[1]T. Jayasree
[2] Kishore Kumar S
[3] Mukesh K
[4] Abisha M
[5] Mageshwari R

# Monitoring and Correction of Human Joints Posture using Flex sensor

Journal of Electrical Systems

***Abstract:*** A large number of the working population have occupations which require long hours of sitting and students spend most of their time on laptop, mobile devices leaning forward, incorrect sleeping posture etc., these mentioned habits lay significant strain on the posture. In fact, after surveying 200 people of various age groups, 76% said that they do not practice good posture. Of those people, more than 90% said that they experience joint pain. A posture monitoring and correction system is developed which is used to enhance the quality of life by providing the support needed to maintain good posture. When the user retains the same posture for a period of 2 minutes, this system will automatically warn the user such that he/she can correct it. The neck posture is monitored by placing the flex sensor over the neck region of C2 – C7 of cervical vertebra and intimated by buzzer sound if the user maintained the same posture for around 120 seconds. This proposed work will be further utilized to analyze the improper use of wrist joint which creates numbness and leads to carpel tunnel syndrome. The flex sensor monitors the wrist joint movement which will placed in the dorsal side of the wrist and give an alarm, besides the maximum extension up to which one can do flexion and extension will also be set so that the over usage of the joint will be intimated by auditory signal.

***Keywords:*** Cervical, Vertebra, C2-C7, Numbness, Carpel tunnel syndrome

## I. Introduction

In today's fast-paced world, where sedentary lifestyles and long hours of desk work have become the norm, maintaining proper posture has become increasingly challenging [1]. Poor posture not only affects one's physical appearance but also leads to a myriad of health issues, including back pain, neck strain, and joint problems. Fortunately, advancements in technology have paved the way for innovative solutions to address this issue.

One such solution involves the utilization of flex sensors for monitoring and correcting human joint posture [2]. Flex sensors are devices capable of detecting changes in bending or flexing. When integrated into wearable devices or embedded within garments, they can provide real-time feedback on the alignment of joints, aiding individuals in maintaining correct posture throughout various activities.

Monitoring and correcting human joint posture using flex sensors offer several advantages over traditional methods [3]. Firstly, it provides continuous, personalized feedback tailored to the individual's movements and body mechanics. This real-time feedback helps users develop an awareness of their posture habits and prompts them to make necessary adjustments to maintain proper alignment.

Moreover, the integration of flex sensors into wearable devices enhances accessibility and convenience [4]. These devices can be discreetly worn underneath clothing, allowing users to receive posture feedback without disrupting their daily routines. Additionally, some systems incorporate wireless connectivity, enabling users to track their progress and receive insights via smartphone apps or other digital platforms.

Furthermore, the application of flex sensors for posture monitoring and correction holds significant potential in various fields, including healthcare, sports performance, and ergonomics [5]. In healthcare settings, it can assist in rehabilitation programs by providing patients with real-time feedback during physical therapy sessions. Athletes and fitness enthusiasts can utilize this technology to optimize their training regimens and prevent injuries caused by poor posture. Additionally, in occupational settings, such as office environments, it can help employees maintain ergonomic posture to reduce the risk of musculoskeletal disorders.

Despite these benefits, challenges remain in the widespread adoption and implementation of flex sensor-based posture monitoring systems. Issues such as sensor accuracy, comfort, and user acceptance need to be addressed to ensure the effectiveness and usability of these solutions.

In conclusion, monitoring and correcting human joint posture using flex sensors represent a promising approach to promoting better posture habits and overall musculoskeletal health [6]. As technology continues to evolve, these innovative solutions have the potential to revolutionize how we approach posture management, empowering individuals to lead healthier and more productive lives [7-10]

2 *Corresponding author: Author 2 Centre for Medical Electronics Department of ECE, College of Engineering Guindy Anna University, Chennai, India
[2] Author 1 , 3, 4,5 Affiliation- Centre for Medical Electronics Department of ECE, College of Engineering Guindy Anna University, Chennai, India

## II. METHODOLOGY

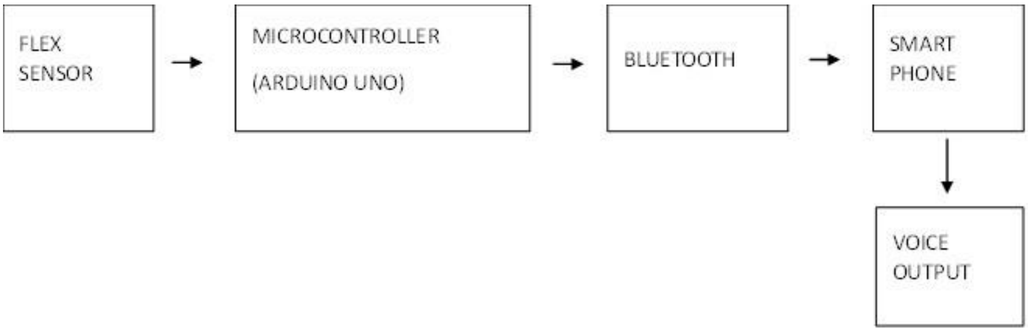


**Figure .1. Block diagram**

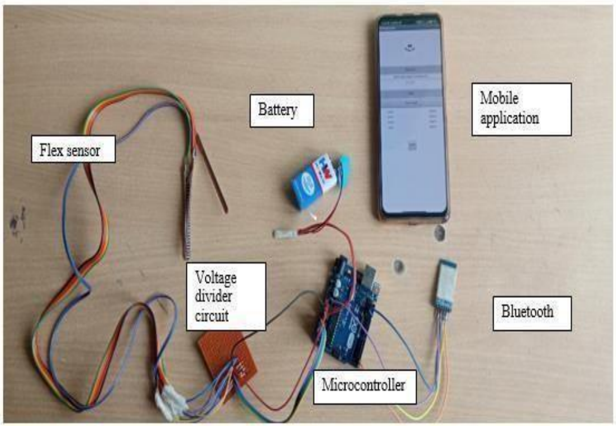


**Figure .2. Representation of the hardware components**

The developed module is shown in figure 2, the four flex sensors with 47 KΩ pull down resistor each is soldered in dot board to form a voltage divider circuit. The output of the voltage divider circuit is given to the Analog pin (A0, A1, A2, A3) of the Arduino. Rx and Tx pins of Bluetooth is given to Tx and Rx pins of microcontroller for receiving and transmitting the data. The 5V and ground pin of Bluetooth module is connected to the respective pins of microcontroller. Battery of 9V is given to the Vin pin of the microcontroller for the power supply.

## III. APP DEVELOPMENT

MIT App Inventor is a web application integrated development environment, originally provided by Google, and now maintained by the Massachusetts Institute of Technology (MIT). It allows newcomers to create application software(apps) for two operating systems (OS): Android, and iOS.

It uses a graphical user interface (GUI) very similar to the programming language Scratch (programming language) and the Star Logo which allows users to drag and drop visual objects to create an application that can run on Android devices, while a App-Inventor Companion (The program that allows the app to run and debug on) that works on iOS running devices are still under development.

*Developed app*

The developed app which is shown in figure 3 is used to intimate the user using voice output when the user maintains same neck and wrist posture for a period of 120 seconds and when the corresponding neck and wrist angle go beyond the maximum mobility angle as given in the app with the help of interfaced Bluetooth module, the Bluetooth is connected to receive the data from the microcontroller and the data (i.e., respective neck and wrist angles (degree)will be displayed in the app according to the user posture.


**Figure 3. Developed mobile app (Flex 360°)**

IV. RESULTS AND DISCUSSION

*A. Flex sensor characteristics*

The characteristic study of the flex sensor is performed by bending the flex sensor with known angle as shown table 1. The flex sensor is made to bend by the degree of 10º each time from -90º to 90º. The voltage drops across the pull- down resistor is measured across it and shown in table 1 and the setup is shown in figure 4.

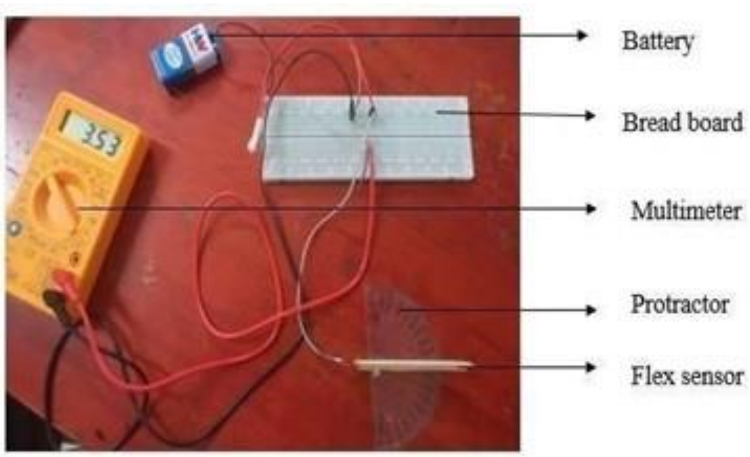


**Figure .4. Flex sensor characteristic study setup**

From this study it is inferred that the resistance of the flex sensor increases with decrease in voltage across the pull down resistor, as the bending angle increases with respect to the flexion and extension of the flex sensor. The resistance is calculated using equation 1 where Vcc is fixed to 5V and R is 47KΩ.

$$V_0 = V_{cc} \frac{R}{R + R_{flex}} \qquad (1)$$

| Angle(degrees) | Voltage(V) | Resistance(KΩ) |
|---|---|---|
| -90 | 2.7 | 40.03 |
| -80 | 2.63 | 42.35 |
| -70 | 2.54 | 45.51 |
| -60 | 2.49 | 47.37 |
| -50 | 2.43 | 49.70 |
| -40 | 2.38 | 51.73 |
| -30 | 2.32 | 54.29 |
| -20 | 2.24 | 57.91 |
| -10 | 2.15 | 62.30 |
| 0 | 1.99 | 71.09 |
| 10 | 1.88 | 78 |
| 20 | 1.85 | 80.02 |
| 30 | 1.82 | 82.12 |
| 40 | 1.76 | 86.52 |
| 50 | 1.74 | 88.05 |
| 60 | 1.68 | 92.88 |
| 70 | 1.67 | 93.71 |
| 80 | 1.6 | 99.87 |
| 90 | 1.58 | 101.73 |

**Table .1. Flexion and extension characteristics of one flex sensor**

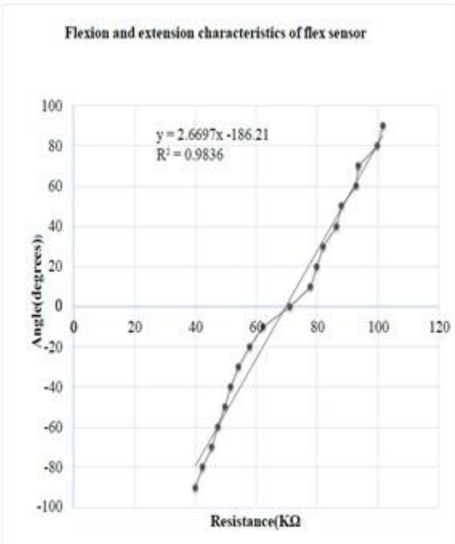


**Figure .5. Represent the characteristics of flex sensor and the regression value is calculated.**

## V. DESIGN MODULE

*A. Sensor placement*

**Sensor placement in neck**

The sensor is placed over the neck region of C2 – C7 of cervical vertebra as shown in figure 6. This part of the vertebra will provide support and base for the movement of head and neck. This region is branched up with different group of muscles that provide mechanical strength and locomotion of the neck [11-14].

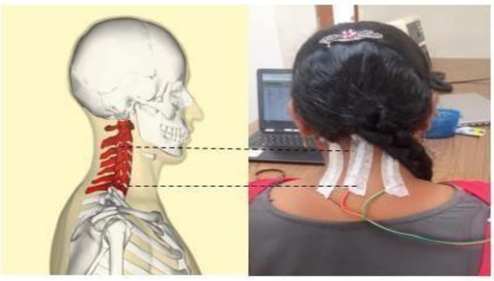

**Figure .6. Neck bone anatomy and sensor placement**

**Sensor placement in wrist**

The wrist is formed by the two bones of the forearm—the radius and the ulna— and eight small carpal bones as shown in figure 7. The carpal bones are arranged in two rows at the base of the hand. There are four bones in each row. The scaphoid bone is one of the carpal bones on the thumb side of the wrist, just above the radius. The bone is important for both motion and stability in the wrist joint.

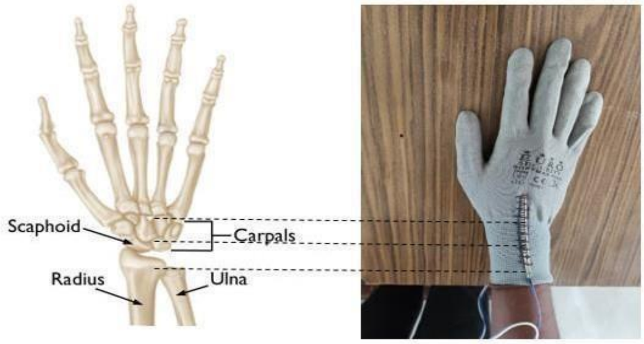


**Figure .7. Wrist anatomy and sensor placement in wrist**

*B. Data acquisition*

The data is acquired at a time interval of every 70 seconds. To check the angle, the mean value of the angle is taken for every 1190 samples, it is considered as one set value and checked with the previous sample. The module is programed in such a way that it checks the mean value for every 70 seconds. Therefore, the angle is checked for every 2 set of samples. If the angle is same, the app will intimate the user by means of voice output. Thus if the person maintaining same posture of neck and wrist for a duration of 70 seconds, the user will change their poor posture with the help of intimation.

*C. Prototype*

The prototype consists of microcontroller, Bluetooth module, 9V battery, dot board with soldered voltage divider circuit that are held below the shoulder with the help of Velcro tape and three flex sensors are placed in the neck region and one flex sensor is attached to the dorsal side of the glove which is worn by the user. This prototype will be comfortable and helps to monitor and correct the user's neck and wrist posture.

**Figure .8. Prototype with flex sensor Placed in the neck**

**Figure .9. Prototype with flex sensor Placed in the wrist**

The prototype which has been designed has been placed in the neck and wrist region is shown in the figure 8 and

9. The time period after which the subject feels the pain (muscle straining sensation) in various posture of the neck is taken and tabulated in the table 2.

The first column in Table 2 represents the subject, the second column represents the time period (in seconds) for the subjects to feel the pain sensation when sitting straight and watching straight respectively. The third column represents the time period (in seconds) for the subjects to feel the pain sensation when sitting straight and turned their head to their right side respectively. The fourth column represents the time period (in seconds) for the subjects to feel the pain sensation when sitting straight and turned their head to their left side respectively.

**Table .2. Time duration data of different subjects**

| Subjects | Straight (seconds) | Right (seconds) | Left (seconds) | Forward (seconds) | Backward (seconds) |
|---|---|---|---|---|---|
| Subject A | 72 | 83 | 81 | 75 | 51 |
| Subject B | 69 | 51 | 101 | 88 | 58 |
| Subject C | 135 | 67 | 39 | 133 | 22 |
| Subject D | 96 | 70 | 84 | 75 | 52 |
| Subject E | 75 | 81 | 73 | 165 | 48 |
| Subject F | 100 | 90 | 71 | 77 | 54 |
| Subject G | 90 | 69 | 83 | 95 | 49 |
| Subject H | 106 | 72 | 65 | 106 | 50 |
| Subject I | 67 | 84 | 92 | 86 | 59 |
| Subject J | 88 | 70 | 52 | 145 | 66 |

The fifth column represents the time period (in seconds) for the subjects to feel the pain sensation when sitting straight and bent their head forward (as they are using mobile phone) respectively. The sixth column represents the time period (in seconds) for the subjects to feel the pain sensation when sitting straight and bent their head to their back side respectively. Ten volunteers of age group 22-23 came forward to give their readings out of which 6 male and 4 female subjects. The average time taken to feel the pain sensation is found to be 89.8 seconds, 73.7 seconds, 74.1 seconds, 104.5 seconds, 50.9 seconds respectively. The overall average time is found to be 78.6 seconds. The figure 10 and 11 represents the visual message displayed in the mobile app to intimate the user to correct their poor neck and wrist posture.


**Figure .10. Visual message displayed to change neck position**


**Figure .11. Visual message displayed to change wrist position**

VI. CONCLUSION AND FUTURE WORK

A human joints posture monitoring and correction system has been developed to correct the poor posture of the neck and wrist. Initially the characteristics of flex sensor have been studied and it is interfaced with the microcontroller. Hc-05 Bluetooth module is interfaced with the microcontroller and the mobile app is developed using MIT app inventor. The flex sensor has been calibrated, where the changes in resistance and angles for flexion and extension of the neck and wrist is obtained. Work has been done to monitor the neck and wrist posture of the user. By this procedure the threshold time limit for indicating pain of the subject is obtained from various volunteers and it is found to be 78.6 seconds. The average time is set as the threshold (70 seconds) time limit for the product. Using this developed module, the visual and auditory notification is sent to the mobile app if the poor posture is detected. If the user is active, which means keep on changing their neck and wrist posture there will be no intimation by the app.

The work can be further extended to monitor the other joints of the body particularly for the elders and sport persons. This will also help the patient undergoing rehabilitation for their quicker recovery. To improve the accuracy, the embedded system sensors like IMU (Inertial Measurement Unit) can be implemented. To avoid external Bluetooth, we can use microcontrollers that have inbuilt Bluetooth like ESP32. This work benefits and helps to improvise the postures and health of every person who got addicted to the electronic gadgets.

## References


[1] A.Kumaresan., M.SureshAnand, K.Deepak Keshav, G.Karthikeyan, B.Vigneshwaran (2019) 'Posture Detection and Alerting System Using Rtsc Algorithm'- International Journal of Engineering and Advanced Technology (IJEAT) ,Volume-9, Issue-1

[2] Gizem Özgül, Fatma Patlar Akbulut (2022) 'Wearable sensor device for posture monitoring and analysis during daily activities: A preliminary study', International Advanced Researches and Engineering Journal, Volume 06, Issue 01, pp.043-048

[3] Mrudula Ganesh Shete, Dr. Ruchita Shah (2019) 'Effect of Posture Correction Exercises and Ergonomic Advices in People Having Postural Abnormalities among Chronic Smartphone Users', International Journal of Health Science and Research, Volume 09; Issue: 7

[4] Santhana Lakshmi.P, Anupam Kumar, Mr.C.Aravindan (2017) 'Posturector- The Posture Corrector', International Journal of Innovative Science and Research Technology, Volume 2, Issue 3

[5] Sasa Jovanovic, Bostjan Simunic (2021) 'Effect of ergonomic Armrest forearm support on wrist posture related to carpal tunnel pressure during computer mouse work', International journal of Industrial Ergonomics, pp.103-220

[6] S.Y.Pattar, S.Unnathi Annapurna, Adithi K.S, Meghala Murali, Syed Saqalain Quadri (2022) 'Alert system for Posture Correction' ,International Journal of Applied Sciences and Technology, Volume 06, Issue 11, pp.95- 101

[7] Vijaya Shetty S, Nishanth M, Sashank R, Umama Kulsum, Chaitra H V (2019) 'Sitting Posture Alerting System for Pain in Back and Neck Region', International Journal of Recent Technology and Engineering (IJRTE), Volume 8, Issue-1

[8] Zahra Abdollahzade, Azade Shadmehr, Kazem Malmir , Nastaran Ghotbi (2017) 'Effects of 4 Week Postural Corrective Exercise on Correcting Forward Head Posture', Journal of Modern Rehabilitation, Volume 11(2), pp.85-9.

[9] Abdullah Beyaz 'Posture determination by using flex sensor and image analysis technique' December 2017 Agricultural Science Digest - A Research Journal 37(04).

[10] Zamir Ahmed , Zhang Yi-Fan zhang, and Habiba Halepoto 'A novel flex sensor-based flexible smart garment for monitoring body postures' Sage journals.

[11] Youngsu Cha ,Kihyuk Nam and Doik Kim 'Patient Posture Monitoring System Based on Flexible Sensors' MDPI Journals Sensors Volume 17 Issue 3.

[12] K. Nirmala Devi, Jose Anand, R. Kothai, J.M. Ajai Krishna,R. Muthurampandian 'Sensor based posture detection system' Materialstoday proceedings Volume 55, Part 2, 2022, Pages 359-364

[13] Abu Ilius Faisal,Sumit Majumder,Tapas Mondal ,David Cowan ,Sasan Naseh and M. Jamal Deen 'Monitoring Methods of Human Body Joints: State-of-the-Art and Research Challenges' MDPI Journals Sensors Volume 19 Issue 11

[14] Rafique Ahmed Lakho, Zamir Ahmed Abro, Jun Chen, and Rui Min 'Smart Insole Based on Flexi Force and Flex Sensor for Monitoring Different Body Postures' Sensors (Basel). 2022 Aug; 22(15): 5469.