Smart Shoe Sole to Gather Foot Plantar Pressure

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Introduction

Our daily routine in life contains numerous activities throughout the day, and our feet play an essential role in every activity. Each activity has a unique foot plantar pressure profile depending upon the actions executed. Foot plantar pressure refers to the pressure exerted by the ankle and foot of a person on the supporting surface during any practical motion or posture. Once extracted, information about the applied pressure can be advantageous for revealing the medical solution required for treatment. In fact, this data has been documented to be a significant factor in the assessment of patients suffering from diseases such as diabetes and peripheral neuropathy.

In the realm of sports-related activities, biomedical advancements have occurred as a result of the expansion of miniscule, lightweight, and energy-efficient healthcare solutions. Similar to individual activities, each disease or disorder has a different behavioral profile of plantar pressure during locomotion. Statistics show that more than 100 million adult Americans are now living with diabetes or prediabetes, a finding which has prompted numerous analyses of the pressure data associated with such medical inabilities. The financial burden of diabetes accounts for over $1 billion per year in medical expenses in the United States alone.

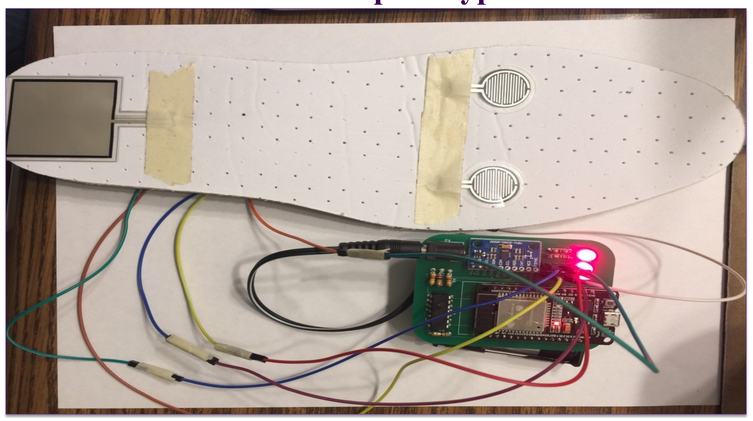
The purpose of this research-oriented project is to provide a wireless means of gathering data regarding foot plantar pressure in order to assess the locomotive activity performed by a particular person and determine the medical issue associated with the extracted profile. This will help in early identification of a disease and complement the medical decision-making process.

Method

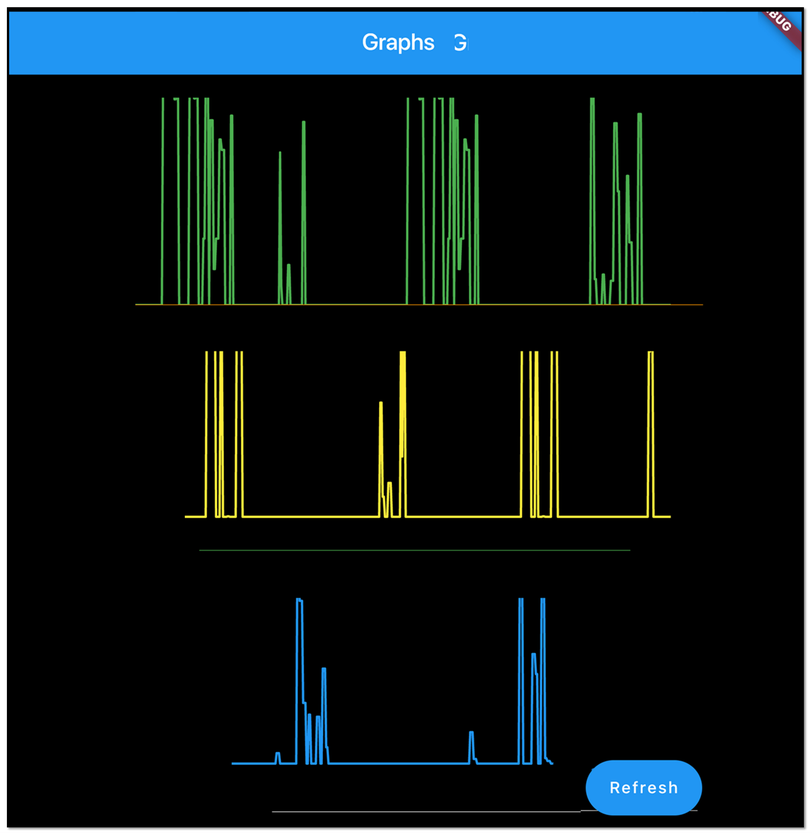
In order to obtain data about the steps taken by the user, we utilized the MPU-9250 multi-chip module that combines an accelerometer and gyroscope in one chip that is connected to the MCU through an I^2C communication protocol. For the foot pressure areas, force-sensitive resistors (FSRs) were connected to the ESP32 microcontroller unit (MCU), and the MCU was programmed to receive data from both the MPU-9250 and the FSRs. Received data was converted to BLE data packets and transmitted to the mobile application we developed. The mobile application, containing weeks and months of recorded history, allows the user to track the daily activity performed.

Results

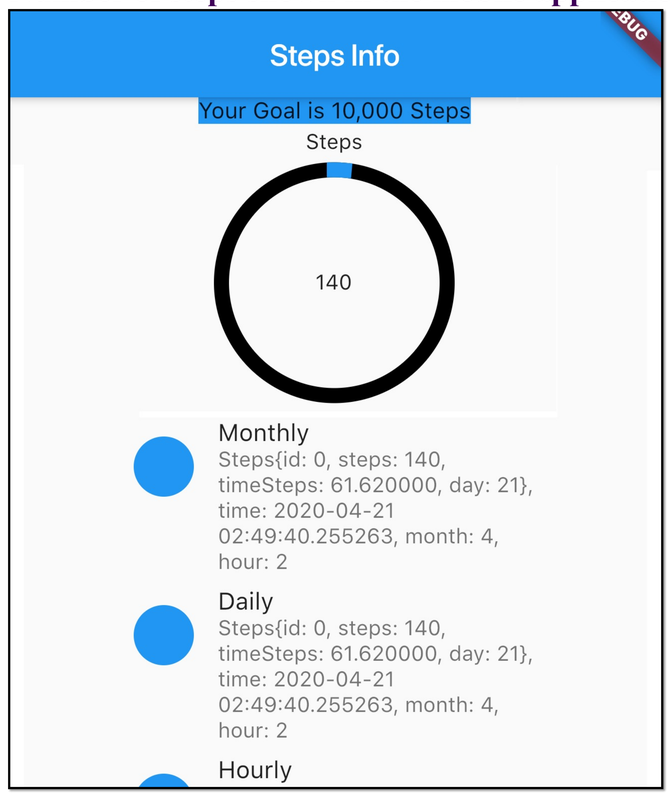
Exhibit of prototype



FSR graphs generated in the mobile application



Number of steps shown in the mobile application



Conclusions

The main conclusion of this project was to show that user health can be monitored through cheap and easily available materials (ESP32, FSRs and MPU-9250). The designed prototype worked efficiently, as the design was translated to a printed circuit board (PCB) and manufactured to be of minimum size so as to easily fit inside the average shoe. In this project, we are pleased to report that our system was robust and worked effectively under many conditions. Using BLE technology greatly reduced the power utilization, while the SQLite provided a good and easily configurable database design. Since it was designed in Flutter (a native application developing SDK by Google), our mobile application can work on both iOS and Android. Future lines of research could utilize this application to identify disease-based user profiles, allowing individuals to be notified at an earlier stage of the detected disease

References

Orlin MN & McPoil TG (2000). Plantar Pressure Assessment, Physical Therapy Volume 80 2000;80; 399-409.