Transilvania University of Brasov
FACULTY OF MECHANICAL ENGINEERING

The 7th International Conference on Computational Mechanics and Virtual Engineering
COMEC 2017
Brasov, ROMANIA, 16-17 November 2017

STUDY OF FOOT PRESSURE- SOLE PRESSURE SENSOR

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Abstract: *This paper presents the study of foot pressure using a sole pressure sensor. The foot pressure distribution analysis is performed with FSR (Force Sensitive Resistor) sensors. FSR sensors allow measurement of physical pressure and weight. The sole was designed to have four FSR sensors for different areas of research like forefoot, midfoot and hind foot. The signal from the sensors was acquired using an Arduino board and then transferred to a PC using a USB cable. The results indicate a low cost solution for the measurement of the foot pressure in various situations allowing mobility of the human subjects. This device can be adapted to study any contact pressure between a body and the surface that is in contact with it.*

Keywords: *foot, pressure, FSR, Arduino, insoles.*

1. INTRODUCTION

It is well known that the environment has an effect on both the human body and the locomotion [1]. There are a multitude of protective devices that have the role of diminishing the harmful effects of environmental factors, which is actually the purpose of human locomotion research.
With the evolution of technology and research in the field of human locomotion, devices for investigation and diagnosis of human locomotion have been developed and perfected. This is what led to the development of systems in many fields of activity such as: medical, sports, shoe design, robotics, etc.
The bipedal movement of the human body was the consequence of the environmental conditions and the evolutionary factor of the upper limbs, which pro-vides us with a clear position superior to the other mammals. The bipedal movement attracted both the foot soles and the weight distribution. Locomotion is the main movement on land and the biped position is at the top of the trophic chain of movement. Locomotion is in conflict with gravitational force, and this puts into play the static and dynamic balance mechanisms. The base of these being the sole of the foot.
Human research is the subject of many scientific projects currently [2]. In the medical field, changes in locomotion reveal key information about people's quality of life and anomalies. This is of particular interest when important information is provided on the evolution of various diseases such as:

- Neurological diseases such as multiple sclerosis or Parkinson's disease;
- Systemic illnesses such as cardiopathies (where locomotion is clearly affected);
- Changes in walking due to post-stroke sequelae;
- Aging, which affects all the population.

Exact knowledge of walking characteristics, monitoring and evaluation over time, allows early diagnosis of diseases and complications in order to find the best treatment.
Platform systems consist of a large number of sensors arranged in a matrix and generally provide a high spatial resolution for planting pressure measurement. These systems are often embedded in the floor or on the walking surface and are commonly used in the "footless" pressure analysis.
The IN SHOE pressure measurement systems include internal soles detection elements and have gained an advantage over platform systems due to their portability. This has facilitated numerous research outside of the lab as well as clinical analysis. One of the greatest advantages of IN SHOE systems is the ability to measure and analyze sequential steps, keeping the foot aligned to the same sensors. Pressure measurement can be affected both by the movement of the inner soles and the movement of the legs inside the footwear. [3], [4], [5]
In order to achieve a low cost solution for testing the foot pressure it was designed a sole that has attached FSR sensors connected to an Arduino board.

2. MATERIALS AND METHODS

Considering the foot, first it was divided into three specific areas for study (figure 1). In these three areas a specific FSR sensor was fixed so that it will acquire in-formation about the locomotion.

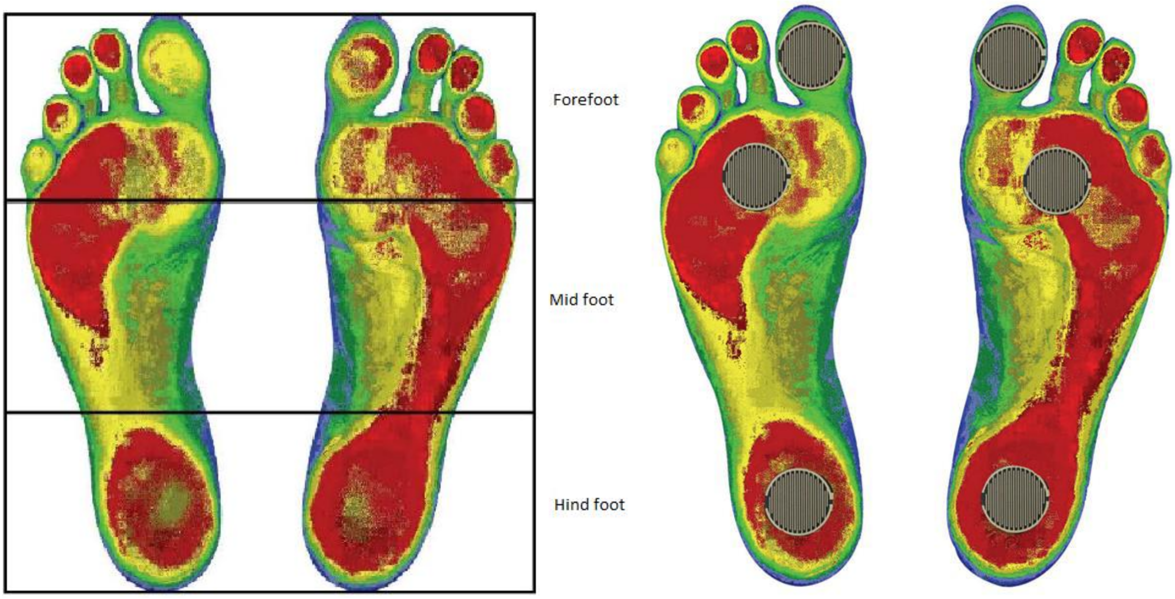

Figure 1: The foot divided into three areas corresponding to the specific FSR sensor.

Three FSR sensors have a diameter of 12,7 mm (figure 2) and one has a diameter of 4,2 mm.

Figure 2: FSR sensor.

The FSR sensor (figure 2) is composed of 2 layers separated by a spacer. The one that pushes harder, more points with active elements touch the semiconductor and make the resistance drop. The FSR is based on a resistor that changes its resistive value (in ohms Ω) according to the pressure force exerted on it.

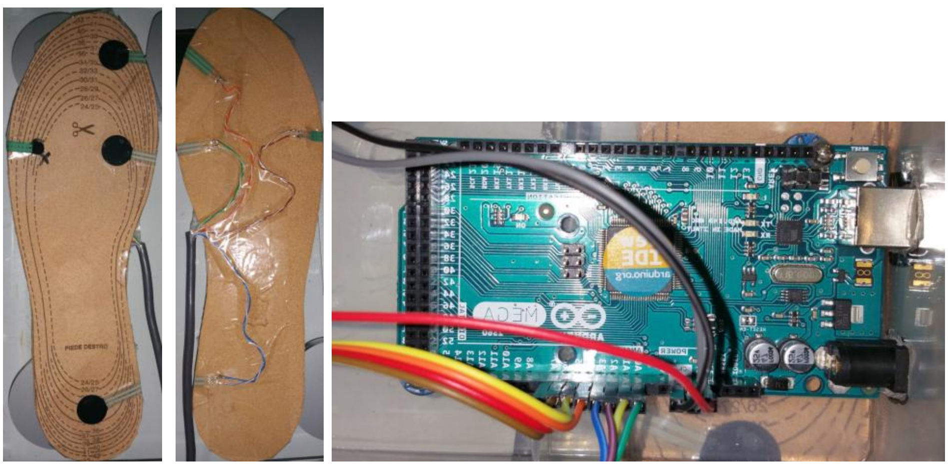

Figure 3: Sole with sensors and the Arduino board connections.

Considering the initial division of the foot into three areas, an additional sensor was added in the midfoot area in order to be more accurate. So four sensors (figure 3) acquire information regarding the most important areas of the foot.

Connecting the sensors to the Arduino development board can be done analogously or digital.

The processing element - Arduino Mega 2560 is a microcontroller card based on ATMega2560. It has 54 digital input / output pins (15 of which can be used as PWM outputs), 16 analog inputs, 4 serial port hardware UARTs, 16 MHz oscillator crystal, USB connection, power cable, ICSP head and button reset. It contains everything it takes to support the microcontroller by simply plugging it in with a USB cable, AC / DC adapter or battery. [6] With this development board, we ac-quire FSR sensor data and then transferred to a PC via a USB cable. The applications used is Arduino-1.6.8. Two UTP (8-wire) cables 1.5 meters long were used to connect the sensors. (UTP cable - used in computer networking).

3. SYSTEM CALIBRATION. RESULTS AND DISCUSSION

Calibration is done with a scale (figure 4) on which the insoles with FSR sensors are mounted. For each value obtained at 100g, 200g, 500g, 1000g, 2000g, 5000g, and 10000g, a value is assigned with which a graph is created. The errors are 0.5% for 1000g.

Figure 4: Soles with the corresponding sensors on the scale.

Due to need of experimental protocols, according to Declaration of Geneva, and ethical committee’s approval, the experimental analysis of the foot pressure of human subjects will be done afterwards in a future paper. These experiments will take into consideration a comparison between the devices presented in this paper and equipment like: FootScan RSscan, Kistler platforms specially designed for this type of analysis but which have the lack of mobility and foot contact in various daily activities.

4. CONCLUSION

The actual configuration has proved to be fitted for analyzing the pressure in the foot during locomotion. It is actually a low cost solution that offers mobility of the human subjects during analysis. There will be made some improvements considering the number of the sensors and also different Arduino boards. We are also interested to use a Bluetooth module to transfer the data more easily. According to what was mentioned above it will be taken into consideration, in a future paper, a statistical comparison between this device and actual commercial equipment in order to determine the reliability of the system.

ACKNOWLEDGEMENT

Practical realization of this project was made possible thanks to funding received in a competition held in the Transylvania University of Brașov as HCA nr.20/01.03.2017 (Annex 3).This study was done with the help of students Gheorghe Bogdan Marius and Popa A..

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