DESIGN SMART INSOLE SYSTEM USING ARDUINO MICROCONTROLLER TO ANALYSIS OF ACL INJURY

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DECLARATION

I declare that this thesis entitled "DESIGN SMART INSOLE SYSTEM USING ARDUINO MICROCONTROLLER TO ANALYSIS OF ACL INJURY is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : MUHAMMAD FAKHIRULLAH BIN ZAINAL

Date : .....

APPROVAL

I hereby declare that I have checked this report entitled "DESIGN SMART INSOLE SYSTEM USING ARDUINO MICROCONTROLLER TO ANALSIS FOR ACL INJURY" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Mechatronics Engineering with Honours

Signature : .....

Supervisor Name : Dr. Fariz b. Ali @ Ibrahim

Date : 5.7.21

DEDICATIONS

I am dedication my thesis to my beloved mother and father, Salbiah Binti Abd Jalil and Zainal bin Bidon who always givemorale support in completing this thesis. I dedicate this thesis to my supervisor, Dr. Fariz Bin Ali@Ibrahim who always supervised my work. I also dedicate this thesis to my fellow friends and people surround me that give cooperation throughout my research.

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ABSTRACT

Anterior Cruciate Ligament (ACL) is common injury that always happen to athlete Malaysia. In order to assist the athletes to do the rehab after surgery from ACL, the project design smart insole system using Arduino microcontroller to analysis for ACL injury was created. In this project, we are proposing a simple but effective smart insole system. This strategy uses force sensitive sensor (FSR-402) in order to get the reading of force apply. This project was assisting by Internet of Thing (IoT) that implement in monitoring system. Five people participated in the experiment which one is ACL injury patient and other four are healthy condition. The experiment will compared between ACL injury patient force value and healthy condition force value. The activity experiment that propose in this porject are walking, running, jumping ank kicking the ball. The component that involed in this project are Arduino Mega 2560, FSR-402 sensor, ESP8266 Wi-Fi module, wire jumper, breadboard, power supply, laptop and smart phone. The nine FSR-402 sensors arranged on insole to get the reading each point at foot plantar of people. Arduino Mega will act as microcontroller to make the system process in expected needed. ESP8266 Wi-Fi module act as connectivity with the Blynk application to transmit the data in moitoring system at the same time IoT was apply in this project.

ABSTRAK

Anterior Cruciate Ligament (ACL) adalah kecederaan yang selalu berlaku pada atlet Malaysia. Untuk membantu atlet melakukan pemulihan setelah pembedahan dari ACL, projek ini merancang sistem insole pintar menggunakan mikrokontroler Arduino untuk analisis kecederaan ACL. Dalam projek ini, kami mencadangkan sistem insole pintar yang mudah tetapi berkesan. Strategi ini menggunakan force sensitive resistor (FSR-402) untuk mendapatkan bacaan daya yang berlaku. Projek ini dibantu oleh Internet of Thing (IoT) yang dilaksanakan untuk sistem pemantauan. Lima orang mengambil bahagian dalam eksperimen tersebut, yang mana satu adalah pesakit kecederaan ACL dan empat yang lain adalah dalam keadaan sihat. Eksperimen akan membandingkan antara nilai daya kekuatan pesakit kecederaan ACL dan nilai daya kekuatan kepada orang yang keadaan sihat. Eksperimen aktiviti yang dicadangkan dalam pembelajaran ini adalah berjalan, berlari, melompat dan menendang bola. Komponen yang terlibat dalam projek ini adalah Arduino Mega 2560, sensor FSR-402, modul Wi-Fi ESP8266, jumper wayar, papan roti, bekalan kuasa, komputer riba dan telefon pintar. Sembilan sensor FSR-402 disusun di insole untuk mendapatkan pembacaan setiap titik di tapak kaki. Arduino Mega akan bertindak sebagai mikrokontroler untuk membuat proses sistem berlaku dengan yang diharapkan. Modul Wi-Fi ESP8266 bertindak sebagai penghubung dengan aplikasi Blynk untuk menghantar data dalam sistem pemantauan dan pada masa yang sama IoT digunakan dalam projek ini.

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LIST OF SYMBOLS AND ABBREVIATIONS

Iot	-	Internet of Thing
FSR	-	Force Sesitive Resistor
ACL	-	Anterior Cruciate Ligament
COP	-	Centre of Pressure

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CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, many athletes need to end their career because of the permanent injury that they received in the activity either young athletes or veteran. The common injury that always happen to the athletes is Anterior Cruciate Ligament (ACL). ACL is the one of the band tissue that hold the bones together within the knee. If anything happens to ACL, it cannot help the knee to keep in stable position also increasing the pain to the knee. The ACL injury almost happen to the sport that required leg as the main part to the activities. Football is the one of the sport that commonly happen ACL injury to their athletes. When happen the ACL injury, the athlete need to do surgery and it takes a few weeks to recovery from the surgery. The full recovery generally takes eight to twelve months or more before athletes can return to their sport career. In this research, the football athletes will be main focus to the ACL injury. In order to make sure the footballer has fully recovery, it need the device that can analyse the condition of the footballer in term of strength and stability. As solution to solve these problem, wearable smart insole system for analysis of ACL injury will becomes the device that can analyse the condition of the football player from fully recovery.

Wearable smart insole system for analysis of ACL injury was created to analyse the strength and stability of the user after recovery from the surgery. The analyse will differentiate between normal football player and the ACL injury football player. This research focuses on the development of wearable smart insole system for basic analysis of designing the PCB in the shoes and prototyping process.

1.2 Motivation

Such a disappointment if there is a talented football player that almost achieve their success life but ACL injury happen to themselves. It was hard to return in sport career as a normal player after recovery from the surgery. In the past, reconstruction of ACL has been advocated as a requirement for return to competitive sports after a tear of the ACL. For the global statistic, Ardern et al have done a systematic review and meta-analysis in USA to determine post-operative return to sports outcomes after ACL reconstruction surgery. Their review found that although 90% 0f the patients achieved successful surgical outcome in terms of impairment based measurement of knee function and 85% successful activity based outcome, only 44% of patients returned to competitive sport and approximately 63% of patients returned to pre-injury level of sports participation [14]. Then, for the local statistic, knee injury in Malaysia increase 172% from 10 years ago. The statement from Director of Sports Medicine Division National Sports Institute (ISN) Dr. Arshad Puji state that in one month, they receive 3 or 4 athletes that involve in knee injury especially in sport of hockey, sepak takraw and netball [16]. From the percentage above, it can see that not easy in return to the field if ACL injury happened to themselves once. Wearable smart insole system for analysis of ACL injury can help to analyse theirself to make sure their condition in aspect mental and physical is fully recovery before return to the field.

1.3 Problem Statement

For the design of smart insole system using Arduino microcontroller to analysis of ACL injury, there is a problem from previous study where the only the insole on the floor as the main design to analyse the force from the user [1]. The user cannot wear the insole because it is not design to fit in the shoe factor of wire management and direct wire data receiving to the monitor. From this problem statement, the limitation of activities experiment will become higher and the result for the user can go back to the field as an athlete is not promising.

Besides that, the second problem statement that need to be consider is calculation of the result. From the previous smart insole system, the result shows that only the value of force that apply on the sensors as the result but what is the conclusion from the result data can get for the user as an athlete. The conclusion of result need to related with the ACL patient user to show that the result can give the feedback either the patient can do their athlete activities or the patient need more rehab to regain their best condition.

The last problem statement for design of smart insole system using Arduino microcontroller to analysis of ACL injury project is method of data receiving. In case to increase the range of the activities experiment, the data receiving need to be more advanced for user can get the reading while doing the experiment by using the wireless method. Then, the data also can receive by using any device either computer of smart phone for the user can monitor the result.

1.4 Objective

The objectives of this project is:

1. To design a wearable smart insole system.
2. To analyse the walking, jumping, running and kicking the ball in term of strength and stability.
3. To apply Internet of Thing (IoT) for the monitor system by using Blynk application.

1.5 Scope

- Target on football player university level.
- The weight of the football player must not more than 70 kg.
- Wearable smart insole system with wireless system.
- Using Arduino as the microprocessor.
- Using Blynk application as the data monitor.

CHAPTER 2

LITERATURE REVIEW

2.1 Force Sensor

2.1.1 Force Sensitive Resistor

Force sensitive resistor (FSR) is the one of the sensor that can be apply for project design smart insole system using Arduino microcontroller to analyse for ACL injury. FSR is the sensor that allow force applied to the contact surface to be measured either in static or dynamic [18]. The range for the FSR is depend on the variation of electric resistance.

Figure 2.1: Force Sensitive Resistor (FSR)

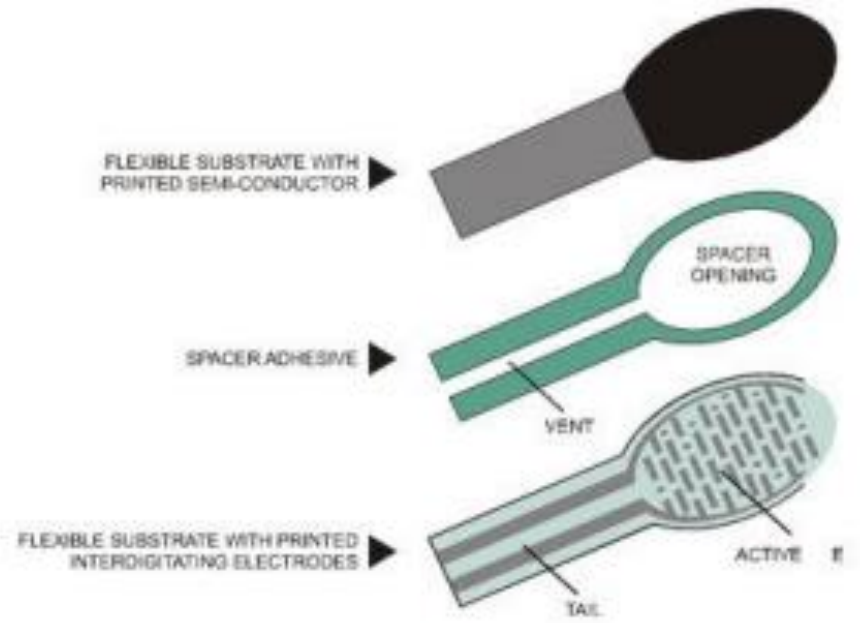

Figure 2.2: The layer of FSR

The FSR is made by two layers that separated by spacer. When the FSR getting force by pressing the sensor, the semi-conductor will touch the Active element and that is make the resistance will go down [19]. The FSR have their class in term of force range. It depends on value of mass that user want to apply on the surface of the FSR. The higher the resistance, the higher the force range of the FSR sensor can be.

2.1.2 Tactile Sensor

Tactile sensor can be used to measure the information from physical interaction with the environment. It can help the smart insole system to getting information about the surface of plantar feet and measure the contact force at defined point. Spatial sensor is the one of the subgroup of tactile sensor which is detect and measure the spatial distribution of force perpendicularly to determine the area and the subsequent interpretation. The figures below show that example of the spatial sensor.

Figure 2.3: Spatial Sensor

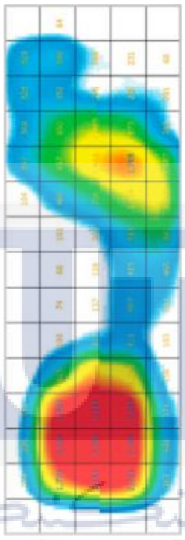

Figure 2.4: Spatial Distribution Insole

Besides that, tactile sensor also can apply the slip sensor function which mean to detect and measure the object movement relatively to the sensor. This can be done either by a specially built slip sensor or by reading the data from a spatial array or a touch sensor. So, this tactile sensor can give the user full of information and data monitor can be more interesting. There is requirement for tactile sensor must be fulfil such as the minimum sensor bandwidth if 100 Hz, the sensor characteristic must repeatable and stable by low hysteresis.

2.2 Microcontroller

In an embedded device, a microcontroller is a compact integrated circuit designed to control a particular operation. A typical microcontroller requires peripherals on a single chip for a processor, memory and input/output (I/O). When it comes to selection of microcontroller for the certain project, it need to know what the required of function that suitable for the selected project

.

The first microcontroller that suitable for smart insole system is ESP32 Development Board. This development board had ESP-WROOM -32 module attached on it that boasts Wi-Fi, Bluetooth, Ethernet and low power support. Its microcontroller was Tensilica 32-bit Single-/Dual-core CPU Xtensa LX6 and the operating voltage was only 3.3V. It also consists 25 digital I/O pins (DIO), 6 analog input pins (ADC) and 2 analog outputs pins (DAC). This development board also have 4MB flash memory, 240 MHz clock speed with IEEE 802.11 b/g/n/e/I of Wi-fimesia access control (M AC). In this system the ESP32 Development Board can be supply at range below than 12V [10]. The sensor will connect to analog to digital (ADC) pin in order to read analog reading value. By using ESP32 Development Board, it can apply the wireless method which mean it free to wearable without any wire attach. ESP32 Development Board have Wi-Fi which is the user want to create their server to monitored the experiment from far away or the user can do something fast connection by using Bluetooth module.

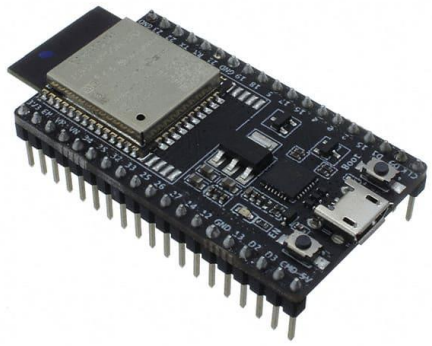

Figure 2.5: ESP32 Development Board

Another microcontroller that can consider to be use for smart insole system is Arduino. Arduino is common used in small project especially for the beginner which is there are many online reference that regarding to Arduino. Usually, Arduino is used as an analog to digital converter (ADC). Arduino is an open source physical computing platform based on a simple I/O board and a development environment that implements the processing/wiring language [11].

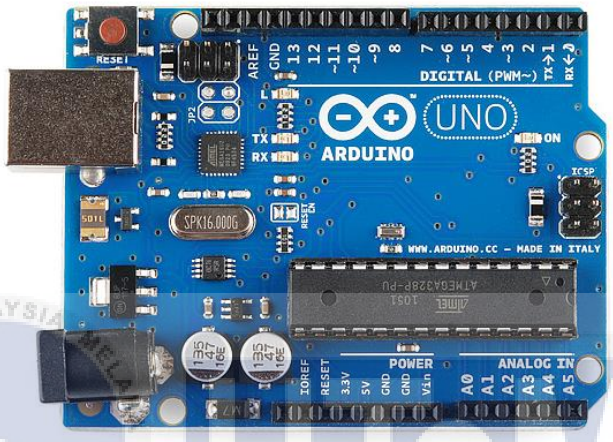

Figure 2.6: Arduino microcontroller

Now days, industry revolution 4.0 use the internet of thing (iot) to communicate or monitor their machine by using server. Raspberry pi is the microcontroller that can transmit the data to the server. For the smart insole system, when the sensor will get pressure on it, it will generate voltage pulses. By using another component that can senses these pulses and sends the pressure point to the raspberry pi. Then this data is sent to the server. By taking the mean of this data foot pressure point is calculated [8].

Figure 2.7: Raspberry Pi microcontroller

2.3 Experiment Position

Experiment position also important to get the different outcome for the analysis data. The position for the experiment must depend on the objective of the project. If the smart insole system is focus on the athletes, the experiment position that suitable to do the analysis usually walking, jumping and running [1]. Meanwhile, if the objective of smart insole system is to focus on the awkward position of the worker, the common experiment position uses are overhead working, squatting, stooping, semi-squatting, and one-legged kneeling [2]. For another case, the elder also need to consider the suitable experiment position for them such as daily activities or walking. Conclude for this experiment position, the positioning is depending on what the person career or the ages of the person to get the analysis outcome.

2.4 Center of Pressure

In order to achieve the result in term of stability, center of pressure (COP) is the one of the element need to prove. The purpose of COP is to represents motion of the human motion. The measurement system to getting the reading of COP are involving two part. The first part is a signal processing unit and the second part is a pressure sensor. Signal processing unit already implant the battery and microprocessor which that microprocessor measures pressure data from the pressure sensor. The pressure data was digitalized with A/D converter. By doing calibration, it can convert the pressure from the A/D values. This study deals with just A/D values, because the target of this study is to measure the COP movement. The data was saved on micro SD card.

In term of calculation of COP, the x-y position of the pressure sensor on insole are determined beforehand. The information of the positions and pressure data enable us to derive the COP positions of C_x and C_y as the following equation from the data.