Design Low-Cost Sensor For Bluetooth Embedded System To Monitor Body Posture During Workout Using Arduino

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Date : 10th June 2016

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Signature : .....

Supervisor's Name : Dr. Wong Yan Chiew

Date : 10th June 2016

For my lovely mother and father

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ABSTRACT

More people than ever are throwing themselves into the challenge of competitive powerlifting. A correct posture is important to avoid the exerciser from injured. This requires a real time monitoring that could always remind the exerciser on the current stage of their posture. Producing such a system could be challenging due to its complexity and cost. Project, a low-cost stretchable sensor for Bluetooth embedded system to monitor body posture during workout by using Arduino microcontroller has been proposed to measure a range of body posture stretch level. Two major part consist hardware and software have been developed. The hardware development will be involving a stretchable sensor and sensing circuitry. For the software, monitoring application has been developed by using MIT app inventor 2. The stretchable sensor has been prototyped using stretchable fabric, carbon powder, and silicone. Sensing characteristic of the sensor has been determined by measuring the variations of resistance due to different stretch levels. The circuitry system consists of HC-05 Bluetooth module to provide wireless interface between smartphone and the hardware. Android application that capable to analyze and monitor body posture in real time has been developed. To complete the system, body strap has been developed by integrating all the hardware and make the system easy to use in workout application.

ABSTRAK

Dewasa kini , semakin ramai orang yang menceburkan diri di dalam sukan mengangkat berat secara kompetitif. Mengekalkan posisi tubuh badan yang betul semasa bersenam adalah sangat penting bagi mengelakkan kecederaan. Dalam konteks ini, sistem pemerhatian secara berterusan bagi sentiasa mengingatkan pengguna tentang posisi semasa badan mereka adalah diperlukan. Adalah mencabar bagi menghasilkan sistem seperti ini berpunca daripada kerumitan dan kos. Di dalam projek ini, penderia berkos rendah untuk sistem terbenam Bluetooth bagi memerhatikan posisi tubuh semasa bersenam menggunakan Arduino telah di dicadangkan bagi mengira tahap bengkokkan tubuh badan. Dua bahagian utama projek ini terdiri daripada pembangunan perisian dan perkakasan telah dibangunkan. Pembangunan perkakasan terdiri daripada penderia boleh regang dan litar penderia. Bagi perisian pula, aplikasi pemerhati telah dibangunkan menggunakan MIT app inventor 2. Prototaip penderia boleh regang telah dibina menggunakan serbuk karbon , fabrik boleh regang dan silikon. Ciri-ciri menderia penderia telah ditentukan dengan mengukur variasi rintangan yang berubah mengikut tahap regangan yang dikenakan. Litar pengesan yang terdiri daripada modul Bluetooth HC-05 membekalkan antarmuka tampa wayar diantara telefon pintar dan perkakas. Aplikasi Android yang berkebolehan menganalisis dan memerhati posisi semasa tubuh badan secara masa sebenar telah dibina. Untuk melengkapkan sistem ini, tali badan telah dibina bagi mangabungkan kesemua perkakas. Tali badan ini menjadikan sistem ini mudah diaplikasikan semasa bersenam.

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CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

Embedded systems are different things to different people. An embedded system is a computerized system that is purpose built for its specific application and task [1]. For this project purpose the system must meet the requirement for real time system. A real-time system must respond to an event within a fixed amount of time otherwise the task is not completed or the error will be occurred [1]. Programmable microcontroller board which is Arduino UNO are used and developed with proposed sensor as the part of the system hardware. Arduino is a small microcontroller board with a USB plug to connect to your computer and a number of connection sockets or GPIO that can be wired up to external electronics, such as motors, relays, light sensors, laser diodes, loudspeakers, microphones, etc. [2]. The GUI of the system are developed on the android platform as both Arduino and android is open source design software and much flexible to work with. By combining both hardware and software the reliable embedded system was created. Wireless interface is created between hardware and software in order to deliver finest user experience to the user.

Weight training is a type of strength training that uses weights for resistance. Weight training provides a stress to the muscles that causes them to adapt and get stronger, similar to the way aerobic conditioning strengthens heart. Weight training can be performed with free weights, such as barbells and dumbbells, or by using weight machines. Strength can be increase through other types of resistance exercises, such as by using body weight or resistance bands [3]. The example of weight training shown in Figure 1.1

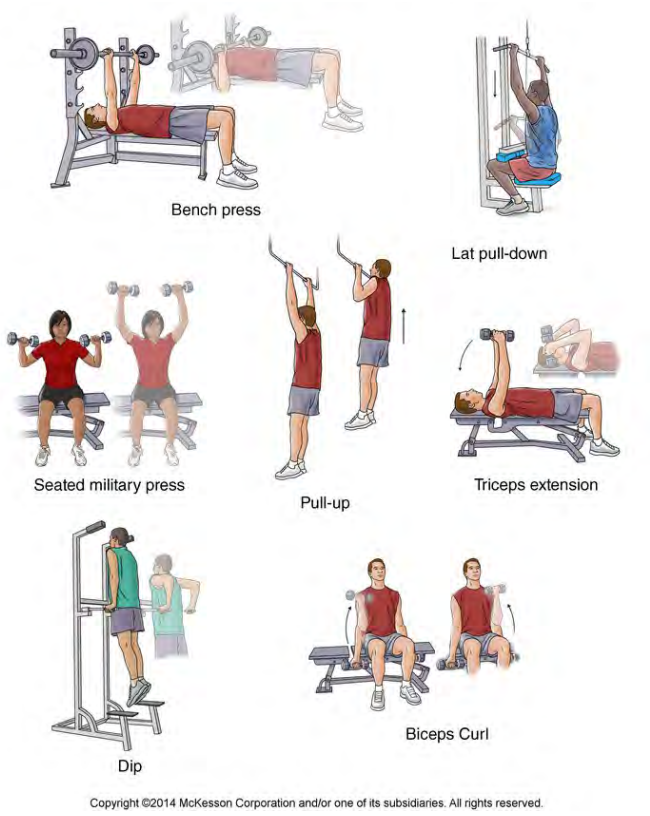

Figure 1.1:Various weight training exercises

The Measurement of body posture is important for determining the range of the body movement and its connection to human health. For the heavy lifting and heavy workout movement, it is very critical to be done properly in terms of posture to prevent injury. The example of bad body posture during a workout are shown in Figure 1.2. Common injuries include sprains, strains, herniated disks, and vertebral fracture and may result from repetitive or incorrect lifting methods, bending, or twisting [4]. To monitoring the body posture, the method that used is by designing a stretchable sensor that latter on the device will be attached to user body in order to measure the body posture. The sensor is developed by using low cost material and very simple fabrication project was used. The sensor must be flexible and stretchable as it also will be reliable for this project's purpose. It is crucial to choose correct sensors in order to produced reliable and stable system.

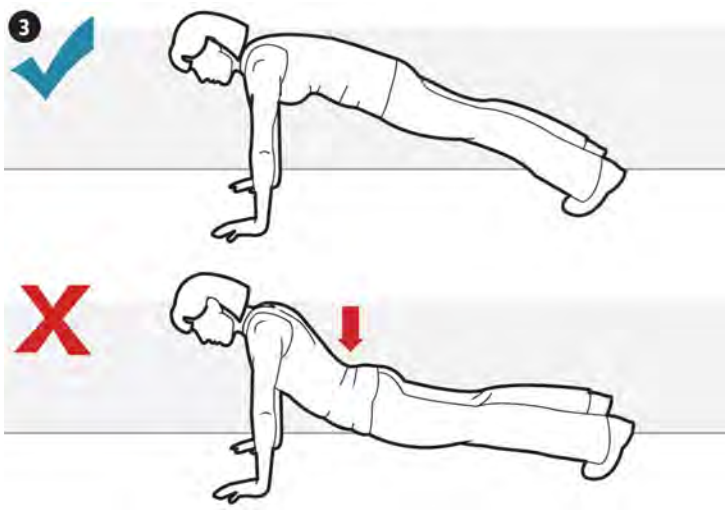

Figure 1.2:wrong and correct body posture during workout

1.2 PROBLEM STATEMENT

- Current commercial system is very pricy.
- Bad workout posture can cause serious injury and probably disability.
- Monitoring a body posture will be hard without a proper system and approach.

1.3 SCOPES OF PROJECT

1.3.1 Hardware

- Design and develop sensor stretch for the system
- Design and develop wireless sensing circuitry by using Arduino UNO and Serial Bluetooth RF Transceiver Module RS232.

1.3.2 Software

- Apps developments in android platform.
- Wireless circuit integration between apps and hardware.

1.4 OBJECTIVE

- To monitor and improve user's workout quality and preventing from injury in heavy lifting by implementing Bluetooth wireless technology.

- Developing low cost Bluetooth wireless circuitry that measure and analyze the body posture.
- Design a friendly and robust mobile app for user to use it during heavy workout.

1.5 THESIS STRUCTURE

This report will be divided into five main chapters. The first chapter will discuss the introduction to this project. The introduction includes the background of this project, problem statement, significant of project and objectives with the scope of the study. As the name implies, the introduction serves as an initial overview of the project will state a goal that will be worked on during the entire project.

A literature review is the second chapter of this report. In this Section, matters regarding this project will be further discussed and elaborated based on the reference of previous study related to development of this project

Methodology will be the third chapter of this report. The methodology includes the elaboration of all the necessary steps and guidelines that is taken to implement this project. It will describe the process flow of the development posture and breathing correction wireless embedded system.

Result and discussion will be on the fourth chapter of this report. The necessary output will be seen from both software and hardware to get the expected output as the purposed of this project.

The conclusion and recommendation will be at the final or fifth chapter of this report, it will conclude the overall results of the project and states either the initial goals or objectives are fulfilled. The contributed paper for this project has been shows in

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The comparison between previous works related on sensor, circuit interface and application is explained in this chapter. The method of sensor fabrication and material used for the similar project has been identified and compared in Section 2.2. Circuit interface research related to this project is reviewed.

2.2 COMPARISON BETWEEN PREVIOUS RESEARCH WORKS

Stretchable sensor could be applied to detect a motion and could be used either on a machine or human. However, the fabrication process is complex due to they need to work by depositing conductive metal lines on a pre-stretchable substrate. Examples of such sensors include stretchable, skin-mountable, and wearable strain presented in previous work [5, 6]. In the previous work, K.Noda, K. Matsumoto, and Shimoyama proposed stretchable force sensor array using conductive liquid to detect robotic motion through measuring the force and stretch from robotic arms [7]. The method to use a conductive liquid complicates the fabrication process and potentially causes leakage while using the sensor. Jumana M. Abu-Khalaf introduces a stretchable sensor solution which only focuses on pressure feature [8]. A stretchable sensor has also been made of carbon-black impregnated rubber [9]. It has the disadvantage of non true linear feedback, and the resistance may vary from batch to batch. Thus, it is not suitable for real time sensor application, especially in monitoring the output signal from body posture during workouts. Currently, there are commercial solutions for body motion sensing technology produced from carbon and stretchable fabric [10]. The sensor will

stretch and deform on applied force. The feedback of the sensor is processed using signal processing circuit board and then transmitted to smartphone. The sensor is in real time feedback. However, the cost is very high. It is about $850 for silicone kit and $650 for fabric kits [10]. Elasticity could be found in most of the stretchable sensors [7-10]. Elasticity provides a durability to the sensing element and makes it better in sensing of bending motion.

Developing a proper circuit interface could be challenging without proper approach. A bad sample data can lead to unstable and unreliable system. The human monitoring system has been introduce in previous researchers [11-13].In the previous research, W.Lawanot, P. Mongkolnam and C,nukoolkit demonstrating a working concept of a smartphone base posture monitoring system to prevent unhealthy neck posture. By using image processing to detecting a face and collecting phone gyroscope sensor data, the system will notify the user for the current posture and alerting for the bad posture while the user using the smartphone[11]. Even though the method is accurate, there are limitations on the system which is it cannot be implemented for the workout. This is due to the user must hold the phone all the time. It is difficult for the workouters to hold phones and workout in the same time. From the previous work by E.Sardini , M.Serpelloni and V.Pasqui, introducing a measurement method for Daylong sitting posture with a new wearable system. The user needs to wear an elastic t-shirt that consist of a sensor that can measure the body posture[12]. The data from the sensor is processed in circuit board and transmitted wirelessly to the pc. The cons for the system is, the Pc is not convenience for workout purpose due to un-mobility features. Android smartphone for body monitoring system is introduced by W.Song, H.Yu, C.Liang. The system consists of humans temperature, electrocardiogram, electro-encephalogram (EEG) detection by different hardware. These data which are gathered by hardware are sent to the Bluetooth receiving device of android smartphone over the Bluetooth transmission equipment which is fixed on our device. They are analyzed and then saved into SD card which is inserted in the android smartphone. The android application has been build by using eclipse software which is more advance software for android developers and requires understanding also knowledge of java programming and of android development.

Implementation of graphical user interface (GUI) in developed system will further increase the user experience value. From the previous research[14-16] , MIT

app inventor 2 has been use as the part of the research development .MIT app inventor 2 has been introduce in previous research by A.Huda and R.Jalaini. The research is focusing on the development of Android based control and monitoring system for leg orthosis[14]. The main function of the system is to help user or physiotherapist to control and monitor the leg orthosis during exercise session. The monitoring system on bio potential has been done in previous research [16]. The real time data acquisition has been explained. Arduino also has been used in previous research[14, 15]. Arduino has been used as the main microcontroller to process the sensor data and transmit the data to the smartphone. Bluetooth wireless has been implemented by previous research [17-19]. The HC-05 module has been use as the wireless module in the research. The module is used due to the price is cheap and wide compatibility for a microcontroller.

2.3 CONCLUSION

From all the review, any gaps in knowledge has been identified and it leads logically to the development of this research. The method to improve the sensor fabrication method has been determined. The suitable method to develop a circuits interface and android application for the system has been choose base on the reviewed paper.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

In this chapter a step by step methodology to complete the system is explained. Sensor development will be the first part of the system development. A stretchable sensor has been developed by using a suitable material. The circuit interface is explained in Section 3.4 consists of wireless circuit and integration of fabricated sensor. The development of monitoring application is explained in Section 3.5. The tools for the development such as Adobe illustrator and MIT app inventor 2 is discussed in detail in Section 3.5.1 and 3.5.2 respectively. A body strap development has been discussed in Section 3.6.

3.2 PROCESS STEP

By following each of the processes the objective of this project is fulfilled which is to develop an intelligent wireless embedded system focusing on posture and breathing correction during workout. From the flow chart shown in Figure 3.1 the process of developing the embedded system is starting by designing sensor. Several literature reviews are made by comparing previous works and existing solution. In order to produce the reliable system, we are developing our own costume sensor. The sensor development is shown in the Section 3.3. After finished the sensor development, the circuitry of the sensor is developed base on developed sensor. The detail of circuitry development is explained in Section 3.4. The development of the user interface or the apps are started developed simultaneously with the development of sensing circuitry. The development step of the software part is shown in the Section 3.5. Figure 3.2 show the illustration of complete system. By using Bluetooth connection, the hardware and software part can communicate and working as complete system.

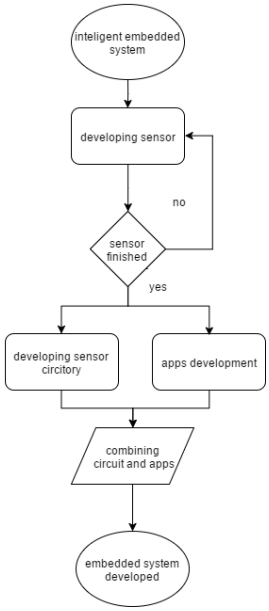

Figure 3.1:project flow chart

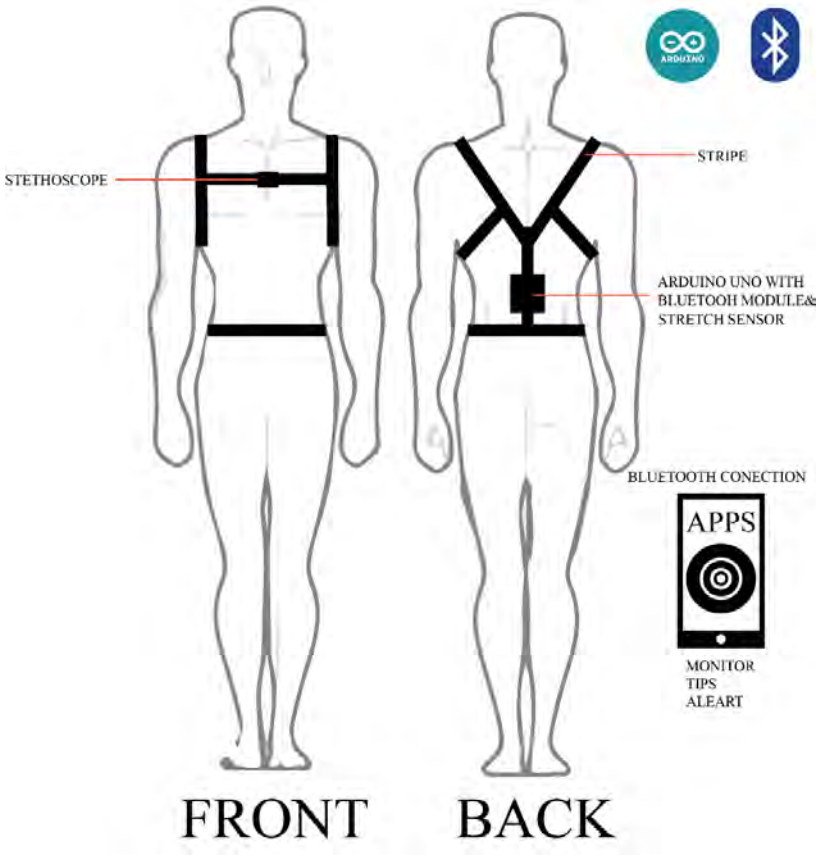

Figure 3.2:system design and expected result.

3.3 SENSOR DEVELOPMENT

The flowchart process for the sensor development has been shown on Figure 3.3. The first step is to find the suitable material for the sensor. The sensor must be flexible and stretchable for the purpose of this project. After the suitable material was found the sensor are fabricated according to specific design. The sensor has been analyzed and tested until it has been optimized. After that, the sensor is packaged and attached to developed body strap to hold the sensor when the sensor is attached to the body.

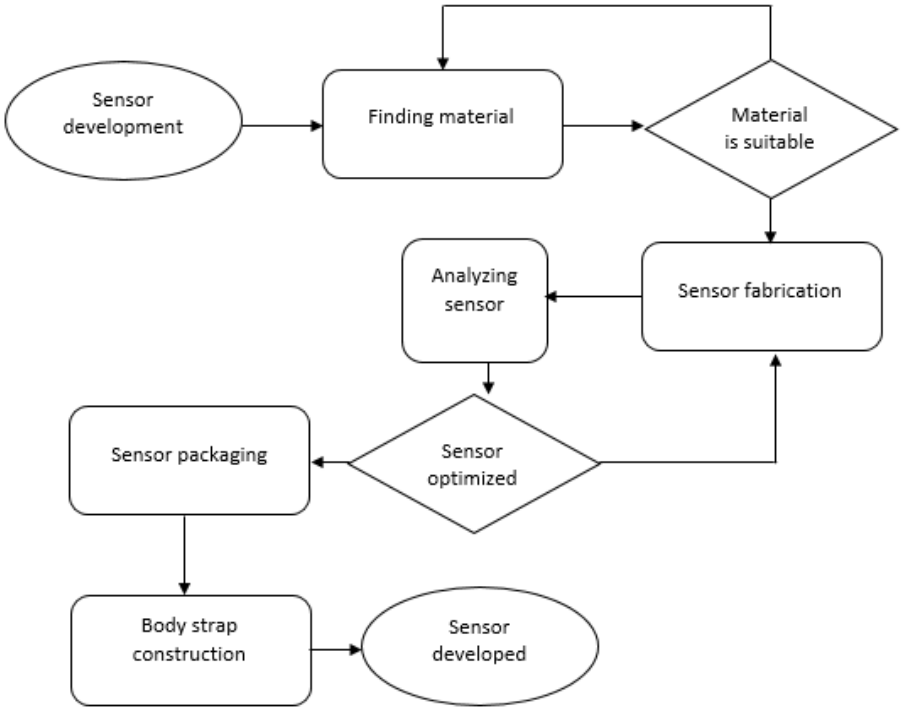

Figure 3.3: Sensor development flowchart

3.4 CIRCUIT INTERFACING.

The sensing circuitry has been built for the system to connect the developed stretchable sensor and Bluetooth module together with the Arduino-UNO. A custom shield that combines both of developed sensor and Bluetooth module consist a simple electronic circuit for Arduino interfacing.

The UNO is a microcontroller board based on the ATmega328P. The picture of the Arduino UNO board is shown in Figure 3.4. 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. [20] . The technical specification Arduino board is shown in Table 3.1.

Figure 3.4: Arduino UNO borad

Table 3.1 : Arduino UNO spesification

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
Length	68.6 mm