AUTOMATIC SCORING SYSTEMS FOR SPORTS KARATE

by

REX ALVIN FRANCIS

DISSERTATION

Submitted to the Business Information System Programme

Universiti Teknologi PETRONAS

In partial fulfillment of the requirement for the

BACHELOR OF TECHNOLOGY (Hons.)

(BUSINESS INFORMATION SYSTEM)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

May 2012

CERIFICATION OF APPROVAL

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Approved:

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May 2012

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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Rex Alvin Francis

ABSTRACT

The objective of the project is to design an automated scoring system for the Kumite or Sparring category in Karate as to improve the conventional scoring system in the World Karate Federation (WKF). The project requires a suitable sensory device to be embedded with the protective equipment and a score display unit that will be fully interacting with the system. This project is intended to tackle the uncertain scoring issues due to the existing scoring system that is solely dependent on the referees' decision. It is often prone to misjudgments, for an example; an unethical judging decision that could affect the quality of the tournament itself.

The project started with the analysis of the main problem in conventional judging system and the construction of literature review base on the studies on the related publishing. The project involved six phases base on the Rapid Application Development (RAD) methodology (Planning, Analysis, Design, Implementation, Testing and Deployment).

As a result, a running prototype of an automatic scoring system has been created. Through the functionality testing that has been performed, the outcome shows that the main objective of the project; to create an integrated and interactive scoring system has been achieved through the ability of the system in performing the task of automatic hit detection and score display update, thus it is able to improve the conventional Karate scoring system.

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List of Abbreviations

ADC	Analog to Digital Converter
FSR	Force Sensitive Resistor
GUI	Graphical User Interface
ICSP	In-Circuit Serial Programmer
IDE	Integrated Development Environment
Op-Amp	Operational Amplifier
WKF	World Karate Federation
PIC	Peripheral Interface Controller
VB 2010	Visual Basic 2010

CHAPTER 1

INTRODUCTION

1.1 Project Background

The evolution of the Ubiquitous or Pervasive Computing technology is not only giving an impact towards individual modern daily lifestyles. Besides, this scope of technology has been further implemented in the sports arena. The combination of sensors, data-communication, and processing ability have assisted numbers of athletes and coaches in the various fields of sports around the world in terms of performance improvement and efficiencies achieved on both training and competition (Dennis S, Parida, Lsakson O, V, Larrson C, 2011). This is due to the numerous data of performance are possible to be recorded during the training session and competition can be transmitted to any remote stations to be further analyzed, and perhaps for the purpose of media broadcast. (Baca A, 2009)

An example of successful implementation of this idea is the RFID (Radio Frequency Identification) race timing system that nowadays being used worldwide for sports such as long distance road running and biking. The system is not only records the accurate starting and ending time of each runner, but also avoiding any unethical act during the race by recording each racer's timing in every check point passed. Other than that, recently sensor technology has been adopted in sports Taekwondo where force sensors are being embedded in the protector vest, combined with data networking and processing ability to creates an automatic scoring system (Chi Ed. H, 2005).

Since many years, after the martial art Karate has been modernized as a sport back in 5 decades ago, other than the review and changes in the rules and regulations (WKF, 2012) there is no effort of creating an electronic system or technology to assist the human based system that is very vulnerable to error and also prone to the abuse of unethical judging decision. Therefore, there is a need for technology assistance to overcome all the shortcomings in the conventional system. Besides, other than avoiding unethical act and all the hassle caused by human error, it will also helps to promotes a competitive and a better standard of tournament due to the improvement achieved in the judging system, also efficiencies that will be gained by getting rid of such issues that may cause delay of progress during the competition. Information such as the total score for each match will be automatically saved for future reference.

Moving on, the system is divided into three different parts or segments that will be integrated together. It consist of the Transmitter, where a sensor will be embedded in the standard protective hand glove together with a first microcontroller unit that will determine the valid input that resulted from any legitimate hit. The second part will be the Base Station or the receiver sides that will receive the signal from the transmitter then forward it to the third part where it placed the score display panel. Each of the parts mentioned are being interconnected by a wireless communication link.

The system basic architecture is depicted as below:

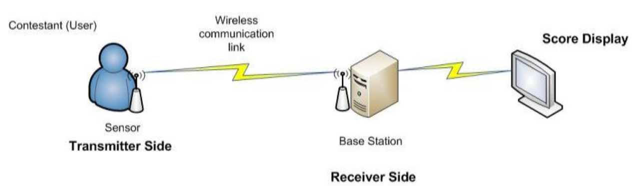


Figure 1: Basic System Architecture

Lastly, the device must be physically robust since Karate is a full contact sport. It should be able to last long enough when force or impact that occurs repeatedly in a high velocity are being applied. The integrated system must be free from any error and most important it able to avoid any signal interference that may affect the functions and performance. Not to forget, the concern regarding the cost of development. To fulfill the criteria, initial survey has been performed to find a suitable sensor for this purpose. It has been considered to apply a Force Sensitive Resistor due to the minimal cost per unit and the capacity of force ranging from 100 to 1000g (Interlink Electronics, 2010). Suitable communication protocol with the required security enhancement will be studied. Among the suggested protocols are ZigBee and Bluetooth since both are consuming a few amount of energy and it allows inter-operability. Application for the display unit will be constructed by using Visual Basic 2010.

1.2 Problem Statement

Since the introduction of Sports Karate back around 5 decades ago, (Wilson W.E 2010) the implementation of judges and referee tournament scoring system has always facing numbers of problems such as:

i. Appointed referee and judges may give the score to their favorite contestant (Bias) (Wilson W.E 2010)
ii. Human errors tend to be occurred. It may affect the decision of the judges and referee and will potentially cause a dispute that will interrupt the match progress.
iii. Match timing (3 or 2 minutes) is being done manually by using stop watch that sometime is not accurate.
iv. Score board is manually operated base on the judges and referee decision. Where human error or unethical decision may happen.
v. Upon the completion match, total score of will be recorded manually (on the paper) based on the final score of both of the contestant by referring to the scoreboard.

Figure 2: WKF standard tournament arrangement

Figure 3: Match on progress: Referee and Judge on duty.

Figure 4: Referee Challenge: Event of simultaneous action.

1.3 Objectives:

1. To create an accurate and automatic system that will solve the problem of human error, and unethical act such as bias judging decision, thus it will promotes competitive and a better standards of tournament.

2. To create an interactive and integrated system for both hit detection and an auto-detect score display unit.

CHAPTER 2

LITERATURE REVIEW

Studies on related works were performed in order to understand the concept on how the implementation of technology in the similar kind of sports (martial art) will assist in solving the issues with the conventional scoring system. Other than that, the purpose of conducting a literature review is to understand on how the application of ubiquitous computing has assisted in improving performance in sports.

2.1 Main literature Review:

"Killer App" of Wearable Computing: Wireless Force Sensing Body Protectors for Martial Arts

This technical paper written by Chi Ed. H, Song .J, Corbin .G from Palo Alto Research Centre's User Interface Research Group and Impact Management is about "Sensor Hogu" or the new technology for scoring system in Taekwondo. Sensor Hogu is a wireless system that implementing piezoelectric force sensors on the protector vest. The system is jointly developed by Stanford Taekwondo Program and the Palo Alto Research Centre.

This technical paper begins with the introduction of ubiquitous computing application in supporting the human daily activities and the latest development on applying this technology in sports taekwondo. It is also mentioned about the existing electronic scoring system in fencing and the set-back of the system. It then proceeds to the introduction of the Sensor Hogu itself, together with the two challenges that they are facing during the pre-development of the system; designing a completely wireless device and it must be flawless all the time. After that it moves on to the system device explanation where the relationship of each device are being discussed; from the sensor attached in the protective vest (hogu), judge's stick, the base station and the score operator.

The specially modified microcontroller was developed with the join collaboration with Texas Instruments. In order to satisfy the requirement of having rugged, low cost and low powered sensor, piezoelectric sensor is being used. Due to the needs to ensure the accuracy of the system, Distributed signal processing architecture is being applied.

Next, the writer explains on how the system is being put in the real practice (testing), where it began by placing the vest on the dummy male upper torso and applying few hits by wide variety of taekwondo player (total of six player), the results obtained was recorded and analyzed. Sparring test was then proceeds with different participants (well experienced) and also involved trained judges. The recorded procedure of the testing was also being examined by a group of independent judges to ensure the validity of the results obtained. Based on the results, the system is not only functioned as desired, but also able to satisfy the user requirement; where the system should not creates any major differences with the conventional system.

Lastly, it is concluded that success has been achieved in creating a wireless and automatic scoring system by using force sensor. Further research will be performed in the future to find the possibility to incorporate the similar principles into different sports or usage, such as military training.

2.2 Main Literature review: ECE 476 Final Project: Electronic Hogu

This project report was written by Kevin and Howard Kim from Cornell University is about their final project "Electronic Hogu". In this project that aims to create affordable automatic scoring system for Taekwondo, both writers implemented piezoelectric sensor at the protector vest ("Hogu") and also created a simple score display.
It begin with the introduction to this project on how the sensor effectively differentiate between valid and invalid hit by applying the "Waveform Analysis" and "Analogue-

Digital Conversion”. Wireless communication via On-Off Keying (OOK) is very important towards the effectiveness of this system. Next both writers explains about the High Level Design, where the system is divided into two sides; the transmitter that consist of the protective vest with the embedded sensors, MCU or Microcontroller, and the wireless transmission circuitry. On the other side of the system is the receiver side that consists of the wireless circuitry, MCU that will process the received bytes and lastly a score display unit.

It moves on to the further explanation on the operating mechanism of the transmitter where impact to the force sensor will create input that is greater than “0”, triggering the desired integration statement that can be sampled around 1/8 * 16Mhz * 1/20 = 10Khz which is sufficient for the reconstruction of the waveform. Also mentioned by both of the writer this sampling rate can be used in order to reduce the instructions of the Microcontroller. While on the receiver side, or the Lab Station, the MCU was coded to be operated in a simple manner where it receives and examine the packet whether the identifier tag is available, if so instruction will be sent to update the score display.

Both writers then proceeds with the hardware details of this project. For the transmitter, piezoelectric sensor was chosen due to the reliability where desired output (small amount of voltage) will be released upon an impact. 9 sensors were installed beneath the protector vest, where all of it does not require any power supply. In order to ensure a better quantitative analysis of the output obtained, a Voltage Divider was installed to differentiate if the sensors produce multiple outputs. Output with a greater voltage (representing a solid hit or impact) will be accepted. For noise filtration, a Butterworth Low Pass filter was chosen in order to attenuate the rapid vibration of the protector vest that produced upon the impact. For safety measure, a Voltage Clamp that serves with the purpose of limiting the voltage that going to the microcontroller is also installed in the transmitter side. The total maximum output of the clamp is 5.7v, where it is insufficient to overload the microcontroller. As mentioned previously, wireless communication is being implemented through On-Off Keying (OOK).

Moving on to the receiver side, RCR-433 Amplitude Shift Keying/On-Off Keying receiver was used. The lab station Microcontroller is mounted on the AVR STK 500 board where it verifies whether the byte of data that resulted from the hit to the sensor has been transferred through the wireless connection. The MCU is also connected to a display unit (a television set) that will display the current score based on the signal received, corresponds to the legit impact on the protector vest.

Both of the writers conclude that the project was a success whereby the desired outcome to have a simple and low cost automatic taekwondo scoring system. However, they do mentioned that further effort should be made in order to improve the system, such as avoiding packet loss, data encryption to prevent interference and lastly the physical design itself.

2.3 Literature review:

Design of a Wireless Scoring System for Fencing Using RFID Technology

This technical paper, written by Alvarez J.A, Christobal M.C, Gamalinda M.T, Miguel Joseph, is about their research on designing a wireless scoring system by using RFID (Radio Frequency Identification Device) as a communication medium. The main objective of this project is to replace the cumbersome tethered wire connection on the conventional system.

It starts with the introduction of the sports and the limitation occurs in the existing system whereby, beside of the limited movement caused by the wired system, the system sometimes unable to recognize and register a valid hit, especially when a simultaneous hits occurred.

It then proceeds with the explanation of the system architecture where it is comprise of transceiver module and a host computer. The transceiver module is composed of various electronic circuits namely the phase-locked loop (PLL), inverter IC and a monostable multivibrator. Other than that, an active RFID tag was installed to send the signals wirelessly to the RFID reader. When a hit occurred, an active RFID tag for transmission will be generated for transmission. At the same time the output from the monostable multivibrator will cause the buzzer to sound as an alert that a hit is made. For the host computer, it serves as the score box that will be fully interacted with the transceiver, where the program that is specially developed by the researchers using Microsoft Visual Studio platform. Signals that received from the active RFID tags will be registered to the program through the RFID reader that connected with the host computer via a USB (Universal Serial Bus) port.

Next, they explained on how the system has been tested based on the two test cases; valid and invalid hit. The outcomes of both of the test have satisfied the requirements where a valid hit should send a signal to the host computer and updates the score display, and vice-versa for the invalid hit.

Through the outcomes of the test cases that have been performed, all of the writers conclude that the main objective of creating a wireless scoring system through application RFID technology has been achieved.

2.4 Literature Review: Which relates Ubiquitous computing and sports performance

2.4.1 Baca A. (2009) Pervasive/Ubiquitous Computing in Sport, Vienna, University of Vienna, Department of Biomechanics, Kinesiology and Applied Computer Science, ZSU, Vienna, Austria

"Like most areas of everyday life, these *pervasive* or *ubiquitous* computing technologies also penetrate the field of sport. Here, these technologies provide new means for developing systems to acquire, process, and transmit data during manifold sportive activities. Various performance data may, for example, be recorded during training and competition and transmitted to remote stations (the notebook of a coach, a broadcasting station, etc.) in almost real time without affecting the athletes during motion execution. Sensors are either attached to the sports equipment or to the athlete's body (e.g. GPS-receivers, accelerometers, and gyroscopes) or are embedded in the environment (e. g. video cameras). "(Baca A, 2009).

2.4.2 Dennis S, Parida, Lsakson O, V, Larrson C Design of user-centred wireless sensor technology in sports (2011): Empirical studies of elite kayak athletes, ICoRD 11, Indian Institute of Science, Bangalore India.

In this technical paper**,** writers found out that the combination of sensors, data-communication, and processing ability has assisted numbers of athletes and coaches in the various fields of sports around the world in terms of performance improvement and efficiencies achieved on both training and competition. Further survey is being done by all the researchers to analyze the effectiveness of those electronics combination in monitoring the performance of the Swedish Kayak athletes.

2.5 Analysis base on the literature review

The first technical paper, "Killer App" of Wearable Computing: Wireless Force Sensing Body Protectors for Martial Arts (Chi Ed. H, 2005), shows that the similar concepts as suggested for this project (utilizing sensor and wireless communication technology) has been applied in improving the available scoring system for Taekwondo. The writer also mentioned that the implementation of the technology (creation of the prototype) has been able to overcome the set back of the conventional electronic scoring system through the automation and also the new approach did not reduce the performance of the contestant.

In the technical paper ECE 476 Final Project: Electronic Hogu (Kim K, Kim, H. 2011), both of the writer has found out that a prototype of automatic scoring system for can be created by using the "off the shelf" or easily available electronic tools and equipments such as sensors and microcontroller.

However, additional works of improvement such as to improve the data communication function must be performed in order to ensure the prototype can be operational.

The third technical paper, Design of a Wireless Scoring System for Fencing Using RFID Technology (Alvarez JA, et. al., 2008), shows that the suggested concept of this project of using Visual Basic development tools on order to create a score display interface that showing the data transferred via a wireless communication link is possible.

Next, research by Baca (2009) and Dennis et al. (2009) found out that the application of ubiquitous computing technology such as sensor and data communication have brought up numbers of benefits for both athletes and sports enthusiast, especially in terms of improving the sporting performance.

Thus, the literature review that have been done have shown that the application of computing technology in sports, especially in martial art is not only possible, but also the automation in the scoring system by implementing sensors and data communication technology will be able to overcome the current issues in the conventional system and will lead towards the performance improvement.

CHAPTER 3

METHODOLOGY

3.1 RAPID APLICATION DEVELOPMENT

A methodology is a formalized approach of implementing the System Development Life Cycle (SDLC), (Dennis, Wixom, Tegarden, 2005). Methodology ensure a proposed program or a system is able to be constructed in a gradual and well planned manner thus the initial result or the finished product will be able to function properly. If needed, review or debugging process can be performed by getting back to early stage of the system development.

There are various types of methodologies that commonly being applied and of course, none of this is always the best. The decision to choose is based on the few criteria; clarity of user requirement, familiarity with technology, system complexity and reliability, and lastly the factor of short time schedule (Dennis, Wixom, Tegarden, 2005). For this project, Rapid Application Development (RAD) has been chosen. This is due to the duration of the project that is less than 10 months (time constraint). By implementing this method, it will speed up the whole development process since it is implementing a quick design phase that emphasizes the usability and functionality of the system (Dennis A., Wixom B.H., Tegarden D, 2005).

RAD encourage flexibility since it allows any changes to be made during the development phase and also review or recheck can be performed in any stage during the progress. These features are important since correctional effort or debugging can be done in a consistent manner thus, avoiding wastage of time and resources.

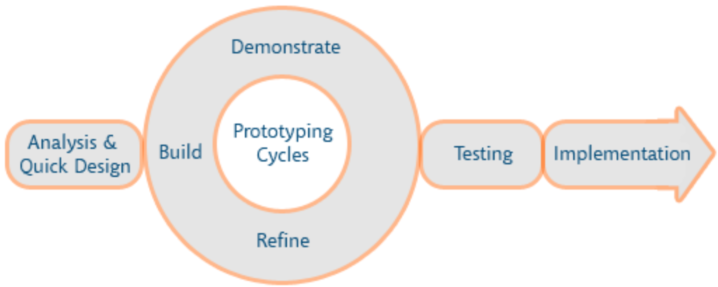


Figure 5: Rapid Application Development (Iblesoft, 2011).

Project development will be based on several cycles that consist of Analysis, Design and Implementation. All of the stages will be revisited accordingly base on the need to better suit any changes and requirements of this project. The cycle will be re-examined continuously based on the end user feedbacks about the first prototype.

3.2 PROJECT PHASES

The phases of the project will be divided into:

3.2.1 System Planning

This phase serves as an initial stepping point whereby it set up the direction of this project and also to allocate all tangible and intangible needs, such as time and the tools required. For the first stage of the project, the initial requirements are based on information from the requirement gathering methods. Firstly, it is being done by having a random interview and informal conversation with the Sports Karate practitioners, such as athletes and instructors with a various tournament experiences. Other than that, information is also gathered through related journals and publications. Besides that, in the System Planning phase, Work Breakdown Structure (WBS) in **APPENDIX B** was done to depict the entire task and the status.

3.2.2 System Analysis

After the basic significant idea has been identified, thorough information gathering were performed by distributing survey questionnaire to the Sports Karate practitioners (athletes, coaches, and instructors). The different of this approach compare to the random interview and informal conversation mentioned in the previous phase, the set of questionnaire is constructed based on the World Karate Federation (WKF) rules and regulations as it is a standard that became a guideline for the conventional Sports Karate scoring system. This is to ensure that information obtain to construct the system planning for this project is totally related with the experience and the real requirements that are needed to improve the conventional system, hence this will also reinforce the problem statements.

3.2.3 System Design

After the detail analysis has been completed, the project then proceeds to the design phase. Compare to the previous phase that focusing on *what do we need* in order to create the system, System Design is to determine on *how we are going to build this system*. Basically, this involves designing the system architecture and constructing a flow chart diagram that will depict the overall mechanism and the logic of the system base on the information obtained in the previous stage. Among the tools that being used are Microsoft Visio, for the sketching of the basic architecture diagram, and the system flowchart. PROTEUS ISIS 7 Professional is being used to draw the schematic diagram of the hardware.

3.2.4 System Implementation

Moving on, base on the outcome of the design phase, a prototype will be created by assembling all the needed hardware components, starting by building the Transmitter by assembling together the components such as the sensor (Force Sensitive Resistor), Operational Amplifier (LM358 Op-Amp), PIC16F877 microcontroller and the XBee Series 2 module. For the software part, the PIC16F877 microcontroller will be programmed by using the MPLAB IDE v8.63. For the interface, Visual Basic 2010 is being used. Both XBee Modules were programmed using a dedicated IDE, the XCTU.

3.2.5 System Testing (Prototype Evaluation)

Once the system has been built successfully, the functionalities of the system will be tested on this phase. In this stage, the prototype will be evaluated and will be checked for any requirements that are not being fulfilled. Since the RAD or Rapid Application Development methodology is being applied for this project, the process of prototyping (system analysis, design, and system implementation) will be repeated continuously until all the requirements are satisfied. Besides, this stage is intended to identify all the bugs or error and to perform the required fix.

3.2.6 System Deployment

Lastly, after all the desired prototype has been created, it will reach the final phase or the System Deployment. In this stage, the ability or the effectiveness of the system will be tested in the real scenario.

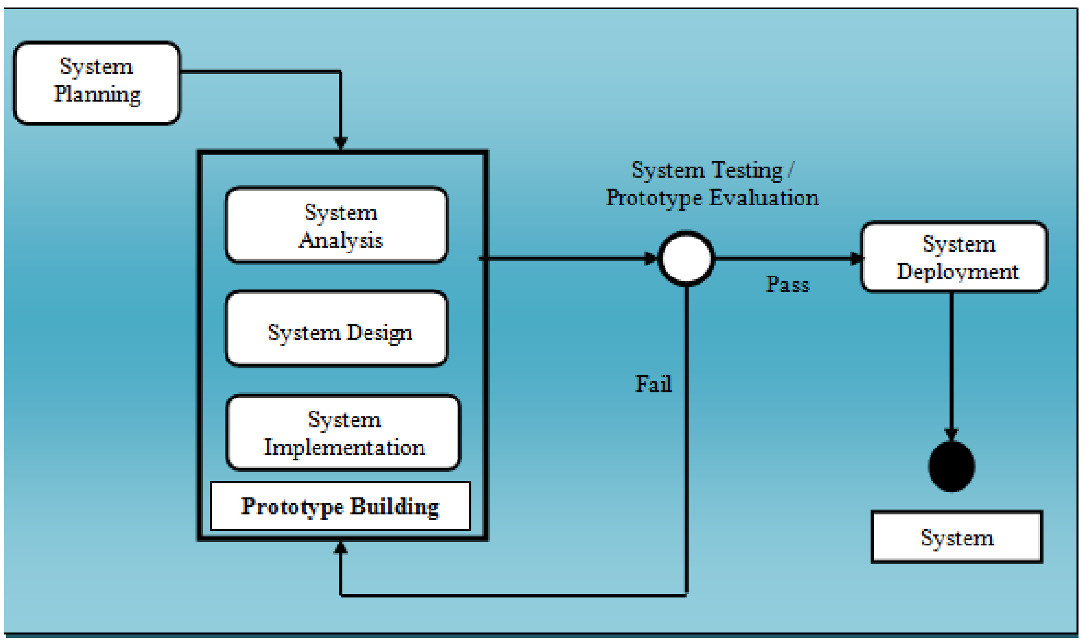


Figure 6: Project Methodology

CHAPTER 4

RESULTS AND DISCUSSION

4.1 PLANNING PHASE DELIVERABLES

According to Dennis, Wixom, and Tegarden (2005) "The planning phase is the fundamental process of understanding *why* an information system should be built and determining how to go about building it". It is important to understand and to assess the needs to build the system and objectives itself. Due to that, a contact has been made with Mr Boblyn Lugas Jr, a 1st Degree Black Belt holder and experienced Karate instructor from Ranau, Sabah. Have been teaching for 5 years and also coaching for the district Karate team, Mr Boblyn said that quite many times some of the judges and referees are being influenced by their personal choice such as favoritism towards a particular contestant when awarding a point. Mistakes often happened whereby; referee or judges sometimes unable to decide which contestant are eligible for score, especially when both of the contestants have simultaneously launched their attacks. Other than that, he did mentioned that sometimes the appointed scorekeeper will committed a mistake whereby, the scoreboard is not being updated as per instructed by the referee. Lastly, the assigned time keeper that monitoring the duration of the match (2 or 3 minutes) will sometime neglect in their task. Thus, happen to know the issues, the Automatic Scoring System for Sports Karate is going to be created in order to meet the main objectives **in overcoming unethical act** in judging decisions and also to **overcome human error**.

4.1.1 Feasibility Analysis

Prior to building a system, a feasibility analysis should be made in order to examine the overall aspects of the proposed project, shown in Table 1 below, a study has been done base on five different category of feasibility or TELOS (Burgees, 2009) that consists Technology (available technical knowledge), Economic (budget allocation), Legal (related rules and regulations), Operational Feasibility (Scope or how the project will overcome the highlighted issues), and Schedule (allocated time frame).

Feasibility	**Evaluation**
Technology	• Technical competency: C and Visual Basic 2010 programming languages. • Guidance is needed for both sensor & microcontroller configuration. • Hardware components available off the shelf (can be purchased easily)
Economic	• Most of the IDE are freely provided by the university. • Allocated budget (RM500) is not sufficient for the purchase of hardware components to create the prototype of scoring system that will represent two competitors.
Legal	System will be created base on the rules & regulations of the World Karate Federation.
Operational Feasibility	Proposed system will overcome the issues mentioned in the Problem statements by directly detecting the valid hit and transfer the signal to the score display.
Schedule	Project duration: 8 months for both Research & Development is sufficient, whereby 4 months are being allocated each part.

Table 1: Feasibility Analysis

Base on the feasibility analysis, the limitation to create this project is the insufficient budget allocation. Therefore, the system prototype will only be created to cover the scoring of a single contestant; however it is still be able to demonstrate the ability of the prototype to overcome the issues in the conventional system.

4.1.2 System Main Components

After the feasibility analysis and further observation on the issues that have been highlighted, four main components that should be made available and fully interacted are on the system are:

i. Hit detection unit

   Serve to detect a hit once impact is occurred. This part will be made by a sensor. For better sensitivity, it is preferable for the sensor to produce a digital input that will be generated. Due to budget constraint, as has been mentioned in the feasibility analysis, the prototype that will be created will only cover the scoring or needs of a single competitor.

ii. Microprocessor

   Serve to process the signal / input from the sensor and will perform the logical process (comparison) before sending it to the wireless transceiver. It will transform the input from the sensor to the form that is readable by the receiver (computer).

   The microcontroller will also serve to detect the received signal from the wireless transceiver that originally from the base and perform a further action, such as to acknowledge the communication.

iii. Wireless transmission

Signal generated by the hit detection unit that has been processed by the microcontroller will be transferred to the receiver via a wireless communication link.

To serve this purpose, ZigBee communication protocol will be implemented due to the low cost, minimal power consumption and the suitability for sensor data transfer (Digi International Inc, 2012).

iv. Display unit.

For this part, a display unit should be able to receive the signal. Signal received will be interpreted as a score and will be displayed. A loop of calculation will be performed if there is an additional signal received from the transmitter. The display unit should be designed base on the requirement of the World Karate Federation. This will be explained further in the Designed Phase Deliverable.

Analysis of needed tools and materials was then performed base on the requirements of the projects. Tools including hardware components that being used for the system development will be explained in the next sub-sections.

4.1.3 Hardware components

i. Force sensitive resistor

This force sensitive resistor will be installed on the standard World Karate Federation protective equipment. It is robust and able to detect a pressure or impact ranging from 1-1000g (Interlink Electronics, 2010).

Refer APPENDIX C, Figure 39: Interlink Force Sensitive Resistor

i. Microcontroller PIC16F877

PIC16F877 is a powerful microcontroller that will serve as a processor to detect and process the input from the sensor before being forwarded to the receiver (Microchip Technology Inc, 2001). **Refer APPENDIX C, Figure 40: PIC16F877 Microcontroller.**

ii. XBee Series 2 module

Serve to transmit and receive the data through ZigBee protocol that will be the medium of wireless communication for this system. (Digi International Inc, 2011) **Refer APPENDIX C: Figure 41: XBee Series 2**

iii. USB PIC Programmer: Cytron UIC00B In Circuit Serial Programmer

UIC00B is an In Circuit Serial Programming (ICSP). Serve as a programmer for the microcontroller. **Refer APPENDIX C, Figure 42: UIC00B ICSP Programmer.**

iv. Cytron SKXBee board without module

Serve as a converter between USB to Serial connection, enabling the XBee module to be connected into a computer for communication (Serial data transfer) or for configuration purpose of the XBee Series 2 module (Cytron Technologies Sdn. Bhd, 2008). **Refer APPENDIX C, Figure 43: Cytron SKXBee.**

v. Texas Instruments LM358 Operational Amplifier

The LM358 Op-Amp will be configured to convert the output of the Force Sensitive Resistor (FSR) from analog to digital output. **Refer APPENDIX C, Figure 44:LM358 Operational Amplifier (Op-Amp).**

vi. 3362 1k Square Trimpot (Potentiometer)

The purpose of the potentiometer is to regulate the voltage supply in the circuit. **Refer Appendix C, Figure 45:3362 1K Square Trimpot.**

vii. Power Supply: 9v Panasonic Extra Heavy Duty

Serve as the power supply for the transmitter. **Refer APPENDIX C, Figure 46: Panasonic Extra Heavy Duty 9v.**

viii. LM317 Voltage regulator

Since the safe operating voltage for most of the electronic components should not exceed 5v (Microchip Technology Inc, 2001) it is important to reduce the amount of the supplied voltage by using the LM317. **Refer APPENDIX C, Figure 47: LM317 Voltage Regulator.**

ix. Breadboard

The breadboard serves as a prototyping platform for the transmitter circuit. Bread board is being chosen to provide convenience, whereby extra works such as soldering is not necessary in order to fix the components. **Refer APPENDIX C, Figure 48: Breadboard.**

4.1.3 Listed below are the software tools that will be used for the development of the system

i. Visual Basic 2010

VB 2010 serves as a rapid Graphical User Interface (GUI) development tools. The interface or the score display of this system will be developed by using VB 2010 since it provides a simple development approach for user interface.

ii. MPLAB IDE v8.63

MPLAB IDE v8.63 is an Integrated Development Environment for PIC Microcontroller programming.

4.2 ANALYSIS PHASE DELIVERABLES

This phase involves taking into consideration all the objectives outlined earlier in the previous phase and gathered all the information in order to further proceeds to the next steps in building the project. In order to obtain more consistent requirements which related to the needs of the intended user of the system (Sports Karate practitioner), sets of questionnaire that being crafted based on the latest World Karate Federation (WKF) rules and regulations which is the standard guideline for the conventional system were distributed. The survey mainly evaluating the perception of the respondent about the conventional system, related to the respondents personal experiences. Total of 42 respondents that consist of Sports Karate practitioners (athletes, instructors, coaches, judges and referee) have taken part in the survey. The questionnaire is divided into two sections, **SECTION A** that consist of questions regarding the respondents personal information and **SECTION B,** questions that are more focusing towards Sports Karate itself and the opinion or perception of the conventional system (base on WKF rules and regulations). Acquiring the personal information as in the **SECTION A** is important, since it serves as an indicator of the level of knowledge of the respondent related to the subject (Sports Karate), such as the belt ranking.

The questions and the results of the survey are shown as below:

4.2. 1. Survey questionnaire and results

SECTION A: PERSONAL INFORMATION

Question A.1: Please specify your gender:

Results:

From 42 of our respondents, 88% or 37 are male and remaining 12% or 5 female. **Refer APPENDIX E, Figure 52: Gender of the respondents.**

Question A.2: Please state your age

Results:

Majority of our respondents are those in the age range of 21-30 years old, which is 60% or 25 respondents. **Refer APPENDIX E, Figure 53: Respondents age.**

Question A.3: Please state your nationality

Results:

All of our respondents (100%) are Malaysian. **Refer APPENDIX E, Figure 54: Nationality of the respondents.**

Question A.4: Please state your belt rank

This question is intended to know the respondent's ranking of seniority in Karate. Usually, colour of the belt indicates the level, i.e. Black belt may represent 1st Degree ranking (1st Dan).

Results:

Majority of our respondents are senior belt holders whereby, 81% or 34 respondents are black belt holders, followed by the 1st grade or the brown belt holders 10% or 4 respondents. Although they are only 2% or 1 respondent that hold a 2nd degree black belt, this make the total of respondents who are senior Karate practitioners as the majority participants of the survey, with the total of 39 respondents. The rest 7% of the respondents (2% or 1 respondent with green belt, and 5%, or 2 respondents are blue belt holders) are junior practitioners. **Refer APPENDIX E, Figure 55: Belt ranking of the participants.**

Question A.4: Please state your role of involvement in Karate:

This question intended to acquire the respondent's type of involvement in Sports Karate.

Results:

Majority of the respondents are Karate athletes, means individual that competing in the tournament, that consist of 66% or 29 of the respondents, this is followed by Instructor / Coach, 29% or 24 of the respondents, and remaining 5% or 2 respondents are Karate practitioners and student. **Refer APPENDIX E, Figure: 56: Respondent role of involvement in Sports Karate.**

SECTION B: GENERAL INFORMATION

Question B.1: How many years you have involved in Sports Karate?

This question enquires the respondent about their involvement in Sport Karate (note that Sports Karate is different than Traditional Karate that did not involve any form of competition). **Refer APPENDIX E, Figure 56: Years of involvement.**

Result:

Majority of our respondents (76% or 34 respondents) have been involved in Sports Karate within the range of 11 to 15 years. **Refer APPENDIX D, Figure 57: Years of involvement.**

Question B.2: Have you ever participated in Kumite (Sparring) competition?

This question is asked since there are 2 different categories in Sports Karate tournament, first is the pattern competition or "Kata" whereby, it is not a combative match between 2 contestants, and the "Kumite" or the Sparring (combative) competition. Therefore we want the feedbacks of the respondents related and focusing in the Sparring / Kumite category as the target environment of the system that will be created.

Refer APPENDIX E, Figure 58: Participation in Kumite Competition.

Result:

It shows that majority of our respondents or 95% (40 respondents) have participated in the Kumite or Sparring competition compare to the small percentage or 5% (2 respondents) that did not have any experience competing in the sparring competition.

Question B.3: If you answered "yes" in the previous question, please specify your highest level of competition that you have joined

Result:

From the 40 the respondents that has answered "Yes" in the previous question (B.2), majority of them have participated in International competition (43% or 17 respondents), followed by State level competition (25% or 10 respondents) and National level competition (17% or 7 respondents), with the least numbers of them have only participated in district level competition. **Refer APPENDIX E, Figure 59: Highest level of competition.**

For the next question, the respondent will refer to the statement below:

Currently, based on the WKF rules and regulations, four judges (Fukushin) will support the match referee (Shushin) in order to determine whether a strike (punch or kick) of a contestant is eligible for score. The scoreboard will be updated by a scorekeeper based on the decision of the match referee (Shushin). Source: Kata and Kumite Competition Rules 7_1 Effective 1.1.2012, World Karate Federation

Question B.4: Base on your experience, what is your opinion regarding to the current approach to the current approach of determining a valid hit of a contestant?

This question requires the respondent to relate their own experience with the excerpt of the WKF rules mentioned above.

Result:

The feedbacks shows that 22 respondent 52% said that improvement is needed, while another 26% or 11 respondents said that the approach is acceptable. 22% or 9 respondents are neutral in terms of their opinion regarding to this matter.

Refer APPENDIX E, Figure 60: Opinion regarding the current approach.

Question B.5: If you answered improvement is needed in the previous question please state the reason.

User that answered "Improvement is needed" in Question B.4 will state their reason(s). In this question, respondent **may pick both of the answers**. Result of the previous question show that 22 respondents agree that improvement is needed.

Results

Since for this question the respondents are allowed two pick both of the answers, almost all of them have chosen both of the answer. Majority has chosen Bias / Unethical decision with 52%. 2 of the respondents exclude the Human Error factor when they chose their answers. **Refer APPENDIX E, Figure: 61 Reasons for needed improvement.**

Question B.6. Referring to your own tournament experience, describe your opinion regarding to the role (performance) of the match Scorekeeper in the overall tournament that you have participated?

In this question, the respondent will evaluate the performance of the scorekeeper or the person that being assigned to operate the scoreboard base on their personal experiences. The feedback obtained will serve to gauge the level of effectiveness of the conventional approach.

Result:

50% (21 respondents) said that they are satisfied with the performance of the scorekeeper, while another 29% (12 respondents) said that the scorekeeper will always committed a mistake when performing their task. Lastly, 21% (9 respondents) said that improvement is needed. **Refer APPENDIX E, Figure: 62 Performance of the scorekeeper.**

Question B.7: Do you think technology will assist to improve the current approach that is being applied (Judging and scoreboard operation)

This question asked the opinion of the respondent regarding the involvement of the technology in making the conventional approach better.

Result:

In this question, 66% or 22 of the respondents agreed that technology will improve the current approach, 24% (10 respondents) mentioned other feedback such as it they are not sure if this will assist the current approach. Other than that, 15% (5 respondents) of the respondents said that they not agree. Another 15% (5 respondents) have a neutral stands regarding to this suggestion. **Refer APPENDIX E, Figure 63: Opinion on technology & improvement of current approach.**

Question B.8: If you answered "Yes" in the previous questions, what is you expectation?

In this question, respondent that has agreed that technology will assist in improving the current approach will be able to state their expectation or desired outcome if technology is really being implemented. As shown in the result of the previous question, 22 of the respondents has answered yes (agreed). For this question, respondents may choose more than 1 answer. Noted that the percentage will only be counted based on the numbers of the participants that has answered the **Question B.7,** this is to maintain the consistency of the result.

Result:

Most of the 22 respondents have chosen almost all of the given answer; therefore there are equal total of percentage in the result, except 24% or 19 respondents have agreed that it will improve the quality of the judging decision. 1 of the respondent (1%) giving a different answer (Others). **Refer APPENDIX E, Figure 64: Expected outcomes of the technology improvement.**

Question B.9: If you answered "Yes" in question 7 which type of technology that you highly recommended?

This question is also directed to all the respondents that have agreed to the suggestion that technology will assist in improving the current approach (Question B.7). Here, opinions of the respondents about the most suitable technology are being acquired. In here, 22 of the respondents may choose more than 1 answer.

As we noted that, same as the previous question, this question will only be subjected to the 22 respondents that have agreed.

Result:

Most of the 22 respondent have chosen more than one answers. However, there are slight differences where 11 (36%) from the 22 respondents have chosen the Wireless Hit detection sensor as the most appropriate technology. It is then followed by the Auto update scoreboard that connected with the hit detection. Another 29% (9) agreed that Photo finish can be the suitable solution. 3% or 1 of the respondent did not give any suggestion. **Refer APPENDIX E, Figure 65: Types of technology recommended.**

Conclusion

For this stage, it shows that the outcomes of the survey that being performed towards the 42 respondents, have supported that there are issues in the conventional scoring system that is currently being implemented, especially with regards to the weaknesses that brings the tendency of unethical act such as bias judging decision, and also human error that may affect the efficiency and effectiveness of the competition itself. The outcomes from the survey has also supported that many of the respondents that consist of the senior Sports Karate practitioners are agreed that technology may assist to improve the conventional scoring system. All the founding of the survey has supported the problem statements that have been mentioned in the early part of this project.

4.3 DESIGN PHASE DELIVERABLES

4.3.1 System Architecture Diagram

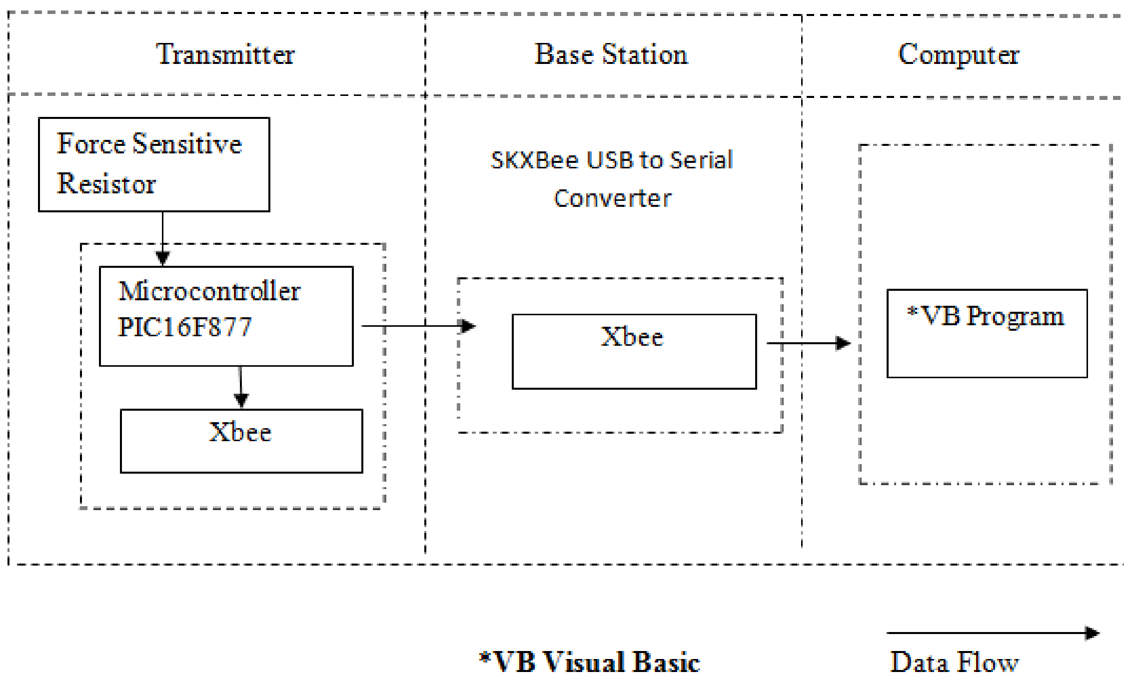


Figure 7: Overall architecture diagram

As mentioned in the planning phase, there are four important components of the system (Hit detection unit, microprocessor, wireless communication, and the display unit). All of the components will be incorporated together to form three physically separated unit as depicted in the System Architecture Diagram above. Although each part is physically separated, each part will be able to communicate in order to function as an integrated system. The logical flow on how the overall system will be operated is shown on the system flowchart. Refer **APPENDIX D** on for the system flowchart.

4.3.2. Preliminary hardware design

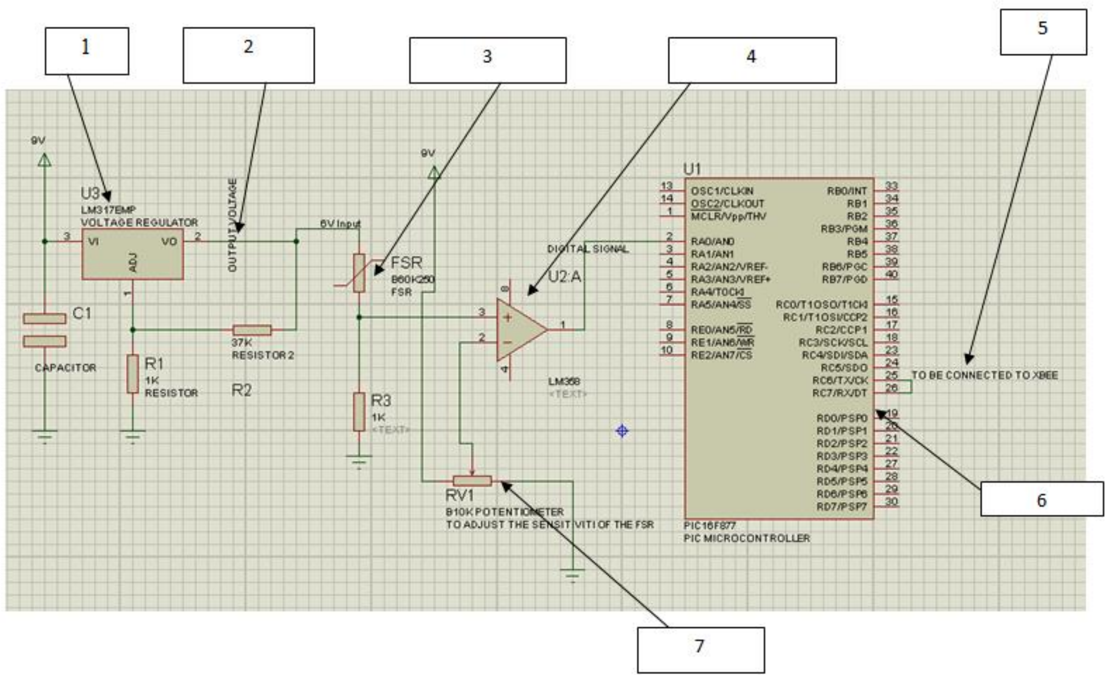


Figure 8: Preliminary hardware design

As show in the figure above, each components as per describe in the Planning phase are planned to be assembled based on the preliminary hardware designed as depicted in the figure above. The labeling (from no. 1 to 7) indicate the purpose of the components and preset configuration (expected functions and ability) base on how all the components are fixed together on the circuit board.

Number	Components / Attribute	Functions / Definitions
1	LM317 Voltage regulator	Decrease the power supply in order to avoid damage to the electrical components.
2	Output Voltage	Release the Output Voltage from the LM317. It will functions as a 5 volt power supply to the entire the circuit after the reduction.
3	Force Sensitive Resistor (FSR)	Serve as a sensor that will detect the impact and will produce an output signal.
4	LM358 Operational Amplifier (Op-Amp)	The Op-Amp serve to convert the signal that produced by the FSR from analog to digital.
5	Pin RC6 and RC7 of the PIC16F877	The connection pins in the microcontroller that will be connected to the XBee series 2 module.
6	PIC16F877	The microcontroller serve as a processor to perform a comparison process base on the instruction / signal received. Pin A0 is connected to the Op-Amp output pin whereby, (Pin no 1) it receives the converted signal.
7	3362 1K Square Trimpot	Serve to adjust the amount of voltage that produced by the FSR after the conversion (Analog to Digital).

Table 2: Hardware design definition

4.2.3 Preliminary Interface Design

As per mentioned earlier, the display unit or the interface will be designed based on the rules and regulations of the World Karate Federation. Beside of displaying the score of the contestant, the scoreboard should display the warnings and penalty if a contestant did breaks any rule of the competition. Visual Basic 2010 will be used to design the interface as shown below.

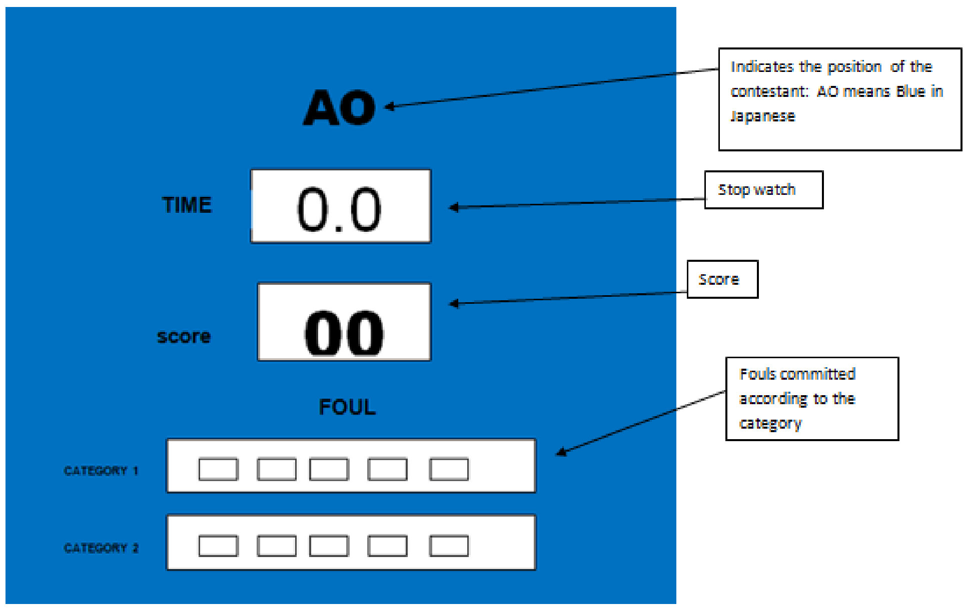


Figure 9: Preliminary interface design

4.4 IMPLEMENTATION PHASE PROGRESS

4.4.1 Steps of Hardware Assembly

In order to enable the hit detection unit to be functioned, the characteristic of the FSR or the Force Sensitive Resistor must be determined first. Then, it will proceed with the configuration of the Operational Amplifier base on the signal generated by the FSR. After the desired output is able to be obtained, the next step is the interfacing of the PIC Microcontroller and the XBee Series 2 module (Transceiver) on the Transmitter circuit will be performed.

The overall steps of the hardware assembly are being shown in the flowchart below:

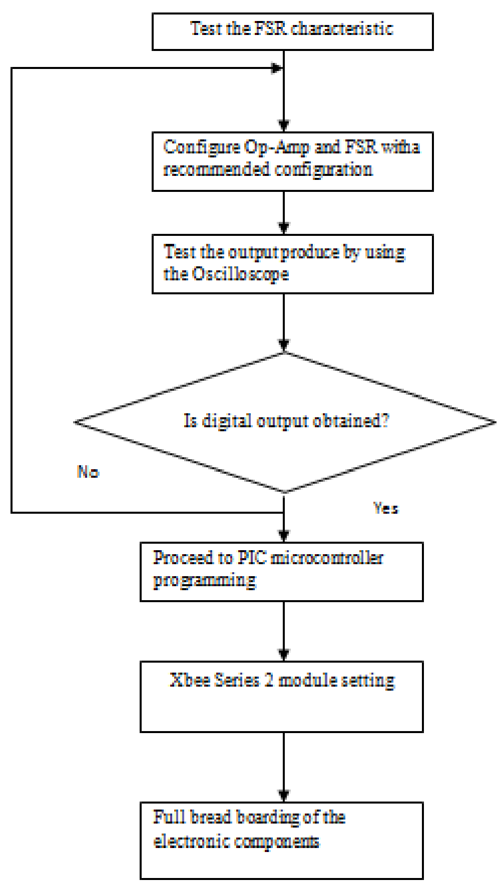


Figure 10: Steps of Hardware assembly

4.4.1.1 Testing the FSR characteristic

The purpose of this testing is to identify the characteristic of the FSR in terms of the voltage that will be generated. This is to determine the configuration of the circuit in order to obtain the voltage that can be detected by the PIC microcontroller (Threshold voltage). In this testing, adjustments are being made by incrementing the voltage (Volts over division) and time starting from the smallest value until a complete Sine wave is appeared. (Interlink Electronics, 2010).

The result of the testing shows as below:

Time: 0.4 Micro Seconds (8 divisions x 0.05 micro second)
Voltage: 2 milivolt (1 division x 2 milivolt)

Figure 11: Result of FSR testing

Since the threshold value or the operating voltage of the PIC microcontroller is ranging from 2v-5.0v (Microchip Technology Inc, 2001), amplification is needed in order to increase the output voltage. Due to that, an Operational Amplifier (Op-Amp) is being installed to perform the task. Details regarding the Op-Amp installation will be explained in the next section.

i. Op-Amp configuration

An LM358 Operational Amplifier is being utilized to increase the output voltage of the FSR. Beside of the need to get the desired voltage, the FSR should be able to **function as a switch**.

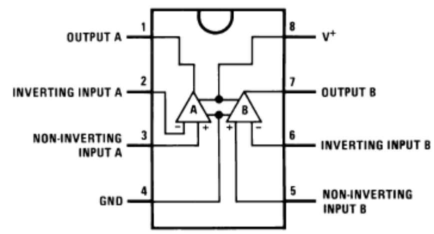


Figure 12: National Semiconductor LM358 Op-Amp (Texas Instruments, 2005)

To achieve this objective, the circuit is being designed as a Variable Force Threshold Switch (Interlink Electronics, 2010). In this circuit design, at zero force or no pressure applied on the FSR, the output of the Op-Amp will be low ("0") and high ("1") if pressure applied. Prior to components assembly, the circuit was design by using Isis 7 Computer Aided Design (CAD) and simulation software.

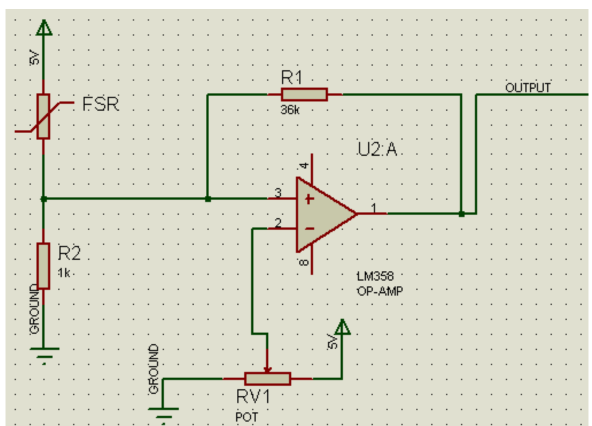


Figure 13: Design of FSR as Variable Force Threshold Switch in Isis 7

Base on Figure 13, the FSR is positioned together with a voltage divider, the R2 resistor connected to the ground. The value of R2 is 1k Ohm. When force is being applied to the FSR, the voltage going to the non-inverting (positive) input, in the pin 3 of the Op-Amp, will be greater compare to the voltage of the inverting input (pin 2 of the Op-Amp), causing the output of the Op-Amp to be toggled high ("1"), the result of the entire configuration is a "switch effect" whereby, a voltage signal will only be produced if force or impact is being applied on the FSR. The potentiometer, RV1, serve to control the triggering voltage or the force threshold needed. For testing and configuration, the designed circuit was assembled on the mini breadboard as shown below

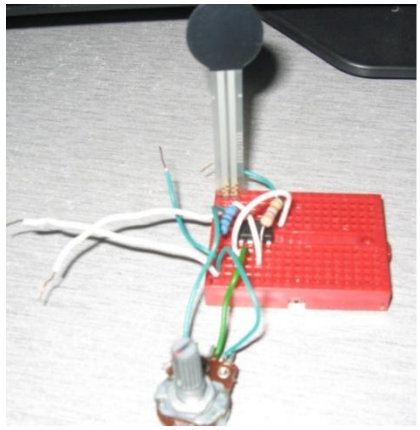
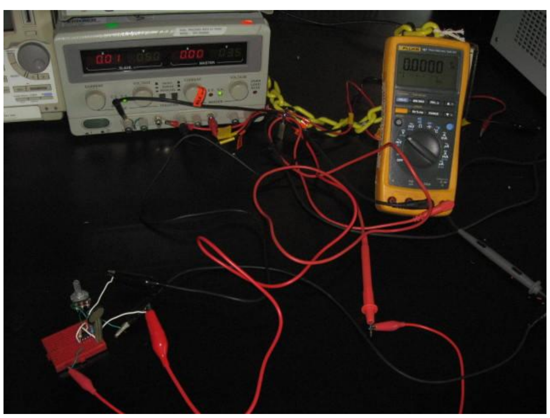
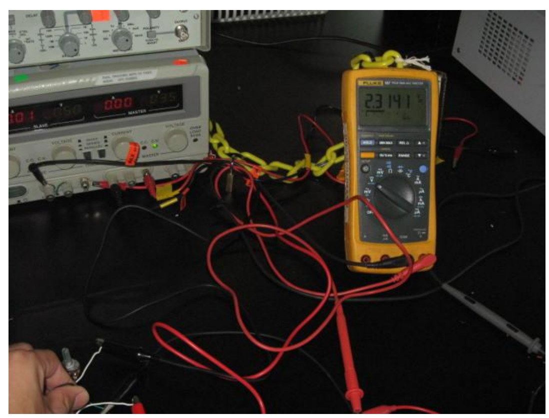


Figure 14: Assembled circuit

The circuit was then being connected to a DC power supply and a multimeter. The DC power supply was set to 5 volts, a general operating voltage for electronic components. The multimeter serves to measure the output voltage that being produced by the Op-Amp. Pressure is applied by doing a fast tapping on the FSR using both thumb and pointing fingers.



a)



b)

a) Figure 15: Multimeter reading without any force applied on the FSR

b) Figure 16: Fast tapping on the FSR and the result on the multimeter

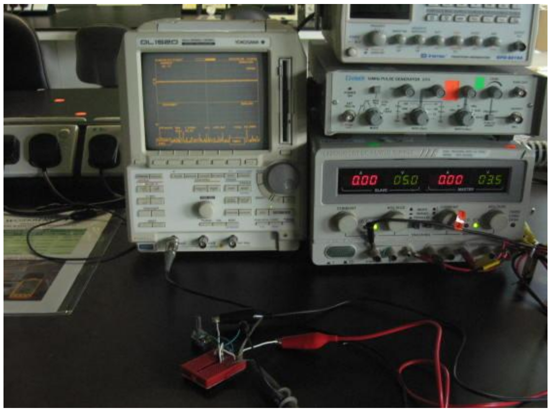
The potentiometer is being adjusted until the multimeter shows the desired voltage for every pressure that being applied. The test was repeated for three times in order to ensure the consistency of the output with the adjustment that being made. Table below shows the results for each of the test repetition.

Test	Multimeter reading (V)
1	2.4v
2	2.1v
3	2.3v

Table 3: FSR test results

In average, the output voltage is 2.2 Volt; the outcome has satisfied the requirements of the PIC microcontroller minimum operating voltage.

In the second testing, the multimeter was replaced by a digital oscilloscope. This is to determine the shape of the waveform, as one of the desired outcome is to obtain a digital output.



a) **b)**

a) Figure 17: Digital Oscilloscope and the circuit

b) Figure 18: Digital waveform resulted from the Variable Force Threshold Switch

Both testing by using the multimeter and the digital oscilloscope have proven that the Variable Force Threshold Switch design of circuit is **suitable** to meet the operating requirement of the PIC Microcontroller 16F877.

4.4.1.2 PIC Microcontroller Programming

PIC16F877 is produced by Microchip Inc. It is a very popular microprocessor device due to the high performance processing capability and also the minimal numbers of instructions needed to make it operational (Microchip Technology Inc, 2001). Other than that, it can be programmed using the C language, thus it reduce the development time of due to the familiarity of the language. [Refer to PIC16F877 pin out: APPENDIX C, fig .11]

To begin with, it started by understanding the basic Pin out of the PIC16F877 itself. Basically, each pin in the PIC has a particular function; therefore, it is necessary to refer the provided datasheet. The most important, is necessary to know the location of the power supply or the VSS pin that need to be connected to the positive (+ve) terminal of the circuit and the VDD or the “Ground” that will be connected to the negative terminal or the “Ground” of the circuit. The VDD is located on the Pin 11 and 32, while the VSS located respectively on the pin 12 and 31. Next, knowing the operational mechanism of the entire circuit that will be assembled (the Transmitter) is important in order to define the setting of the PIC. As we may know, input that will be generated by the combination of the Op-Amp and the FSR (configured in the previous section) is an analogue input. Therefore, the next step is to choose the appropriate input pin. Referring to the supplied datasheet, pin no. 2 or the Port A0 (RA0) of the PIC has been chosen due to the suitability for both analog and digital input. Next step is to know the requirements of setting for other device that will be interfaced together with the PIC. For the system, the XBee Series 2 module needs to be connected to the Serial/UART communication pins, which are Port RC6 for the transmitter TX, and RC7 for the receiver (RX).

The following step is to proceed with the programming of the microcontroller. Code development is being performed by using the MPLAB IDE v8.63 IDE. The input from the FSR comes in the form of voltage (analog), thus a conversion is needed in order to enable the microcontroller to process and create a signal that can be transmitted to the receiver; this is due to the nature of the digital signal that is more differentiable by electronic circuit e.g. the microcontroller, since it propagates more efficient compare to the analogue signal (Rouse, 2005). The function code on the Figure 19 serves to read the available analog to digital converter channels (ADCON). If signal detected in any of the ADCON, the ADC will be activated signal (ADCON=1) to enable conversion and it will be deactivated once conversion has been completed (ADCON=0).

```
}
//Function to Read given ADC channel (0-13)
unsigned int ADCRead(unsigned char ch)
{
   if(ch>13) return 0;  //Invalid Channel

   ADCON0=0x00;

   ADCON0=(ch<<2);   //Select ADC Channel

   ADON=1;  //switch on the adc module

   GODONE=1;  //Start conversion

   while(GODONE); //wait for the conversion to finish

   ADON=0;  //switch off adc

   return ADRESL;
}
```

Figure 19: Function to perform analog to digital conversion

```
int read_a2d(unsigned char channel)
{
ADCON0=0b00000001;
ADCON1=0b10000000;
ADCON0=(ADCON0&0xC7)|(channel<<3);
delay(5);
ADGO=1;
while(ADGO==1) continue;
GODONE=1;
while(GODONE==1) continue;
return((256*ADRESH+ADRESL)/10.2);
}
```

Figure 20: Function to perform the conversion operation

Conversion will be performed base on the function shown in the Figure 20. The third and the fourth line (ADCON0=0b00000001 and ADCON1=0b10000000) set up the 1st bit of ADCON0 and the last bit of ADCON1 respectively. Whereby, setting the first bit or the ADON in ADCON0 as shown above will cause the analog to digital converter to be activated. The purpose of setting the 8^{th} bit in ADCON1 is to set the conversion format to 10 bit converter (Vijay, 2008), therefore the range of conversion (in Bit value) if from 0 to 1024 or 2^10 (Vijay, 2008). ADGO in the line 7 serve to start the conversion, whereby by setting it high (ADGO = 1) it will start the conversion by setting the GODONE or the bit that serve to start the conversion operation to high (GODONE = 1). The line return ((256*ADRESH+ADRESL)/10.2) will return the value of the conversion. Once the coding has been completely written, the full program can be build to generate a **HEX** file. To program the microcontroller the UIC00B In Circuit Serial Programming (ICSP) device will be used to load the generated .hex file into the microcontroller. PicKit2 is the software that transfers the HEX from the computer to the microcontroller.

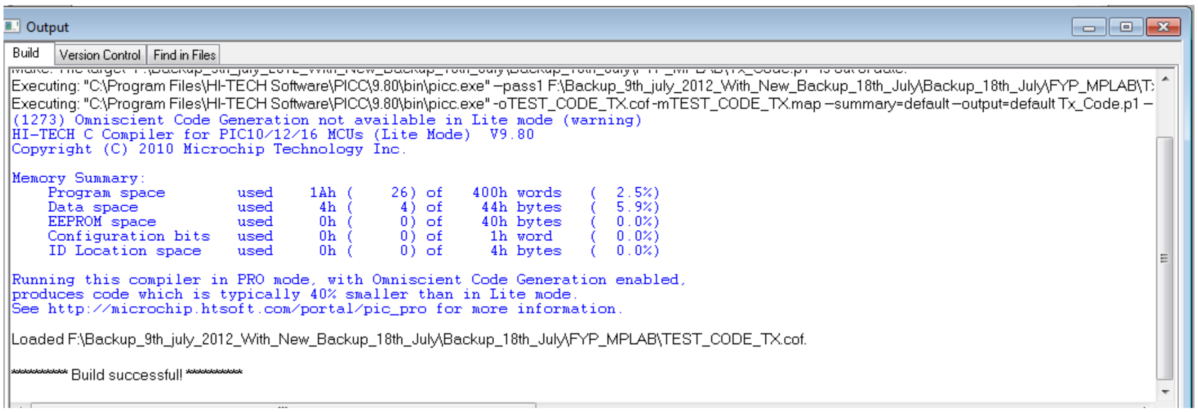


Figure 21: Written code has been build successfully.

4.4.1.3 XBee configuration

As mentioned previously, data communication of the system will be performed through a wireless communication by using the Zigbee protocol. To achieve this, XBee module will be utilized for the data transmission (Refer APPENDIX C, fig .12 for XBee Series 2 pin out).

Base Station configuration

To begin with, the module will be fixed on the development board, SKXBee for programming purpose with the XCTU Application Programming Interface.

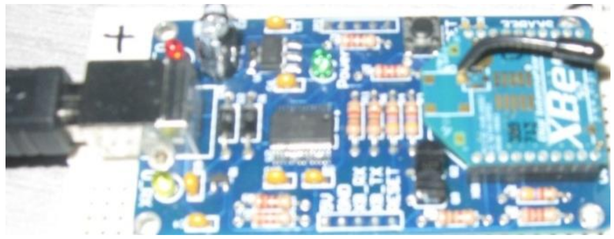
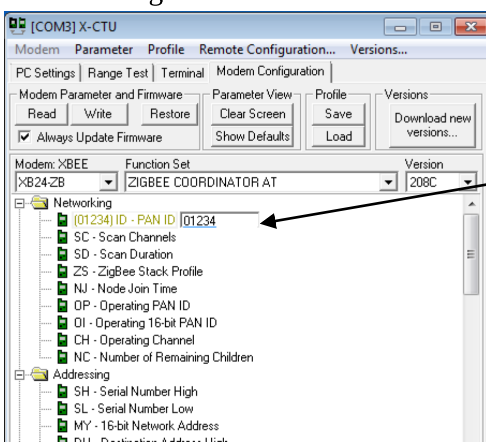


Figure 22: XBee module with SKXBee development board



The first step is to set up the PAN ID. In here, the PAN ID of the transmitter was set to “01234”

Figure 23: Setting up coordinator PAN ID

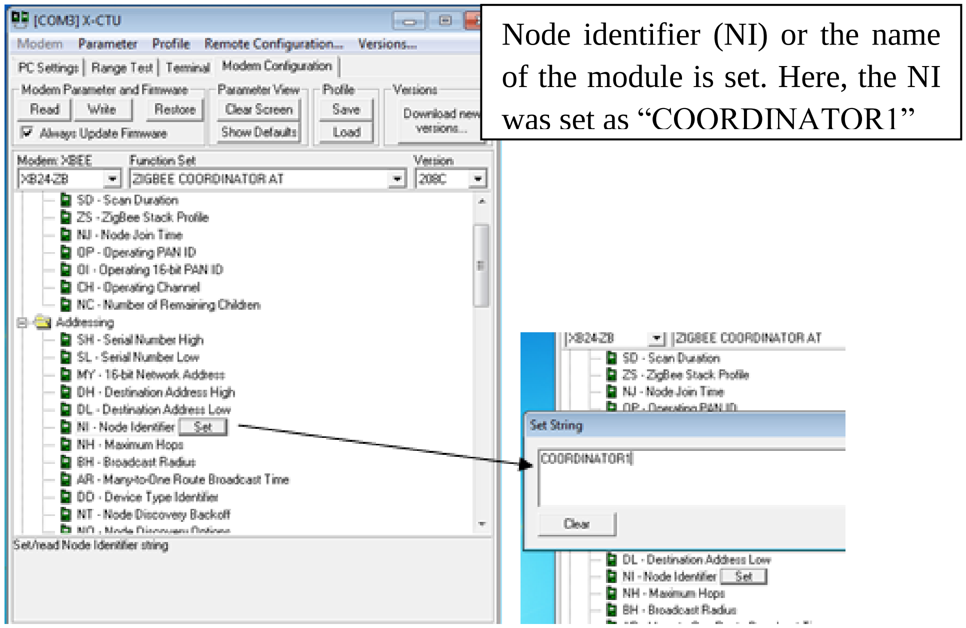


Figure 24: Setting up the XBee coordinator for the base station

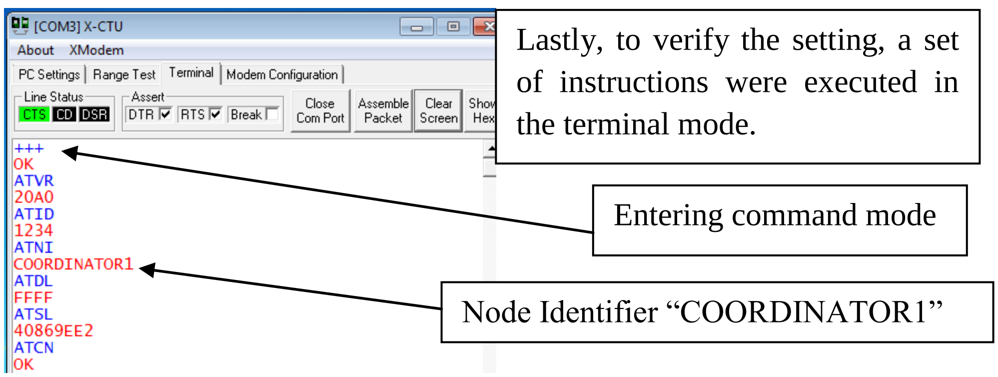


Figure 23: Verifying the pre-set XBee setting

Transmitter (Tx)

XBee module that will be used as a transmitter has been soldered together with a 20 pins breaker board. This is to enable the module to be fixed on the breadboard.

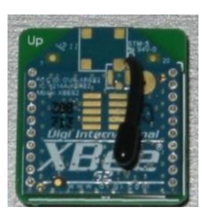


Figure 25: XBee Series 2 module soldered with breaker board.

Similar configurations were performed on the transmitter module. Except, as shown in the figure below, the Node Identifier or the ATNI was set as "ROUTER1"

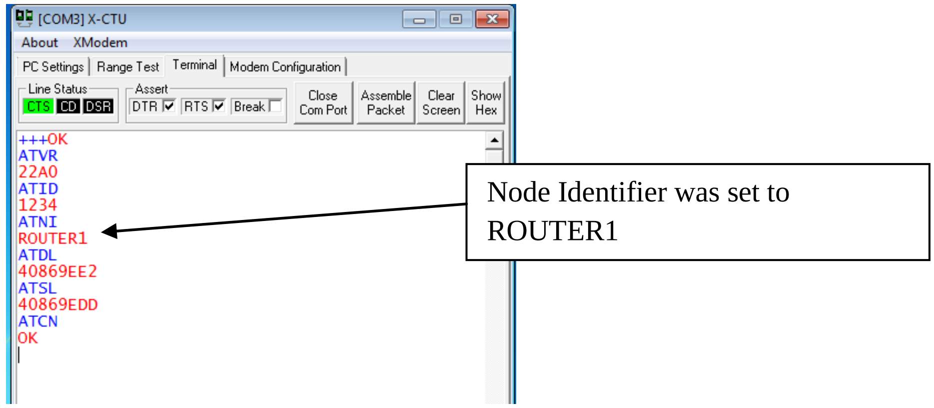


Figure 26: XBee Router Configuration

4.4.1.4. Full bread boarding of the components.

The final step in the hardware development is to assemble all the components that have been configured into a single circuit board as shown in the Preliminary hardware designed (Figure: 8).

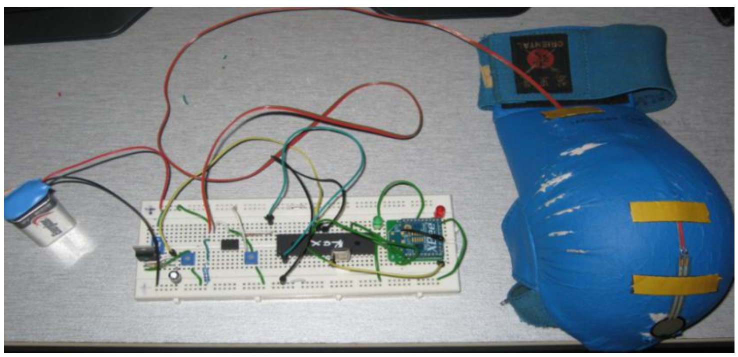


Figure 27: Prototype Transmitter Circuit

To make the prototype more realistic, FSR was embedded into a standard World Karate Federation hand protector. To do that, rainbow cable with the length of 1m is being used to connect to the sensor and the transmitter board.

Figure 28: FSR & rainbow cable

Figure 29: Fixing FSR into hand protector

Figure 30: Hand protector with embedded FSR

The second XBee Series 2 modules will be connected to the Cytron SKXBee. The device combination will act as a base station, whereby, it will send or receive the signal from the transmitter. With this, the hardware assembly steps have been completed

.

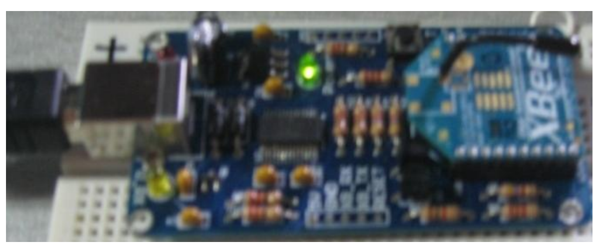


Figure 31: Cytron SKXBee and XBee Series 2 Module

4.4.2 Steps of Interface Design

There are 3 steps involved in the interface design. The first step is designing the layout of the score display. Then it followed by creating the system Graphical User Interface (GUI), and the last step is the programming works to will the GUI and other logical functionalities of the system.

4.4.2.1 First Step: Designing the layout of the score display.

The preliminary interface design depicted in the Figure 9 will serve as the layout of the score display unit. It was further design in the VB 2010 program as shown below:

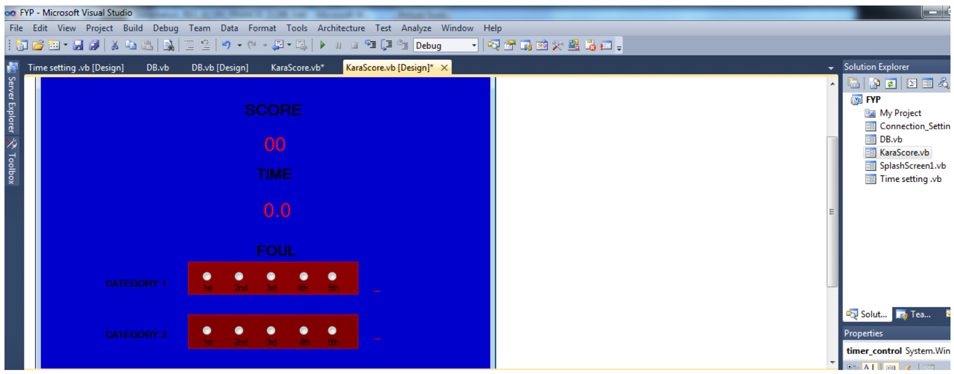


Figure 32: Layout design in the Visual Basic 2010 program

There is a slight different between the layout in the Figure 9 and the Figure 32, whereby the foul indicator is being represents by a sets of Radio Buttons, this is due to the features of the radio button that will only accepts a single input and did not allow the user to click or choose more than 1 of the list within the same group. This is also base on the compliance of the World Karate Federation rules and regulations, whereby, contestant that committed a penalty for a second time and beyond within the same category, will received another different level of penalty without maintaining the previous penalty that has been issued to the contestant previously (World Karate Federation, 2012).

4.4.2.2 Second Step: Creating the system Graphical User Interface.

The system interface will also serve as a control panel to set up functions such as the timer and the connection setting as shown in Figure 33.

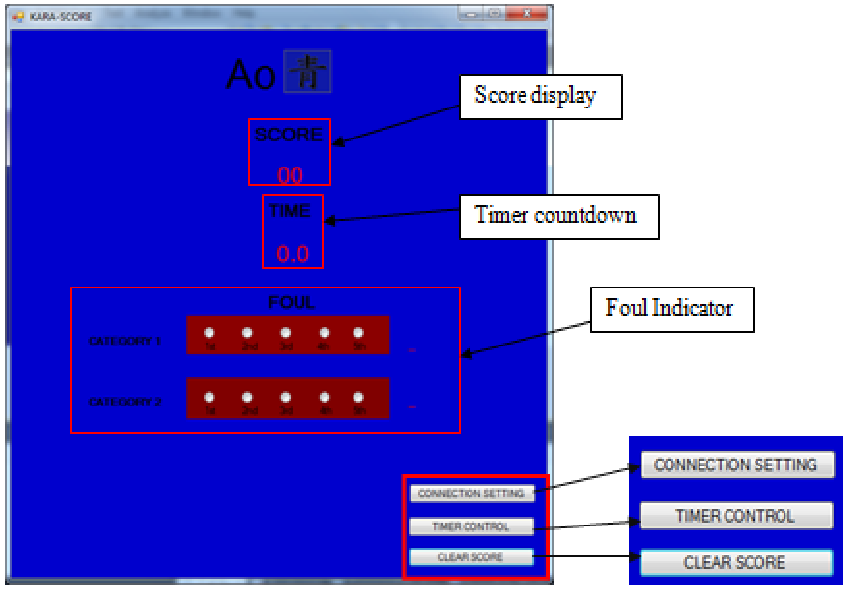


Figure 33: System Interface

Explanations for the available GUIs are given as below:

i. Foul indicator:

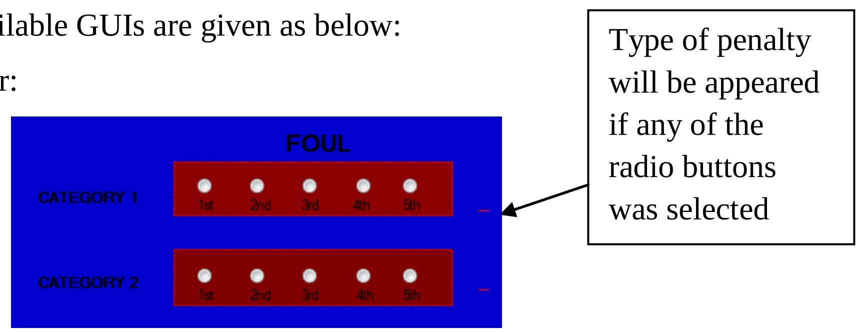


Figure 33: Foul Indicator

Base on the WKF rules and regulations there are 2 categories of foul that divided into Category 1 and Category 2. Category 1 complies with the action that involves aggression or attacking techniques that are not allowed in the rules of the competition. While for the Category 2, is subjected to any action or indiscipline behavior such as pretending as being injured by the opponent (World Karate Federation, 2012).

For this function, the operator of the scoreboard will click the radio button base on the category and numbers of penalty that has been issued by the referee. The penalty committed will be displayed on the text line. The match will be terminated if the fifth radio button is selected in any of the category (disqualification) (World Karate Federation, 2012).

ii. Time control

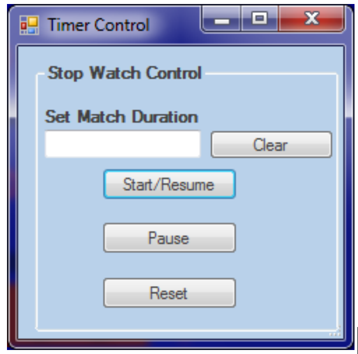


Figure 34: Timer control panel

This section of GUI enable user to control the stop watch or the timer function by setting the match duration (in minutes) and execute the timer countdown by pressing the Start/Resume button.

iii. Connection setting

To operate the system, user need to connect the base station (SKXBee) on the computer USB port. Then, communication with the transmitter can be made by connecting to the available "COM" port in the drop down list.

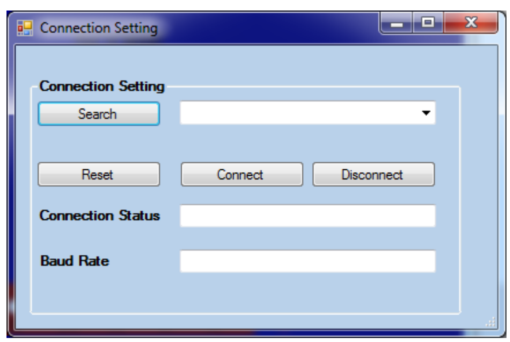


Figure 35: Connection Setting

4.4.1.3 Third Step: Interface programming

The third step involves the setting of the logic control for the interface. As the main function of the interface is to display the updated score, the program should be able to detect and receive any incoming signal or input from the transmitter. Therefore, the program is configured for full time listening of the serial port and to detect any signal in unexpected time throughout the pre-set match duration.

To serve this purpose, the _DataReceived function (instance) from the System.IO.Ports class of the Visual Basic will be utilized (Universiti of Minessota College of Science & Engineering, 2012). In the second line: `UpdateFormDelegate1 = New UpdateFormDelegate(AddressOf UpdateDisplay)` is an object that will call the method that serve to update the score display and perform the looping operation once a signal is being detected. The entire codes for the system can be referred in the **APPENDIX H.**

```
'To read COM Port for data
Private Sub ComPort_DataReceived(ByVal sender As Object, ByVal e As SerialDataReceivedEventArgs)
    UpdateFormDelegate1 = New UpdateFormDelegate(AddressOf UpdateDisplay)
    Dim n As Integer = ComPort.BytesToRead() 'find number of bytes in buf
    comBuffer = New Byte(n - 1) {} 're dimension storage buffer
    ComPort.Read(comBuffer, 0, n) 'read data from the buffer
    Dim current_score As Integer = CInt(comBuffer(0))
    Me.Invoke(UpdateFormDelegate1) 'call the delegate
End Sub
```

Figure 36: Function to read COM port

```
Private Sub UpdateDisplay()
    Static display_score As Integer = 0
    MsgBox("Point Scored!: Yuko")
    display_score += 1
    score_display.Text = CStr(display_score)
End Sub
```

Figure 37: Function to perform score display update

4.5 SYSTEM TESTING

System testing is a crucial element for the system quality assurance. The test process is implemented to execute the system in order to check the performance, limitation and competency as well as for future references. This phase is important since all the outcomes will verify if the released prototype is able to fulfill the project objectives or vice-versa. All the important functions of systems that consist of the communication system, timer and the foul indicator have been tested and the results are promising (Refer **APPENDIX F** for the full report of testing). The most important is the outcome for the testing of the communication system whereby, other than able to connect and communicate between both transmitter and receiver, the signal that being generated by applying force on the FSR has been transmitted and received by the base station.

It satisfies the condition of the testing whereby, the score display on the interface must be updated, and a message box of notification will be appeared as shown in the Figure 38.

The result obtained from the testing has verified that the main **objective of this project; to create an automatic scoring system through the integration of hit detection and score display updates has been achieved.**

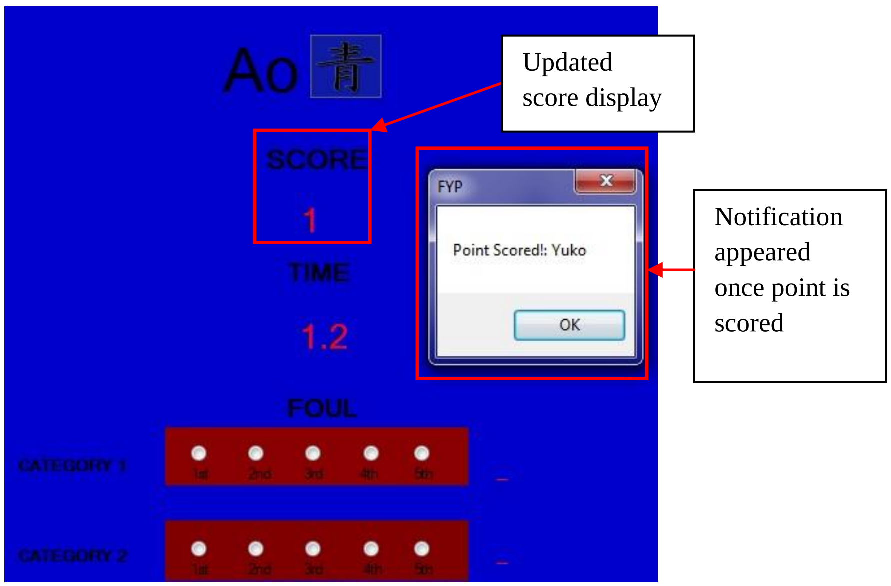


Figure 38: Result of data transmission

CHAPTER 5

CONCLUSION AND RECCOMENDATION

5.1 CONCLUSION

The project started with project definition and objectives identification. It then proceeds on by doing some reading and research through the related materials such as technical papers, articles, online resources, books, and not to forget, consultation and advice from individuals with the knowledge of the related subject matter. Through the research and studies that have been performed, the first prototype has been produced and tested. Testing results shows that the **main objective of this project; to create an automatic scoring system for sports Karate has been achieved**. As per requirement of the RAD methodology, the prototypes will be further refined until fully finalized product that can be utilized in the real scenario of Karate competition is created. Through this project, issues in the conventional scoring system will be able to be overcome, thus it will improve the standard of the competition.

5.2 FUTURE WORK

5.2.1 Suggested future work to improve the current features of the systems

Definitely, in every invention, improvement is needed in order to create a product that will be fully operational in the real environment. Budget has been the main constraint of this project, whereby it inhibits the capacity in creating a prototype that able to cover the full scenario of Karate competition itself, e.g. a prototype of scoring system that represents two contestants in a match. Therefore, the future development should create a system (hit detection and score display) that will cover both of the contestants.

Hit detection function can also be applied to detect a valid hit from kicking techniques by applying sensors and wireless transceivers (XBee Series 2) on the foot protector.

To further improve the main function of the prototype, studies should be made to find a sensor that is suitable to replace the Force Sensitive Resistor (FSR). Although FSR is able to be utilized to represent the main functionality (hit detection) of the system prototype, sometime the effectiveness of the FSR in giving an accurate reading is affected when it is fitted inside the WKF standard hand protector, since mounting the FSR in an uneven surface will reduce the effectiveness of the FSR. Also, because FSR is a variable resistor that will react when pressure is being applied, a sudden change of force (especially when pressure is being released from the sensor) will create multiple signals within a very short time, thus it will affect the accuracy of the system, since the signal produced other than the valid hit will also be looped and updated by the score display.

Lastly, to enable the system to be utilized in the real competition environment, extensive works of miniaturization is needed, thus the hardware part of the system will be wearable and ergonomic by the competitor, therefore it will not constraint the movement and the performance of the athlete.

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APPENDICES

APPENDIX A: PROJECT GANTT CHART AND MILESTONES

ACTION ITEMS		SEPT/OCT					NOVEMBER					DECEMBER				OUTPUT
		W 1	W 2	W 3	W 4	W 5	W 6	W 7	W 8	W 9	W 10	W 11	W 12	W 13	W 14	
STAGE 1: PLANNING	Submit proposal		■													
	Gain approval		■													
	Identify methodology			■												Project methodology
STAGE 2: ANALYSIS	Conduct research on suitable sensor & wireless protocol			◆												Suitable sensor & system communication protocol
	Analyze the conventional system (WKF Rules)			■												
	Create literature review			◆												Literature review
	Analysis system architecture					■										
	Surveying the price of needed tools / components					■										Acquired tools / hardware
	Create survey & Interview questions										◆					List of survey questions
	Conduct survey & Interview										◆					Respondents feedback
	Compile survey & Interview results											◆				Survey result
DESIGN	System architecture design						◆									System architecture diagram & flowchart
	Preliminary hardware design						◆									Schematic design
	Interface design						◆									System interface
IMPORTANT DATES	Proposal submission		■													
	Announcement of list of approved titles			■												
	Talk / Lecture for FYP 1	■	■	■	■		■	■								
	Submission of extended proposal (10%)						■									Extended proposal
	Proposal defence (40%)										■					
	Interim report submission (50%)											■				Interim report

ACTION ITEMS		MAY/JUN					JULY					AUGUST				OUTPUT
		W 1	W 2	W 3	W 4	W 5	W 6	W 7	W 8	W 9	W 10	W 11	W 12	W 13	W 14	
DEVELOPMENT / IMPLEMENTATION	Sensor interfacing & Op-amp configuration			◆												Force sensor configured as a switch
	Microcontroller programming			◆	■	■										Programmed microcontroller
	Xbee configuration						◆									Operational Xbee
	Full hardware assembly						◆									First hardware prototype
	Hardware & Interface Integration							◆								First integrated system
TESTING	Release first prototype							◆								First system prototype
	Conduct functionality testing								■							Identified working components
	Analyze and evaluate test result										■					Conclusion on the first prototype
	Produce dissertation										■					Dissertation
	Debugging										■	■	■			
DEPLOYMENT	Release debugged prototype												◆			Functional prototype
	Involve Karate practitioner in the product testing												■			Feedback from intended participants
IMPORTANT DATES	Submission of progress report							■								Progress report
	Pre-Sedex										■					Presentation poster
	Dissertation submission											■				Dissertation
	Viva (Oral presentation)													■		
	Technical report submission														■	Finalized thesis
	Final dissertation submission (Hardbound)														■	

APPENDIX B: WORK BREAKDOWN STRUCTURE

Project Activities			
Stage	**Phase**	**Activities**	**Status**
1		**Proposal & Approval**	
		Submit project proposal	Completed
		Gain approval on the project topic	Completed
2	**1**	**Analysis**	
		Critical review on the conventional system & other related existing automatic system.	Completed
		Conduct research on suitable sensor & wireless protocol	Completed
		Conducting literature review	Completed
		Analysis of basic hardware assembly & architecture	Completed
		Submission of Extended Proposal	Submitted
	2	Searching and identifying the tools & technology for development	Completed
		Surveying the price of sensors & availability of other tools	Completed
		Set up an interface design / framework	Completed
		Proposal Defense	Completed
	3	**Design**	
		Waveform analysis, device assembly, and system integration	Completed
		Submission of Interim Report	Submitted
		Perform testing on the sensor data capture	Completed
		Submission of Progress Report	Submitted
		Release the first model of prototype	Released
		Debugging	Completed
		Pre-SEDEX	Closed
	4	**Development**	
		Putting the system into test with the real participants	Completed
		Debugging (Optional)	Completed
		Analyze the evaluation result	Completed
		Submission of Draft Report	Completed
		Produce Dissertation	Completed
		Submission of technical paper & dissertation.	Closed
		Oral Presentation	Closed
3		**Submission**	Closed

Table 4: Work Breakdown Structure

APPENDIX C: HARDWARE COMPONENTS

Figure 39: Interlink Force Sensitive Resistor

Figure 40: PIC16F877 Microcontroller

Figure 41: XBee Series 2

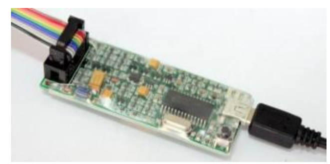

Figure 42: UIC00B ICSP Programmer

Figure 43: Cytron SKXBee

Figure 44:LM358 Operational Amplifier (Op-Amp)

Figure 45:3362 1K Square Trimpot

Figure 46: Panasonic Extra Heavy Duty 9v

APPENDIX C: HARDWARE COMPONENTS

Figure 47: LM317 Voltage Regulator

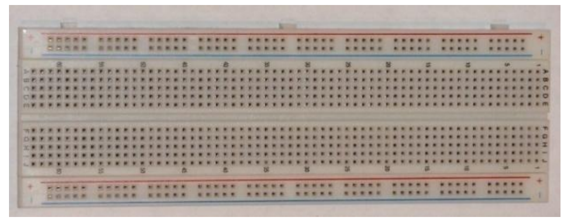

Figure 48: Breadboard

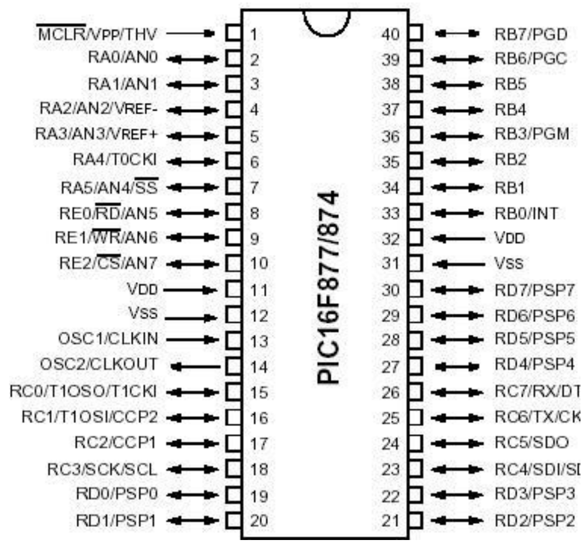

Figure 49: PIC 16F877 Microcontroller pin out

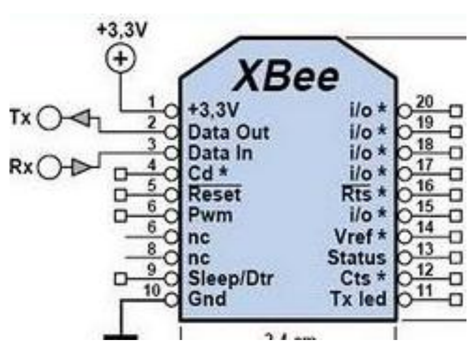

Figure 50: XBee Series 2 pin out

APPENDIX D: SYSTEM FLOWCHART

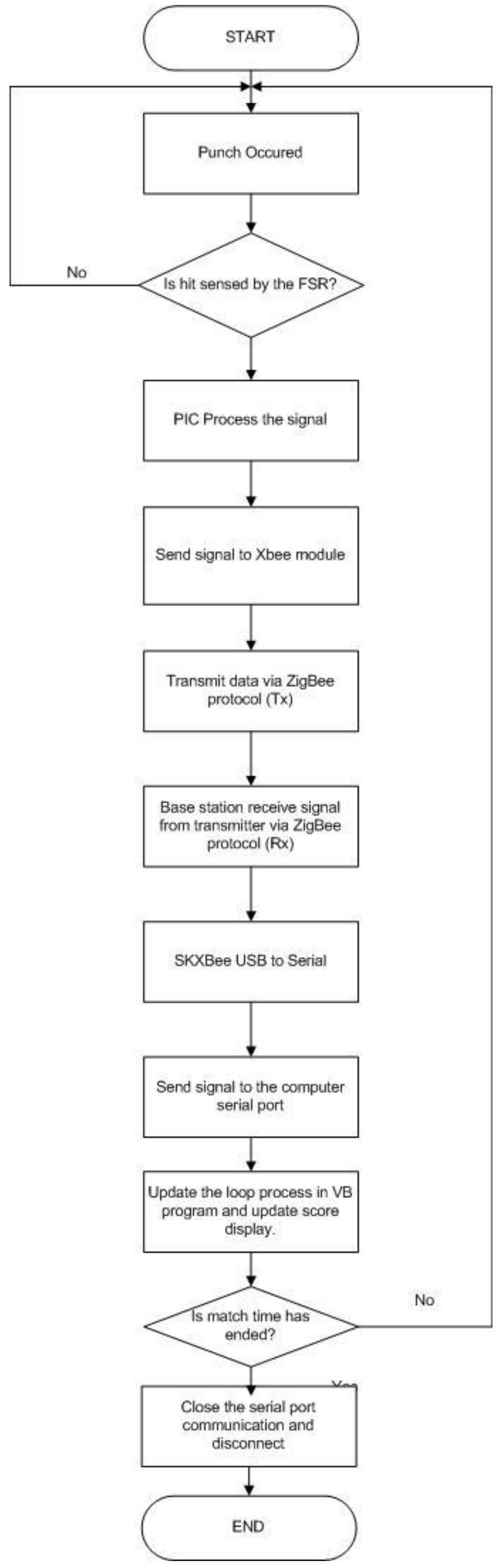

Figure 51: System Flowchart

APPENDIX E: SURVEY RESULTS

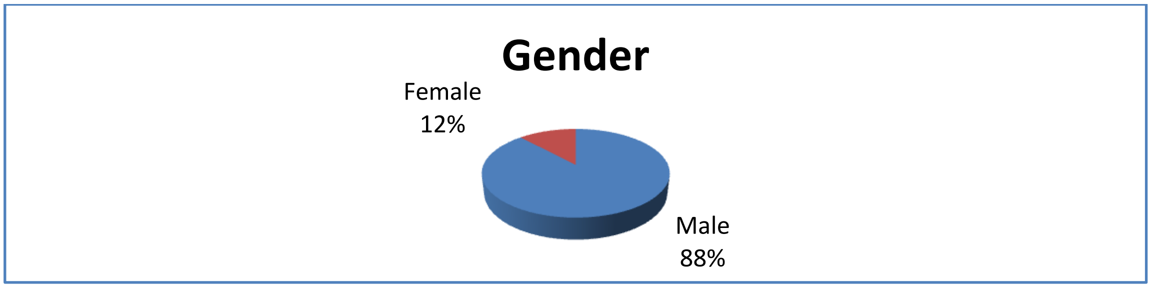

Figure 52: Gender of the respondents

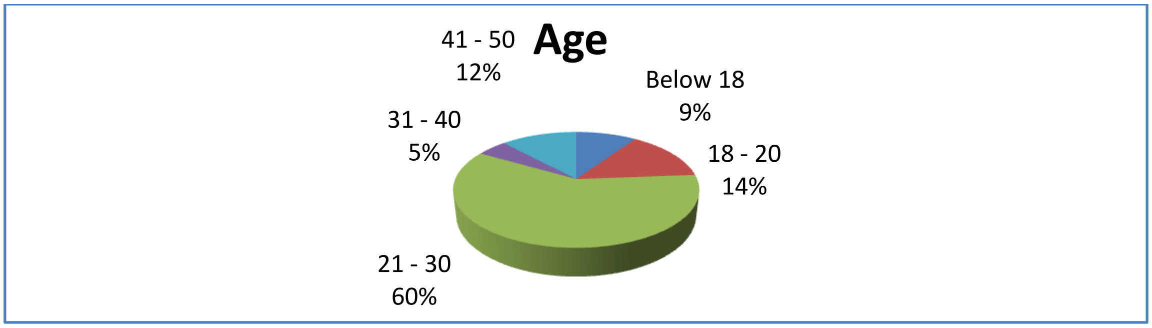

Figure 53: Respondents age

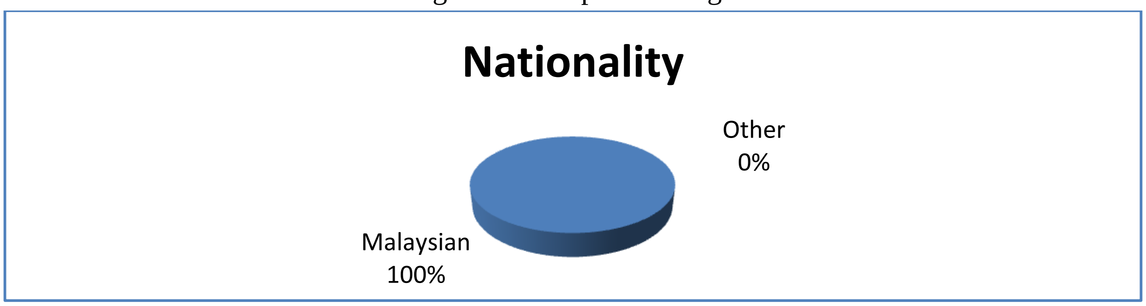

Figure 54: Nationality of the respondents

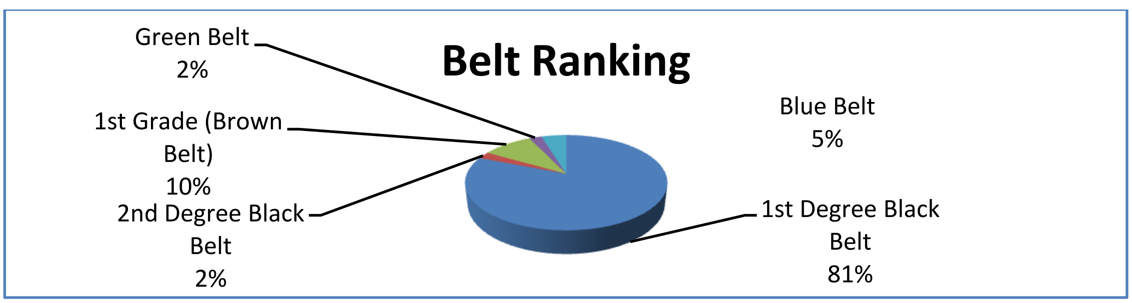

Figure 55: Belt ranking of the participants

APPENDIX E: SURVEY RESULTS

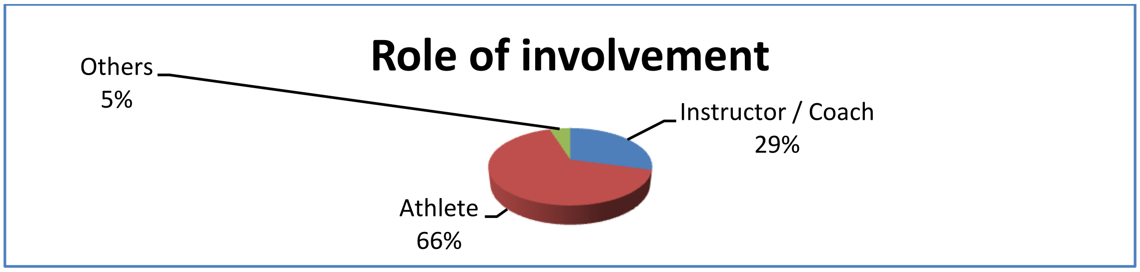

Figure 56: Respondent role of involvement in Sports Karate

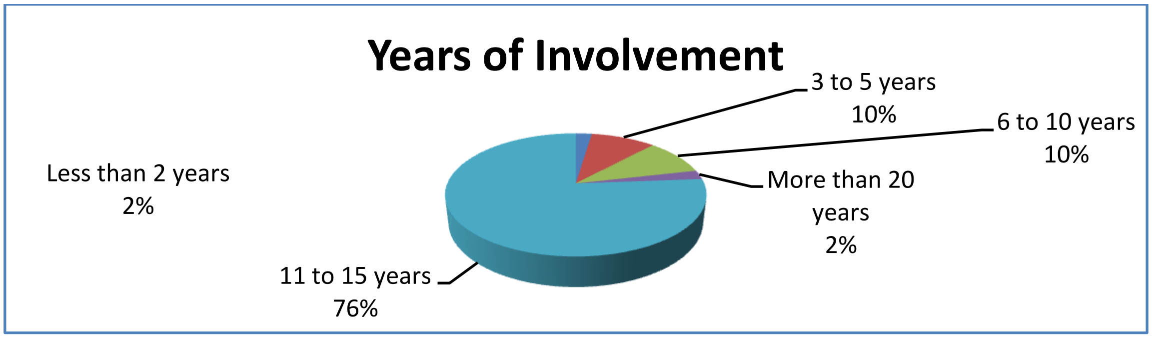

Figure 57: Years of involvement

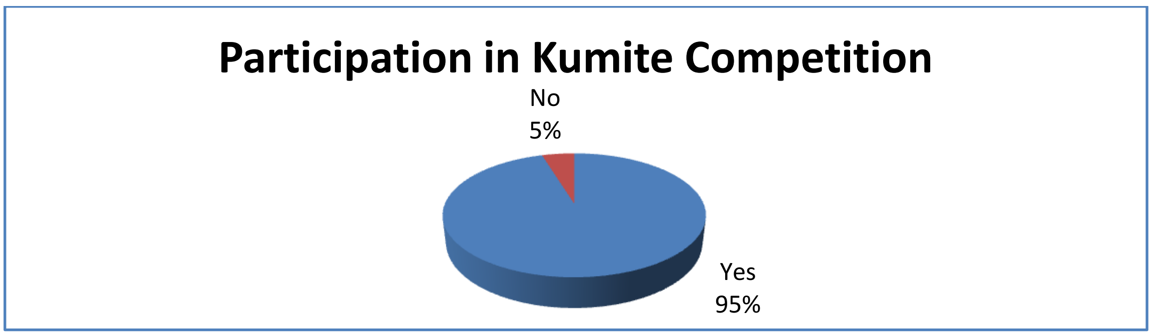

Figure 58: Participation in Kumite Competition

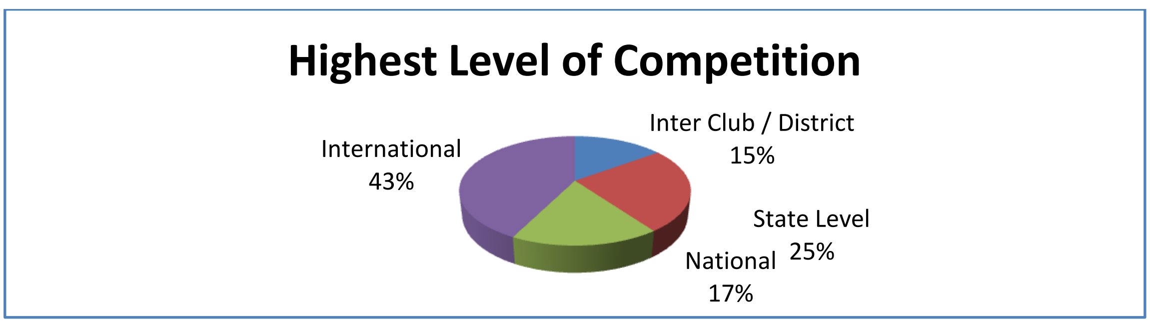

Figure 59: Highest level of competition

APPENDIX E: SURVEY RESULTS

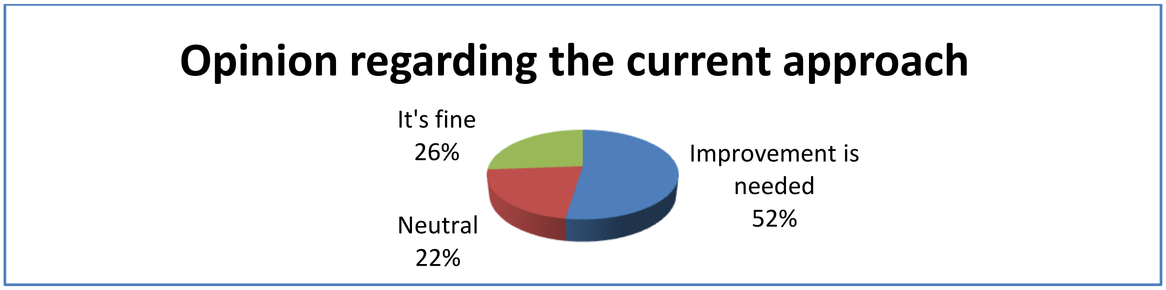

Figure 60: Opinion regarding the current approach

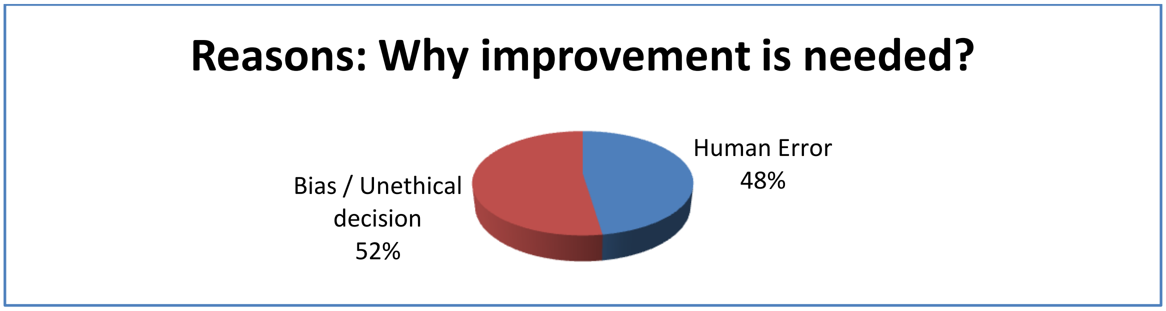

Figure 61: Reasons for needed improvement

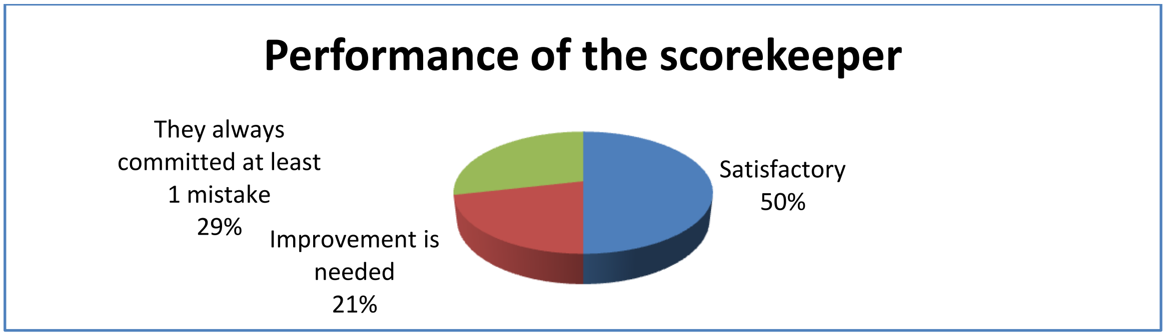

Figure 62: Performance of the scorekeeper

APPENDIX E: SURVEY RESULTS

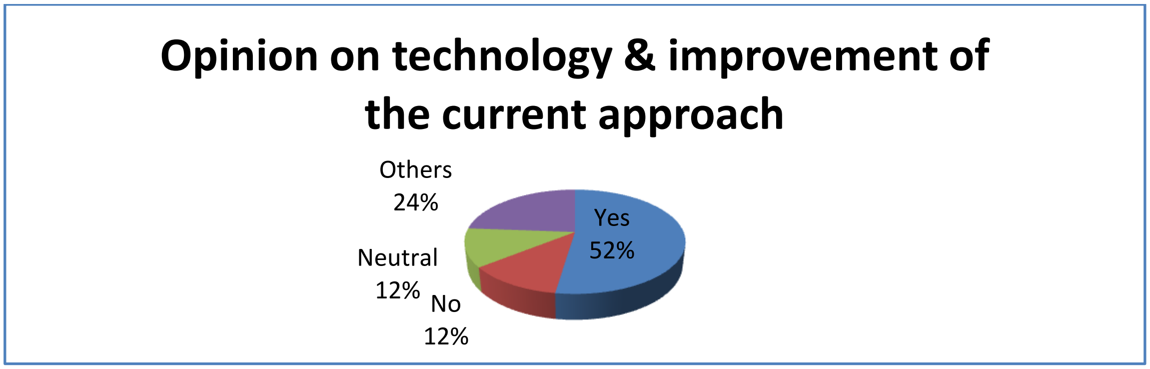

Figure 63: Opinion on technology & improvement of current approach

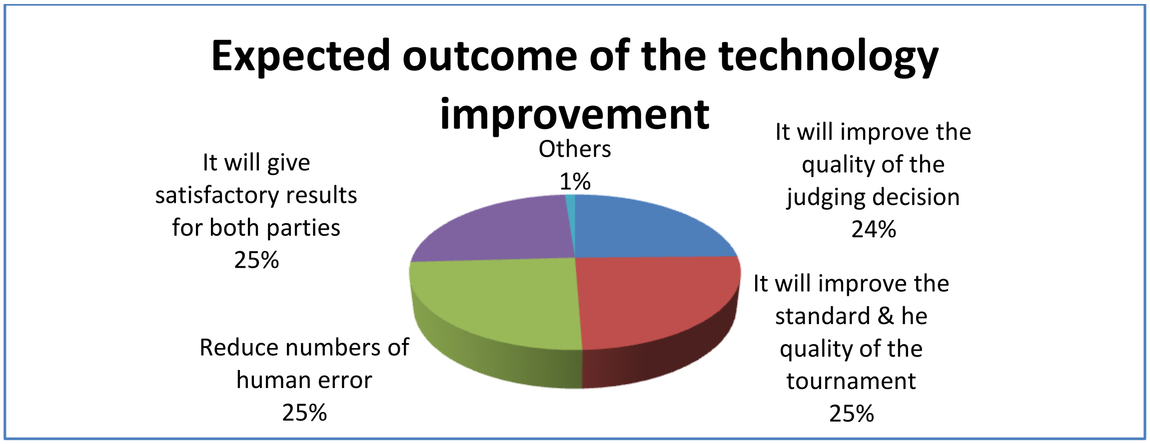

Figure 64: Expected outcome of the technology improvement

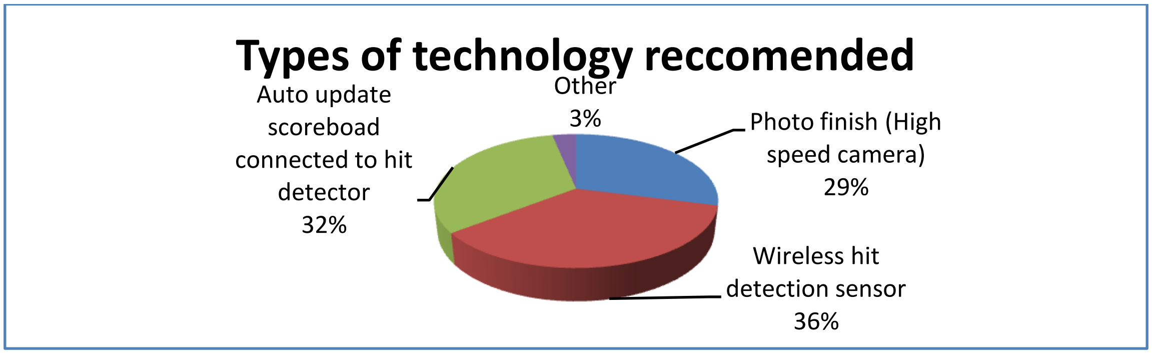

Figure 65: Types of technology recommended

APPENDIX F: FUNCTIONALITY TESTING RESULTS

Table 5: Functionality Testing Results

No	Function	Action Performed	Expected Test Result	Actual Test Result	Pass / Fail
1.	Transmitter and Receiver communication	Range testing using XCTU	Packet “Good” transmission will be shown in the XCTU Range Test Panel	“Good” packet of data obtained with 100% success (Figure: 66)	Pass
2.	Communication System	Press the “SEARCH” button	Connected COM port listed in the drop down list.	“COM3” listed in drop down menu (Figure:67)	Pass
		Select appeared COM Port & Press “CONNECT” button	Baud rate and connected port will be shown on the text box.	“9600” appeared in the baud rate Text box shows “COM3 Connected.” (Figure:67)	Pass
		Press” CONNECT” Without selecting COM Port	Notification appeared	Message box “Please select COM PORTS” Shown. (Figure: 68)	Pass
3.	Data transfer	Impact will be applied on the hand protector with the FSR	Score display will be updated	Input received by the receiver XBee, (SKXBee RX LED blinking), score display updated (Figure:38)	Pass
4.	Timer	Type ”1” in the SET MATCH DURATION” Text box	Countdown will be started for 1 minute. When “0” reached, program will be terminated.	Stop watch halted in “0”. Message box “Match ended” will be shown. (Figure: 69)	Pass

	Timer	Pressing “PAUSE” button	Stop watch will be halted	Stop watch is paused	Pass
5.	Foul Indicator	Press the 1st radio button for CATEGORY 1	“CHUKOKU” will be appeared in the text line	Successfully display text (Figure:70)	Pass
		Press the 2nd radio button for “CATEGORY 2”	“KEIKOKU” will be appeared in the text line	Successfully display text (Figure:70)	Pass
		Press the 5th radio button for “CATEGORY 1”	“SHIKAKU” will be appeared in the text line. Message box "DISQUALIFY" will be appeared	Successfully display text and message box (Figure:71)	Pass
		Press the 5th radio button for “CATEGORY 2”	“SHIKAKU” will be appeared in the text line. Message box "DISQUALIFY" will be appeared	Successfully display text and message box (Figure:72)	Pass

Figure 66: Successful loopback communication

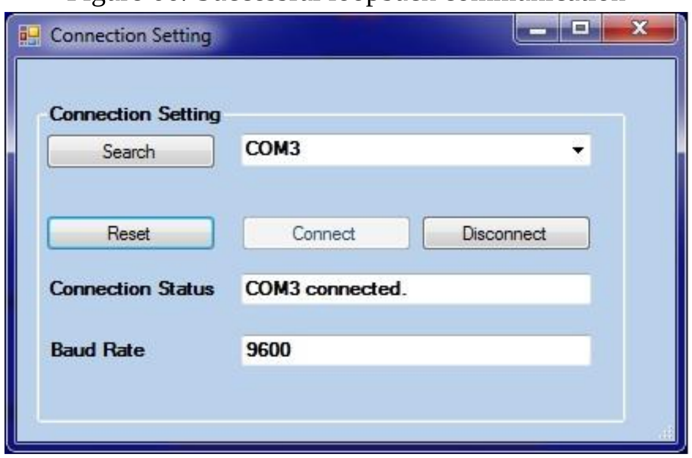

Figure 67: System connected to the available COM port

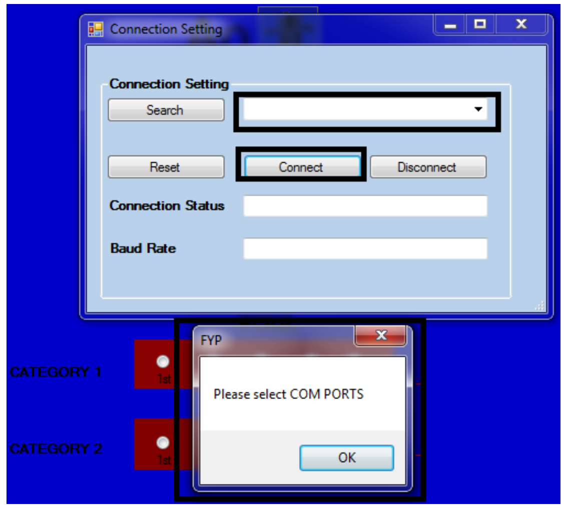

Figure 68: Attempt to connect without selecting COM port.

Figure 69: Timer countdown.

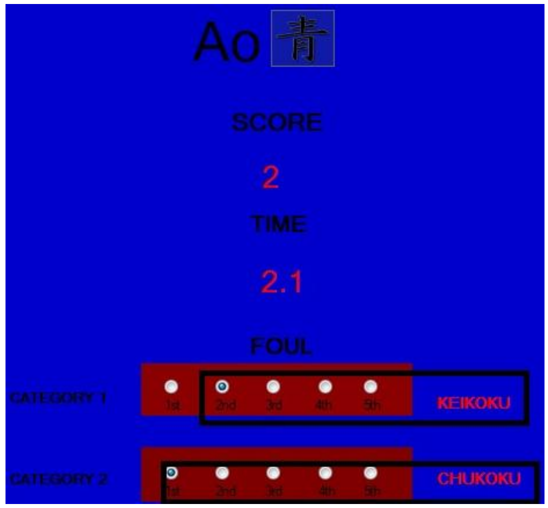

Figure 70: Foul indicator testing result

Figure 71: Foul indicator testing result, Category 1 disqualification.

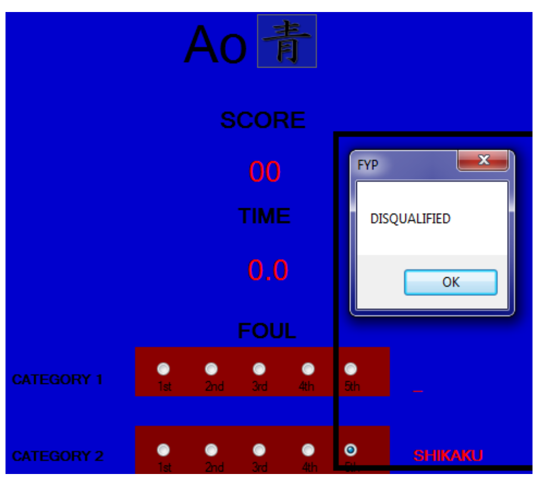

Figure 72: Foul indicator testing result, Category 2 disqualification.

APPENDIX G: PIC 16F877 MICROCONTROLLER CODING

```
#include <pic.h>
__CONFIG(0X3F32);
char FSR_IMPACT;
void tx_data(char); //Defining a sub-function.
void delay(unsigned long i);
unsigned int ADCRead(unsigned char ch);
void usart_init(void);
void uart_send(unsigned char data);
int read_a2d(unsigned char channel);
int adc;
void main(void)
{
//set each port and registries below here
//set I|O input output
TRISA = 0b00000001;  //configure PORTA I/O direction
TRISB = 0b00000000;   //configure PORTB I/O direction
TRISC = 0x80;            //configure PORTC I/O direction RC6 Input and 7 Output TRISD =
0b00000000;       //configure PORTD I/O direction
PORTB = 0x00;                  //Clear port B all output pin
PORTC = 0x00;               //Clear port C all output pin

PORTD = 0x00;
usart_init();
while(1)
{
  adc = read_a2d(0);
  uart_send(adc);
}}
```

```
void tx_data(char a){
putch(a); //UART write character (a). "A" first output frm PIC
delay(50);   //Delay for 50 milliseconds.
}

//Function to Initialise the ADC Module
void ADCInit()
{
ADCON1=0b10001010;
}
//Function to Read given ADC channel (0-13)
  unsigned int ADCRead(unsigned char ch)
{
if(ch>13) return 0;  //Invalid Channel
ADCON0=0x00;
ADCON0=(ch<<2);   //Select ADC Channel
ADON=1;  //switch on the adc module
GODONE=1;  //Start conversion
 while(GODONE); //wait for the conversion to finish
ADON=0;  //switch off adc
return ADRESL;
}
void delay(unsigned long i)
{
for (; i>0; i--);
}
```

```
void usart_init(void){
        SPBRG=129; //set baud rate as 9600 baud
        BRGH=1; //baud rate high speed option
        SYNC=0; //enable asychrounous mode
        TXEN=1; //enable transmission
        TX9 =0; //8-bit transmission
        RX9 =0; //8-bit reception
        CREN=1; //enable reception
        SPEN=1; //disable serial port
}


void uart_send(unsigned char data)
{
        while(TXIF==0);                    //only send the new data after
        TXREG=data;                        //the previous data finish sent
}

int read_a2d(unsigned char channel)
{
ADCON0=0b00000001;
ADCON1=0b10000000;
ADCON0=(ADCON0&0xC7)|(channel<<3);
delay(5);
ADGO=1;
while(ADGO==1) continue;
GODONE=1;
while(GODONE==1) continue;
return((256*ADRESH+ADRESL)/10.2);
```

APPENDIX H: VISUAL BASIC 2010 CODING

MAIN FORM

```
'Created by: Rex Alvin Francis
'Semester: May 2012
'FYP Title: Automatic Scoring System for Sports Karate
'Form Name:KaraScore
'This is the main form / public class for this program that contained the score
display,timer control, and serial communication function

Imports System
Imports System.ComponentModel 'To implement run time and design behaviour of
compenents and control
Imports System.IO.Ports ' To implement serial communication



Public Class KaraScore
    'Variable Definition
    Public transmitt As Integer
    Dim rec_data As String
    Dim rec_data1 As String

    Public WithEvents ComPort As New IO.Ports.SerialPort 'declare serial port
    Private comBuffer As Byte()
    Private Delegate Sub UpdateFormDelegate()
    Private UpdateFormDelegate1 As UpdateFormDelegate

    'When user load the form
    Private Sub KaraScore_Load(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles MyBase.Load
        For i As Integer = 0 To My.Computer.Ports.SerialPortNames.Count - 1
            Connection_Setting.ComPortBox.Items.Add( _
              My.Computer.Ports.SerialPortNames(i))
        Next

 'Handler that points the data received event to the name of the procedure that
does the work, using this line
        AddHandler ComPort.DataReceived, AddressOf ComPort_DataReceived

        'All radio button are set to default
        CK_1_CHUKOKU.TabStop = False
        CK_1_KEIKOKU.TabStop = False
        CK_1_HAN_CHUI.TabStop = False
        CK_1_HANSOKU.TabStop = False
        CK_1_SHIKAKU.TabStop = False
```

```
        CK_2_CHUKOKU.TabStop = False
        CK_2_KEIKOKU.TabStop = False
        CK_2_HAN_CHUI.TabStop = False
        CK_2_HANSOKU.TabStop = False
        CK_2_SHIKAKU.TabStop = False
    End Sub

    'when user closing the panel
    Private Sub KaraScore_FormClosed(ByVal sender As Object, ByVal e As
    System.Windows.Forms.FormClosedEventArgs) Handles Me.FormClosed
        Try
            ComPort.Close()
            transmitt = 0
        Catch ex As Exception

        End Try
     End Sub

    'To open the form for connection setting
    Private Sub Connect_setting_Click(ByVal sender As System.Object, ByVal e As
    System.EventArgs) Handles Connect_setting.Click
        Connection_Setting.ShowDialog()
    End Sub

    'To the open form for timer setting
    Private Sub Button2_Click(ByVal sender As System.Object, ByVal e As
    System.EventArgs) Handles timer_control.Click
        Time_setting.ShowDialog()
    End Sub

    Private Sub match_record_Click(ByVal sender As System.Object, ByVal e As
    System.EventArgs)
        DB.ShowDialog()
    End Sub

    'Timer control for the stop watch
    Private Sub Timer1_Tick(ByVal sender As System.Object, ByVal e As
    System.EventArgs) Handles Timer1.Tick
        watch.Text = watch.Text - 0.01
        If watch.Text = "0" Then
            Timer1.Enabled = False
            MsgBox("Match Ended")
            ComPort.Close()

        'stop timer and disconnect if match ended
        If watch.Text = Time_setting.set_match_dur.Text Then
            Timer1.Enabled = False
            MsgBox("Match Ended")
            ComPort.Close()
        End If

    End Sub
```

```
'To read COM Port for data
    Private Sub ComPort_DataReceived(ByVal sender As Object, ByVal e As
    SerialDataReceivedEventArgs)
    UpdateFormDelegate1 = New UpdateFormDelegate(AddressOf UpdateDisplay)
    Dim n As Integer = ComPort.BytesToRead() 'find number of bytes in buf
    comBuffer = New Byte(n - 1) {} 're dimension storage buffer
    ComPort.Read(comBuffer, 0, n) 'read data from the buffer
    Dim current_score As Integer = CInt(comBuffer(0))
    Me.Invoke(UpdateFormDelegate1) 'call the delegate
    End Sub


'To update the score
    Private Sub UpdateDisplay()
    Static display_score As Integer = 0
    MsgBox("Point Scored!: Yuko")
    display_score += 1
    score_display.Text = CStr(display_score)
    End Sub

'To reset the score display back to "00"
    Private Sub Button1_Click(ByVal sender As System.Object, ByVal e As
    System.EventArgs) Handles Button1.Click
    score_display.Text = "00"
    End Sub

'Radio button control for the "Category 1" foul

'Category 1, 1st penalty
    Private Sub CK_1_CHUKOKU_CheckedChanged(ByVal sender As System.Object,
    ByVal e As System.EventArgs) Handles CK_1_CHUKOKU.CheckedChanged
    cat_1.Text = "CHUKOKU"
    End Sub

'Category 1, 2nd penalty
    Private Sub CK_1_KEIKOKU_CheckedChanged(ByVal sender As System.Object,
    ByVal  e As System.EventArgs) Handles CK_1_KEIKOKU.CheckedChanged
    cat_1.Text = "KEIKOKU"
    End Sub

'Category 1, 3rd penalty
    Private Sub CK_1_HAN_CHUI_CheckedChanged(ByVal sender As System.Object,
    ByVal e As System.EventArgs) Handles CK_1_HAN_CHUI.CheckedChanged
    cat_1.Text = "HANSOKU-CHUI"
    End Sub

'Category 1, 4th penalty
    Private Sub CK_1_HANSOKU_CheckedChanged(ByVal sender As System.Object,
    ByVal e As System.EventArgs) Handles CK_1_HANSOKU.CheckedChanged
    cat_1.Text = "HANSOKU"
    End Sub
```

```vb
'Category 1, 5th penalty and termination of match
        Private Sub CK_1_SHIKAKU_CheckedChanged(ByVal sender As System.Object,
        ByVal e As System.EventArgs) Handles CK_1_SHIKAKU.CheckedChanged
        cat_1.Text = "SHIKAKU"
        Timer1.Enabled = False
        MsgBox("DISQUALIFIED")
        ComPort.Close()
        End Sub

 'Radio button controls for the “Category 2” foul

 'Category 2, 1st penalty
        Private Sub CK_2_CHUKOKU_CheckedChanged(ByVal sender As System.Object,
        ByVal  e As System.EventArgs) Handles CK_2_CHUKOKU.CheckedChanged
        cat_2.Text = "CHUKOKU"
        End Sub

'Category 2, 2nd penalty
        Private Sub CK_2_KEIKOKU_CheckedChanged(ByVal sender As System.Object,
        ByVal e As System.EventArgs) Handles CK_2_KEIKOKU.CheckedChanged
        cat_2.Text = "KEIKOKU"
        End Sub

'Category 2, 3rd penalty
       Private Sub CK_2_HAN_CHUI_CheckedChanged(ByVal sender As System.Object,
       ByVal e As System.EventArgs) Handles CK_2_HAN_CHUI.CheckedChanged
       cat_2.Text = "HANSOKU-CHUI"
       End Sub

'Category 2, 4th penalty
        Private Sub CK_2_HANSOKU_CheckedChanged(ByVal sender As System.Object,
        ByVal e As System.EventArgs) Handles CK_2_HANSOKU.CheckedChanged
        cat_2.Text = "HANSOKU"
        End Sub

'Category 2, 5th penalty and termination of match
        Private Sub CK_2_SHIKAKU_CheckedChanged(ByVal sender As System.Object,
        ByVal e As System.EventArgs) Handles CK_2_SHIKAKU.CheckedChanged
        cat_1.Text = "SHIKAKU"
        Timer1.Enabled = False
        MsgBox("DISQUALIFIED")
        ComPort.Close()
        End Sub

End Class
```

CONNECTION SETTING

```
Public Class Connection_Setting
  'Created by: Rex Alvin Francis
  'Semester: May 2012
  'FYP Title: Automatic Scoring System for Sports Karate
  'Form Name: Connection_Setting
  'When Connect button is pressed (To Connect)

 Private Sub Btn_connect_Click(ByVal sender As System.Object, ByVal e As
 System.EventArgs) Handles Button_connect.Click

      If KaraScore.ComPort.IsOpen Then
          KaraScore.ComPort.Close()
      End If
      Try 'check connection - all on comport group box
          With KaraScore.ComPort
              .PortName = ComPortBox.Text()
              .BaudRate = 9600 '115200
              .Parity = IO.Ports.Parity.None
              .DataBits = 8
              .StopBits = IO.Ports.StopBits.One

          End With
          BaudRate_msg.Text = KaraScore.ComPort.BaudRate

      'On ComPort text box
       KaraScore.ComPort.Open()
       ComPortDisp.Text = ComPortBox.Text & " connected."
       Button_connect.Enabled = False
       Button_disconnect.Enabled = True
       KaraScore.transmitt = 1
       Button_Search.Enabled = True
       Reset_button.Enabled = True


      Catch ex As Exception
          'MsgBox(ex.ToString)
          MsgBox("Please select COM PORTS")

      End Try
  End Sub
```

```
 'When Disconnect button is pressed (To cancel / disconnect)
 Private Sub Button_disconnect_Click(ByVal sender As System.Object, ByVal e As
 System.EventArgs) Handles Button_disconnect.Click


      Button_Search.Enabled = True
      Try
          KaraScore.ComPort.Close()
          ComPortDisp.Text = KaraScore.ComPort.PortName & " disconnected"
          Button_connect.Enabled = True
          Button_disconnect.Enabled = False
          KaraScore.transmitt = 0
      Catch ex As Exception
          'MsgBox(ex.ToString)
          ComPortDisp.Text = KaraScore.ComPort.PortName & " disconnected"
          Button_connect.Enabled = True
          Button_disconnect.Enabled = False
          KaraScore.Timer1.Stop()

      End Try
      End Sub

  'When Search button is pressed (To search available COMPorts)
  Private Sub Button_Search_Click(ByVal sender As System.Object, ByVal e As
  System.EventArgs) Handles Button_Search.Click
      ComPortBox.Items.Clear()

      For i As Integer = 0 To _
        My.Computer.Ports.SerialPortNames.Count - 1
          ComPortBox.Items.Add( _
             My.Computer.Ports.SerialPortNames(i))
      Next
      Button_disconnect.Enabled = False
  End Sub

End Class
```

TIMER SETTING

```
Public Class Time_setting
    'Created by: Rex Alvin Francis
    'Semester: May 2012
    'FYP Title: Automatic Scoring System for Sports Karate
    'Form Name:KaraScore
    'This form contain the control functions of the timer/stop watch



    'Clear Set match duration text box
    Private Sub clear_button_Click(ByVal sender As System.Object, ByVal e As
    System.EventArgs) Handles clear_button.Click
        set_match_dur.Text = ""
    End Sub
    'Start the timer/stop watch count down
    Private Sub start_time_Click(ByVal sender As System.Object, ByVal e As
    System.EventArgs) Handles start_time.Click
        KaraScore.watch.Text = set_match_dur.Text
        KaraScore.Timer1.Enabled = True
    End Sub

    'Halt/pause timer/stop watch count down
    Private Sub pause_time_Click(ByVal sender As System.Object, ByVal e As
    System.EventArgs) Handles pause_time.Click
        KaraScore.Timer1.Enabled = False
    End Sub



    'Reset the timer/stop watch to 0.0
    Private Sub reset_time_Click(ByVal sender As System.Object, ByVal e As
    System.EventArgs) Handles reset_time.Click
        KaraScore.Timer1.Enabled = False
        KaraScore.watch.Text = "0.0"
    End Sub


    Private Sub Time_setting_Load(ByVal sender As System.Object, ByVal e As
    System.EventArgs) Handles MyBase.Load

    End Sub
End Class
```

APPENDIX H: TECHNICAL REPORT

Automatic Scoring System for Sports Karate

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Abstract The objective of the project is to design an automated scoring system for the Kumite or Sparring category in Karate as to improve the conventional scoring system in the World Karate Federation (WKF) by means of sensors and wireless communication technology. The main challenge of this project is to create an accurate and interactive scoring system to solve the shortcomings in the conventional approach, in particular the human errors and the tendency of being bias by the tournament referee and judges. Implementation of sensors on the approved hand protector with a combination of microprocessor and ZigBee wireless communication protocol are the main components in the prototype.

Keywords: Karate, Kumite, Automated Scoring Systems, Ubiquitous Computing, XBee, Zigbee.

1. Introduction

The evolution of the Ubiquitous or Pervasive Computing Technology is not only giving an impact towards individual modern daily lifestyles. Besides, this scope of technology has been further implemented in the sports arena. The combination of sensors, data-communication, and processing ability have assisted numbers of athletes and coaches in various fields of sports in terms of performance improvement and efficiencies achieved on both training and competition (Dennis P et.al., 2011) Numerous data can be recorded by means of sensors during the training session and in competitions. The recorded data can then be transmitted to any remote stations for further analysis (Baca A, 2009). After the martial art Karate has been modernized as a sport back in 5 decades ago, other than making review and changes in the rules and regulations of this sport [10] there was very little effort in creating an electronic system or using wireless technology to enhance the conventional scoring system. It is no doubt that the conventional scoring system is very vulnerable to error and also prone to the unethical judging procedures and decision. Therefore, there is a need of technology assisted scoring system to overcome these shortcomings. Besides, other than avoiding unethical act and the hassle caused by human error, it will also help to promote a better and fair standard of tournament. The proposed prototype uses the Force Sensitive Resistor (FSR) to serve as a hit detection sensor. The detected hit signal will be transferred to a score displaying unit by a pair of XBee Series 2 transceiver that communicates through ZigBee communication protocol (base on IEEE 802.15.4 framework) [12]. XBee Series 2 was chosen due to its capability of data transfer within the range of 10 meters, a distance that is able to cover the standard Karate competition area (8 meters). XBee Series 2 is capable of high speed data transmission. It uses 2.4 Ghz frequency band [12]. The system interface was developed mainly by Visual Basic 2012. Figure 1 shows the basic overview of the architecture of the proposed prototype.

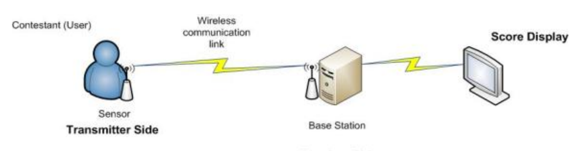

Figure 1: Basic system architecture

Project objectives

This project comes with two objectives. Firstly, to create an accurate and automatic scoring system that will overcome the problem of human error and unethical act (bias judging decision). Secondly, to create an interactive and integrated system for hit detection and score display unit.

2. Methodology

Rapid Application Development (RAD) was chosen for this project development. This is due to the time constraint of the project that is less than 10 months. RAD will assist to speed up the whole development process since it implements quick design phase that emphasizes the usability and functionality of the system (Dennis A et.al, 2005).

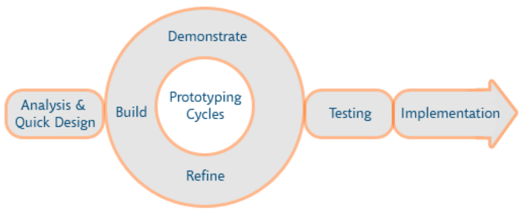

Figure 2: Rapid Application Development

2. A) Project phases:

The phases of the project were divided into:

System Planning

For the first stage of the project, the initial requirements are based on the information collected from the requirement gathering procedure. Information gathering was done by having ~~a~~ random interviews and informal conversations with sports Karate practitioners, such as athletes and instructors with various tournament experiences. Information is also gathered through related journals and publications. Besides that, in this phase Work Breakdown Structure (WBS) is conducted to depict the entire task and the status.

System Analysis

Thorough information gathering were performed by distributing survey questionnaire to the sports Karate Practitioners. This is to ensure that information obtain for the system planning is relevant with the project's goals.

System Design

This phase provides direction on how the proposed system will be built. Shown in Figure 3 is the overall architecture of the proposed prototype that consists of 3 different parts (Transmitter, Base Station, and the Computer). This phase is also involved the design of the system interface.

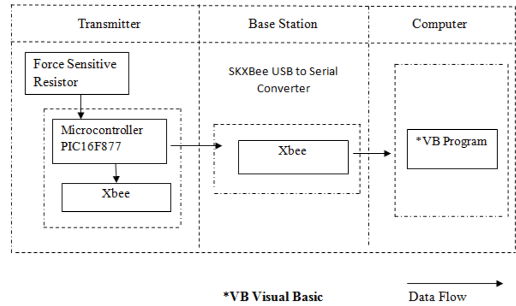

Figure 3: Overall system architecture

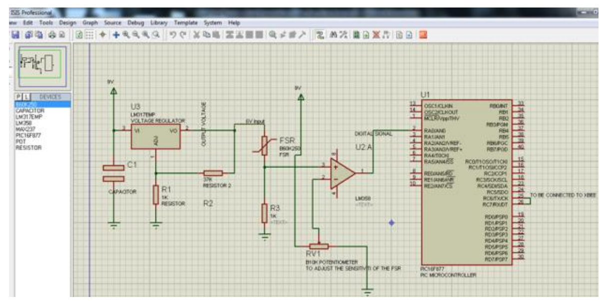

Figure 4: Preliminary hardware design

System Implementation

The system transmitter will be constructed by assembling the hardware components according to the steps shown in Figure 6. The FSR is tested in order to know the characteristic that will further decide the configuration of the microcontroller. The test reveals that the sensor produces 2 milivolts of output, whereby it is below the minimum operational voltage of the microcontroller that requires the input to be at least 2 volts [7]. Therefore, the signal will be amplified using LM358 Operational Amplifier (Op-Amp) by combining both of the FSR and Op-Amp to create a Variable Threshold Switch [4]. The integration caused the FSR to create a "switching" effect once impact or force is being applied on it. The microcontroller, the PIC16F877 was programmed to perform the Analog to Digital (A2D) conversion. MPLAB v8.63 IDE was used for the code development purpose.

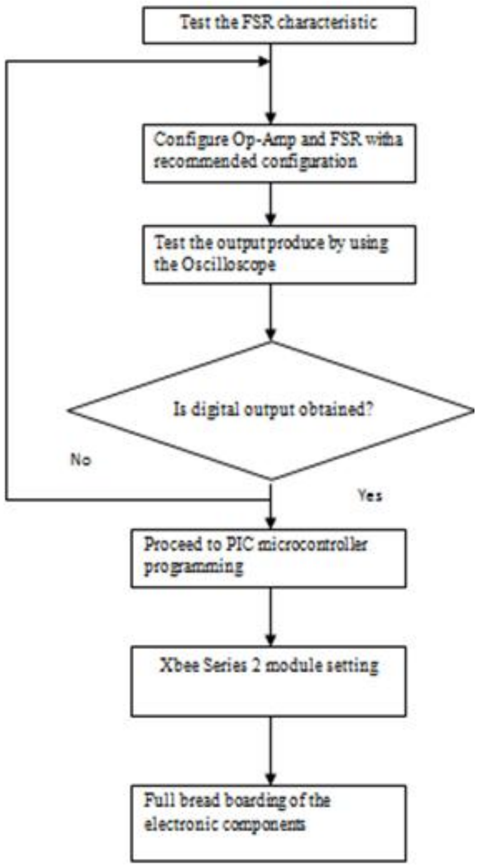

Figure 6: Steps of hardware assembly

```
int read_a2d(unsigned char channel)
{
ADCON0=0b00000001;
ADCON1=0b10000000;
ADCON0=(ADCON0&0xC7)|(channel<<3);
delay(5);
ADGO=1;
while(ADGO==1) continue;
GODONE=1;
while(GODONE==1) continue;
return((256*ADRESH+ADRESL)/10.2);
}
```

Figure 7: Microcontroller function code for A2D conversion.

Completed codes are compiled and converted into .Hex format that was loaded into the microcontroller using the PICkit2 programmer. The implementation phase continues with the configuration of the XBee Series 2 using the API dedicated for the module configuration, the XCTU.

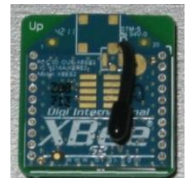

Figure 8: XBee Series 2 module

Figure 9: Destination address of the transmitter (left) and receiver (right) base on each module serial number

Both of the XBee Series 2 transceivers were configured to perform 2 way point-to-point communication function. Figure 9 shows the destination address setting for each of the XBee modules. Finally, all components will be fixed on the breadboard to create the complete transmitter device for the system prototype.

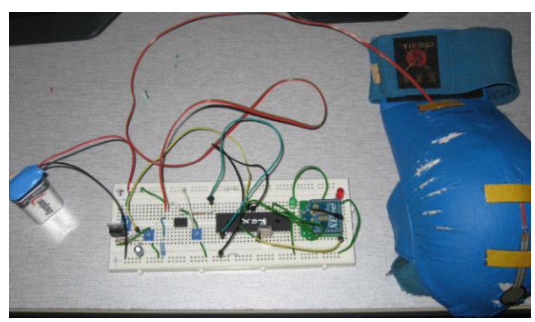

Figure 11: Prototype of the tranmitter circuit with FSR attached on the standard hand protector

Figure 12: Receiver at the base station (computer)

The system interface was designed base on the requirements of the World Karate Federation, whereby the current score, penalty issued and timer count down should be displayed [12]. Besides functioning as a displaying unit, system configuration such as connection and timer setting will be performed through the system interface. The system interface is configured to search for the active serial (COM) ports in the computer that is connected to the receiver (base station). Figure 13 is the port listening function that enable the system to received signal in an unexpected time upon the connection with the active serial port has been initiated.

```
'To read COM Port for data
Private Sub ComPort_DataReceived(ByVal sender As Object, ByV
    UpdateFormDelegate1 = New UpdateFormDelegate(AddressOf U
    Dim n As Integer = ComPort.BytesToRead() 'find number of
    comBuffer = New Byte(n - 1) {} 're dimension storage buf
    ComPort.Read(comBuffer, 0, n) 'read data from the buffer
    Dim current_score As Integer = CInt(comBuffer(0))
    Me.Invoke(UpdateFormDelegate1) 'call the delegate
```

Figure 13:Visual Basic function for port listening

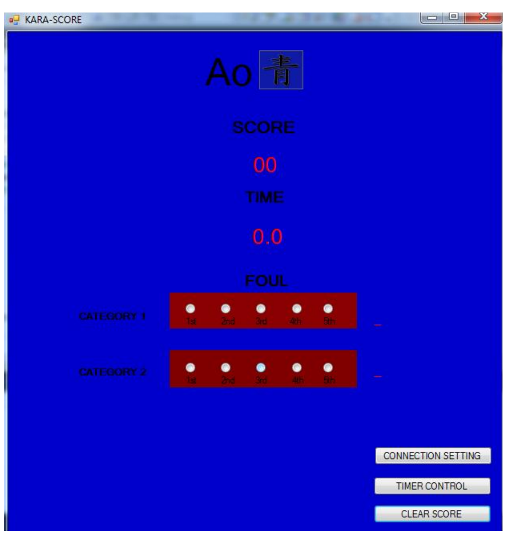

Figure 13: System Interface

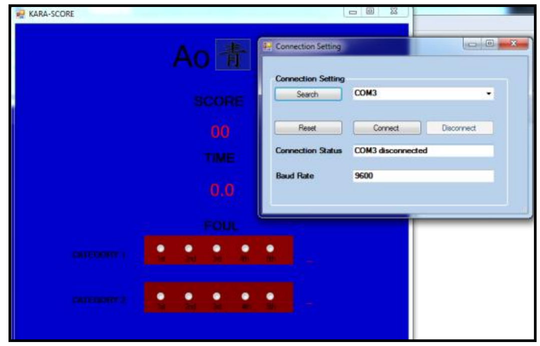

Figure 14: Connection setting

System Testing (Prototype evaluation)

The prototype will be checked for any unfulfilled requirements. Since the RAD Methodology is being applied for this project, the process of prototyping (system analysis, design, and system implementation) will be repeated continuously the entire requirements have been satisfied. This is also a stage intended to detect any error that might exist in the system by running a set of test cases to evaluate the overall performance of the prototype.

System Deployment

Lastly, after the desired prototype has been fully completed, it will reach the final phase or the System Deployment. In this stage, the ability of the system will be demonstrated in the real scenario. However, in order to achieve this stage, extensive effort of miniaturization is necessary to make the device to be wearable and can be used by the Karate athlete in the real environment.

Results and Discussions

The results from the executed test cases in the System Testing phase have shown that the system is able to perform all the basic functionalities i.e. connection and data transfer, score display, timer count down, and the foul indicator. The most important is the ability to update the score display once the signal from the transmitter is received (Figure 15). However, technical issue does exist whereby sometimes two different signals is generated by the sensor when impact has occurred causing the system to execute the loop of score display update twice. The issue is caused by the nature of the Force Sensitive Resistor that is built by a thin film resistor material that sometimes will produce another output voltage or signal once the pressure is being released.

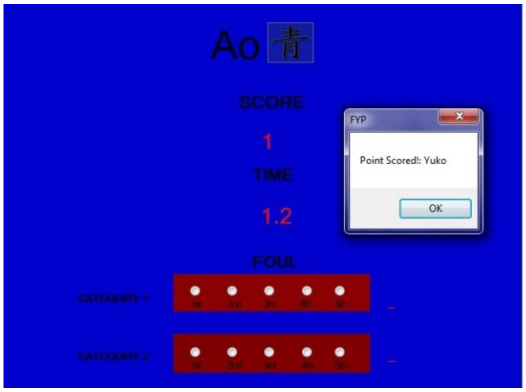

Figure 15: Result of the data transfer testing

Conclusion

The positive outcomes of the executed test cases show that both of the objectives of this project have been accomplished by getting the desired system automation. Hence, the created proposed prototype has also fulfilled the criteria of the World Karate Federation especially in terms of the design of the score display unit.

Recommendations and Future works

To further improve the hit detection function, sensor that is more accurate should be used. FSR that sometime does not permit an accurate hit detection whereby there is a tendency multiple signals are being generated within a short time. Also, FSR does not guarantee an accurate reading if it is not mounted on a flat surface (e.g. standard karate hand protector). Therefore, finding an alternative for more accurate sensor is advisable. Moving on, the system can be enhanced by adding a database capability to enable details such as match information to be recorded for future reference, such as total score of the contestant.

Other than that, sensor can be implemented in the foot protector in order to enable hit detection from kicking technique. The hardware prototype must be miniaturized as small as possible, thus it can be used in the real scenario of Karate competition. Lastly, to make the system to be accepted in the real sporting arena, collaboration should be made with the related sports governing bodies such as the Malaysian and the World Karate Federation. Endorsement from both agencies will enable the adoption of the system by updating the available rules and regulations that will ensure the usage of the proposed system to be accepted into the practice.

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