Foot Pressure Measurement And Analysis

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***Abstract*—: Measurement of human activities has changed the perspective of medical field and human health analysis. Foot plantar pressure is the pressure field that acts between the foot and the support surface during everyday locomotor activities. Information derived from such pressure measures is important in gait and posture research for diagnosing lower limb problems, footwear design, sport biomechanics, injury prevention and other applications. Wireless foot plantar pressure system is proposed suitable for measuring high pressure distributions under the foot with high accuracy and reliability.**

To determine foot plantar pressure during the day-to-day activities and real-time analysis, one needs a compact system capable of measuring foot pressure and providing accurate results. This project presents a low cost, reliable, compact foot plantar pressure acquisition system which we are developing. Strengths and boundaries of present-day structures are discussed and a foot plantar pressure device is suitable for measuring excessive stress distributions under the foot with excessive accuracy and reliability. Various applications would need a different number of sensors spread over inside the shoe-sole. In this work, our investigation is restricted to simple applications like measuring the foot pressure when the person is walking freely without any load, or to analyze the data from various measurements of different age groups and state the anomalies present in it. Our Project provides unique insight on foot function, helping clinicians conduct more complete assessments and objectively evaluate treatments. It includes a flexi pressure sensor module that determines the foot pressure distribution in actual time on webserver that allows us to visualize and analyze the information. At the end of the experiment, real-time results in the form of intensity graph and graphical data of pressure point with a particular weight have been achieved. A frequency domain data is also plotted and analyzed in order to detect issues in postures or joints. A reference study of this data with the ideal situation will lead us to the early detection of joint issues

Keywords— Foot pressure measurement, Application of force sensing resistor, foot plantar pressure; pressure sensor; wireless system foot plantar pressure; wireless system

I. Introduction

The development of miniature, lightweight, and energy efficient circuit solutions for healthcare sensor applications is an increasingly important research focus given the rapid technological advances in healthcare monitoring equipment, microfabrication processes and wireless communication. One area that has attracted considerable attention by researchers in biomedical and sport related applications is the analysis of foot plantar pressure distributions to reveal the interface pressure between the foot plantar surface and the shoe sole. More recently innovative applications have also been made to human identification, biometric,monitoring,posture allocation and rehabilitation support systems . Based on this research it is clear that techniques capable of accurately and efficiently measuring foot pressure are crucial to further developments.

The plantar pressure systems available on the market or in research laboratories vary in sensor configuration to meet different application requirements. Typically the configuration is one of three types: pressure distribution platforms, imaging technologies with sophisticated image processing software and in-shoe systems. In designing plantar pressure measurement devices the key requirements are spatial resolution, sampling frequency, accuracy, sensitivity and calibration [3]. These requirements will be discussed in detail later.

In-shoe foot plantar sensors have paved the way to better efficiency, flexibility, mobility and reduced cost measurement systems. For the system to be mobile and wearable for monitoring activities of daily life, the system should be wireless with low power consumption.

II. Literature Survey

. Feet provide the primary surface of interaction with the environment during locomotion. Thus, it is important to diagnose foot problems at an early stage for injury prevention, risk management and general wellbeing. One approach to measuring foot health, widely used in various applications, is examining foot plantar pressure characteristics. It is, therefore, important that accurate and reliable foot plantar pressure measurement systems are developed. One of the earliest applications of plantar pressure was the evaluation of footwear. Lavery et al. [4] in 1997 determined the effectiveness of therapeutic and athletic shoes with and without viscoelastic insoles using the mean peak plantar pressure as the evaluation parameter. Since then there have been many other studies of foot pressure measurement; for example, Mueller [5] applied plantar pressure to the design of footwear for people without impairments (i.e., the general public). Furthermore, Praet and Louwerens [6] and Queen et al. [7] found that the most effective method for reducing the pressure beneath a neuropathic forefoot is using rocker bottom shoes and claimed the rocker would decrease pressure under the first and fifth ray (metatarsal head). The metatarsal heads are often the site of ulceration in patients with Cavo varus deformity. Queen et al. indicated that future shoe design for the prevention of metatarsal stress fractures should be gender specific due to differences in plantar loading between men and women

With regard to applications involving disease diagnosis, many researchers have focused on foot ulceration problems due to diabetes that can result in excessive foot plantar pressures in specific areas under the foot. Diabetes is now considered an epidemic and, according to some reports, the number of affected patients is expected to increase from 171 million in 2000 to 366 million in 2030 [9]. Improvement in balance is considered important both in sports and biomedical applications. With respect to healthcare, pressure distributions can be related to gait instability in the elderly and other balance impaired individuals and foot plantar pressure information can be used for improving balance in the elderly [11]. Based on the above discussion, it is crucial to devise techniques capable of accurately and efficiently measuring foot pressure.

III. Design implementation

Determination of foot pressure requires a proper identification method of pressure points on the foot. Pressure points in the foot are those that get continuously involved in the walking pattern and gait cycle of particular weight and age person. When placing a foot on the surface, pressure occupies on the foot and got distribute based upon the shape and its position on the surface along with its geometrical details. In order to make pressure measurements on the foot for diagnosis purposes, there are 10 pressure points are considered as very ideal points which have been illustrated in Figure 2. As it can be seen from the Figure 2 that there are 10 main points on the feet where pressure can be measured for further analysis and according to that we have decided to detect and measure pressure from Central forefront of sole. We have taken a sole and attached a Flexi force sensor [13] at central forefront area shown in Figure 2.

After attaching the sensor on both soles (left and right), the sensor input is taken directly into ESP32 microcontroller and further processing is done on it. Real time sensor output from both sensors is streamed on a local webserver for monitoring purpose. Personalized login is needed for getting specific real time data from specific person. Age, health problems and weight are registered to the account which helps to analyze joint issues or for gait analysis.

Webserver is designed in such way that individual credentials are saved with login data and real-time pressure data is saved inside ESP32 microcontroller for converting time domain data into frequency domain data. The data is saved in .csv format and is extracted for conversion to frequency domain using Fast Fourier Transform Algorithm using Matlab 2020a software. Frequency Spectrum of data is plotted with the time domain data of both (left and right foot) for further anomaly detection purpose.

Following table shows the parameters used for time to frequency conversion:

Sr. No.	Parameter	Value
1.	Sampling Frequency	0.000667
2.	Sampling Period	1.4993e+03
3.	Length of Signal	9549

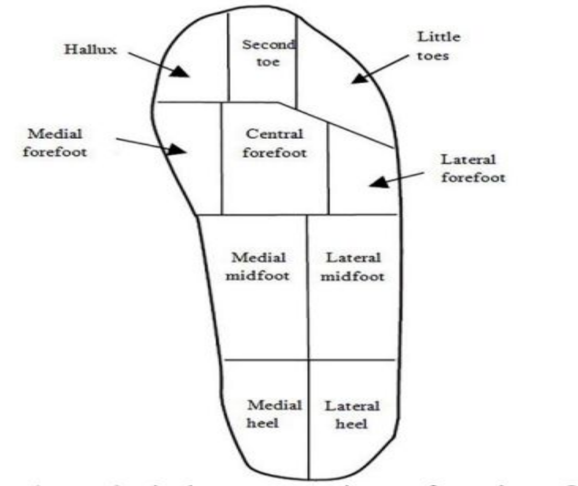

Fig.2. Ideal Pressure Points at Foot Planer

3.1 Hardware Implementation

Components used are ESP32 Microcontroller and two Flexi force pressure sensors.

1. ESP32 Microcontroller:

ESP32 is a series of low-cost, low-power system on a chip microcontroller with integrated Wi-Fi and dual-mode Bluetooth. The ESP32 series employs a Tensilica Xtensa LX6 microprocessor in both dual-core and single-core variations and includes built-in antenna switches, RF balun, power amplifier, low-noise receive amplifier, filters, and power-management modules. ESP32 is created and developed by Espressif Systems, a Shanghai-based Chinese company, and is manufactured by TSMC using their 40 nm process. It is a successor to the ESP8266 microcontroller.

Used here for sensor interfacing and relaying real time data on webserver and for storing sensors value in a file.

Fig.5. ESP32 Controller

2. FlexiForce Pressure Sensor

The FlexiForce A502 is a square sensor, with asensing area measuring 50.8 mm x 50.8 mm (2 in. x 2 in.). [13]It has benefits of being thin and flexible, low power, ideal for prototyping and integration and easy to use.

It has range from 0 to 222N and is superior than conventional pressure sensor.

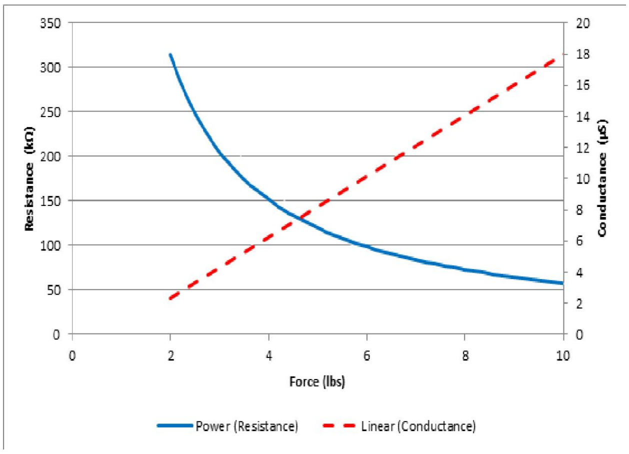

Fig.6. Characteristic Sensor Output

Fig.7. Flexi Force Sensor

IV. Block Diagram

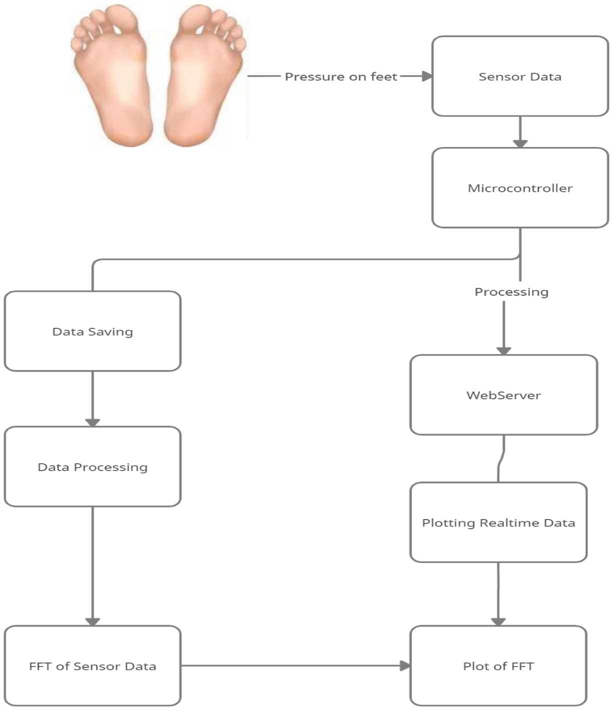

Fig.8. Block Diagram

V. Results

Realtime pressure signal is transformed into frequency domain using Fast Fourier Transform Algorithm and is linked with the specific person's data and is uploaded for further usage. Frequency domain results are plotted in the following plots:

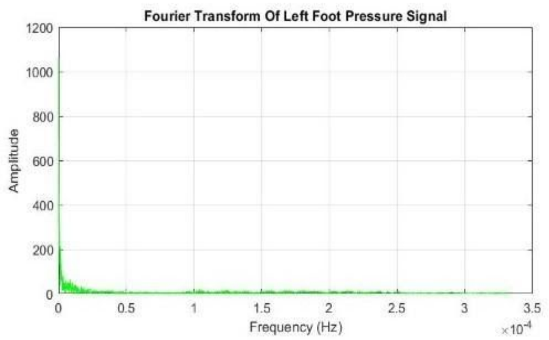

Fig.9. Fourier Transform of Left Foot Pressure Signal

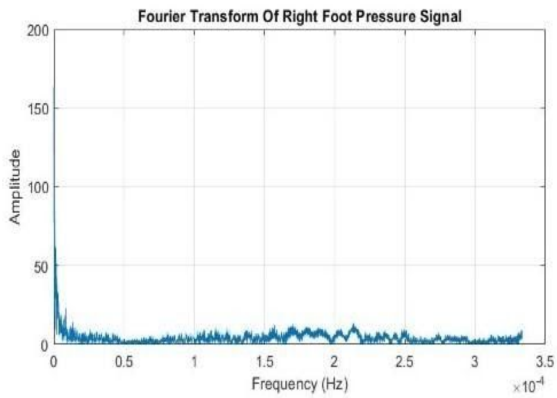

Fig.10. Fourier Transform of Left Foot Pressure Signal

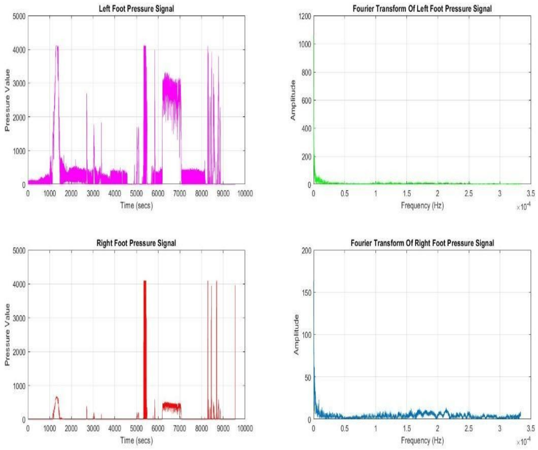

Fig.11. Time Signal and its corresponding Fourier Transform.

VI. Conclusion

Real-time foot pressure sensor data is relayed on a webserver for experts to analyze the pressure on feet from anywhere without having any presence and can additionally analyze the data in frequency domain.

VII. Future Scope

Every technology has its improving end and hence keeps the pace of enhancing newer technology time to time, so regarding to this paper joint issues identification or gait analysis using neural networks or deep learning from incoming sensor data will enhance the ability to pinpoint the issues which are occurred due to improper posture or imbalance of pressure on the feet.

VIII. Final design of Prototype

Fig.12. Final design of Prototype

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