have a lot on their plates to take care of their health. Even people who have a lot of things going on in their lives can maintain their physical and mental health. A typical treadmill, on the other hand, can only be used inside of enclosed spaces, while a treadmill bicycle can be ridden on public highways. This makes the treadmill bicycle more versatile than a traditional treadmill. This innovation addresses a common criticism levelled against conventional treadmills, namely that they are fixed in place and deny users the opportunity to simulate running in natural environments. The proposed method offers a comprehensive solution by completing the task in its entirety through the addition of wheels to the treadmill bicycle andthe subsequent transformation into a walking cycle. [2]

A. The Treadmill

The frames of treadmills that are marketed in their normal configuration are often constructed of steel, although the frames of newer, more expensive models are typically made of aluminium. These are the two most common sorts of materials that are utilised in the building of frames. If you plan to maintain your treadmill for a very long period of time or if your weight is extremely close to the machine's maximum capacity, you should consider purchasing one with a frame made of aluminium because it is more durable than other varieties. When beginning and stopping the treadmill, you should make use of the treadmill rails, which are also referred to as bars or grips.[2] Handles are another name for the rails that go along the top of a treadmill. Because the handrails are not meant to be held throughout the entirety of your workout on the treadmill, you will need to position them in a location that is not only convenient but also out of the way to avoid getting in the way of your workout. When you do find yourself in a position where you require the grips, you want them to be not only comfortable but also simple to get access. [3-5]

B. Walking Belt

The walking surface of a treadmill is composed of a narrow belt that is continuously moving and a rigid plate that is maintained in place between the two surfaces of that belt.As can be seen in Figure 1 When the transverse load of footfalls is applied to the walking surface of the treadmill, this plate will provide support so that the treadmill may continue to function properly. Before commencing your workout, it is imperative that you take into mind the belt size of your treadmill if you intend to run or jog on it. If you plan to spend the most of your time walking, the size of the belt you wear won't matter as much as it would otherwise. The conventional width for belts is 19 inches, and their length is typically 50 inches. Despite the fact that this appears to be a suitable width and length, you need to bearin mind that the belt fits onto a deck, which integrates a section of the frame in addition to your console. This is something that you need to keep in mind at all times.

ISSN(Online): 2584-1025

Therefore, even though the measurements of your belt are 19 inches by 50 inches, the dimensions of the place in which you will be running may be 16 inches by 45 inches. To restate, if the only activity that you want to perform on your treadmill is walking, then the size that you have should be fine. If you want to give running a try, however, you will require a belt that is both wider and longer than what is typically worn since when we run, our bodies have a propensity to sway slightly from side to side. [6,7]

The augmented width will enable individuals to sway without encountering any obstructions from the frame, while the augmented length will allow for jogging with a normal stride without the potential hazards of tripping or falling off the treadmill.

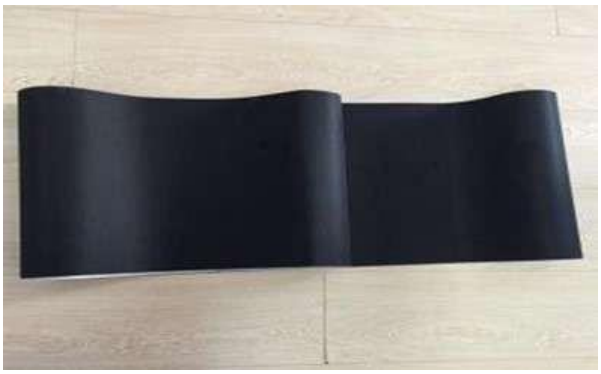

FIGURE **1** TRAEDMIL BELT

C. Wheels

A wheel is a component that has a circular shape and may rotate freely. It is held in place by an axle bearing and has a graphical representation that can be found in Figure 2. The wheel is a crucial component of one of the six basic machines, which is known as the wheel and axle, and it is also the machine's namesake.[5] Axles and wheels are essential parts of the machinery that enables the transportation or movement of huge objects while simultaneously supporting a load or carrying out mechanical labour. The usage of wheels involves a wide variety of applications, some of which include, but are not limited to, the steering wheel of a ship, the potter's wheel, and the flywheel. The use of axles and the ability of wheels to allow motion through rolling both contribute to a significant reduction in friction.

The requirement that the wheel must have a moment applied about its axis in order for it to circle can be met by gravityor by the application of some other external force or torque, but only one of these possibilities can meet the need.[6] In a single statement, the outline can be summed up as follows: "the outside edge of a wheel will be retaining the tyre." When applied to vehicles such as automobiles, it will produce the outer circular design of the wheel on which the inner edge of the tyre is fixed. This design may be seen from the outside of the vehicle. Because of this, the vehicle will be able to travel with less resistance. A large hoop, for instance, is the component of a bicycle wheel that is exposed to the outside and is attached to the extremities of the spokes. The bicycle's tube and tyre are both housed within this section of the wheel of the bicycle. [8-10]

FIGURE 2 WHEEL

D. Rollers

Even if the bicycle does not go forward when being ridden on bicycle rollers, which are a specialist sort of bicycle trainer, it is nevertheless feasible to ride a bicycle indoors using these devices. As may be seen in Figure 3, Because rollers, unlike other forms of bicycle trainers, are not attached to the frame of the bicycle in the same manner that other types of bicycle trainers are, the rider needs to be able to keep their balance while exercising on the rollers.[7] The rider of the bicycle moves forward and backward on top of the bicycle rollers, which normally come in sets of three for the front wheel. Because one of the back rollers is connectedto the front roller of the bicycle through a belt, the movement of the pedals on a bicycle will cause the front wheel to spin when the bicycle is being ridden by a human. In most cases, the spacing between the rollers of a bicycle can be adjusted to correlate with the length of the wheelbase of the bicycle. The front roller will typically be adjusted in such a way thatit is positioned some distance in front of the hub of the front wheel. This is the case in the majority of cases. [11-13]

Figure 3. Rollers

E. Bearing

One moving machine portion that acts as support for another moving machine element is referred to as a bearing. The moving machine has a component known as the journal.[8] Bearings allow for relative movement between the contact surfaces of the various sections while still effectively transferring the load. The process of reducing or removing frictional resistance results in a loss of power. It is possible to utilise a lubricant to decrease the amount of frictional resistance, the amount of wear, and the amount of heat that is produced. Lubricant use is a common application for mineral oil that has been processed further from crude petroleum.

ISSN(Online): 2584-1025

The bearings are held in place by a bearing block that is a part of it. Cast iron is the material that is used to produce it . Every bearing that is made use the machine frame in some way. [14,15]

FIGURE 4. BEARINGS

A lubricant may be used to reduce frictional resistance, wear, and to dissipate the heat produced. Mineral oil that has been refined from petroleum is frequently used as lubricant. It has a bearing block to hold the bearings. Cast iron is used to make it. The machine frame is used to produce every bearing.

F. Flywheel

The term "flywheel" refers to a rotating mechanical device that is employed for the purpose of storing the energy that is generated by rotation. Flywheels have something called the moment of inertia, which gives them the ability to withstand changes in the speed at which they are turning.[9] The amount of potential energy that may be collected from a flywheel is proportional to the cube of its spinning speed. When a torque is applied to a flywheel, the flywheel's rotational speed increases, and the quantity of energy that the flywheel stores as a result of this increase is increased. On the other hand, a flywheel makes use of speed in order to release energy that has been accumulated. [16,17]

FIGURE 5 FLYWHEEL

G. Sprocket

A sprocket refers to a wheel that has been specifically shaped and furnished with tooth structure, cogs, or additional sprockets, intended to engage with a chain, track, or any other perforated or indented material. This wheel can also be referred to as a sprocket wheel. Sprockets and the wheels that they spin on are both capable of being referred to as gears in certain contexts. As can be seen in Figure 6, A "sprocket" is generally understood to refer to any wheel that has radial projections and is designed to support a chain that runs over it. This particular application of the word "sprocket" occurs quite frequently. In contrast to a gear, a sprocket is never directly coupled to another sprocket, and whereas a pulley does not have any teeth, a sprocket does. A sprocket also has teeth, whereas a pulley does not. Even though they rotate in the same direction, sprockets and gears are never actually connected to one another in any way. The illustration can be found in figure 6.

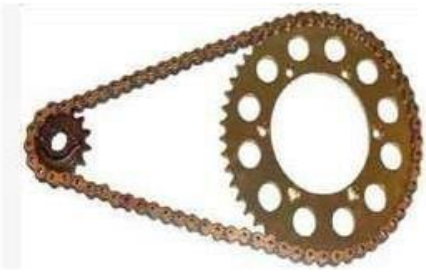

FIGURE 6 SPROCKET

II. WORKING PRINCIPLE

When a bicycle is converted into a treadmill, the rider moves forward by walking or running on a surface designed for walking. This causes the bicycle's rear wheel to turn, which in turn moves the bike forward. The moving belt that serves as the walking surface on a treadmill has a rigid plate sandwiched in between its two surfaces in order to provide additional support. When the walking surface of the treadmill is subjected to a transverse load from footfalls, this plate acts as a backup to support it. The original treadmill had a support plate that was an unaltered sheet of pressed particle board that was 0.75 inches thick. This support plate was not modified in any way.[12] This was fastened to the frame of the treadmill in four different locations using wood screws that were positioned in close proximity to the sheet's four corners. The plate was supported vertically when it was lying on the rails in a depressed position by two rubber pads that were positioned so that they were centered under the longest edge of the surface and halfway between the two places of rigid installation.

According to the paperwork that was included with the treadmill, the flexible multi-point mounting system was developed with the intention of lessening the plate's overall rigidity by providing more support than would be feasiblewith a direct attachment to two solid rails. This was done in an effort to make the treadmill more user-friendly. This support was intended to serve as an alternative to the support that would be provided by a direct attachment. Both the thickness and the stiffness of the surface of the particle board were significantly higher than what was required to entirely eliminate any and all perceptible deflection in the system. In order to mitigate the compliant impact of the rubber supports, additional aluminium reinforcements were introduced intermediate the sheet and the rails, users were unable to identify the change in stiffness that happened as a result of the modification. This was because the change

ISSN(Online): 2584-1025

occurred so quickly after the adjustment was made. We came to the conclusion that in order to develop the optimum impact-absorbing walking surface that is also capable of lowering the impact forces that are associated with running and walking, there will need to be certain adjustments made.

In addition to that, the bottom face of the sheet of particle board featured two metal brackets that were oriented outward in a direction away from the sheet. When the system was operational, they were arranged in such a way that the conveyor belt would pass over them in the order listed above, one after the other. In the event that the belt moved away from the centred position of its rollers, this had the effect of automatically maintaining the belt's alignment by generating a restoring force.[18-21]

If the belt was shifting away from its centre while it was resting on its rollers, this resulted. As soon as we start using the treadmill, the back wheel will begin to move, which will cause the flywheel to build up momentum. Once the flywheel has gained initial momentum, the bicycle will continue to go forward due to the momentum that is created by the flywheel. In addition to that, we used a gear system to attach a dynamo to the rear wheel of the vehicle. As a consequence of this, the dynamo spins and generates electricity each time you use the treadmill. This power can then be stored in a battery and used at a later time. The design model can be seen in Fig.7.

FIGURE 7 3D DESIGN OF BICYCLE

CONCLUSION

It performs its duties admirably both on the inside and the outside of the house. This makes use of technology that decreases the amount of petrol that is consumed, which is an absolute requirement in the modern world. It is viable to utilise it as an infrastructure for an indoor locomotive device in retail malls, warehouses, open marketplaces, vast offices, and other conditions that are analogous to these kinds of locales. The employment of a device such as this one helps to ensure that pedestrian law enforcement officials do not become exhausted during the course of their shifts. Pedestrians moving through expansive campuses may also find that the use of this product is to their advantage. In future we can able to develop a fuel-saving car for people who do not ride bicycles.

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ISSN(Online): 2584-1025

MIT UNIVERSITY'S – ABHIVRUDDHI
JOURNAL VOL.3 (01) , JUNE , 2023 pp- 77-82

Survey on Techniques Available for Sugarcane Maturity Testing

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***Abstract*— In this paper, the most recent techniques for sugarcane maturity testing are reviewed. The best time to harvest sugarcane is determined by sugarcane maturity testing, which has a major impact on both sugarcane quality and yield. Traditionally, labor-intensive and time-consuming methods like refractometry and polarimetry have been used to determine the sucrose content in sugarcane. In contrast, new developments in non-destructive techniques like near-infrared spectroscopy (NIRS) and spectroscopy imaging have shown encouraging results in the provision of quick and precise sugarcane maturity testing. The principles and instrumentation of these cutting-edge methodologies, the data analysis methods employed, the difficulties and potential future paths for sugarcane maturity testing are all covered in this review article. It is possible to significantly increase the efficiency and accuracy of sugarcane maturity testing through the integration of cutting-edge technologies, giving farmers crucial knowledge to maximize the yield and quality of their sugarcane crops.**

Keywords*— *sugarcane maturity, advanced technology, Test sensor, AI, ML

I. INTRODUCTION

A vital cash crop grown for the production of sugar and bioenergy sugarcane is grown all over the globe. A crucial element that profoundly influences sugarcane production and quality is the best time to harvest. Thus, determining the ideal harvesting period requires gauging the sugarcane's maturity level. Refractometry and polarimetry are time- and labor-intensive traditional techniques for determining the amount of sucrose in sugarcane. However, new developments in cutting-edge technologies, including near- infrared spectroscopy (NIRS) and spectroscopy imaging, have demonstrated encouraging results in the provision of quick and precise sugarcane maturity testing. The goal of this review paper is to give a summary of the most recent technological developments in sugarcane maturity testing [1].

The world's second-largest producer of sugar after Brazil, India contributes significantly to the global sugar market by producing roughly 15% and 25% of the world's sugar and sugarcane, respectively [2]. It contributes to an important boost to the growth of the nation's social and economic structures, respectively. There are currently 597 functioning sugar factories, 309 distillations, 213 power generation plants, and multiple pulp, paper, and chemical-based establishing units that are all a part of the sugar processing sector. The sugar sector is assisted by four that lead the sugarcane plant research organisations, 22 state sugarcane research points, and world-class sugar machines producers, vendors, and technical specialists. [3]. In order to satisfy domestic sweetener demand, the industry produces about 300-350 MT of cane, 23-25 MT of white sugar, 6-8 MT of jaggery, and khandsari on an average of 5 million ha, or about 3% of the gross cultivable area in the nation. In addition, about 2.9 billion liters of alcohol, 2,330 MW of electricity, and numerous chemicals are produced [4].

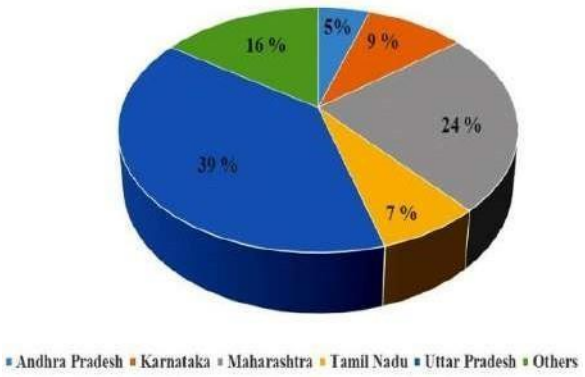

Fig 1 Largest sugarcane-producing states in India

The most common commercial methods for evaluating the Brix content of sugarcane are the refractometer,, Brix hydrometer, spectroscope, and chemical analysis commonly performed in the electronic saccharimeter of Brix. Amongst them, a spectroscope is a one-of-a-kind non-invasive instrument that enables continuous tracking in addition to rapid tests that can be carried out with a high degree of accuracy. On the other hand, monitoring in real time is not practicable because of the tremendous cost of doing so [5]. A wide array of non-destructive technical devices, such as electromagnetic sensors, image processing, ultrasound, magnetic resonance, and laser excitation, can be used to observe the physicochemical features of food. These instruments are generally utilised for the detection of physicochemical parameters such as Brix and TSS. (Total solids that are soluble). Instruments that rely on food scent, capacitive sensors, and spectroscopy (NIR, which stands for near-infrared spectroscopy, and MIR, which stands for medium-infrared spectroscopy) can be used to calculate the amount of sugar that is present in sugarcane. [6]. Sugarcanes are deemed mature and prepared for harvesting when theyreach a certain minimum Brix value. Mukhtar's maturity study included additional criteria for when sugar cane is considered ripe, such as when all but the bud of the cane are visibly dried up leaves. Or we could say that the most leaves fall off of the sugarcane when it reaches maturity [7].

ISSN(Online): 2584-1025

The equal percentage of %brix of sugar cane in the bottom and upper parts of the plant is a chemical sign that the plant is mature. We must conduct a measurement in order to learn the sugar concentration of the sugarcane in the field. Cutting some samples of sugar cane plants and squeezing them into the milling, then transferring the liquid solution to the laboratory for identification, is the most current technique for determining sugar content. This approach is regarded as a challenging, costly, and time-consuming approach. There is a chance of using an alternative technique to determine the sugar content. As a light source, they used a photometric detector emitter (LED), and the sensors they used were LDR and photodiode array. Yeh and Tseng (2006) also made an effort to create a low-cost spectrometer using LED and LDR. However, all of the instruments mentioned above should be used with sugar cane watery solution. It denotes the destruction of the tested substance. Additionally, using LEDs as a light source has a range drawback. Naderi-Boldaji provided a description of a non-destructive technique. They used a parallel plate capacitor to explain the technique for calculating sugar content based on the characteristics of the dielectric constant. They suggest the non-destructive Brix meter, which is founded on the optical characteristics of sugar content, as a result of the concept of non-destructive measurement. This method of measuring using a photometer and spectroscopy methods employs the Brix scale. Our device uses a photodiode array as a detector and LEDs as its light source [8].

This research used the portable, inexpensive, and non-destructive Vis/SWNIR method to forecast sugarcane Brix based on stalk scanning. The PLS systems provided a good level of constraint for both the baseline ranges and the estimated amounts of the reflectance and absorbance spectra, with R2 values of 0.91 and 0.89, respectively. With an overall accuracy of 83.1%, the ANN that was used to divide Brix into various quality classes had produced acceptable classification performance ranging from 50 to 100% accuracy. Overall, this research has shown that the combination of ANN and Vis/SWNIR spectroscopy possesses the ability to be utilised for real-time quality monitoring in order to fulfil PA criteria. This review article provides a detailed overview of the techniques used to determine sugarcane maturity.

II. REVIEW AND TESTING METHODS

A. Advanced methods of sugarcane maturity testing

Two primary techniques are available in advanced methods: a destructive method and a non-destructive method.

B. Destructive method

destructive methods of sugarcane maturity testing provide accurate and detailed information about the composition of sugarcane samples, but they require specialized equipment and expertise, and they destroy the sample in the process.

C. Lipid polymer membrane method (sweetness sensor)

Sugarcane maturity testing frequently makes use of sweetness test instruments. These sensors are made to measure a sample's sweetness or sugar content, which is a crucial indicator of how mature it is [9]. There are many different types of technology, but sugarcane skin scanning is the most prevalent. That strategy also functions well in the field of agriculture. markers of fruit and vegetable maturity. The two groups into which maturity has been divided are physiological maturity and horticultural maturity [10]. The maturity index serves as a sign that a commodity is available for harvest. The timing of harvest is determined using this as a guide. A. Physiological development: When a fruit or vegetable reaches this stage of development, it has experienced its greatest growth and maturation The various formulation types offered on the pharmaceutical market come in a variety of forms, but tablets and capsules are the most widely used [11].

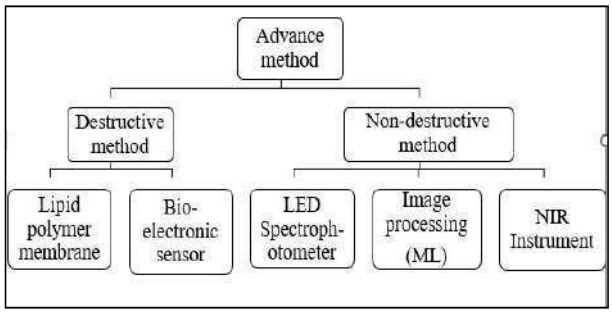

Fig 2 Advance methods of sugarcane maturity testing

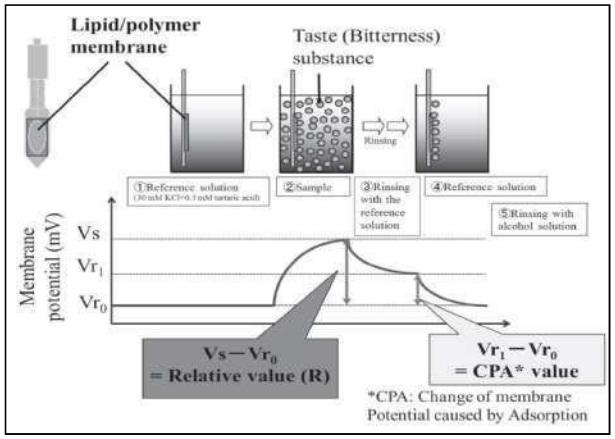

Fig 3 Lipid polymer membrane [11]

These formulations provide numerous advantages, such as dosage accuracy and relatively high stability, as well as the ability to alter the medication release profile in order to delay or keep a therapeutic effect. However, their palatability is crucial for patient adherence and effective medication, especially if they have a bitter flavor [12]. have investigated the variations between the Insent taste-sensing device for pharmaceutical formulations and the ASTREE electronic tongue. Both systems have benefits and drawbacks, according to those writers. Because each taste sensor membrane reacts to a particular flavor, the Insert taste sensing system excels at quantifying taste attributes like bitterness strength. However, this approach cannot identify all substances [13].

D. Bio-electronic sensor method

An appropriate pattern recognition tool and a sensor array with limited individual discrimination were described as the electronic tongue. established the terminology for liquid potentiometric analysis used globally [14]. In this context, the term "electronic tongue" refers to a multisensory system that makes use of a wide range of low-selective instruments and advanced mathematical signal processing methods based on pattern recognition and/or multivariate analysis. This device is employed to classify data. Its operation is founded

ISSN(Online): 2584-1025

on measuring a large number of samples and using principal component analysis to monitor their variability. (PCA) [15].

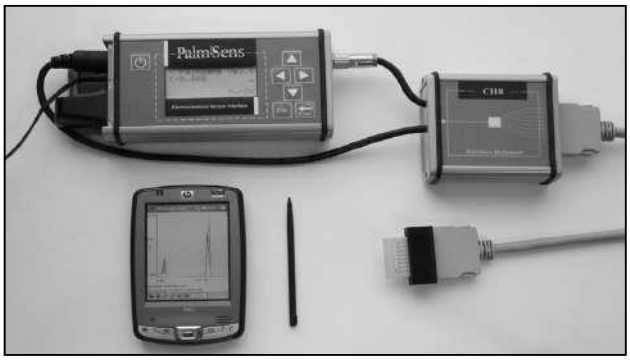

Fig 4 Bio electronic sensor

As a consequence, the data are divided into distinct groups according to various sample characteristics. The created artificial tongues make use of the electrochemical properties of samples. Potentiometry and voltammetry, which employ a variety of modified working electrodes, are used to provide appropriate responses and are adequate detecting systems. Electrochemistry was replaced with systems based on visual and piezoelectric principles (Surface Acoustic Wave, Quartz Crystal Microbalance) [16].

E. Non-Destructive method - LED Spectrophotometer method

Non-destructive methods of sugarcane maturity testing involve analyzing the sugarcane without damaging or destroying the sample. These methods are becoming increasingly popular in the industry because they are faster, more convenient, and do not require the destruction of the sample.

Modern tools like LED spectrophotometers are used to check the sugarcane's ripeness. They are based on the spectrophotometric principle, which entails determining how much light is absorbed or transmitted by a sample at various wavelengths [17]. illumination-emitting diodes (LEDs), as opposed to conventional lamps or lasers, are used as the illumination source in LED spectrophotometers. LED spectrophotometers are used to gauge the sugar concentration of the juice during sugarcane maturity testing. The LED spectrophotometer produces light with a particular wavelength and gauges how much of it reaches the sample [18].

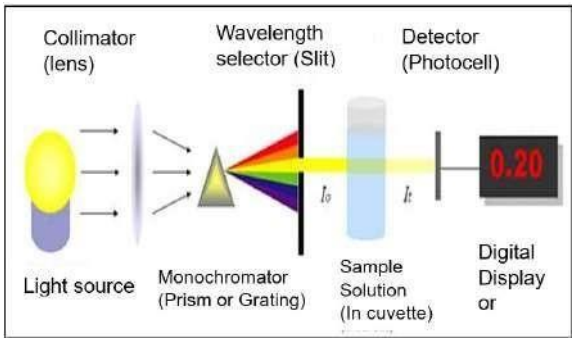

Fig 5 LED Spectrophotometer [18]

The sample's ability to absorb light is proportionate to how much sugar is present. Due to their advantages over conventional spectrophotometers, such as low power consumption, high sensitivity, cheap cost, and a long lifespan of the LED light source, LED spectrophotometers are preferred. They are ideal for field applications due to their portability and compactness [19]. In the sugarcane business, a variety of LED spectrophotometers, including benchtop and handheld models, are employed. Handheld spectrophotometers are appropriate for use in the field, whereas benchtop spectrophotometers are best used in laboratories. The DS2500 UV-Vis Spectrophotometer, the Jenway Genova Nano UV/Vis Spectrophotometer, and the spectrophotometer are a few of the well-known LED spectrophotometer models used in the sugarcane business.

F. Non-Destructive method - Image processing (ML) method:

Methods of image analysis are frequently employed to gauge sugarcane maturity. These techniques involve examining digital pictures of samples of sugarcane and extracting characteristics that indicate maturity. Utilizing color-based techniques, the maturity of sugarcane samples is determined by examining their hue [20]. These techniques extract color characteristics from the images, such as hue, saturation, and intensity, using image processing algorithms. The maturity level of the sample is then determined by comparing the color characteristics to a reference color chart. Utilizing texture-based techniques, the maturity of sugarcane samples is determined by examining their structure. These techniques derive texture characteristics from the images, such as entropy, contrast, and homogeneity. The samples are then categorized into various maturity levels using the texture characteristics. A model is trained using a dataset of images of sugarcane and the associated maturity levels in machine learning-based methods [21]. The model learns to categorize the pictures based on their maturity level by extracting features from them using image processing algorithms. Then, the learned model can be used to forecast the maturity level of fresh samples of sugarcane. Images of sugarcane samples are taken using multispectral imaging at various light frequencies. After that, spectral characteristics that are suggestive of maturity are extracted from the images using image processing algorithms. Compared to color-based and texture-based approaches, these techniques can offer more comprehensive information about the sugarcane samples [22].

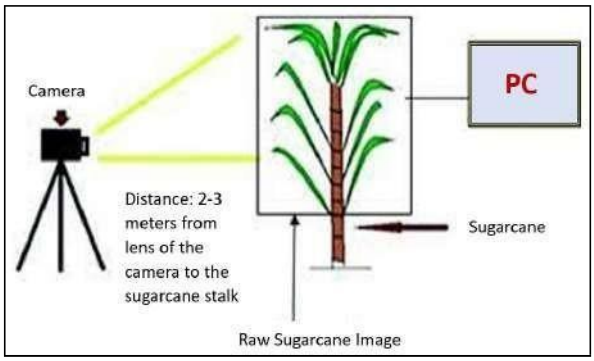

Fig 6 Image processing method for sugarcane maturity testing

ISSN(Online): 2584-1025

Orbital images are frequently used in agriculture to identify large-scale spectral fluctuations brought on by soil and crop features. This aids farmers in making better management decisions by giving diagnostics for agronomical crop factors. For instance, the definition of management zones for annual harvests through the use of orbital. [23].

G. Non-Destructive method -NIR Instrument method

Sugarcane ripeness can be assessed quickly and non-destructively using a technique called near-infrared spectroscopy (NIRS). By measuring the sugarcane samples' near-infrared reflectance or transmittance, NIRS generates a spectrum that can be used to identify the molecular makeup of the sample [24]. By measuring the sucrose concentration of the juice obtained from the sugarcane stalks, one can ascertain the sugarcane's maturity. By examining the near- infrared spectrum of the sugarcane samples, NIRS can be utilized to forecast the sucrose concentration. The sugarcane samples' near-infrared spectra reveal details about their molecular make-up, including the amount of sucrose present [25,26].

A spectrometer, a light source, and a sample holder are the usual components of the NIRS device used to assess sugarcane maturity. Depending on the measurement method, the sample holder may be a reflectance or a transmission cell. In the reflectance setting, the sample is mounted on the sample holder and exposed to the near-infrared light [26]. The sample is positioned between two clear windows in transmission mode, allowing the near-infrared radiation to pass through the sample. The near-infrared reflectance and transmittance of the sugarcane samples over a variety of wavelengths are measured by the NIRS instrument. The acquired near-infrared spectrum is then processed using chemometric methods like principal component regression (PCR) or partial least squares regression (PLSR). These methods make it possible to predict the correlation between the near-infrared spectrum and the sucrose content. The maturity of sugarcane can be ascertained by examining the near-infrared spectrum of the sugarcane samples after the connection between the near-infrared spectrum and the sucrose content has been established.

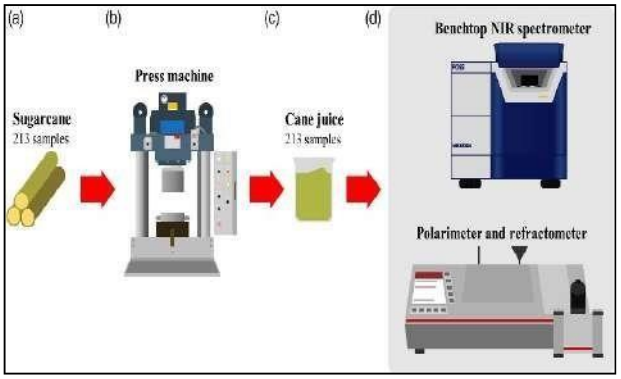

Fig 7 NIR Spectroscopy method [26]

The near-infrared spectrum can then be used to forecast the sucrose content and identify the sugarcane's maturity [27,28]. The data is obtained from the various literature and content is highlighted in the Table-1. The dataset mentors about the year, methods used and corresponding findings obtained by the various researchers has been listed. Next to that, further discussion is carried out and pointed out in the results and discussion section.

III. Result and Discussion

In the current review paper, there is a debate regarding advanced methods of sugarcane maturity assessment. This paper examines 27 works to determine whether or not those papers are relevant to this subject. There are a total of 15 papers that can be accessed, with 8 of them referring to destructive techniques of sugarcane maturity testing and 11 of them pertaining to non-destructive methods of sugarcane maturity testing. The scope of the other studies is extremely vast.

The process of determining the maturity of the sugarcane is an essential step for the sugar industry since it has a substantial impact on the amount of sugar in the final product, as well as the yield and quality of the product overall. Brix and Pol readings, which are often used to determine the maturity of sugarcane, can be labour- and time-intensive to measure, in addition to occasionally producing inaccurate results. However, as a result of developments in technology, a number of sophisticated methods have been developed. These methods provide precise, non-destructive, and speedy evaluations of the sugarcane crop's development stage.

Fig 8 Total papers available for sugarcane maturity testing

The Near-Infrared Spectroscopy (NIRS) technique is one of the more sophisticated ways to gauge sugarcane ripeness. NIRS is a quick, non-destructive technique that measures how well sugarcane samples transmit or reflect near-infrared light. The method produces a spectrum that can be used to identify the chemical makeup of the sample, including its sucrose content. The sugar business has widely adopted the NIRS method because it has been demonstrated to be an accurate and trustworthy method for determining sugarcane maturity. [29-31]

An further cutting-edge strategy for figuring out when sugarcane is ready to be harvested is to use various sensors and imaging techniques. These methods involve the utilization of several pieces of equipment such as thermal imaging, laser-induced fluorescence, and hyperspectral cameras in order to monitor the evolution of the sugarcane's physical and chemical properties over time. It has been demonstrated that these sensors are accurate and dependable ways for evaluating the maturity of sugarcane, and the data that they collect may be utilized to construct models that can predict when sugarcane will attain maturity.

ISSN(Online): 2584-1025

TABLE I. FINDINGS FOR THE EXPECTED SURVEY YEARWISE MENTIONED THE INFORMATION FROM LAST DECADES

REF. NO.	YEAR	METHODS USED	FINDINGS
[1]	2014	-	This paper gives about general introduction about sugarcane production in India.
[2]	2021	Ultra brix device	Utilizing Brix monitoring from planting to harvest, Ultra Brix can also be used as a support tool in the creation of best practices in agricultural management, cultural treatments, and the study of new varieties (genetic improvement).
[3]	2012	Remote sensing technique	In comparison to merely counting canes, the laborious and expensive measurement of early-season yield offers a marginally stronger prediction.
[4]	2019	LED-Refractometer method	The findings demonstrated that, when compared to a digital spectrophotometer used as a reference instrument to measure the sugar content of a solution, the LED-refractometer can measure sugar content of sugarcane plantations in the field with an accuracy of 95%.
[5]	2013	NIR Spectrophotometer	In order to predict sugar content from skin scanning, the potential use of a visible and shortwave near infrared (Vis/SWNIR) spectroscopic method was assessed.
[6]	1972	-	The respected paper reviews about soil condition suitable for sugarcane production and gives positive point to increase maturity of sugarcane.
[7]	2014	Image processing (Sampling Technique)	The main factors to be taken into account when developing a measurement technique and sampling mechanism in the field are also covered.
[8]	2018	HSV (Hue saturation value) technique	The proponents discovered that there is a substantial shift in Hue and Saturation values as sugarcane crops mature through a series of experiments in the HSV color space.
[9]	2016	Sweetness test sensor	The objective of this review is to explore the benefits and drawbacks of taste sensors in assessing the flavor and palatability of various oral dosage forms.
[10]	2007	Lipid polymer electrode	For use as nonspecific amperometric sensors for blind analysis on actual matrices, such as various fruit juices from various fruits or different brands, three distinct electrodes were put to the test.
[11]	2020	Sweetness Detection, Fdc2214, STM32	A gadget that measures the sweetness of sugar water is suggested, and its processor is an STM32 single chip microcomputer. The FDC2214 sensor is used to measure sugar water content.
[12]	2006	Electronic tongue, Sequential injection analysis	An acceptable comparison was also made using the technique to determine anions in synthetic samples and actual water samples.
[13]	2009	Electronic tongue, Bioelectronic tongue	This study contrasts different (bio)electronic tongue types. Applications in food and environmental analysis are addressed along with the design and operating principles of potentiometric and voltammetric electronic tongues.
[14]	2011	Taste sensor, Electronic tongue	The Astree electronic tongue and the Insent taste sensing system are already widely available. Additionally, there are numerous experimental prototype iterations available.
[15]	2010	Taste cell sensor, Electrochemical impedance spectrum	This article proposes a novel sweet taste cell-based sensor for the detection of tastes. On the carbon screen-printed electrode, human colorectal carcinoma NCI-H716 cell lines are grown that express gustducin and the sweet taste receptor T1R1/T1R3.
[16]	2010	Electronic tongue	The outcomes demonstrate the potential of the electronic tongue for analysis of drug masking effects and microencapsulation impact detection.
[17]	2020	Image processing, Data analysis	This study's goal was to ascertain the impact of Funneliformis mosseae KKU-BRP-KK6-2, an arbuscular mycorrhizal fungus (AMF), inoculation on sugarcane physiology during the maturation and ripening phases under field circumstances.
[18]	2012	Object Based Image Analysis (OBIA) Data Mining (DM)	The purpose of this study was to create a technique for automating the mapping of sugarcane over large areas using time-series remote sensing data.
[19]	2020	UAV-LiDAR; random forest regression.	Their research offers recommendations for determining the ideal planting density, minimizing the negative effects of human activity, and choosing the best tillage techniques for real cultivation and production.
[20]	2018	Maturity analysis using image processing	The maturity identification comparison module, which employs the 90.16% accurate RandomForest algorithm, used the Hue and Saturation frequencies of both mature and immature sugarcanes as data.
[21]	2021	remote sensing, orbital images	The study's methodology involved creating forecasting sugarcane production models that combined time-series orbital imaging with machine learning.
[22]	2021	Non-destructive method, Artificial Intelligence	A thorough review is offered, building on earlier reviews that primarily addressed the crop's spectral behavior and takes into account the advancements made with new data analysis methods and better data sources.
[23]	2013	NIR Spectroscopy	They used a portable near infrared (NIR) instrument to explore the non-destructive measurement of the sugar content of cane stalks.
[24]	2012	NIR Spectroscopy	A low cost visible and shortwave near infrared (VIS eSWNIR) spectrometer and an artificial neural network were assessed for their potential in the non-invasive measurement of pineapple's soluble solids content.

ISSN(Online): 2584-1025

[25]	2018	UAV ,Yield estimation, Remote sensing	The very high spatial resolution of UAV images and OBIA's sophisticated image classification show a lot of promise for enabling farmers and associated sectors to forecast yield prior to harvest.
[26]	2008	NIR Spectroscopy	They used a portable near infrared (NIR) instrument to explore the non-destructive measurement of the sugar content of cane stalks.
[27]	2017	Image processing	Using metrics from time series of the normalized difference vegetation index (NDVI) from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor and an ensemble model of artificial neural networks, the goal of this research is to forecast the sugarcane yield in So Paulo State, Brazil. (ANNs).

CONCLUSION

In summary, the utilisation of cutting-edge methodologies may significantly contribute to an improvement in both the efficiency and accuracy of the sugarcane ripeness testing process. Many cutting-edge methods, such as the NIRS method, sensors and imaging methods, machine learning algorithms, and artificial intelligence, have been developed and deployed within the sugar business. These methods provide rapid, non-destructive, and accurate assessments of the maturity of the sugarcane, which can assist in increasing the amount of sugar that can be produced as well as the overall quality of the end product.

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