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A NOVEL WIRELESS SMART SHOE SYSTEM FOR GAIT ANALYSIS IN OLDER ADULTS

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ABSTRACT
Walking is the most basic and natural mode of human motion generally performed automatically by healthy adults. Because of the probability of falls, older adults require more attention during walking than the younger adults. Falls happen during their daily living activity and such falls often leads to morbidity and in severe cases mortality. Gait impairments are one of the biggest risk factors for falls. Specifically, in elderly health care, gait analysis is an important tool to assess fall risk and fall prevention. In this project, the main objective is to develop a multi-sensory system that study abnormal walking patterns to predict a cautious gait in older adults. For this study, a smart phone and a smart shoe with pressure sensors and a Wi-Fi communication module is used to monitor the patient's gait. The proposed system can warn the user as well as the caregiver about their abnormal gait and possibly save them from forthcoming injuries from fear of falling.

KEYWORDS: IoT, Smart phone, Gait, Sensor, Smart shoe.

I. INTRODUCTION
Falls have significant social and economic importance due to the high incidence of falls among the rapidly growing "old" populations. According to statistics of World Health Organization in 2012, approximately 28-35% of people aged 65 and over fall each year, increasing to 32-42% for those over 70 years of age. However, older adults are typically weak, more liable to fall, have slower reactions and thus are more likely to be injured than toddlers and athletes, who also fall regularly. Approximately, the percentage of all reported falls in older adults that lead to injuries are about 40-60%, of which 30-50% are minor injuries, and 5-6% result in fractures. Most of the older adults who suffer a fracture after a fall, never regains previous levels of mobility, and 20% of falls-related hip fractures results in death within one year.
Falling also cause social and psychological consequences. The main social consequences are, a fall can lead to loss of independence and loss of social engagement, as well as broader societal costs. Psychologically, 54% of people aged over 70 express a fear of falling, and that leads to reduction in their physical and social activities. The main consequences of fear of falling are a reduction in physical performance, a reduction in mental performance, an increased risk of falling, and progressive loss of health-related quality of life. A fall event in an older adult can also affect the spouse, family and friends of that person, in particular generating concern for the safety of their loved one. This may leads to an increased focus on caring for the older person including hiring a caregiver. The incidence of injury and development of fear of falling are considered as one of the primary reasons given for moving into nursing homes.
Human gait analysis for predicting falls due to cautious gait is the subject of many current research projects. Accurate and reliable knowledge of one's gait characteristics at a given time and, even more importantly, monitoring and evaluating them over time, will enable early diagnosis of abnormality in gait to predict falls. This diagnosis will also help to predict and prevent users from an injury. In the field of biomedical engineering, gait analysis has been a fundamental method and assistive tool to characterize human locomotion. Gait analysis has attracted the interest of researchers and clinicians.

In wearable sensors based gait analysis, motion sensors are worn or attached to various parts of the patient's body, such as the foot, wrist and waist. Such sensors are accelerometers, gyrosensors, force sensors, strain gauges, inclinometers, goniometers, and so on. These sensors can measure various characteristics of the human gait. The various signal recorded by these sensors can be used to perform the gait analysis in human.

In this project, a smartphone based gait analysis system using shoe-worn sensors has been presented. Since mobile phones are highly portable, smartphone-based gait detection systems have the potential to function almost everywhere. With the recent development in mobile technology, the smartphone based gait detection systems have become more popular as their computational abilities have increased. Ideally, the pressure sensor shoes (smartshoe) can automatically analyze gait. Therefore, we focus on smart gait detection for preventing fall injuries and assessing gait in general. To address these issues, we propose a smartphone based gait detection system that can alert the user as well as person's caregivers about their abnormal walking patterns.

II. LITERATURE REVIEW

The traditional methods used to analyze human gait parameters in medical fields are semi-subjective. These analyses were carried out by specialists who observe the quality of a patient's gait by making him/her walk. In some cases a survey is conducted in which the patient is asked to give a subjective evaluation of the quality of his/her gait. The main disadvantage of these methods is that they give subjective measurements, particularly when we are concerning accuracy and precision. So this has a negative effect on the diagnosis, follow-up and treatment of the pathologies.

The development of new technologies has given rise to devices and techniques which allow an objective evaluation of different gait parameters, which results in more efficient measurement and providing specialists with a large amount of reliable information on patients' gaits. This technique reduces the error margin caused by subjective techniques. The devices used for human gait analysis can be classified into two different approaches: those based on non-wearable sensors (NWS) or on wearable sensors (WS). An NWS system requires controlled research facilities where the sensors are located and capture data on the gait while the subject walks on a clearly marked walkway. In contrast, WS systems have the ability to analyze data outside the laboratory and capture information about the human gait during the person's everyday activities. There are also hybrid systems that use a combination of both methods.

AKM Jahangir et al. proposes a multisensory system that studies abnormal walking patterns to predict a cautious gait in older adults. For this study, a smartphone built-in sensor and a smart-shoe with a Wifly communication module is used to discretely monitor insole pressure and accelerations of the older adults motion[1].

E Klimiec et al. presented a system to evaluate human mobility by gait analysis, carried out in natural conditions. Foot plantar pressure is measured using a shoe insole with 8 piezoelectric sensors placed in different anatomical zones of the foot, and placed inside a sports shoe. A wireless transmission system is used to transmit voltage values to the computer[2].

Tanmay Bhosale et al. proposed a system which focused on measuring the different gait parameters by using gyro sensors. They mounted 3 gyro sensors at different joint positions of leg and took readings from those gyro sensors using I2C communication protocol. They used MSP430F5257 as central processor. Data is processed by microcontroller, whereas the computer terminal is basically to display the data in graphical format[3].

R. Takeda et al. proposes a method in which measurement of human gait posture was carried out using wearable sensors such as a tri-axial acceleration sensor and three gyro sensors[4].

Susu Jiang et al. proposed a system in which a cell phone and a three dimension accelerometer are used to develop a fall risk prediction system. Accelerometer offers a practical and low cost method of objectively monitoring human walking. Here the gait stability and gait symmetry are calculated and evaluated by Dynamic time wrapping algorithm [5].

N. Shibuya et al. designed wireless gait analysis sensor (WGAS) system for real-time fall detection using a Support Vector Machine (SVM) classifier [6].

Ashwini Khot et al. proposes system which contains a 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 [7].

Ali Saeedi et al. developed a device which contains 32 force sensitive resistors (FSRs), used to measure plantar pressure and an ARM-based microcontroller converts the plantar pressure to a digital pattern. This pattern is then transmitted to a host laptop, by means of a RF module [8].

In this paper a smart phone - and smart shoe based system is developed for human gait analysis to predict falls in older adults. The design of proposed system is highly secure and inexpensive because it requires only a smart phone with low cost smart shoes.

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III. MATERIALS AND METHODS

Methodology

The architecture of the system is shown in Figure 1. The main parts of this system are a smart shoe and a smart phone. Smart shoe consists of piezo-resistive pressure sensors and communication module. In this system, the piezo-resistive pressure sensor is used to measure the pressure exerted on the foot while walking. Here four piezo-resistive pressure sensors are placed on shoe insole to assess the pressure distribution, out of which two are placed in the forefoot region and the remaining two in the rear foot region.

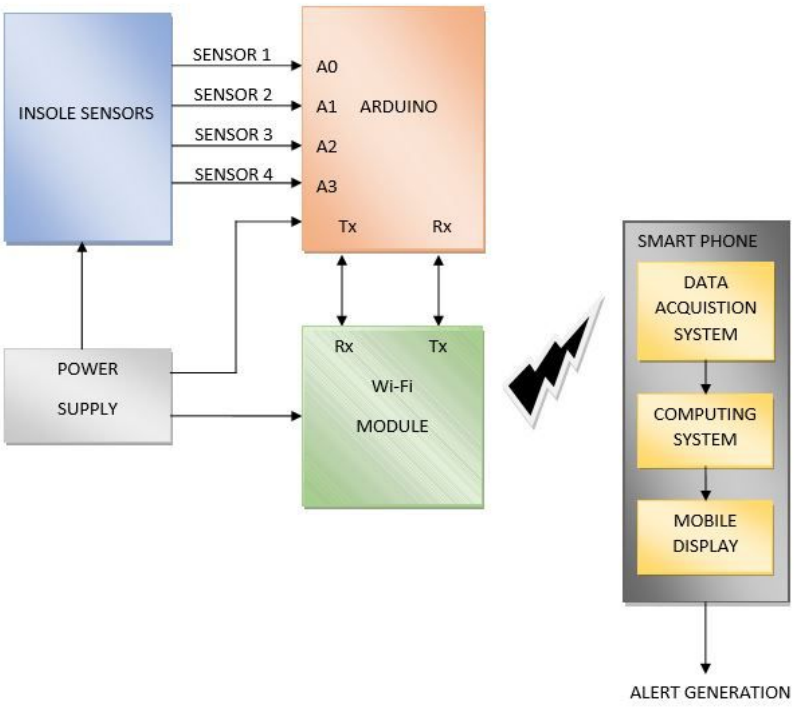

Fig. 1. Block diagram of proposed system

The communication module comprises of an Arduino Uno and a Wi-Fi module with a battery power supply. The Arduino is an open-source physical computing platform based on a simple I/O. This module amplifies the signal and transfers the amplified signal to the smart phone through a Wi-Fi communication network. In order to process the pressure data, the communication module has two different software tasks. One is for the Arduino and another is for the Android. The Arduino is programmed to read analog signals from the shoe sensors and to create a data packet that converts the signal into digital form. Subsequently, Arduino sends those packets to the smart phone in response to the data sending request. Smart phone collects pressure data over a period of time and different walking patterns for the same subject will be recorded. After receiving the data through the Wi-Fi communication network, it is processed inside the mobile phone to identify the abnormality in a walking pattern. In order to identify whether the gait is cautious or not, Decision tree algorithm is used. This algorithm classifies the gait into normal and cautious gaits by analyzing the available sensor data. The moment the abnormality is detected in the walking pattern, the system enables a warning alarm to the subject through an audio message and vibration, to alert them about an imminent fall related injury and also the system will send a message to the caretaker saying that the patient is having walking abnormality.

Classification Algorithm

Classification algorithm used in this project is Decision tree. Decision tree is a popular type of machine learning algorithm. It consists of nodes and branches. Branches are used for connecting the nodes. The top node of the tree is called the root, includes all the training data, which are finally split to classes. The bottom nodes of the tree are called the leaves, and which indicating classes. All nodes except the leaves are defined as decision nodes, where training examples are split into distinct classes based on one attribute. In the testing progress, every new testing data goes into a specific branch from the root, following a matching path to a particular leaf.

IV. RESULTS AND DISCUSSION

Pressure measurement is carried out by using FSR 402 force sensor. The output from sensor is connected to analog input of Arduino Uno and corresponding values are analyzed using serial monitor. After that Arduino sent these values to smart phone through Wi-Fi communication network created by ESP 8266 Wi-Fi module. Next, pressure values corresponding to different walking patterns are stored and which is then classified using the Decision tree method. This algorithm classifies different gait patterns to cautious and normal. Whenever a cautious gait happens then smart phone warns the older adult and also provide a feedback to caregivers.

V. CONCLUSION

In this project, a wireless system is developed that is used to analyze gait using smart-shoe sensors through a real time detection of abnormality in users gait patterns. The proposed system can detect and predict cautious gait that can lead to a fall in older adults.

Gathering the results from gait analysis are useful in medical programs, fall prediction in the elderly, physical therapy, and sports training. Through detailed gait feature analysis, therapists can quantify the rehabilitation progress of the patients after surgery, and the corresponding treatment and training can be customized according to an individual's status.

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VII. REFERENCES

[1] AKM Jahangir A. Majumder, Sheikh I. Ahamed, Richard J. Povinelli, Chandana Tamma, Roger O. Smith, "A Novel Wireless System to Monitor Gait Using Smartshoe-Worn Sensors " in IEEE 39th Annual International Computers, Software & Applications Conference, volume 2, pp.733-741, 2015.

[2] E Klimiec, B Jasiewicz, J Piekarski, K Zaraska, P Guzdek and G Kołaszczyński, "Measuring of foot plantar pressure- possible applications in quantitative analysis of human body mobility" in IOP publishing, 15 March 2017.

[3] Tanmay Bhosale,Hemant Kudale,Varun Kumthekar, Shreyash Garude, and Prasad Dhumal, "Gait Analysis Using Wearable Sensors" in International Conference on Energy Systems and Applications (ICESA), IEEE, 267 - 269, 2016.

[4] R. Takeda, S. Tadano, M. Todoh and S. Yoshinari, "Human Gait Analysis using Wearable Sensors of Acceleration and Angular Velocity" in 13th International Conference on Biomedical Engineering, Springer, 1069-1072, 2009.

[5] SusuJiang,BofengZhang,andDamingWei,"TheElderlyFallRiskAssessment and Prediction Based on Gait Analysis" in 11th IEEE International Conference on Computer and Information Technology, 176 - 180, 2011.

[6] N.Shibuya,B.T.Nukala,A.I.Rodriguez,J.Tsa,T.Q.Nguyen,S.Zupancic,and D.Y.C. Lie, "A Real-Time Fall Detection System Using a Wearable Wireless Gait Analysis Sensor and a Support Vector Machine (SVM) Classifier" in Eighth International Conference on Mobile Computing and Ubiquitous Networking (ICMU), IEEE, 66-67, 2015.

[7] Ashwini Khot, and S.S.Patil, "Body weight measurement, Body weight measurement, calibration and Gait analysis using feet pressure for physiotherapy" in American Journal of Computer Science and Information Technology (AJCSIT), 2016.

[8] Ali Saeedi, Farshad Almasganj, and Malike Pourebrahim, "Plantar Pressure Monitoring by Developing a Real Time Wireless System" in 21st Iranian Conference on Biomedical Engineering (ICBME), IEEE, 211-214, 2014.

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