POLITEKNIK SULTAN SALAHUDDIN ABDUL AZIZ SHAH

FINAL YEAR PROJECT REPORT

IOT BASED NON-INVASIVE GLUCOSE MONITORING SYSTEM FOR DIABETIC PATIENT

SUPERVISOR NAME : DR. BAHARUDDIN BIN MUSTAPHA

NO.	NAME	MATRIC'S NUMBER
1.	NUR FATIHAH BINTI KHAIRUL MUNIR	08DEU17F2007
2.	SITI HAJAR FARHANA BINTI HASMUEI	08DEU17F2008

TABLE OF CONTENTS

ABSTRACT

The development of technology is very rapid at present, especially in the field of medical engineering. This paper focuses on an insole that can check the glucose level of a person by putting their feet on the insoles. It provides information about gait mechanics and has a wide range of applications, in clinical situations. In this project the sensors are used to gain insight about infrared, skin sensor of diabetic person. It is also wearable real-time monitoring and feedback faces the challenge of patient adherence. The insole consists of an array of sensors. The pressure-sensing smart insole system provided unique feedback to both patient and provider in ways that contributed to the prevention of pressure as well as highlight the importance of prescribed a non-invasive method. Real-time visualization of pressure mapping which are using internet data is also incorporated because it makes it much easier to understand the data needed.

CHAPTER 1

1.1 INTRODUCTION

Diabetes is a disease that occurs when the blood glucose, also called blood sugar, is too high. Blood glucose is the main source of energy and comes from the food eaten by human. Insulin, a hormone made by the pancreas, helps glucose from food get into the cells to be used for energy. Some 3.6 million Malaysians are suffering from diabetes, the highest rate of incidence in Asia and one of the highest in the world, said Health Minister Datuk Seri Dr. Dzulkefly Ahmad. Seven million Malaysian adults are likely to have diabetes by 2025, a worrying trend that will see diabetes prevalence of 31.3% for adults aged 18 years and above, he added. This exponential increase is significantly within type two diabetes, which is largely the result of excess body weight and physical inactivity. The government is giving serious attention to this increase as it is becoming a major economic burden on the healthcare system and national economy. Dr. Dzulkefly said although Malaysia has a parallel public and private system, the majority of treatment for chronic diseases is provided by the public health system heavily subsidized by the government at a “significant cost”. A macroeconomic study in 2011 showed the cost at about RM2bil, representing 13% of the healthcare budget for the year 2011. The analysis reflects that this cost could be as high as RM3.52bil if societal costs were included. The one-day event held at Sunway Medical Centre brought specialists to discuss the latest developments in acute and general medicine.

The hardware used are infrared sensors, skin sensors as an assistant to the infrared data so that the program can match the data of the infrared and the skin sensors. It also using Arduino MK1000, Light Emitting Diode (LED) and buzzer to help detect the glucose level needed. Based on our observations and research about the relationship between the infrared and the glucose level, when the infrared is between range of 70 – 80 bpm, the skin sensor are needed to sense the heat of the person's feet as if the range of data of the person heart rate is equal to the heat of a normal person whom does not having diabetes, the data of the glucose level will appear at the phone or apps used by using internet (wifi). This is because the heat of the skin whom having diabetes is more heater than the normal person usual range. As the heart rate will be put on the feet to sense the heat and the heart rate as it physically a little far from the person heart itself. So, using skin sensor to help the heart rate data that combine to easy the program to produce a good result and exact data that we want for the person.

By using wifi, the application that used are Thingspeak for appearing the result or data of whether the person that are being examine is having diabetes or not with the relationship between the infrared data and the heat of the skin. Thingspeak is an IOT internet of thing platform that are collected data that sense at the same time and show it on the phone or PC used. By connecting to the internet, by just need to log in the account on the link and inserting the personal information and sense the feet, automatically the data will appear with the analysis needed.

At the insole, buzzer and LED with difference colour which are white and green is put to react with the glucose level shown. The buzzer will sound beeping when the results or the data of the glucose level for the person is high. The green LED will on if the glucose level is normal whereas the white LED will on if the glucose level is low.

1.2 PROBLEM STATEMENT

This project is created to address the aforementioned problems with gait laboratories, video and IMU and enable gait monitoring in real life. This device looks similar to an insole and is able to monitor both inertial and pressure information from both feet. The Smart Insole system comprises a low-cost sensory insole and application software on both smartphone and computer for data storage and visualization. The insole consists of an array of sensors, an ultra-low power micro control unit (MCU) and Bluetooth low energy (BLE) wireless transmission module, a channel multiplexer (MUX), a battery and a micro-Universal Serial Bus (USB) connector module . The application software provides visualization and a real-time guided feedback to the user.

1.3 OBJECTIVE

- To develop a hardware prototype for non-invasive glucose monitoring system.
- To get the results of glucose level for the patients.
- To gain insight about glucose level faster.
- To develop a software for non-invasive glucose monitoring system.
- To develop interface for non-invasive glucose monitoring system.
- Testing the schematic diagram of glucose monitoring system.

1.4 SCOPE OF PROJECT

- Old patients especially diabetes.

1.5 IMPORTANT OF RESEARCH

- Detect the glucose level of the patients which also have diabetes.

CHAPTER 2

LITERATURE REVIEW

Pressure measurement is already used in a variety of situations. It provides information about gait mechanics and has a wide range of applications example as in clinical situations. Pressure measurement is already used in a variety of situations. It provides information about gait mechanics and has a wide range of applications example as in clinical situations especially for diabetic patients. In this project, the sensors are used to gain insight is about infrared distribution. Real-time visualization of pressure mapping is also incorporated because it makes it much easier to understand the data.

The measurement of infrared and skin sensors is an important technique used by medical personnel for diagnosing and treating a wide range of non-communicable diseases and conditions. By measuring and especially monitoring a patient's infrared, medical personnel can be alerted to the related health condition at an early stage, increasing the likelihood of successful treatment. While indirect methods of skin sensor monitoring, such as with a pressure skin’s sensor and infrared sensor, are often desired for quick pressure readings, these methods can be inaccurate by as much as 10 percent, making them undesirable for longer term blood pressure monitoring of more critical patients. Consequently, direct blood pressure monitoring methods are preferred for patients with serious or critical conditions due to their improved accuracy and easier long-term implementation. Antonio et al. [1] had developed an implemented and instrumented as an IOT system, in which all the measurements were carried out in vivo to measure the glucose level by using sensor on the hand without needed to prick the patient’s finger to obtain the blood.

Moreover, T. N. Gia et al. [2] have designed an IOT-based system architecture from a sensor device to a back-end system for presenting real-time glucose, body temperature and contextual data (i.e. environmental temperature) in graphical and human-readable forms to end-users such as patients and doctors. This method investigate energy consumption of the sensor device and design energy harvesting units for the device. The work provides many advanced services at a gateway level such as a push notification service for notifying patient and doctors in case of abnormal situations (i.e. too low or too high glucose level).

The results show that the system is able to achieve continuous glucose monitoring remotely in real-time. In addition, the results reveal that a high level of energy eficiency can be achieved by applying the customized IF component, the power management unit and the energy harvesting unit altogether in the sensor device., Meghanachandrashekar et al. [3] had system puts forward a smart patient health tracking application that uses sensors and microcontroller to track patient health and provides precautionary messages to the patient's mobile phone. In application system uses Cholesterol level as well as blood glucose level to keep track of patient health. If system detects any abrupt changes in the patient's cholesterol or blood glucose level, the system automatically alerts the user about the patient status from the server in the hospital. J.N.M. Boncy et al [4] assessment is carried out by monitoring the patient's body sensor values (ECG, BP and blood glucose) in a web based link using IOT (Internet of Things).

CHAPTER 3

METHODOLOGY

In this proposed system considered as two parts software application and hardware kit. In software application will have the ability to monitor the patient's health continuously, particularly to measure the blood glucose level.

HARDWARE

1. Arduino Uno

Figure 3.1

Arduino Uno as in Figure 3.1, is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button.

2. Infrared Pulse (IR) Sensor

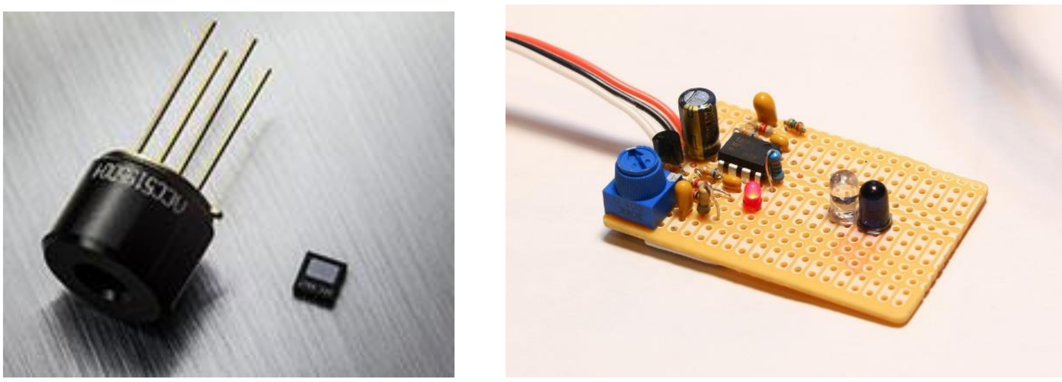


Figure 3.2

This pulse sensor as in Figure 3.2, fits over a fingertip or toes and uses the amount of infrared light reflected by the blood circulating inside to do just that. The proposed system consists of a near infrared sensor and skin sensor. The near-infrared sensor is used to obtain the glucose level of the person. The glucose level here is obtained without capturing the blood samples from human body.

3. Hc-05 Bluetooth Module

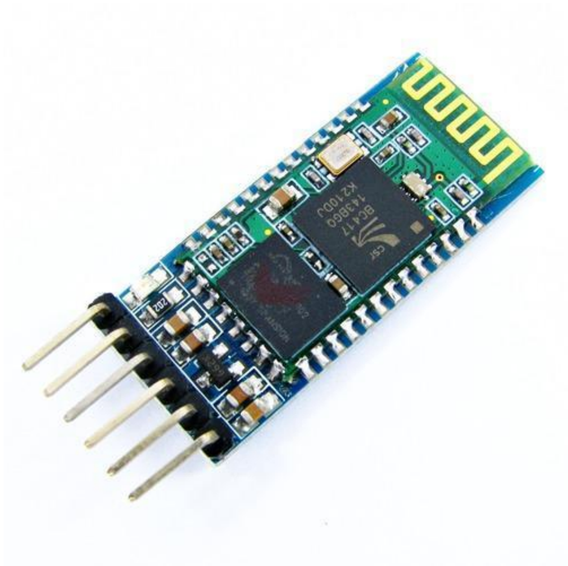


Figure 3.3

The RN-42 Bluetooth Module as shown in Figure 3.3, provides a reliable method for creating a wireless serial communication interface between two devices such as a microcontroller, PC, cell phone, or another module. This module can pair up with devices supporting Bluetooth SPP (Serial Port Profile) to establish a serial interface. The RN-42 Bluetooth Module is breadboard-friendly and is compatible with all 5 V and 3.3 V microcontroller platforms.

4. AA battery cell.

Figure 3.4

Batteries as shown in Figure 3.4 are a collection of one or more cells whose chemical reactions create a flow of electrons in a circuit. All batteries are made up of three basic components which are an anode (the '-' side), a cathode (the '+' side) and some kind of electrolyte, a substance that chemically reacts with the anode and cathode.

SOFTWARE

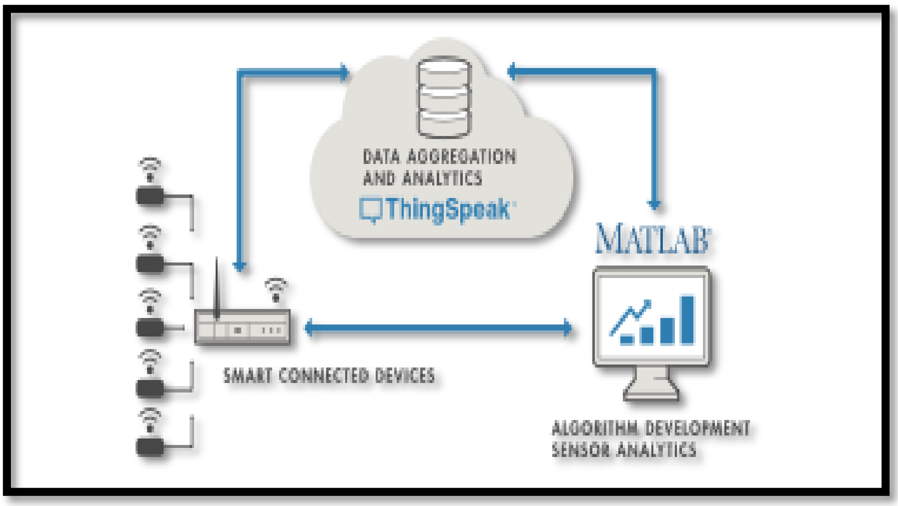
1. THINGSPEAK

ThingSpeak™ is an IoT analytics platform service that allows you to aggregate, visualize and analyze live data streams in the cloud. ThingSpeak provides instant visualizations of data posted by your devices to ThingSpeak. With the ability to execute MATLAB® code in ThingSpeak you can perform online analysis and processing of the data as it comes in. ThingSpeak is often used for prototyping and proof of concept IoT systems that require analytics.

Internet of Things (IoT) describes an emerging trend where a large number of embedded devices (things) are connected to the Internet. These connected devices communicate with people and other things and often provide sensor data to cloud storage and cloud computing resources where the data is processed and analyzed to gain important insights. Cheap cloud computing power and increased device connectivity is enabling this trend.

IoT solutions are built for many vertical applications such as environmental monitoring and control, health monitoring, vehicle fleet monitoring, industrial monitoring and control, and home automation.

At a high level, many IoT systems can be described using the diagram below:



On the left, we have the smart devices (the "things" in IoT) that live at the edge of the network. These devices collect data and include things like wearable devices, wireless temperatures sensors, heart rate monitors, and hydraulic pressure sensors, and machines on the factory floor.

In the middle, we have the cloud where data from many sources is aggregated and analyzed in real time, often by an IoT analytics platform designed for this purpose.

The right side of the diagram depicts the algorithm development associated with the IoT application. Here an engineer or data scientist tries to gain insight into the collected data by performing historical analysis on the data. In this case, the data is pulled from the IOT platform into a desktop software environment to enable the engineer or scientist to prototype algorithms that may eventually execute in the cloud or on the smart device itself.

An IoT system includes all these elements. ThingSpeak fits in the cloud part of the diagram and provides a platform to quickly collect and analyze data from internet connected sensors.

FLOWCHART

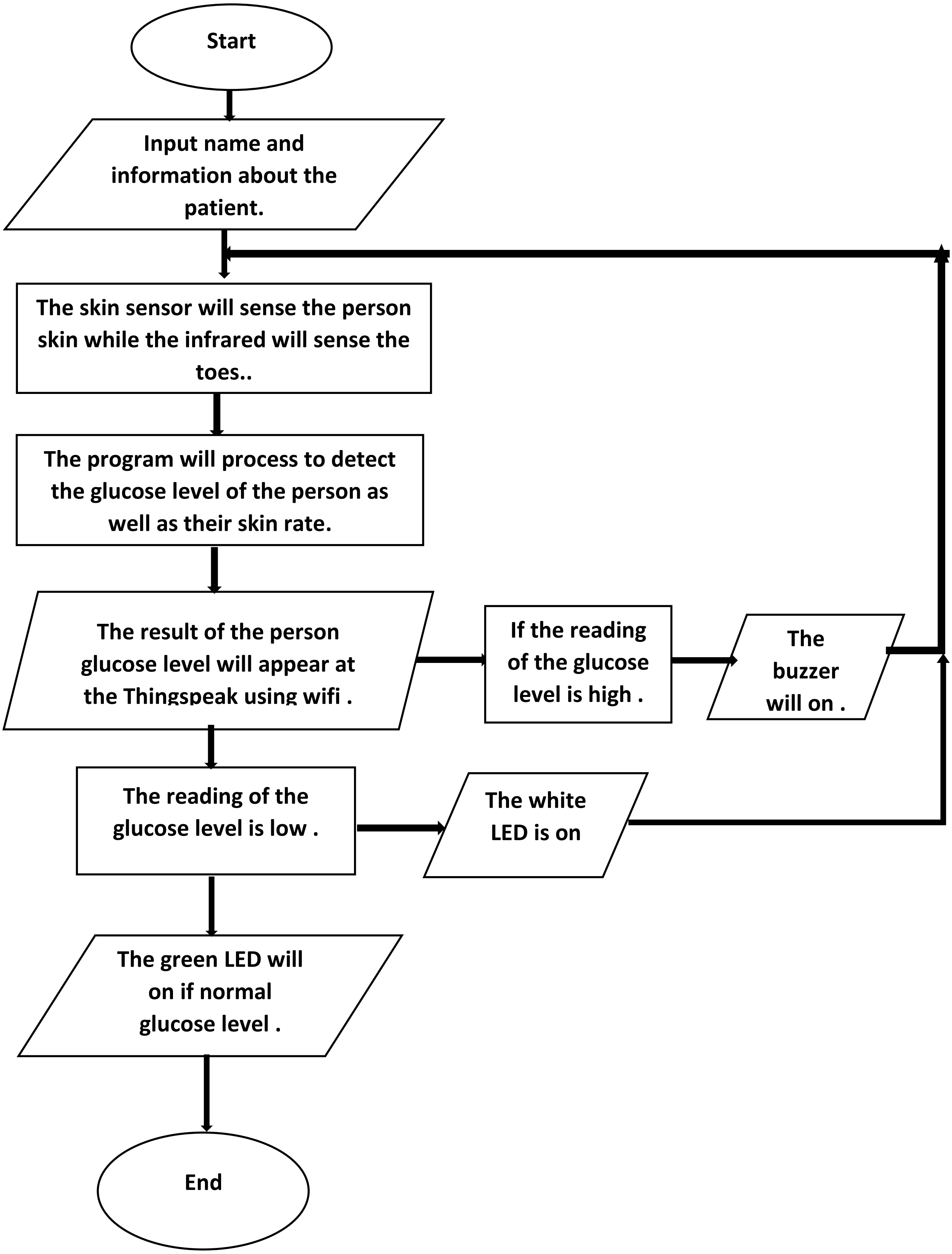


Figure 3.4 The flowchart of the monitoring system.

BLOCK DIAGRAM

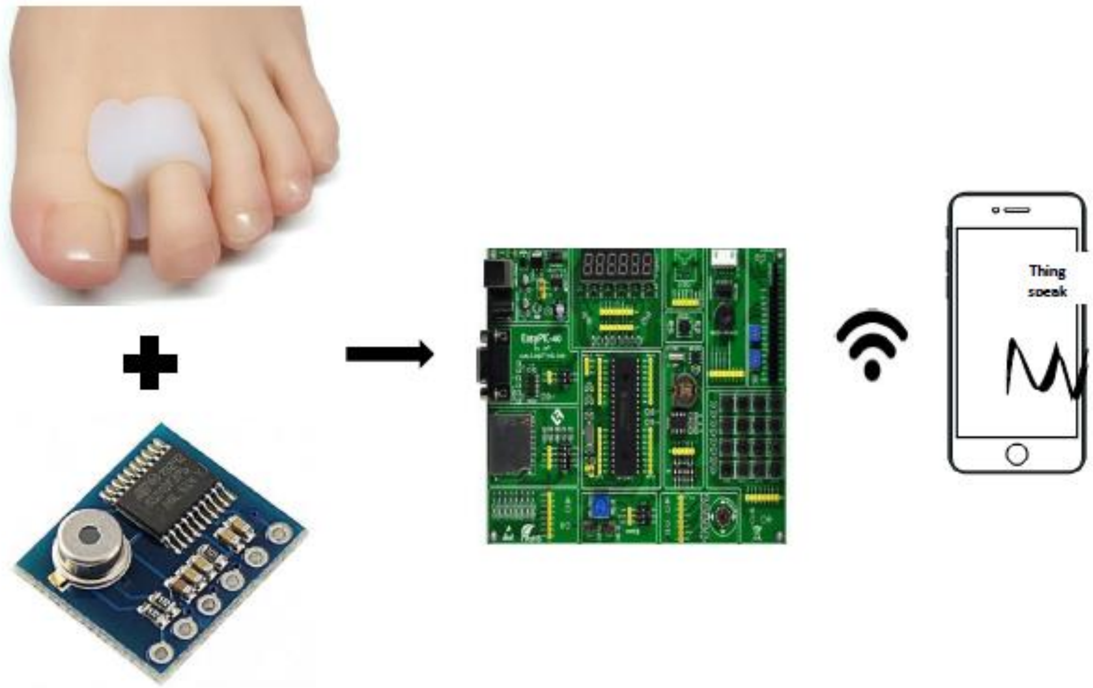
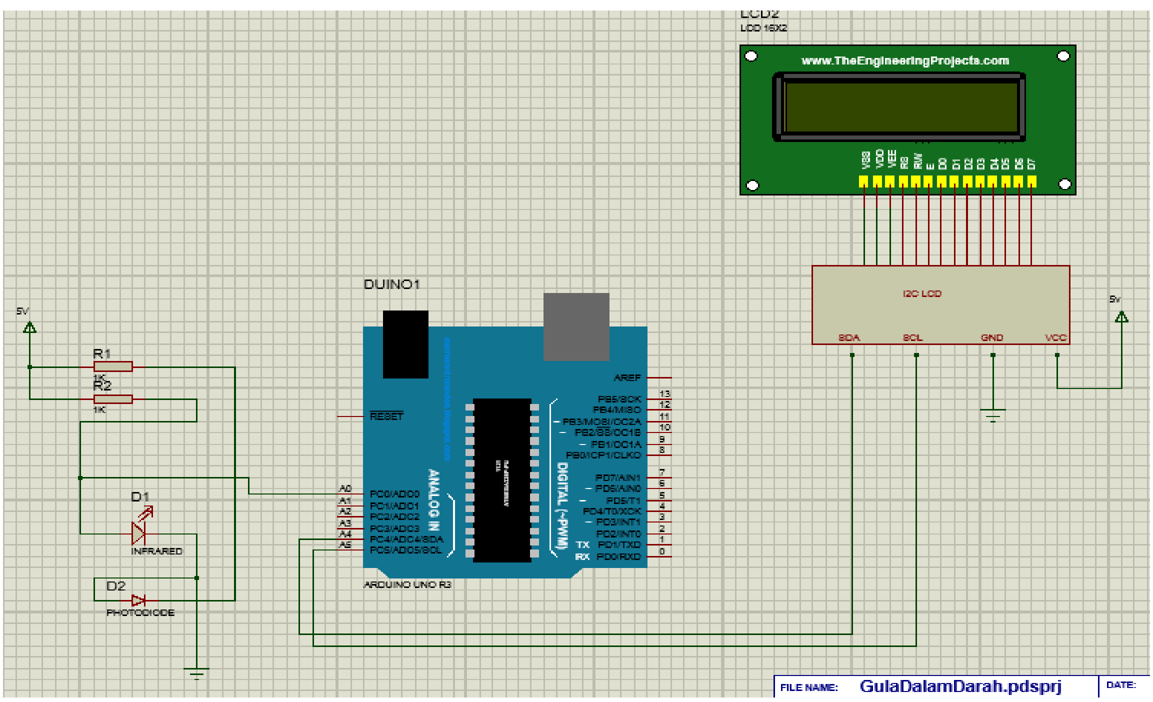


Figure 3.5 The block diagram of the monitoring system.

CIRCUIT



CHAPTER 4
DATA ANALYSIS AND RESULT

Based on the analysis and testing, the data shown that the glucose level can be detected by non-invasive rather than we had to prick the patient's finger and use their drop of blood to know their glucose level. Glucose monitoring system is also equipped with a low-cost inertial measurement unit including a AA battery cells, an Arduino Uno and infrared sensor (IR) to capture the gait characteristics in motion. This system also can offer precise acquisition of gait information.

Meanwhile, it is lightweight, thin and comfortable to wear, providing an unobtrusive way to perform the gait monitoring. Furthermore, a smartphone graphic user interface is developed to display the sensor data in real-time via Bluetooth low energy. They perform a set of experiments in four real-life scenes including ascending or descending stairs and slope walking, where gait parameters and features are extracted. Finally, the limitation and improvement, wearable and usability, further work and healthcare-related potential applications are discussed. Tests were done prior to each components involved to ensure its functionality for both hardware and software. The verification and calibration of the selected component are discussed. The blood glucose level measurement results obtained from the proposed system.

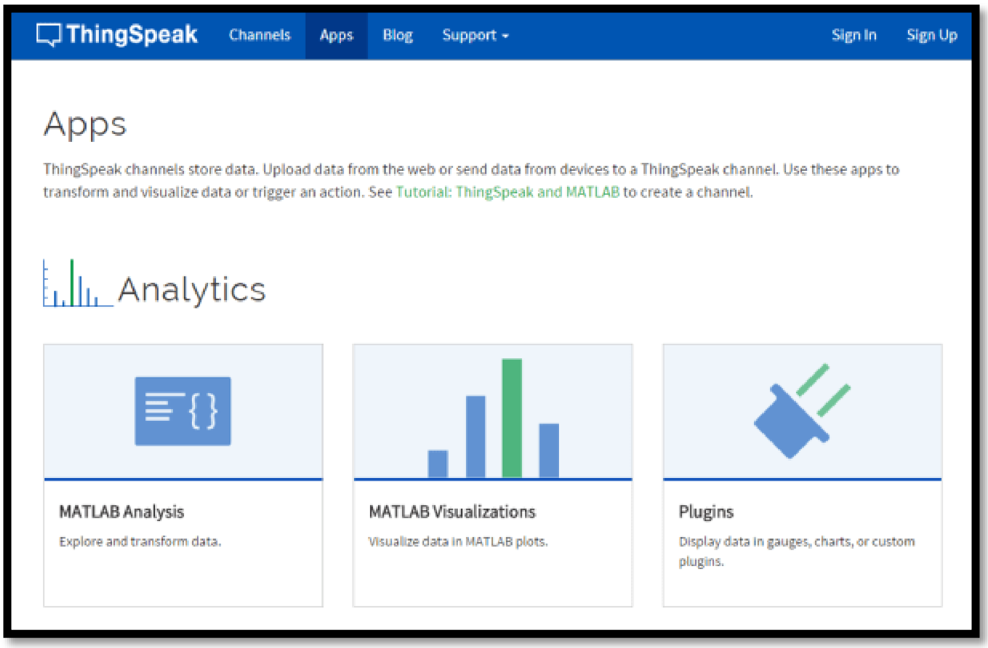


Figure 4.1 The home screen for the application used for the glucose level appears.

Figure 4.1 shows that the home screen used for this data of glucose level to appear. This will using IOT and Bluetooth to connect the monitoring system with the apps. As long as the information to enter the apps is already, the data can be obtain from anywhere.

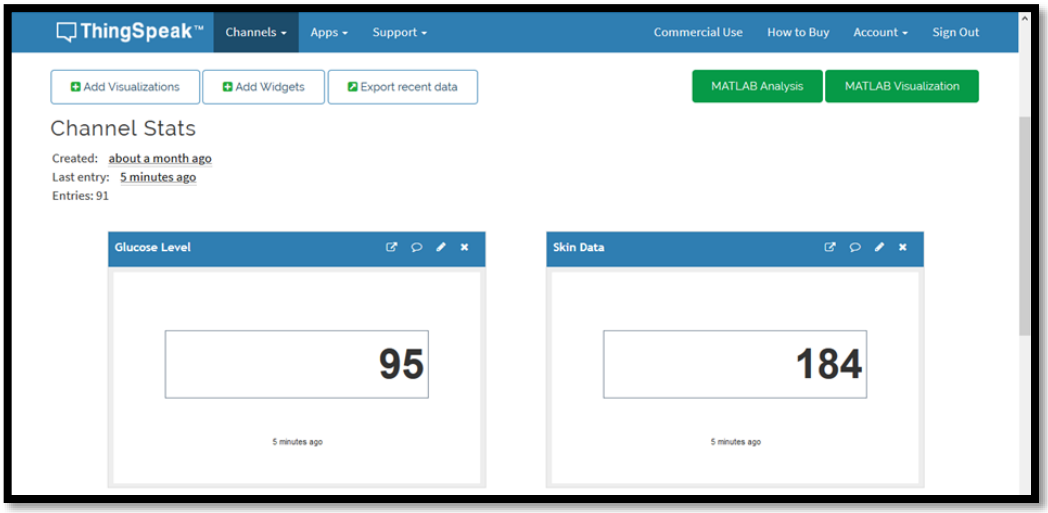


Figure 4.2 The data comes out.

Figure 4.3

Figure 4.3 shows that the glucose level data also appear resulting at the prototype that being tested. As it LED green will light up if the glucose level is normal. If the glucose level is low, the LED white will light up instead of the green LED. As for the high glucose level, the buzzer will sound indicate and warning the patient that their glucose level are high and need to see the professional doctor.

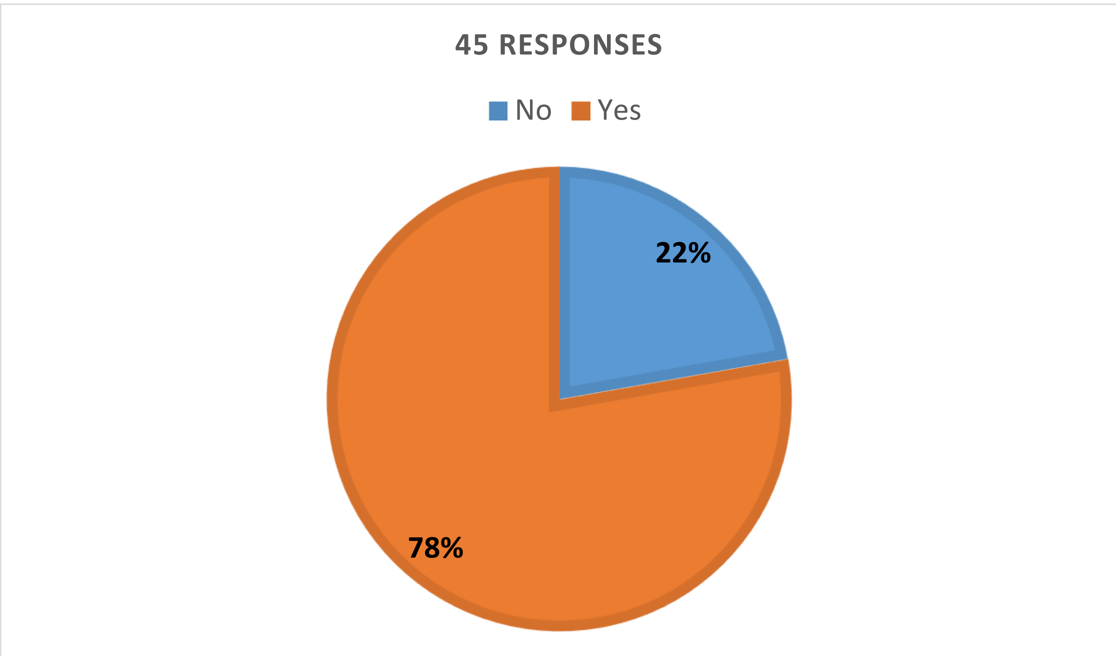
Based on the results, the prototype gives small different values at all time of measurement for glucose level and skin data. However, it is considerably acceptable since the readings values is in standard range as the normal level of glucose level in Fig. 4.2 above. According to the results, the patient's can being detected early if they are having diabetes or not by the reading of the glucose level on the results. To ensure the usability of the developed machine, the reliability test for infrared pulse measurement has been carried out and the results show that the glucose level respectively, which is very small and still in the acceptable range. The proposed device could be used for commercialization of glucose level measurement and future reference for technical students and researchers.

Comparison between laboratory and self-monitoring techniques.

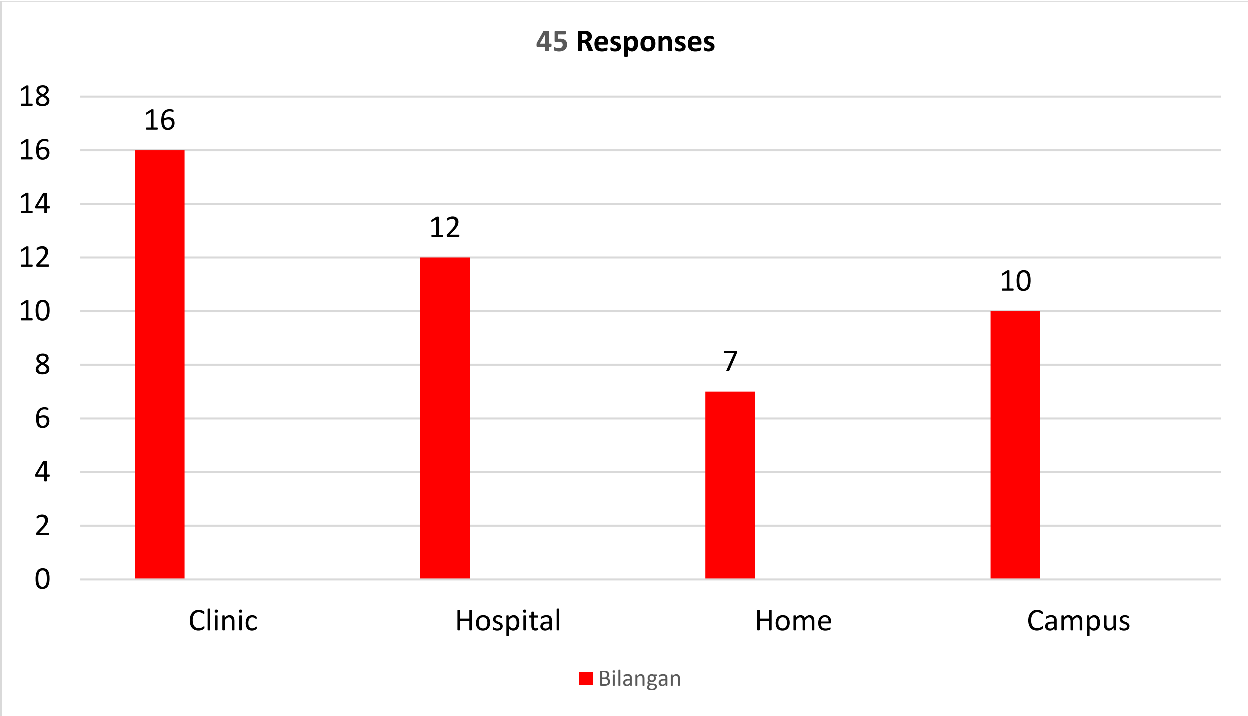
Characteristics	Laboratory	Self-Monitoring
Accuracy	Very good	Good
Sensitivity	Very good	Good
Measurement time	Long	Quick
Trained laboratory personnel	Yes	No
Sample type	Blood, serum, plasma, urine	Infrared Sensor (IR)
Blood extraction method	Invasive	Non-Invasive

This is the question that we ask from the people and their responds. From here we found that the non-invasive glucose monitoring system is get a lot of demands.

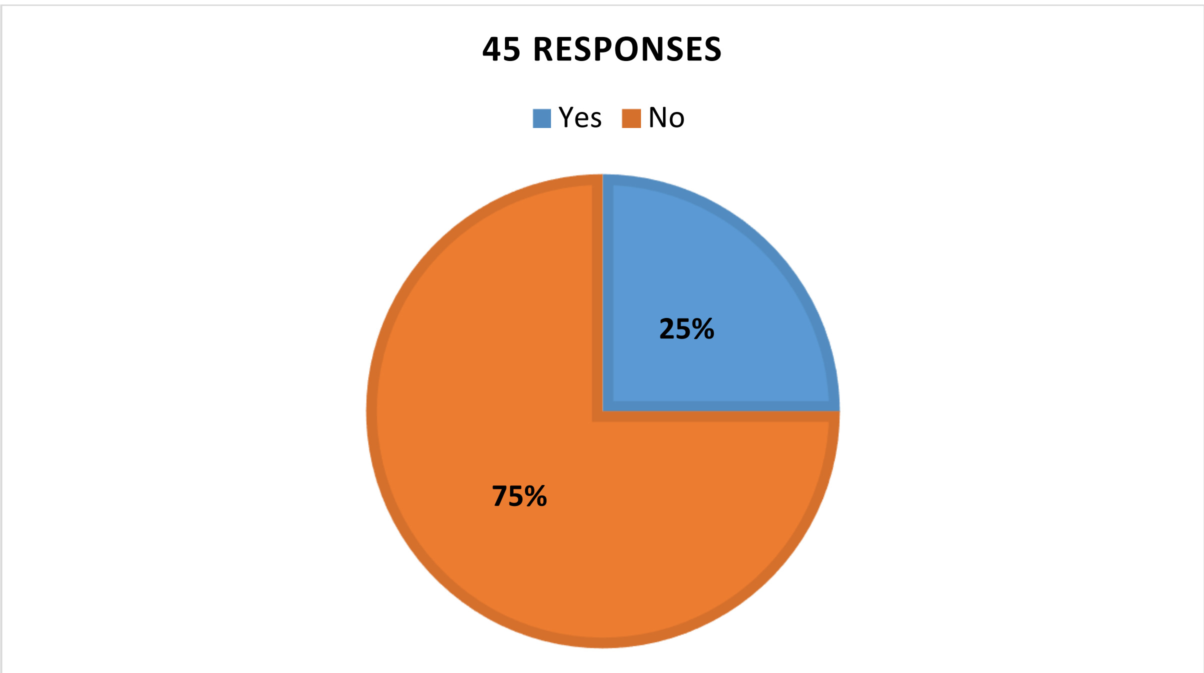
1. Did you ever check your glucose level?



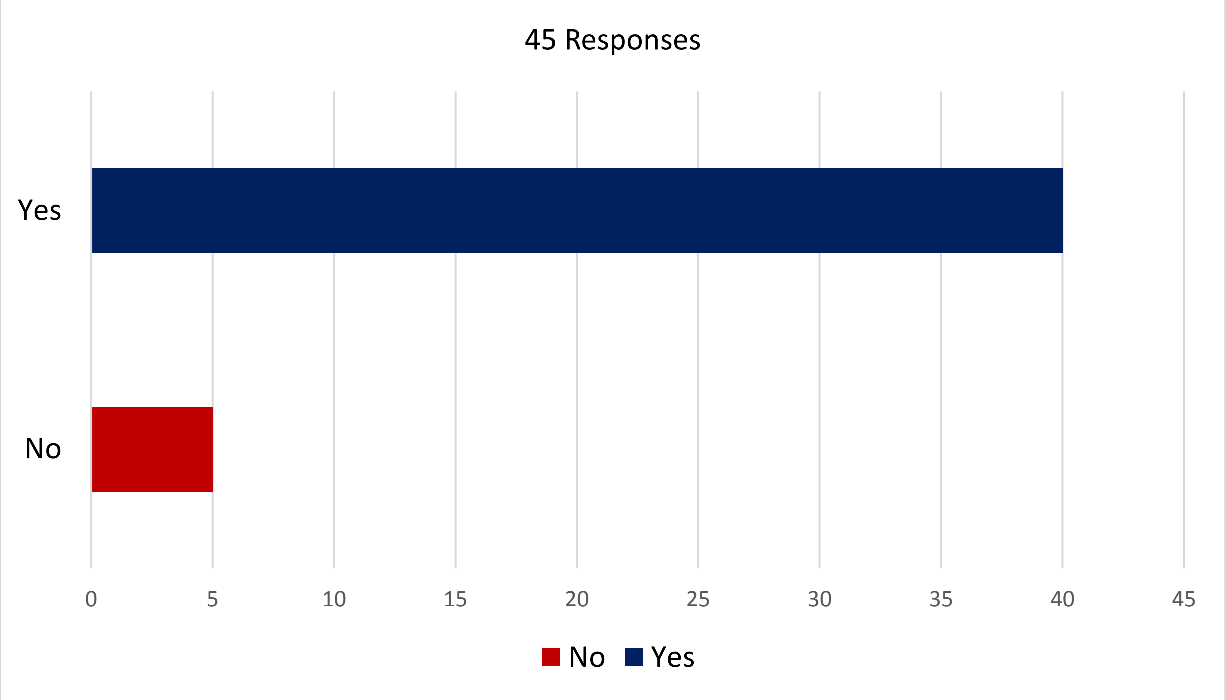
2. If you are want to check your blood glucose level, where did you usually go?



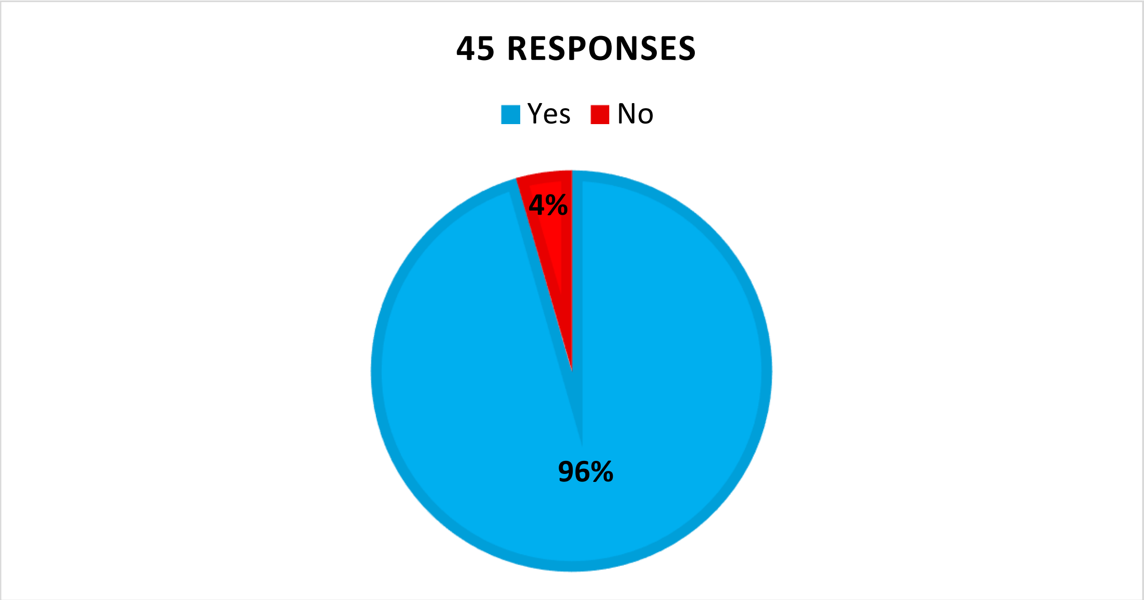
3. Did you ever had high blood glucose level as you tested?



4. If you want to test your blood glucose, did you need to take your blood sample?



5. Do you think that this product need to be in market?



Based on the survey from students and peoples, this product are become the benefit more to people if it is in the market .

CHAPTER 5

CONCLUSION

There are three major conclusions can be drawn from this project. Firstly, the developed device exhibits a full working system. The objective to develop a hardware prototype for non-invasive glucose monitoring system also had been achieved. The system which operates on sensing principle is suitable to be located at any medical institutions such as private clinics, government hospital and even can be employed at home. It is also suggested that by using this instrument, people may save their time to travel and get their blood pressure being check regularly as the results of glucose level for the patients by gain insight about glucose level faster. Indirectly, this shows the benefit of proposed system to meet the demand of health. Secondly, the developed device adapted the wireless technology and using smart phone which enable the user to view the previous results of blood pressure at any time on the smart phone. This makes the results more valuable for future reference. Thirdly, it can be seen that the machine proposed new prototype for medical instrument which can be used as a medium for Telemedicine application. Furthermore, this instrument has a potential to be improved in the future.

REFERENCE

[1] J. J. Crosbie, J. Burns, R. A. Ouvrier, Pressure characteristics in painful pes cavus feet resulting from Charcot–Marie–Tooth disease, Gait & Posture, 28 (2008) 545–551.

[2] D. D. L. Rodriguez, J. Assal, Biofeedback can reduce foot pressure to a safe level and without causing new at-risk zones in patients with diabetes and peripheral neuropathy, Diabetes Metab. Res. Rev., 29 (2013) 139–144.

[3] A. Nagel, F. Fernholz, C. Kibele, D. Rosenbaum, Long distance running increases plantar pressures beneath the metatarsal heads: A barefoot walking investigation of 200 marathon runners, Gait & Posture, 27 (2008) 152–155.

[4] Tekscan Inc., Pressure mapping, force measurement & tactile sensors, www.tekscan.com/products-solutions/systems/f-scan-system,accessed:16 April 2015.

[5] Novel, The pedar system – The quality in-shoe dynamic pressure measuring system, http://www.novel.de/novelcontent/pedar, accessed: 16 April 2015.

[6] Moticon GmbH, Mission: Sensing foot dynamics, http://www.moticon.de/products/product-home, accessed: 16 April 2015.

[7] Orpyx Medical Technologies Inc., Monitor pressure underfoot with the Surrosense RXTM, http://orpyx.com/pages/surrosense-rx, accessed:16 Apri 2015.

[8] A. M. Tan, F. K. Fuss, Y. Weizman, Y. Woudstra, O. Troynikov, Design of low cost smart insole for real time measurement of plantar pressure, Procedia Technology (2015) in print.

[9] L. Wang, T. Ding, P. Wang, Influence of carbon black concentration on piezoresistivity of carbon-black-filled silicone rubber composite, Carbon, 47 (2009) 3151-3157.

[10] Z. Saracha, Validation of plantar pressure measurements for a novel In-shoe plantar sensory replacement unit, J. Diabetes Sci. & Tech., 7(5) (2013) 1176-1178.

[11] R. Ferber, T. Webber, B. Everett, M. Groenland, Validation of plantar pressure measurements for a novel In-shoe plantar sensory replacement unit, J. Diabetes Sci. & Tech., 7(5) (2013) 1167-1175.

[12] Liebau J, Berger A, Pallua N, et al. Reconstruction of plantar defects. Eur J Plast Surg. 1997;20:300–305

SUPERVISOR

This report has been reviewed and validated as it fulfils the requirements if the final project design as set fourth.

Disclaimed by

Signature:

Signature's name: