Posturainer: A Posture Training Device for Postural Control and Adaptive Gait

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***Abstract*—In this day and age, improper posture is turning into an extremely serious problem and is one of the leading causes of Spine-Related Chronic Diseases. This product aims to handle this grave issue. Posturainer is an easy to understand device which calibrates itself diversely for each user. It's lightweight and versatile and is supposed to worn on the back supported by a belt. It warns the user when they leave their perfect stance and thus, it trains them to maintain it. The stance can be diverse for various assignments in a day and this product works immaculately in all cases. It has a clever admonition framework which comprises of vibratory motors, that will be a mix of motors vibrating showing to the user the heading to where their optimal stance lies. This product can be controlled from a user-friendly mobile application which can be disabled as per their convenience. It records the occasions an individual sluggards and the undertaking wherein he slumps and relying upon that information, it shows a daily analysis of the user on the application.**

Keywords- Internet of Things, Device to Device Communication, lifestyle, gyroscope, accelerometer

I. Introduction

Back pain is one of the leading causes of global disability. With the ever increasing work pressure and office hours among the professionals worldwide, there has been a significant rise in the number of people suffering with chronic back pain due to their incorrect posture. Back pain is said to be one of the most common causes of absence in the work place among professionals of all age groups. [1] People don't realise how grave the issue is until the issue becomes so serious that the person ends up slouching at all times with a perpetual back ache. The consequences of incorrect posture includes tension and pain in the neck, upper back, lower back, and shoulders along with poor circulation of blood and digestion and misaligned spine.

[2] [3] The surgery options for the treatment of chronic spine disorders is extremely painful and expensive, however due to the development of biotechnology and physiological signal processing preventive technological solutions have become a great alternative [4]. The degree of Lower Back Pain is different for different people. It typically ranges from mild ache which is commonly reported, to extremely intense levels where basic spine movement might become a difficult task for patient. Nonetheless, initial stages of back pain disorders can be treated with basic rehabilitation programs administered with advice from physiologists or preventive devices. [4]

There are various aspects to be considered to create a system/device that shall be able to prevent back pain due to poor posture of the body like the requirement to consider that the system should be endowed with a capacity to differentiate and detect different postures. A variety of posture detection systems have been developed by innovators looking for prevention solutions, some of them use sensors detecting pressure [5], electromyography (EMG) that are sensors based on direct contact for instance [6], [7], push buttons [8] or sensors for video surveillance, these have a non-intrusive methodology [9], [10] et cetera.

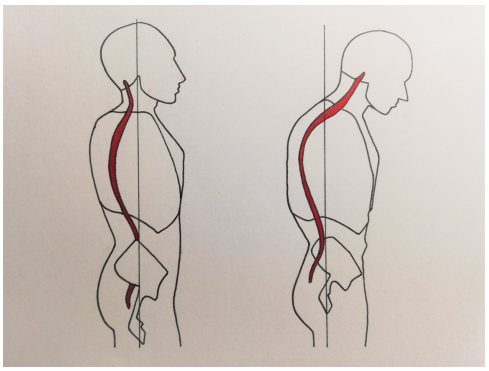

Figure 1: Correct Human Body Posture (left) and Incorrect Human Body Posture (right)

The present product relates to improvements in the posture of a person. With increasing pressure of work on people, there has been a significant increase in the number of people suffering from posture related problems and also in the gravity of these problems. People don't realise how grave the issue is until the problem becomes so serious that the person is slouching all day, in every task he does.

The challenges of these existing solutions like inaccuracy in judgements, uncomfortable design and expensive components have been resolved by this product- Posturainer which is a one stop solution for any user irrespective of their age, sex, lifestyle et cetera.

This paper explores the possibility of developing a product called Posturainer which on proper usage and implementation shall reduce the risk of chronic back pain disorders to a huge extent.

II. Materials Used

Hardware Requirements:

- 3-D printed case
- FRDM k64
- Arms processor
- Battery
- Vibration motors (Four)

Software Requirements

- Octave [11]
- Mbed online [12]

III. Methodology

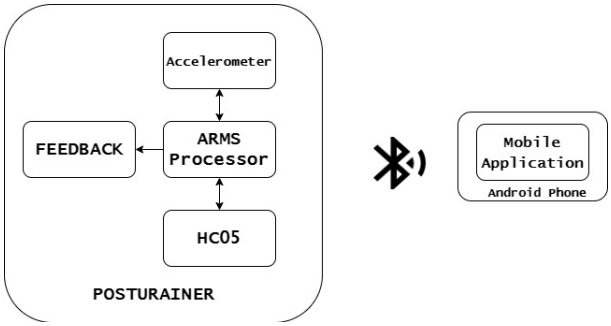

Figure 2: Basic Structure of Product

A. Fetching Origin Values through Accelerometer and Gyroscope

A gyroscope based wearable system that is connected to an array of vibration motors controlled by a centralized microprocessor and is powered by a portable rechargeable battery. The system measures the changes in inclination and alerts users via 'adaptive vibration warnings'. The overall working comprises of:

- First element that consists of a calibration-enabled gyroscope that records ideal or stability values and records it for individuals.
- Second element that consists of an analog to digital conversion circuit that gives output to the ARM microprocessor.
- Third element that consists of feedback given to the user using vibration motors and LEDs.
- Fourth element that consists of a bluetooth connection to enable all communication channels.
- Fifth element that has a mobile application-controlled analysis and report of the usage of the invention.
- Sixth element that ensures a user-friendly all-time-wear device that distinguishes slouching from bending activities.
- Seventh element that makes the system easy to install, calibrate and stick-to-wear in operation.

A system to alert the user about moving into an improper posture and suggesting to the user the direction of movement through adaptive warnings. The system comprises of:

- First element is the gyroscope that records the direction and degree of displacement and sends the values to the microprocessor
- Second element is the microprocessor that having taken values from gyroscope processes them and sends signals to ON the corresponding motors
- Third element are the motors that function on microprocessor's command and suggest the direction of movement to the user. The warnings continue till the user is back to normal

B. Simulations on Octave:

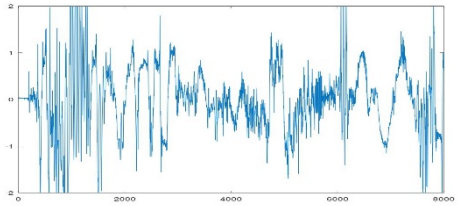

Figure 3.1: Accelerometer raw signal

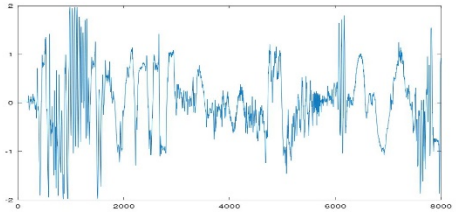

Figure 3.2: Accelerometer signal through low pass filter

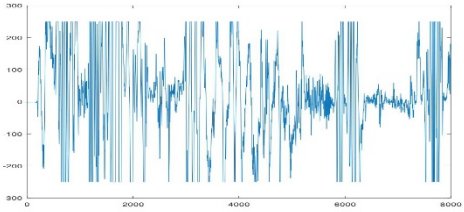

Figure 4.1: Gyroscope raw signal

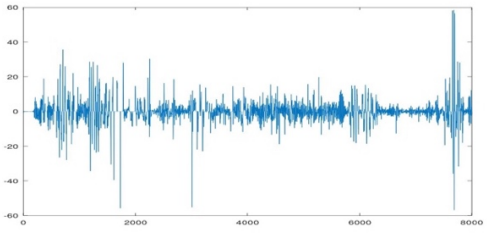

Figure 4.2: Gyroscope signal through high pass filter

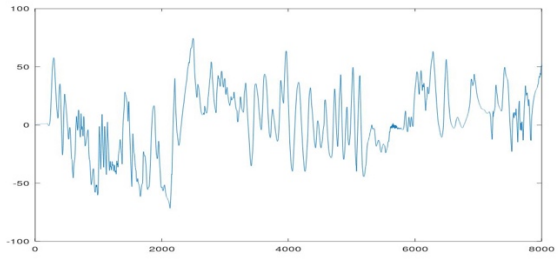

Figure 5: Combinational value of Accelerometer and Gyroscope filtered signals

Displacement contains high frequency noise so to remove this noise from the raw data of accelerometer we pass it through a low pass band stop filter. This helps us in smoothing the accelerometer displacement data. Similarly the gyroscope contains low frequency noise so to avoid these errors in the final output we remove the noise in the raw data by passing it through high pass filter. The same is conveyed by the Figs 3 and 4. Further to get the roll and pitch of the body we pass the the filtered data from accelerometer and gyroscope through a complementary filter. The output of the same is shown in Fig 5. We use a complementary filter because we know both the advantages and disadvantages of gyroscope and accelerometer. And when we combine the output of both of them together we get a better result as both of their disadvantages are removed by their complementary advantages.

C. *Working of Product*

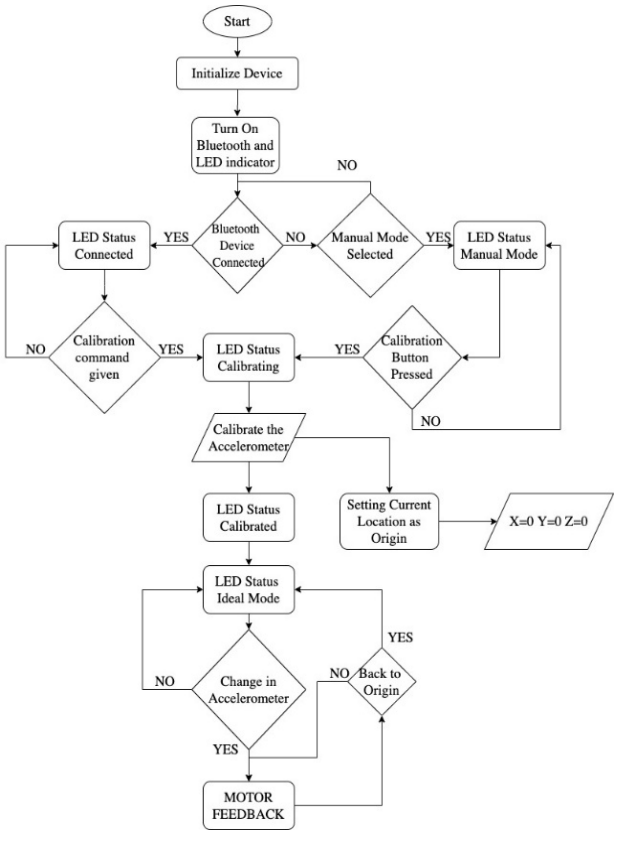

Figure 6: Flowchart showing working of the Product

D. *Three Modes of Operation*

In this product, there are three modes of operation namely the Calibration mode, Incorrect posture mode and correct posture mode.

Figure 7: Calibration Mode

In the Calibration mode, the origin values for the Accelerometer and Gyroscope are fetched using the previously mentioned process as the values change with every individual and has to be calibrated each time a new user wears this product. The 'Calibration mode' is given significance by displaying an LED Light of Blue Colour.

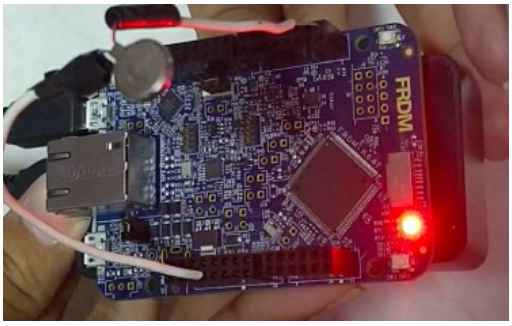

Figure 8: Detection of incorrect posture

After the Calibration the vales of their correct posture are recorded. Post that if the user slouches i.e if they exercise a poor posture, the product goes into 'Incorrect Posture' Mode which is signified by an LED Light of Red Colour and the motor starts vibrating hence giving feedback informing the user about the same.

Figure 9: Correct Posture

After the feedback is given, user rectifies their posture and adapts to a healthy lifestyle, this 'Correct Posture' Mode is given significance by displaying an LED light of Green Colour.

E. Testing of Product Prototype

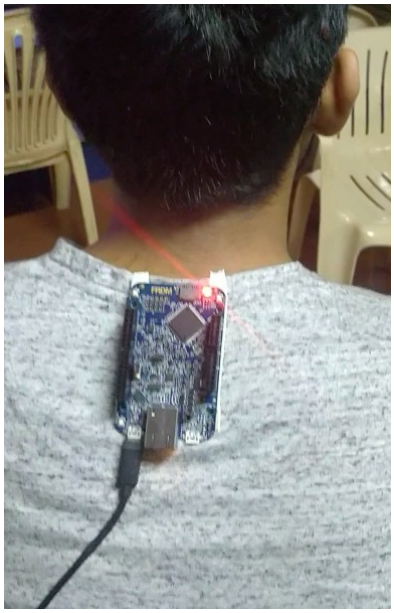

Figure 10: Incorrect Posture

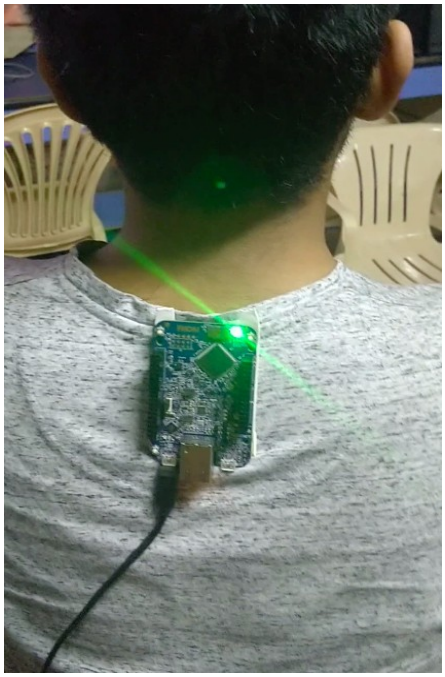

Figure 11: Correct Posture

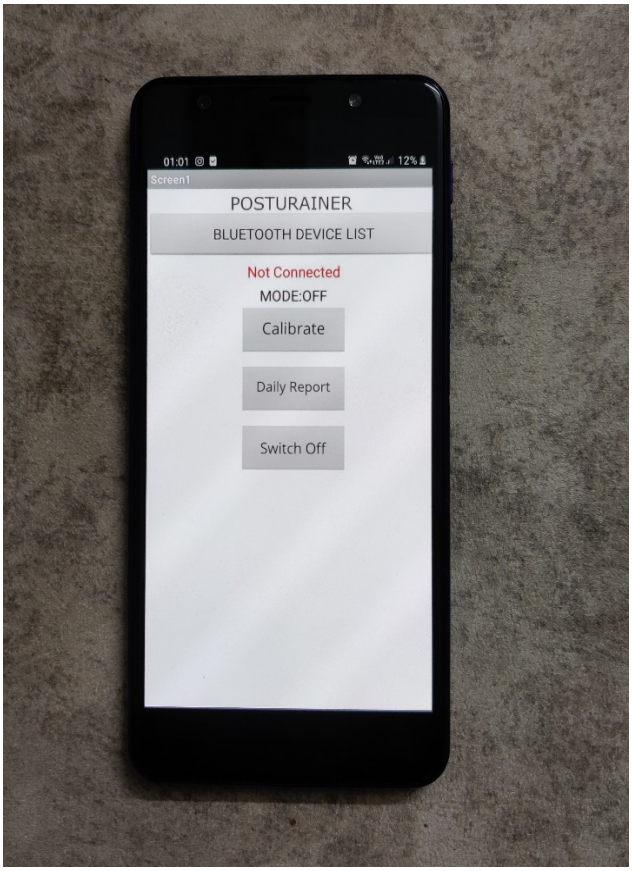

Figure 12: Mobile Application Prototype

IV. Future Scope

Posturainer (A posture training device for postural control and Adaptive Gait) has an immense potential to play a vital role in the domain of biotechnology in the coming future. Since this is only a prototype device used for the proof of concept, the actual implementation of the product will have custom made Lithium ion batteries. To make this product more versatile and a success in the industry there could be integration of the device in regular wearable clothes. The device can be embedded into fiber wear for better and natural user experience. The device's mobile application can be upgraded by making a statistical report of posture observed by the device throughout the period of use and this data could further be used for medical research in human back problems and challenges. In the future the upgraded tracking abilities of this product may allow the user to enhance their self-management medical capacities.

F. Mobile Application Prototype

V. Conclusion

The objective of this project is to develop an efficient and a convenient product called Posturainer. The ideology behind this project is to find a sustainable solution for the problem of improper posture rising in today's world. A system for monitoring one's posture and giving the user warnings in the form of vibrations whenever there is slouching or a considerable sustained change in one's posture. An easy to install wearable device will be attached to the back of the user and calibrated to his own posture needs. The warnings indicate the direction of slouch and continue until the user turns it off manually or returns back to a stable position. Care is also taken to avoid unnecessary warnings. The detailed analysis of this training session from the user is made available to a mobile application. The mobile application is connected to the device using Bluetooth and can also control the working of Posturainer- your personal posture trainer.

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