DECLARATION

I hereby, declared this report entitled "Portable Wireless Heart Rate Monitor for Elderly Patients" is the results of my own research except as cited in references.

Signature : …….

Author's Name : ……

Date : ……

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electronics Engineering Technology (Telecommunications) with Honours. The member of the supervisory is as follow:

……

(Project Supervisor)

ABSTRAK

Kadar jantung adalah data yang penting bagi manusia untuk meramalkan keadaan kesihatan mereka. Melalui kemajuan teknologi, orang boleh memantau kadar jantung mereka sendiri melalui mesin ECG dan beberapa peralatan perubatan yang lain. Namun, alat-alat ini perlu mengambil sedikit masa untuk mengukur kadar jantung pengguna. Sesetengah peranti juga keras untuk membawa bersama-sama kerana saiz yang besar dan berat badan mereka. Oleh itu, projek ini akan memberi tumpuan kepada pemantauan jangka panjang bagi pesakit tua yang dibenarkan untuk tinggal di rumah mereka di bawah sahabat ahli keluarga atau jururawat swasta dan ia adalah mudah untuk membawa bersama-sama.

Projek ini menggunakan kesederhanaan Arduino UNO dan plug and play sensor kadar jantung untuk Arduino sebagai tulang belakang projek ini. Bagi pemantauan mudah, Bluetooth akan digunakan sebagai medium untuk menghantar data dari Arduino supaya membuat pengguna lebih mudah untuk memantau kadar jantung melalui telefon pintar mereka.

Akibatnya, pengguna akan dapat memantau kadar jantung melalui telefon pintar dengan memasang Terminal Bluetooth dalam telefon pintar mereka dan menyambung ke modul Bluetooth yang digunakan dalam projek ini. Kadar jantung ditunjukkan akan berada dalam bentuk yang berterusan di mana kadar jantung pengguna akan dikesan di setiap saat.

ABSTRACT

Heart rate is a significant data for human to predict their health condition. Through the advancement of technology, people are able to monitor their own heart rate through ECG machine and some other medical devices. Yet, these devices need to take some time to measure the heart rate of user. Some devices are also hard to bring along as of their large size and of their weight. Hence, this project will focus on a long-term monitoring for elderly patients who are allowed to stay at their home under the companion of their family member or a private nurse and it is easy to bring along.

This project utilise the simplicity of Arduino UNO and a plug and play heart rate sensor for Arduino as the backbone of this project. As for easy monitoring, Bluetooth will be used as a medium to transmit the data from Arduino so making user more easy to monitor the heart rate through their smartphone.

As a result, user will be able to monitor heart rate through smartphone by installing Bluetooth Terminal in their smartphone and connect to the Bluetooth module used in this project. The heart rate shown will be in a continuous form where the heart rate of user will be detected in every second.

ACKNOWLEDGEMENT

Firstly, I would like to thank to my supervisor, Mdm. Izadora binti Mustaffa for providing me the title of this Final Year Project. Without my supervisor, I would have been clueless about what to do for my final year project. Also, my supervisor has been guiding us in writing the report for final year project. As I know, under Puan Izadora, there are twelve students with twelve different project titles. Yet, she is able to memorize all of them and also helped to develop ideas for the content in the report and ensure that we excel in our final year project. I would also like to thank my panel, Mr. Nurulhalim bin Hashim and Puan Siti Haryanti binti Hairol Anuar for taking time to listen to my presentation and evaluate my project report. Their comments have elevated the project to become potentially more commercial. I am highly indebted to all of them.

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CHAPTER 1

Introduction

1.0 Introduction

This chapter will present all the description of this research which is about the Portable Wireless Heart Rate Monitor for Elderly Patients (PWHRM) by declaring the background and the objectives and also the scope of this project. The objectives of this project are to solve the problem statements declared in this chapter.

1.1 Background of Project

Heart attack has been a major cause of death rate in the world. In our country, coronary heart disease is ranked number one in our country's death causes as recorded in world life expectancy (World Health Rankings 2014). Elderly patients are more prone to having a heart attack. Hence, to easily observe the heart rate of an elderly patient or patient with heart diseases, the idea of wireless heart rate monitor is produced. Accident can happen at anywhere and anytime. Although there is no proof that heart rate is linked with heart attack, it is always better to monitor pulse and heart rate from time to time although symptoms of heart attack is not directly linked to heart rate.

A heart rate monitor is a device that measures a user's heart rate. The heart rate monitor has an electrode attached to the skin to monitor the electrical voltages in the heart. Then, a radio signal is transmitted, which measures the user's heartbeat. The receiver then translates this into beats per minute or percentage of a theoretical maximum heart rate.

1.2 Problem Statement

For elderly patient, their health condition is unstable and their heart condition depends only on their heart rate. They have slower heart rate caused by the abnormalities of their heart rhythms(Knutson 2014) . The slow heart rate of an elderly patient may vary from time to time and may not recognised by the patient's family Hence, their heart rate need to be monitored periodically using the ECG machine in the hospital.

Some elderly patients are reluctant to stay in the hospital and wanted to stay at home with their family members. Since there are chances that the patient is living alone and there are no anyone besides him, if any incident happens, it is difficult for an elderly patient to call for help. Hence, PWHRM could solve the problem and notify the patient's family member about his/her heart rate.

1.3 Objectives

The purposes for this project are:

1) To identify which microcontroller will be used
2) To identify the circuit of the portable heart rate monitor
3) To design wireless heart rate monitor

1.4 Scope of Work

A variety of microcontroller will be studied and compared. The specification of each microcontroller will be studied and the most suitable microcontroller for this project will be chosen at the end.

The circuit of PWHRM will be construct after the study of the connection of a battery to power on the Arduino board to make it portable. The connection of the pulse sensor and Bluetooth module to the Arduino board will also be studied.

Several heart rate sensors and wireless technologies will be studied based on their pricing and specification. After comparing these, the optimal sensor and wireless technology will be decided for this project.

1.5 Thesis Outline

This report consists of five chapters, including introduction (Chapter 1), literature review (Chapter 2), methodology (Chapter 3), result and discussion (Chapter 4) as well as conclusion (Chapter 5). The theory and implementation of the project with title "Portable Wireless Heart Rate Monitor for Elderly Patients" will be discussed in details in this report.

Chapter 1 consists of the overview of this project. In this chapter, background, problem statement, objectives, work scope, block diagram as well as thesis outlines of this project is explained in detail.

Chapter 2 consists of overview of related equipment concerning heart rate and pulse measurement projects which related to the application of heart rate monitor that had been conducted by other researchers. A brief introduction of the relevant projects will be discussed in this chapter. The function and information about the technology and components used in this project will be explained in detail.

Chapter 3 consists of the methods used to implement this project. Hardware development as well as software development of the project and operation of the circuit will be explained in this chapter.

Chapter 4 consists of the results of this project. The performance of the portable heart rate monitor will be explained in details in this chapter. Problems that occurred during the implementation of this project will be also discussed in this chapter.

Chapter 5 concludes the project's performance and applicability in real life situation. Recommendation for future work to improve the PWHRM is described.

1.6 Conclusion

The background and the motivation of project has been explained. The work scope basically outline the steps need to be carried out in order to fulfill the objectives. Last but not least, the outline of this thesis is also stated at the end of this chapter.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

The heart rate and pulse is often confused since both are calculated using beat per minute (bpm). However, the difference is that heart rate is measured from the thorax with the transmitter of heart rate monitor or through electrocardiograph (EKG). While pulse is the mechanical pulse of blood flow in capillaries caused by the contractions of the heart in sixty seconds. Pulse can be measured from earlobe or fingertip using a pulse meter or photocell sensor. When used outdoor, the changes in ambient light will affect the result of pulse meter.

2.1 Heart Rate Monitor

A heart rate monitor is a device that measures a user's heart rate. The heart rate monitor has an electrode attached to the skin to monitor the electrical voltages in the heart. Then, a radio signal is transmitted, which measures the user's heartbeat. The receiver then translates this into beats per minute or percentage of a theoretical maximum heart rate.

A normal heart rate is in placed 60 to 100 beats per minute (bpm). A man who is extremely athletic, may has a kindness heart rate as low as 40 bpm. According to Edward Laskowski of the Mayo Facility, if an adult with lower heart rate, it means that the function of the heart is more efficient and the person can perform cardiovascular exercises better (Knutson, 2014).

2.1.1 How the heart works

The heart is a muscle that pumps blood into circulatory system. The pumping action is caused by the electrical system of the heart, which leads to heartbeat. When the heart beats, it will send electrical impulses. The American Heart Association states that in a time frame of 70 years, a person's heart can beat up to 2.5 billion times and pumps around 2000 gallons of blood and beats 100.000 times each day. Yet, one is able to experience an abnormal heart rate. Abnormal heart rate occurs when the frequency of the electrical impulses is changed suddenly, which is called arrhythmia. Hence, a heart rate can goes too fast or too slow (Knutson, 2014).

When a heart beats too slow, it is called bradycardia, a term which used for heart rate is under 50 bpm. Elderly may experience bradycardia with a higher frequency. Although a low heart rate may not resemble danger, yet, it may cause some side effect such as fainting, dizziness, light-headedness and fatigue (Healthwise Staff, 2011).

Similarly, when a heart beats too fast, it is called tachycardia, a scientific term used to describe people with a high heart rate with 100 bpm. This condition is often seen in the elderly. Tachycardia may be caused by unhealthy lifestyle, hypertension, hyperthyroidism and many other reasons. This could cause shock, pain, anaemia, dizziness and sometimes chest pain (Nordqvist, 2015).

Table 2.1: Bradycardia and Tachycardia

Arrhythmia	BPM	Causes	Effect
Bradycardia	< 50	• Medicines • Infections • Hypothyroidism	• Fainting • Dizziness • Light-headedness • Fatigue
Tachycardia	> 100	• Hypertension • Hyperthyroidism • Unhealthy lifestyle	• Shock • Pain • Anaemia • Chest pain

2.3 Review of Related Works

2.3.1 Heart Rate Monitoring and Data Transmission via Bluetooth

After reviewing the work "Heart Rate Monitoring and Data Transmission via Bluetooth" by (Prasad Kumari Nisha, Yadav Vinita, 2015), the heart rate of a user is detected by a pulse sensor. Similar to this project, their project is also used Arduino as the microcontroller and the model is Arduino UNO SMD R3 to determine the heart rate beat per minute (BPM). In their work, they used Bluetooth as the medium to transmit the heart beat or data to the LCD display through serial communication and the graphical form of the heart beat can be viewed from the monitor using Sensor graph, which is an Android application which receives data from the UNO board.

Besides, they also installed a software named Amarino, which is compatible to the Android operating system. This software allows user to interface between Arduino library and their smart phone. As this, the project is quite low in cost as they used Bluetooth and some free software.

2.3.2 Heartbeat Monitoring and Alert System Using GSM Technology

As a means of making heart rate monitor portable and flexible, the work "Heartbeat Monitoring and Alert System Using GSM Technology", by (Ufoaroh S.U ; Oranugo C.O; Uchechukwu M.E, 2015), was conceived by researches. It explains how much consideration and improvements has been made in to the functionality of the device in terms of cost, design, size, weight and portability.

This project uses another type of sensor which is an IC sensor or miniaturized pulse sensor which claimed to have a high sensitivity towards changing in heart rate and another wireless technology which is GSM. To calculate the heart rate, this project also used Arduino UNO as the microcontroller and a LCD display to show the heart rate of the user and will also send current BPM value via SMS. This project also includes a buzzer where the buzzer will set off an alarm when the BPM value is above

or under a fixed value. This can alert the user or people around the user that the heart rate of the user is abnormal.

This heart rate monitor is also portable where the size is small and the LCD display has replaced the pc display. This project also emphasizes on long range where there is no limit of distance for the wireless technology to be functioned as this project used GSM technology. This means that a patient's heart rate is notifiable even though the patient is out for a work or out for a walk. This project also features another interesting configuration where user can reconfigure the program to suit the style of the user.

2.3.3 XBee Wireless Sensor Networks for Heart Rate Monitoring in Sport Training

In the work title "XBee Wireless Sensor Networks for Heart Rate Monitoring in Sport Training"(Zulkifli et al., 2012) . This project used some different component compared to others work. The amount of component of this project is a little higher than others work and also the model of Arduino of this project is different. The model of Arduino of this project is Arduino –Nano ATmega168. The components for this project were a Garmin Heart Rate Strap and ANT+, a receiver nRF24AP1, a XBEE transmitter and a XBEE receiver.

The cost of this project is little higher than others work as a Garmin device is involved in this project. This project used the concept of peer to peer (P2P) network where a connection is established between the receiver and the ANT+ and mesh network is also established to centralize all the data. Before a heart rate data is being transmitted to the centralized centre, the heart rate data will be stored and a unique ID will be given to the heart rate data by the nRF24API. The centralized centre is consist of XBEE receiver and a computer. The functioning range of this project is up to 100m just by using XBEE. The power consumption for this project is also higher than other project as an additional of 3.3V is required to power up both XBEE and nRF24API. This project is special if compare to others work. This project used some high-tech

component and is able to monitor two-person heart rate at the same time. This can be done by using two Garmin Strap which has different serial number.

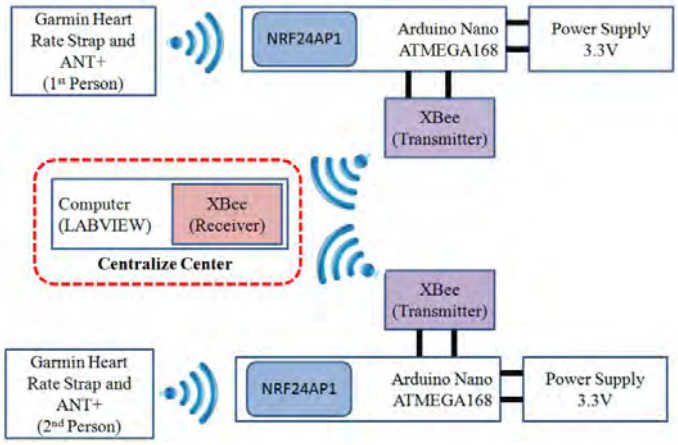

Figure 2.1: Block Diagram of the System

2.3.4 Summarization

There are several systems in existence that was developed with similar function. Three of these systems are reviewed and studied. The results are tabulated in Table 2.2.

Table 2.2: Summarization of reviewed work

Reference	Measured parameter	Sensor	Wireless Datacom type
Prasad	Heart rate	Pulse sensor	Bluetooth
Ufoaroh	Heart rate	IC sensor	GSM
Zulkifli	Heart rate	Garmin Heart Rate Strap	XBee

From the three reviewed work, each of these systems has their own advantages and disadvantages. For the work from Prasad, the cost is quite low as it utilizes free application. Yet, user is unable to monitor their heart rate without sitting in front of a laptop as it is not portable.

The system developed by Ufoaroh is portable and flexible. User can bring along this system to anywhere they wanted. One of the advantages of this system is that it included a buzzer as an alarming component so that if the user's heart rate is above or below the fixed value, the buzzer will set off an alarm to notify the people

around. User could monitor their heart rate on a LCD display. The disadvantages of this system is that it required user to purchase another sim card or periodically top-up the credit of their sim card as this system uses GSM as a medium to transmit the data.

Zulkifli developed a system which is meant for the purpose of monitoring heart rate for athletes. The advantage of this developed system is it can monitor the heart rate of two persons at the same time using LABVIEW on the computer. Because of this, this system required two sets of components. Hence, causing the cost of this system is quite high compared to other systems.

2.3 Review of Hardware

There are several microcontrollers available in the market that is suitable for this project. Table 2.1 is the summarization of key parameters for Arduino UNO and Raspberry Pi Model B.

Table 2.3 : Comparison between Arduino UNO and Raspberry Pi

Name	Arduino UNO	Raspberry Pi
Price	RM 90	RM 105
Size	2.95”x2.10”	3.37”x2.125”
Processor	ATMega 328	ARM11
Digital GPIO	14	8
Analog Input	6-10 bit	N/A
Dev IDE	Arduino tool	IDLE, Scratch, Squeak/Linux

2.3.1 Arduino UNO

Arduino UNO is a microcontroller board based on the ATmega328. It includes 14 digital input/output pins, where 6 of the pins are for PWM outputs. Below is the image of Arduino UNO.

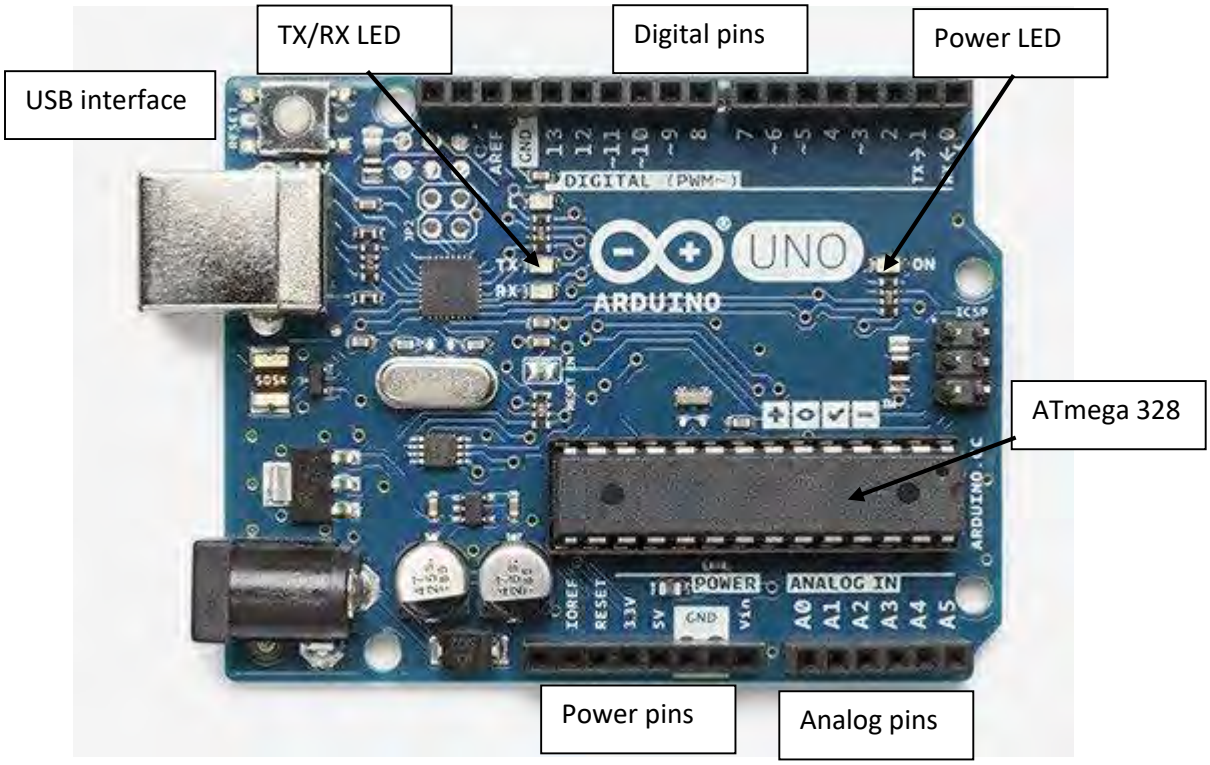

Figure 2.2: Arduino UNO board (Arduino UNO 2016)

On the left side of Figure 2.2 is the original Arduino UNO board without the labelling of some significant component on the board and on the right side is the UNO board with labelling of component. The analog input consists of 6 pins, a 16MHz crystal oscillator, a USB connection for programming, a power jack for power supply, an ICSP header, and a reset button.

To turn on the UNO board, simply insert a USB connection or with an external power supply. The board will automatically choses its power source. External non-USB power source can come from an AC-DC adapter or simply a battery. The adapter can be connected by plugging a centre-positive plug into the power jack. If using a battery, the leads from the battery can be inserted into the ground (Gnd) and Vin pin of the POWER connectors. The recommended voltage of power supply to the board is 7V-12V. If the voltage is less than 7V, is afraid that the board will become unstable and if the voltage is more than 12V, high voltage may damage the board.

The UNO board has 32kB of flash memory, 2kB of SRAM as well as 1kB of EEPROM, which comes from ATmega328. From the 14 digital pins on the board,

every each of them can be function as input or output. Each of them operates at 5 volts. Each pin has their own specialized functions. Pin 0(RX) and Pin 1(TX) are used to receive and transmit transistor-transistor logic (TTL) serial data. They are connected to the corresponding pins of ATmega328 USB to TTL serial chip.

Pins 2 and 3 as External Interrupts: These pins can be configured to trigger an interrupt on a low value, a rising or falling edge or a change in value. The details can refer to attachInterrupt() in Arduino programming.

PWM outputs are Pins 3, 5, 6,9,10, and 11. These pins could provide a 8-bit PWM output with the analogWrite() function. SPI Communication are for Pins 10, 11, 12, and 13 support SPI communication. Even though it is provided by the underlying hardware, yet currently it is not included in the Arduino language.

Pin 13 is connected to a built-in LED where the LED will on when the pin is on HIGH and vice versa. Besides digital input and output, the board also consists of 6 analogue inputs. Each of them provides 10-bit resolution, which is same to $2^{10} = 1024$ different values. By default, they will measure 5 volts from ground. However, the upper limit and the range of UNO can be changed using the AREF pin and analogReference() function.

The board can be programmed with free download Arduino software. After downloading the software, go to Tools>Board menu and select "Arduino UNO w/ ATmega328". For further details, user can see the reference and tutorials. The machine language used for Arduino is Arduino language, which is similar with basic C/C++ programming where it is easier to learn and use when compared to Raspberry Pi and Beagle Bone as user need not to learn extra machine language such as Linux.

Apart from this, the board has an auto reset feature. Every time a new coding is uploaded to the board, it will automatically reset and delete the old coding inside the bootloader. User can disable this feature by cutting the trace on the board. If user want to enable the auto reset feature, use can solder the trace with labelled "RESET-EN". Another way to disable the auto reset feature is to connect a 110-phm resistor from 5V to the reset line.

2.3.1.1 Technologies in ATmega328

ATmega328 is a single chip microcontroller found in the UNO board. It is a low-power CMOS 8-bit microcontroller based on enhanced RISC architecture. The parameters of ATmega328 will be shown in the table below.

Table 1.4: Parameters of ATmega328(ATmega 2016)

PARAMETERS	VALUE
Flash	32 Kbytes
RAM	2 Kbytes
Pin Count	32
Max. Operating Frequency	20 MHz
CPU	8-bit AVR
# of Touch Channels	16
Hardware QTouch Acquisition	No
Max I/O Pins	26
Ext Interrupts	24
USB Interface	No
USB Speed	No

As in the Table 2.2, the 32kB flash memory of the UNO board is provided by this single chip microcontroller as well as the 1kB EEPROM and 2kB of SRAM.

Complementary metal-oxide semiconductor stands for CMOS, a modern technology used to develop ATmega328. This technology is used in the semiconductor field where most of today's microchips are manufactured by using this technology. Semiconductors are made of silicon and germanium, materials which conduct electricity only under certain circumstances. By doping, impurities such as phosphorous and boron are added into the semiconductor and making them becomes a full scale conductor either as a N-type (electron carrier) or a P-type (hole carrier). In CMOS technology, these 2 types of transistor are used in an interrelating way that a current gate will be formed and electrical can be control effectively. Theoretically,

CMOS is better in power consumption. Hence, CMOS allows very high integration (Jain, 2012).

Reduced Instruction Set Computing (RISC) is another modern technology used in developing ATmega328. RISC is designed to carry out a smaller number of computer instructions and this provides higher performance when combined with microprocessor architecture. Hence it can operate at higher speed which it will perform millions of instructions per second.

Here are some advantages of RISC. In RISC architecture, it is possible to develop a faster and simpler microprocessor. By this, the coding of microprocessor will be easier and more space can be used on the microprocessor. More efficient code can be produced with a higher level of compilers as RISC tend to use smaller set of instructions (Gillette, 2005).

2.3.2 Raspberry Pi

Raspberry Pi is a cheap, credit-card sized computer. To use it, user need to plug into a monitor and use a standard keyboard and mouse. The programming language for Raspberry Pi is Scratch and Python. As it is a microcomputer, hence, it can perform like a desktop computer, from web browsing, to playing high-definition games(Horan, 2013).

Raspberry Pi 3 is the third generation of Raspberry Pi model after Raspberry Pi 1 and Raspberry Pi 2. Raspberry Pi 3 operates using a 1.2 GHz 64-bit quad-core ARMv8 CPU. It has an 802.11n wireless LAN and Bluetooth 4.1.

Raspberry Pi might be difficult for some user as the algorithm for Raspberry Pi is Linux or Scratch. User need to fully understand the algorithm for Raspberry Pi as the computer language of Linux/Scratch is much more difficult than C or C++ language. Raspberry Pi can be considered as an advanced version of computer language programming.