Original Article

# Body weight measurement, calibration and Gait analysis using feet pressure for physiotherapy

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## ABSTRACT

Abnormal gait caused by stroke or other pathological reasons can greatly impact the life of an individual. Being able to measure and analyze that gait, it is often critical for rehabilitation. Understanding the distribution of various physical parameters such as distribution of pressure and weight in foot etc. are helpful for the physiotherapist in the treatment. Now a day's elderly injuries due to fall is becoming decreasing due to influential constituent of Methodical studies on gait detection systems. Diverse range of foot disorders are diagnosed with the help of information collected from plantar pressure measurement system. Foot pressure analysis is useful for medical diagnosis such as analysis of lower limb problems, footwear design, sports biomechanics, injury prevention and research in gait analysis. So the main purpose of the research is to develop a low cost gait analysis system, by capturing human plantar pressure. This paper proposes system which employ small pressure sensor module that measures foot pressure distribution and for analyzing the data from sensor a smart application in software tool is developed on PC. ZigBee is used as a wireless communication module between sensor connected insole and software tool. For physiotherapists these results are very useful for further diagnosis and treatment of patient.

**Keywords**: Gait, Rehabilitation, Planter Pressure, ZigBee, Wireless Communication

## INTRODUCTION

Now a day's health associated problems are one of the most challenging problems to be solved, in which gait related problems are of great importance. Due to current technical limitations, accurate and objective percentage body weight/weight-bearing values and gait characteristics in basic functional activities of daily living have Elude research investigation. So understanding of pressure distribution in foot which is complex biophysical system is great importance in today's research fields. It is important to study and examine person sole (plantar) pressure for the duration of the loaded phase of walking (gait) on hard substrate as this can afford important data of pressure and forces characteristic that can be active on specific part of the foot. In Static or dynamic conditions It will check the load distribution in plantar region and determine the pressure or load for the analysis of the forces acting on the sole of foot. Barefoot load distribution characteristic differ from person to person due to a range of factors such as the variations in the walking speed, body weight, individual age, foot geometry and step of foot. For describing the human behavior of walking a medical term gait is used.

This walking pattern for a normal person differs from age to age. This pattern is described with the help of gait cycle. Gait cycle is the duration between the heel strikes of any one leg on ground to the placing of same heel on the ground. Physiotherapy requires mainly foot contact duration and pattern of foot pressure to analyse the normality and abnormality of the person. This pressure information is useful for the diagnosis of lower limb problems, footwear design, sports biomechanics, injury prevention and research in gait analysis. Barefoot load distribution characteristic differ from person to person due to a range of factors such as the variations in the walking speed, body weight, individual age, foot geometry and stride length. However, pacing velocity and the structural variations in the foot arch significant influences the foot load distribution from person to person. Almost all methods that are utilized today for this purpose consists of specialized hardware accompanied by custom designed software are which results into high costs. So there is a need to develop an optimized system which will be economically useful to the physiotherapist.

## PROPOSED SYSTEM ARCHITECTURE

The proposed work aims to design body weight measurement and gait analysis. Feet pressure will be determined by planter pressure distribution and timing parameters will be determined by the duration of contact. It is useful to check the walking normality or abnormality. From this we will be analyze the nature of foot placement and the way we walk. Sensors connected to sole sense the weight and accordingly give pressure dissemination of that particular node. Temporal variables such as stance time, single limb support time etc., distance variables and speed parameters get changed with respect to change in applied pressure. Based on these parameters weight calibration and gait analysis will be done.

The proposed work aims to design body weight measurement and gait analysis. The block diagram of proposed work is as shown in Figure 1.

A. Low-Cost and Flexible Sensor insole:

Pressure sensors are usually based on one of three physical principles: (i) capacitive, (ii) piezoelectric, or (iii) piezo resistive.

Capacitive pressure sensors can operate statically as well as dynamically, and their measurements are highly reproducible. However, their capability for detecting pressure is limited, since they are sensitive to moisture and comparatively cost-intensive to manufacture due to a necessary complex filter system in the electronics to reduce noise. Piezo resistive pressure sensors can measure statically as well as dynamically with less susceptibility to noise. Their electronics are less complex than those of the above-mentioned sensors. Although piezo resistive sensors have disadvantages concerning drift and durability compared to capacitive or piezoelectric sensors piezoelectric pressure sensors do not need an external power supply and can measure with high sensitivity? They are less sensitive to temperature influences.

B. Selection of transceivers module:

For the selection of transceiver module following modules are considered. These are most commonly used modules while wireless data transmission. This module selection is done using some basic parameters like transmission range which are necessary to consider for system performance. (i)Bluetooth module, (ii) RF Module (iii) Zigbee Out of these modules ZigBee S2 is suitable for our work. So we have chosen ZigBee S2. ZigBee (S2) has long transmission range (120m), also have inbuilt ADC which is suitable for proposed system with RF data rate- 250kbps and Supply voltage- 2.8v- 3.3v. Before the communication of ZigBee's started first configuration of ZigBee modules is necessary so ZigBee is configured with X-CTU software which is open source software.

C. Software tool:

Qt Designer is a tool for designing and building graphical user interfaces (GUIs) from Qt widgets. Qt Creator includes a code editor and integrates Qt Designer for designing and building graphical user interfaces (GUIs) from Qt widgets. Qt supports many compilers, including the C++ compiler and the Visual Studio suite. Qt uses standard C++ with extensions including signals and slots that simplify handling of events, and this helps in development of both GUI and server applications.

For kinematic motion analysis four piezoelectric sensors are positioned at the bottom of foot. Using the Pressure points of a human body shown in figure 2.The various timing parameters and pressure distribution are measured using these sensors. Most of the pressure is measured from the front foot and back foot regions. Considering this, we have placed two of our sensors in the front foot region and two of them are in the back foot region as described in table 1. Here piezo-electric pressure sensor is used for measuring the force while walking. The voltage of this sensor changes with the change in pressure. Voltage changes only when pressure is applied to the round area at the end of the sensor, while being flexed this voltage does not change. This pressure output is given to PC with the help of suitable wireless module. In this system ZigBee is used as a Communication module between pressure data and software tool. A software tool will be used to display the output on the PC. The various parameters were measured and displayed with the help software tool. Output of GUI window is designed in software tool is as shown in Figure 3(a), (b). This is designed for indicating the pressure points in sole where pressure sensor is connected and gait parameters respectively.

## EVALUATION AND APPLICATIONS OF THE SYSTEM

Each user's personal and measured data is collected and saved to the PC database. With the help of this collected data evolution of user's pressure distribution and gait analysis is done.

A. Gait parameters analysis

Gait analysis is a complex procedure, and there are several important features for identifying the normal and pathological walking patterns. Some features are general and important for any kind of applications, such as cadence, stride length, stride height and speed. Some features are applicable for specific domains. For example, the pressure balance of locomotion between two feet is important for analyzing fall prevention, and pressure hotspot mobility is critical for diabetes, foot protection and ulcer prevention. IN this system, the number of peaks, standard deviation (SD) and step frequency of individual sensor were calculated for the participant's trial of each data segment. The correlation of the spatiotemporal and foot clearance parameters was calculated to investigate common information between parameters. In the foot region mean pressure changes in left and right foot before and after removing the pressure is as shown in Figure.3 (a), (b), (c). B. Application scenarios proposed system could be applicable for gait prediction not only among the elderly, but also in gait disorders identification among children, physical rehabilitation patients, environmental monitoring, human behavior analysis, and social networking research. In addition, the increased level of mobility allows the smart shoe to be used in other pieces of equipment, such as a prosthetic knee. Among others, in this section we demonstrate two classes of applications to describe the functional requirements of our system.

(i) Self-gait training assistance for elderly people

The system will support self-gait training to maintain the walking ability of elderly people who need preventive care. In other words, prospective users are people whose walking ability might decline in the future, even though they are currently able to walk without assistance. The system will provide users with instructions to bring them closer to the ideal gait by assessing gait information, e.g., stride length, or the balance of the center of mass or the angle of the toe/ heel, based on their walking abilities.

(ii) Gait disorder relief for patients with Parkinson's disease

A number of patients with Parkinson's disease have freezing of gait (FOG) that makes it difficult to start walking or a senile gait that makes the stride shorter. Our system could notify the user when FOG state occurs, which will help the care giver to assess the patient accurately.

## CONCLUSION

This paper presented a wireless system to analyse pressure distribution and gait using pressure sensor to detect the abnormality in users' gait patterns. The proposed smart insole system utilizes the capabilities afforded by the smart health architecture. In future, we expect to test our system with real data from elderly users with chronic gait problems in order to test the chronological stability and long term viability of our approach. With the help of this system we can collect discrete data. To improve the accurateness of different people for better target the future population more data will be necessary. This work however provides a compact theoretical and evident substance for the next phase of design.

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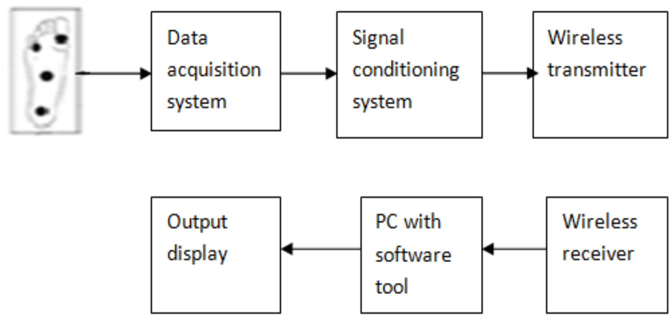


Figure 1: block diagram of proposed system

| Sensor | Position |
|---|---|
| FS1 | Posterior metatarsal |
| FS2 | Heel(hind foot) |
| FS3 | Great ball(forefoot) |
| FS4 | Little ball(forefoot) |

Table1. Insole sensing position

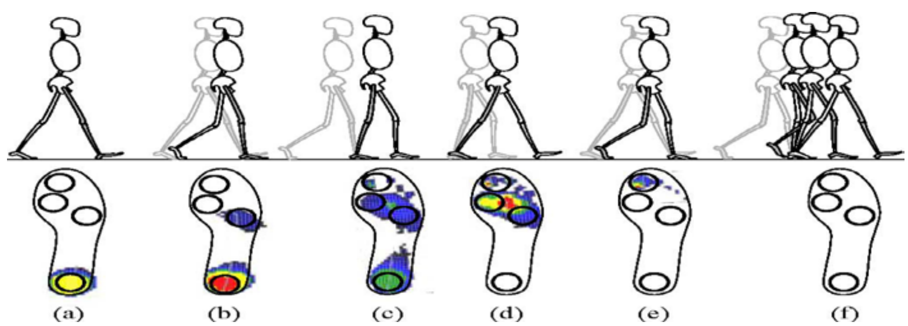


Figure.2: Pressure points of a human body

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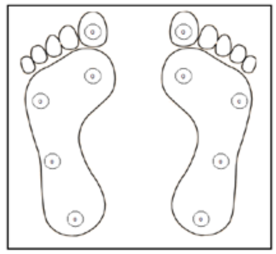

Figure.3 (a)

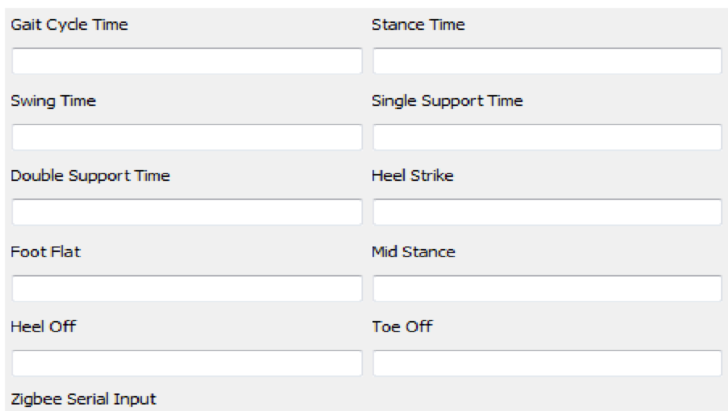


Figure.3 (b)
Figure.3 (a), (b): Output of GUI window

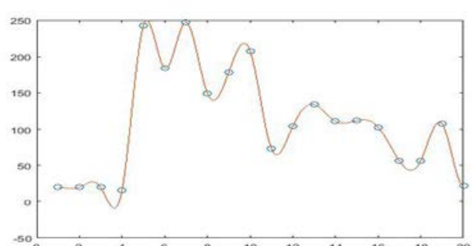


Figure.3 (a)

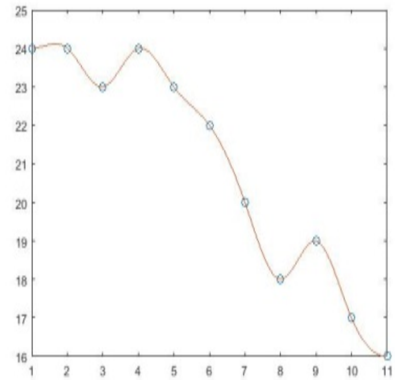


Figure.3 (b)

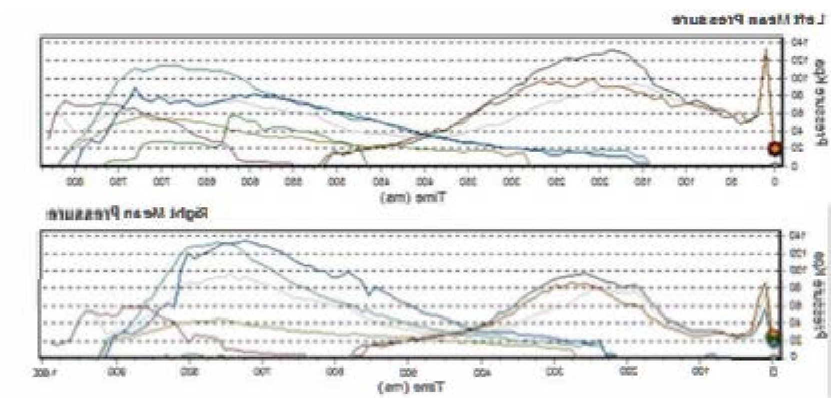

Figure.3 (a) Graph after applying pressure (b) Graph after removing pressure (c) In the foot regions mean pressure changes