A Review on Applications of Flex Sensors in Teleoperation

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***Abstract*— A flex sensor is a sensor that detects defection or bending. Materials like plastic and carbon can be used to create this sensor. The carbon surface is mounted on a plastic strip, and the sensor's resistance changes when the strip is turned away. As a result, it has sometimes referred to as a bend sensor. Because the number of turns is related to the changing resistance. A flex sensor uses the principle of change in internal resistance to detect the angle formed by the user's finger at any given time. Hand flexes in different combinations form a gesture, which can be translated into into spoken phrases. The flex sensor uses less power than an accelerometer, and it is unaffected by human body angle faults that are not parallel to the gravity line. It is easy to use and transport at the same time. Neck posture can be divided into two categories: poor posture and excellent posture. In order to determine the correctness of the device's categorisation. Teleoperations are simply remote operations that require flexible operations that can be carried out with sensors, allowing flexible sensors to be used in a variety of applications.**

***Keywords*— Robots, Flex Sensors, Gesture control, Teleoperation, Flex, Applications**

I. Introduction

There is a need to communicate with technology in a more advanced manner in a world where it is always evolving. Because most of us have seen many science fiction movies, we have definitely noticed that using different fingers on our hands is one of the most efficient ways of communicating with technology. Hand gestures are a way of communicating with others that relies heavily on nonverbal cues like finger motions. Such hand movements are second nature to us and play a vital role in our daily lives. It enables you to express yourself clearly while maintaining the conversation's flow. When we communicate with others via hand gestures, they perceive us more clearly. The blind use them as well, as if it were a reflex action. Hand Gesture Recognition (HGR) is one of the most essential areas that will have a big impact on the future of technology. HGR to speech conversion is one of the

II. Hand Gesture Recognition Using Flex Sensor

A flex sensor is the most important component in this research. All of the used components are from a hardware prototype with flex sensors attached to the fingers [11]. When flex sensors are bent, the resistance of their terminals varies, allowing them to detect motion in a specific area of the body. The Flex sensor does not have polarized terminals. There are no positive or negative terminals as a result.

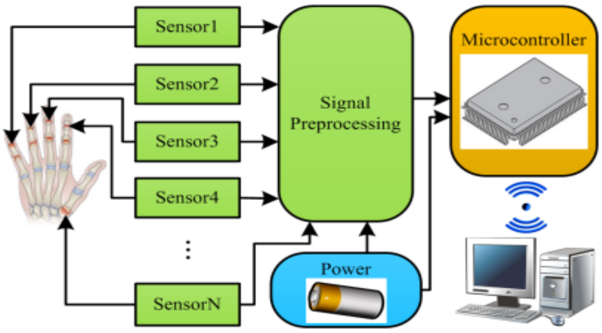

Fig. 1. The basic structure of a glove-based system.

As the bend/flex in the Flex sensor increases, the resistance increases. The connection created in order to interface with the Arduino is shown. Following the foundational work, we move on to obtaining data from the flex sensors' actual situations, i.e., when they are attached to fingers and the readings measure the bending of each finger to which they are attached, as shown in fig.1. To prepare the setup, the following steps were taken:

With this example, the hand was covered in white surgical gloves. It is carried out in order to determine how perspiration affects the Flex sensors. The Flex sensors were then connected to the index and middle fingers of the right hand. Elastic bands were used to keep the sensors in place. Long copper wires were used to connect the flex sensors to the

Arduino and resistor, as shown in the circuit schematic. This was a hand motion in which the index and middle fingers curled within each other. This class name denoted a hand gesture in which both the index and middle fingers were fully stretched and held in a V shape.

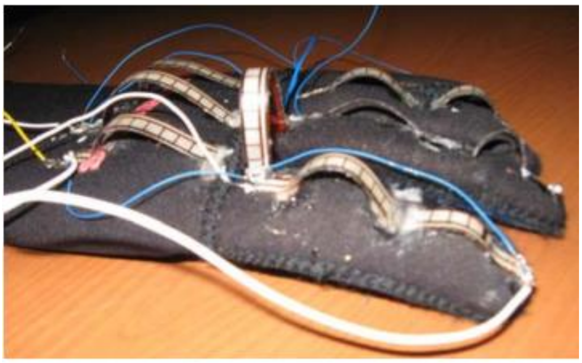

Fig. 2. Hardware prototype developed using Flex Sensor.

Hand gestures can be used to communicate with a variety of electrical gadgets. This manner of getting information has the potential to significantly alter each of our lives. People who are unable to speak can employ the concept of hand gestures being converted into speech in real time by a machine [11]. Very soon, the application will be observed in a range of sectors. This fueled our desire to go on to the final and most critical part of our project: hand motion recognition.All processed data was trained, validated, and tested using several machine learning models. The fundamental goal for utilizing this model is to get the highest possible accuracy even if there is some alteration in the data for training or testing due to external influences.

III. MONITORING NECK POSTURE WITH FLEX SENSORS

A flex sensor is a passive resistance sensor made by uniformly coating the surface of a flexible substrate with conductive substance. The sensor can withstand bending, vibration, heat shock, and other forces. The author employs equipment to improve neck health in the cervical vertebrata region of the neck [3]. It connects the C1 to C7 joints of the cervical vertebrae. The surface conductive substance is stretched, and the gap expands [3], increasing resistance. The flex sensor resistance changes with the degree of bending of the cervical vertebrata, as seen in fig.3.

Fig. 3. Cervical Vertebrata from C1 to C2 joints

To allow BLE communication and data processing, the nRF52832 chip is used as the core processor. The flex sensor signal is sampled using the chip's built-in ADC [3]. The architecture of the hardware system It is divided into four sections: (1) the nRF52832 SOC, which, after the internal ADC gathers data, delivers it to the mobile phone/PC; (2) the vibrating motor/LED, which informs the user. (3) The reset key, which is used to restore the system to its original state.

Fig. 4. Hardware actual photo.

We have coding for fixed data is $\alpha = 30°$ in such a way that, based on data received by the microcontroller.

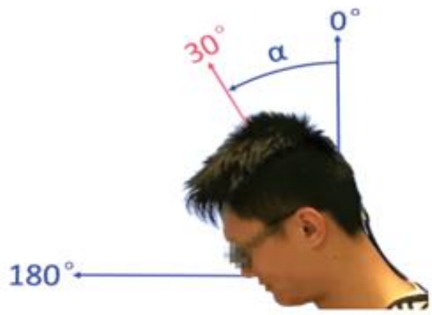

Fig. 5. Monitoring neck posture.

As we can see here, we used two flex sensors back to back for determine the forward and backward movement of the neck [3]. We connect flex sensors to the micro-controller with power supply where analog signals get converted into digital signals.so, we get information about the bending angle $\alpha = 30°$. In this way we can determine how much the neck is rotating in degree for to and fro motion. Where NPG = Neck Posture Good and NPB = Neck Posture Bad So, coding is as follows

```
while Neck Posture Not Change do
Update DD;
Update FD;
  if   FD (sensor front) < DD (sensor
front) and
         FD (sensor back) > DD (sensor
back) then
            Neck Posture = NPB;
 Else
            Neck Posture = NPG;
end if
end while
```

IV. SOFT PNEUMATIC ACTUATORS WITH EMBEDDED FLEX SENSORS

Soft pneumatic actuator (SPA) with internal fluidic channel patterns [5] are made of extremely elastic elastomer materials that deform when the internal channels are compressed, causing the actuator to move in a predetermined direction. The response of this type of actuator is governed by its morphology, which is determined by the geometry of the internal fluidic channels and the characteristics of the materials used in manufacturing.

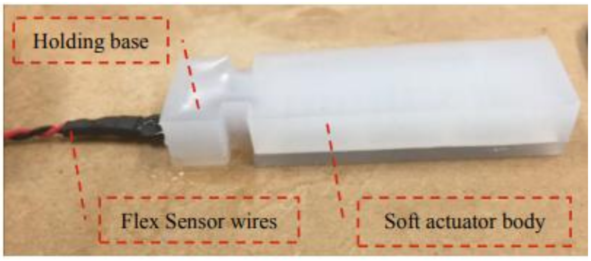

Fig. 6. Soft actuator sample with an embedded flex sensor.

A flexible but inextensible strain-limiting layer in the form of paper or fabric can be applied to the base of a normal soft pneumatic actuator to prevent it from elongating and instead create a bending motion similar to that of a human finger.

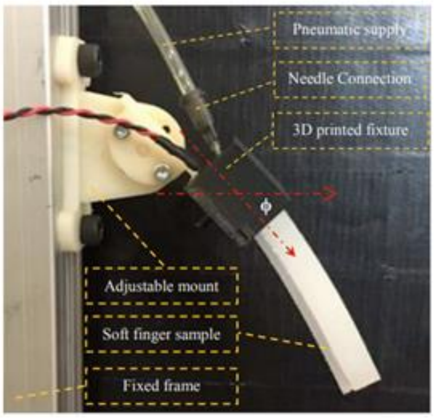

Fig. 7. Experiment setup fixing the tested soft fingers.

The main procedure for building SPAs is moulding silicone rubbers into the correct shape using 3D printed moulds with the negative of the features to imprint, as illustrated in fig.7, and then connecting the components together after curing to produce the final shape of the actuator[5]. A soft finger with ribbed channel morphology was constructed out of a common silicone rubber material called as Ecoflex-50. The soft finger dimensions were calculated using previous research that defined the bending response and force production of a set of soft fingers with different interior channels. A modular interface that puts the tested soft finger inside its bending plane at the correct orientation using a fixed frame configuration with variable 3D printed mounts. The input pneumatic supply flows through a tube with a 1.6 mm needle [5] connected to its end, as illustrated in fig. 7, to allow for quick switching between finger samples during testing. The tip of this needle travels through a locating hole in the 3D printed fixture to penetrate the soft finger at the base of the internal channels [5]. The flow rate of the pneumatic supply can only be modified by varying the magnitude of the input pressure and its duration since the needle has a fixed intake diameter.

Soft fingers were repeatedly activated at varying magnitudes and durations of the provided pressure input to confirm the repeatability of the sensory feedback. When given with a step pressure input of 12 Psi [5] for various periods, a plot for the internal pressure measured versus the subsequent flex sensor data was constructed. The flex sensor value decreases as the internal pressure rises in the cycle illustrated, until the pneumatic supply is shut off and the soft fingers begin to retract back to their original shape.

Higher actuation lengths resulted in a systematic elongation of the observed response, as illustrated in fig. 8. When a consequence, providing the input pressure remains constant and the material does not break, the soft finger will continue to bend according to the same connection between the internal pressures and flex sensor readings as the actuation length is extended [5].

Higher actuation lengths resulted in a systematic expansion of the observed response, which was reproducible. When a result, providing the input pressure remains constant and the material does not break, the soft finger will continue to bend according to the same connection between internal pressures and flex sensor readings as the actuation duration is increased.

V. CONCLUSION

A resistive flex sensor was placed within the soft actuator's strain limiting layer and its resistance changes when the soft actuator bends. During actuation, an internal pressure sensor connected to the pneumatic supply measures the reaction of internal pressures. The soft actuator was put through its paces by putting it in various positions on a testing bench and repeatedly activating it with a controlled pneumatic supply. To validate the obtained models, a new data set was created by testing the soft actuators in untrained operating circumstances. The vision system used the recorded sensory data to compare the expected bending angles to the actual values measured. When evaluating the models in untrained circumstances, the error in anticipated values increased using both methodologies, as expected. Both techniques increased the inaccuracy in anticipated values when testing the models in untrained circumstances, as expected. A finger motion capture device based on a flex sensor is used as an input device to the system; it gives accurate sensitivity and improved outcomes. Following the successful construction of a wireless link between the human hand and the robotic hand, wireless signal transmission through Zigbee device has been completed. A flex sensor-based robot was used to control the robotic system and capture human finger activity.

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