

Design of Real Time Heart Rate Monitoring System With ARDUINO UNO R3 Based on Android Application

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Abstract—The heart is an important organ for humans. Heart disease has claimed many lives. It happened because not everyone can do regular heart checks. High cost and time wasted could be the reason. Even a lot of heart disease is detected when a disease was so severe that treatment be late. Though the heart is the organ that affects other organs, in other words, the good performance of the heart as the source of much-needed work of other organs. One of the things that can be done is to check regularly to determine the condition of the heart through a number of heartbeats per minute. By knowing the condition of the heart then anyone can change the pattern of life and maintain food intake better, so that the heart will change to a more healthy condition. Therefore the heart rate monitoring system application to be made. Only by writing gender and age, everyone can use it and do not have to wait for a medical expert. The application can determine the condition of the heart in good condition, weak or bad through the calculation of the number of heartbeats using easy way, so that they can consult with medical experts and of course heart health can be maintained without taking expensive and complicated way, simply by changing lifestyle and exercise regularly. This application runs on Android based smartphones that connected to ARDUINO UNO R3 modul to detect heart rate.

Keywords—heart rate; heart condition; android; arduino

I. INTRODUCTION

Android is an operating system based on Linux for mobile devices that includes an operating system, middleware and applications. Android provides an open platform for developers to create applications. In this research, android use to design heart rate monitoring system to periodic check heart condition manually. This application can reduce cost and time wasted that maybe needed if check heart condition at hospital.

The problem that identified in this research is how to design heart rate monitoring system based on android system so anyone can periodic check their heart condition with low cost and not wasted time. Restrictions given in the design is:

- Minimum system is Android v2.2 (Froyo).
- Use Arduino Uno R3 with pulse sensor to detect heartbeat.
- Android app created with software Juno Eclipse Service Release 2.

- Classification of heart condition based on age and gender with the measurements on the conditions do not perform activities.
- Heartbeat condition that produced a good performance to bad levels, and furthermore conditions based on self-care to consult with the medical

II. HEART

Heart is the center of the circulatory system of humans and other animals. The human heart has 4 rooms . The room is part of the "auricle" while the two spaces below it called "the chambers of the heart". Bulkhead that connects between the chambers and the right auricle called bicuspid Valva (Pearce , 2007).

In contrast to the right, the left chamber and foyer are Valva trikuspidalis (tri:three), amounting to three pieces of muscle. Obtained from the literature , different numbers of Valva is actually a result of human adaptation because it reflects the amount of work the valve from the heart. That is the right hand side function only pump blood into the pulmonary artery dirty (arteries : heart out, pulmo : the lung). Well part of the left side to work harder so Valva trikuspidalis maintain blood flow to the heart so forth. This is due to the function of the left ventricle heart pump blood throughout the body clean through the aorta (major artery).

Function from the left ventricle that is heavier (to pump blood around the body) so it takes a stronger heart muscle, therefore, the muscle mass of the left ventricle thicker than the heart muscle on the left wall. Parts of the human heart may be seen in Figure 1.

A. Heart Rate

Rate is an examination of an artery or arteries. Speed measured pulse is measured at several points such as the radial artery pulse at the wrist, brachial artery in the upper arm, the carotid artery in the neck, on the back of the knee popliteal artery, the artery dorsalis pedis or posterior tibial arteries in the legs.

Heart can be used as an indicator of health, it can be observed with the increase in pulse rate at rest. The right time to check the pulse rate is when we wake up in the morning and before doing any activity. At that time we still relaxed and the body is still free from substances such as

nicotine and caffeine bullies. We can check for yourself by feeling the pulse of our particular body part.

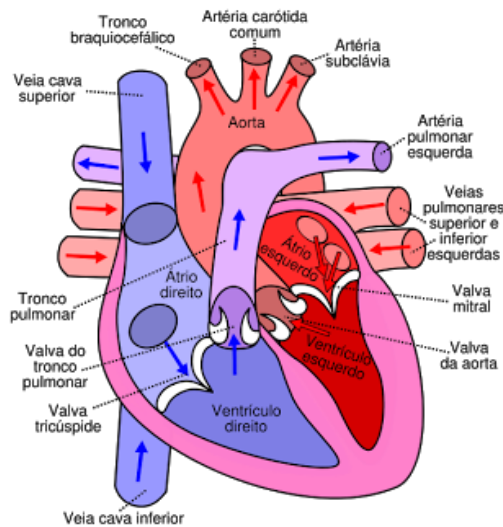


Figure 1. Human heart

Goals determine the amount of a person's heart rate is:

- To know the working of the heart
- To determine the diagnosis
- To immediately aware of any abnormalities in a person's

While places calculating heart rate is:

- Radialis Artery : On the wrist
- Temporal Artery : In the temple bone
- Caratis Artery : On the neck
- Femoral Artery : In the groin
- Dorsalis Pedis artery : On the back foot
- Arterial Politela : On the knee crease
- Arterial Bracialis : At the elbow crease
- ICTUS Cordis : On the wall rib, 5-7

Factors affecting the heart rate is :

- Sex
Proper heart rate achieved at the maximum working women is higher than men. At the young men to work a maximum of 50 % on average work pulse reaches 128 beats per minute, the woman 138 beats per minute. At maximum working men work an average pulse reached 154 beats per minute and in women 164 beats per minute .
- Type of activity
Heavy or light work intensity effect on the pulse. Length of work, rest periods, and the rhythm of the work in accordance with the optimal capacity of humans to influence the pulse rate not to exceed the maximum limit. Limit the ability of work already accomplished when working pulse numbers (an average of 24 pulse during work) reached 30 beats

per minute and a resting pulse above numbers. Currently working pulse is not continuous uphill and after work to recover in resting pulse after ± 15 minutes.

- Seniors
Pulse rate will gradually settle oxygen needs during growth . In adults the effects of physiological age can affect the cardiovascular system. At older ages more than less mature age determination of the pulse can be trusted . Pulse frequency at different ages , between the ages of infancy to adult age. Pulse rate is highest in infants later pulse frequency declines with age.
- Weight loss
Obese individuals may have a higher heart rate range. This is because a larger body more and more burden on the heart to pump blood.
- Drug
Intake of various drugs can affect heart rate intensity.
- Medical Conditions
Those who memili heart disease, high blood pressure or diabetes, may have a higher heart rate. In addition, certain medical disorders also bring variations in heart rate. This is the reason why the pulse is used as a tool to diagnose health problems.
- The state of emotional or psychological
Psychological conditions may affect heart rate. Anger and excitement can accelerate one's pulse rate. Fear, anxiety, and sadness can also slow down a person's pulse rate .

B. Measurement of Heart Rate

Heart rate measurement is useful to determine the condition of the body with reference to sex and age. Table I describes how the criteria heart beat of a man by age. While in Table II is the condition of a woman's table. In the table are listed under several conditions including :

- VERY GOOD ONE
This condition is generally experienced by a person who focuses on a sports field. Intensity while resting heart rate will be more stable which indicates the condition of the body is very healthy. Because with exercise, heart health will work better .
- VERY GOOD
Number of human heartbeats by age and sex in a very good condition.
- GOOD
Number of human heartbeats by age and sex in normal conditions.
- MORE THAN ENOUGH
This condition shows the heart rate in a state is sufficient.

- **ENOUGH**
This condition shows that the performance of the heart in pretty good condition.
- **BAD**
In this condition, the heart rate in unfavorable circumstances.
- **VERY BAD**
Conditions such as heart rate shows that the heart in a bad state, it needs more attention.

III. ANDROID

Android is a Linux based operating system for mobile phones such as smartphones and tablet computers. Android provides an open platform for developers to create their own applications for use by a variety of mobile devices. Initially, Google Inc. bought Android Inc., newcomers who make software for mobile phones (Suprianto, 2012). Then to

develop Android, formed the Open Handset Alliance, a consortium of 34 companies for hardware, software, and telecommunications, including Google, HTC, Intel, Motorola, Qualcomm, T-Mobile, and Nvidia.

At the inaugural release of Android, November 5th, 2007, with the Open Handset Alliance Android states support the development of open standards on mobile devices. On the other hand, Google released the Android code under the Apache license, a license software and open standard mobile device.

In this world there are two types of distributors operating system Android. The first fully supported by Google or Google Mail Services (GMS) and the second is completely free distribution without direct support Google's otherwise known as the Open Handset Distribution (OHD).

TABLE I. MAN HEART RATE STANDART

Heart rate						
Age Condt.	18-25	26-35	36-45	46-55	56-65	65+
Very Good One	49-55	49-54	50-56	50-57	51-56	50-55
Very Good	56-61	55-61	57-62	58-63	57-61	56-61
Good	62-85	62-85	63-86	64-87	62-87	62-85
More than enough	86-89	86-90	87-90	88-91	88-91	86-89
Enough	90-93	91-94	91-95	92-96	92-95	90-93
Bad	94-101	95-101	96-102	97-103	96-101	94-99
Very Bad	102+	102+	103+	104+	102+	100+

TABLE II. WOMAN HEART RATE STANDART

Heart rate						
Age Condt.	18-25	26-35	36-45	46-55	56-65	65+
Very Good One	54-60	54-59	54-59	54-60	54-65	54-59
Very Good	61-65	60-64	60-64	61-65	60-64	60-64
Good	66-89	65-88	65-89	66-89	65-88	65-88
More than enough	90-93	89-92	90-93	90-93	89-93	89-92
Enough	94-98	93-96	94-98	94-97	94-97	93-96
Bad	99-104	97-102	99-104	98-103	98-103	97-104
Very Bad	105+	103+	105+	104+	104+	104+

A. Architecture of Android System

Android Operating System has the following main components (Suprianto, 2012):

- **Application**
Android provides a set of key applications such as: email client, the program Short Message Service (SMS), calendar, maps, browser, contacts, and others. All applications are written using the Java programming language.
- **Application Platform**
Framework for applications written using the Java programming language is the equipment used by all applications, both native applications on the phone such as contacts, SMS and boxes, as well as applications written by Google or Android developer. Android offers developers the ability to build innovative applications. Developers are free to take advantage of the device hardware, access location information, run background services, set alarms, and added a warning to the status bar. Developers have full access to the same framework APIs used by the main application. Framework application had the following parts:
 - Activity Manager
 - Package Manager
 - Windows Manager
 - Telephony Manager
 - Content Providers
 - Resource Manager
 - View System
 - Notification Manager
- **Libraries**
Android has a set of library C / C ++ used by the various components of the Android system. These capabilities are seen by the developers through application framework. Some of the main library are described as follows:
 - System C Library
 - Media Libraries
 - Surface Manager
 - LibWebCore
 - Scalable Graphics Library (SGL)
 - 3D Libraries
 - FreeType Library
 - SQLite
- **Android Runtime**
Is the location where the major component of the DVM placed. DVM is designed specifically for Android at run time in a limited environment, where limited battery, CPU, memory, and storage of data is a major focus. Android has an integrated tool that is "dx" which converts generated byte code of (. JAR) into a file (. DEX) so it becomes more efficient by

code to run on a small processor. It is possible to have some kind of DVM running on a single device at the same time. Core libraries written in Java and contains a set of classes, I / O and other equipment.

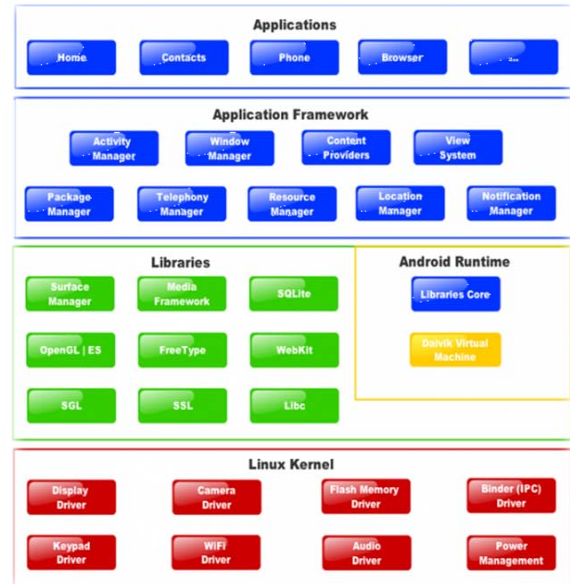


Figure 2. Android Architecture

- **Linux Kernel**
Android architecture based on Linux 2.6 kernel that can be used to manage security, memory management, process management, network stack, and driver models. The kernel also acts as an abstract layer between the hardware and the entire software stack.

B. Android SDK (Software Development Kits)

Android SDK is a tool for programmers who want to develop applications based on google android. Android SDK includes a comprehensive set of development tools. Android SDK consists of a debugger, libraries, handset emulator, documentation, sample code, and tutorials (Suprianto, 2012). Android currently supports x86 architecture on Linux (any distribution to modern desktop), Mac OS X 10.4.8 or greater, Windows XP or Vista. Requirements include the JDK, ApacheAnt and Python 2.2 or later. Officially supported IDE is Eclipse 3.2 or more by using the Android Development Tools plugin (ADT), with the developer can use a text editor to edit Java and XML files and use the command line tools to create, build, debug your Android applications and device control Android (eg, reboot, installing software package with remote).

Android apps bundled into the format .apk and stored in the folder /data/app. Users can run the command adb root to access the folder because the root has permission to access the folder.

Appearance of the Android SDK Manager application can be seen in Figure 3.

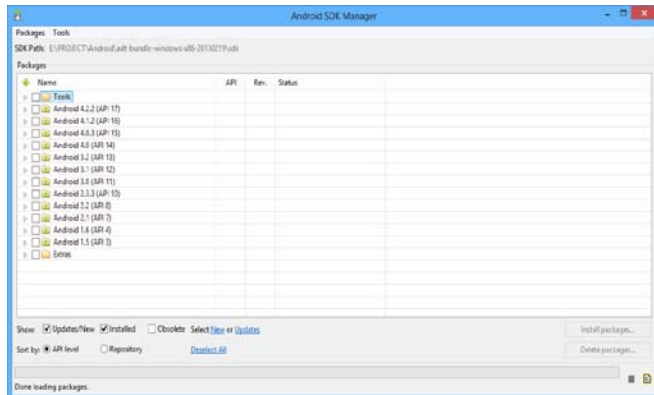


Figure 3. Android SDK Manager

C. Android Development Tools (ADT)

Android Development Tools (ADT) plugin for Eclipse is designed for Android application development. ADT allows Eclipse to be used in making a new Android app, making user interface, adding a component based framework API Android, application debugging, and packaging Android applications. Android Development Tools configuration software is:

- Open Eclipse.
- After the Eclipse window is open then we need to install the ADT Plugin in Eclipse so that Eclipse can recognize tools - tools that exist on Android.
- Choose Help → Install New Software. After that it will display a window like Figure 4.

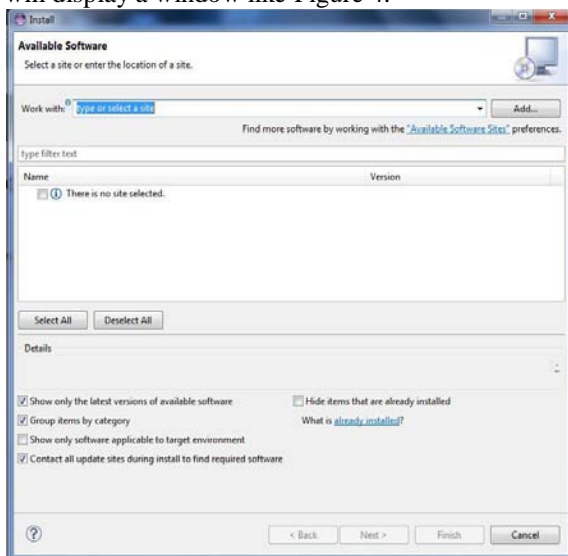


Figure 4. ADT Windows installation

- In the above window we will perform the installation process on the Eclipse ADT plugin. This installation

process requires an internet connection then make sure the laptop / pc connected to the internet.

- In the Install window click the Add button. Then will appear the window "Add Repository" in the Name the contents of the "ADT Plugin" and the contents of the Location section: "https://dlssl.google.com/android/eclipse/" and press Ok. This process is shown in Figure 5.

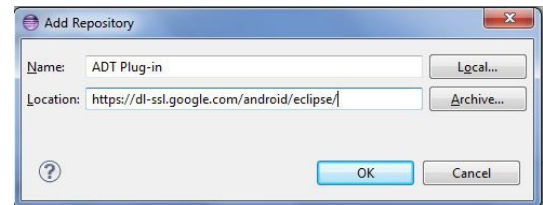


Figure 5. Add Repository ADT Plug-in

- After the above process, we will return to the Install window. In the Install window there will be several options. Mark on the Developers Tools and then press Next. Eclipse will check availability and validity. If there is no problem, press Next, accept the agreement and press Finish granted. Eclipse will download and install the desired packages. Wait for it to finish then Restart Eclipse.

IV. ARDUINO UNO R3

Arduino Uno R3 is a microcontroller board based on Atmega 328. This kind of Arduino has 14 pin I/O digital (of which 6 pin can be used as PWM outputs), 6 analog inputs, 16 MHz ceramic resonator, USB type B port connection, a power jack, ICSP header, and a RESET button. For input voltage Arduino Uno R3 obtained from various sources including computer via USB cable, AC-DC adapter or battery to run this board (Arduino, 2013).

Arduino Uno does not use the FTDI USB driver chip-to-serial as used on other types of Arduino. Arduino Uno R3 has used Atmega16U2 features, whereas for type Atmega8U2 used only up to version R2. Atmega series converter is programmed as a USB-to-serial. Arduino Uno R3 has the Atmega16U2 resistor connected to ground, making it easier to put into DFU mode. For full specifications on the Arduino Uno R3 can be seen in Table III.

Arduino Uno R3 has the addition of new features. Among added SDA and SCL pins are close to the AREF pin. Then the RESET and IOREF pins which allows to adapt to the voltage provided from the board. This kind has not-connected pins that used as a reserve for the purpose of development. Then the removal of the RESET button on the side of the Board. The latter is the use of Atmega16U2 replace Atmega.

"Uno" means "one" in Italian and giving the name as a mark of Arduino 1.0 release. Uno and version 1.0 to version of the Arduino reference for further developments. Arduino

Uno is the latest in a series of USB Arduino board, and a reference model for the Arduino platform, as a comparison with the previous version.

TABLE III. ARDUINO UNO R3 SPESIFICATION

Parameter	Specification
Microcontroller	Atmega328
Operation Voltage	5V
Input Voltage (recommendation)	7-12V
Input Voltage (limit)	6-20V
I / O Pin Digital	14 (6 as PWM output)
Pin InputAnalog	6
DC I / O Pin	40 mA
DC Pin 3.3V	50 mA
Flash Memory	32 KB (Atmega328)
SRAM	2 KB (Atmega328)
EEPROM	1 KB (Atmega328)
Speed	16 MHz

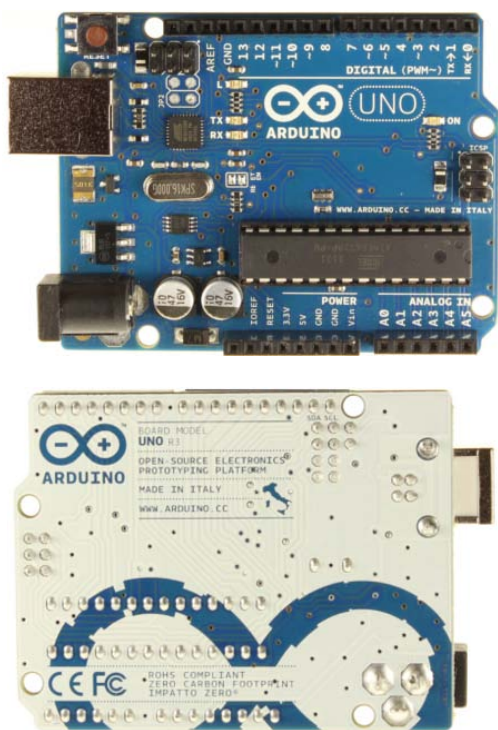


Figure 6. ArduinoUnoR3

Arduino Uno R3 can be seen in Figure 6. Arduino Uno can be powered via the USB connection or with an external power supply. Resources will be selected automatically. External (non-USB) power can be derived from the AC-DC

adapter or battery. In the AC-DC adapter input can be connected by plugging a connector size 2.1 mm with center-positive plug into the already available on board. While the use of batteries can be inserted into the Gnd and Vin pin headers of the power connector.

Arduino Uno R3 can operate on an external voltage 6 to 20 volts. Although the Arduino Uno R3 can be voltage less than 7V, however, this has resulted in instability. Then when using a voltage of more than 12V, the voltage regulator and the heat will damage the board. The recommended voltage is 7 to 12 volts.

V. DESIGN

Block diagram of the heart rate measuring device uses pulse-sensor based on Arduino Uno R3 that integrated with android system can be seen in Figure 7.

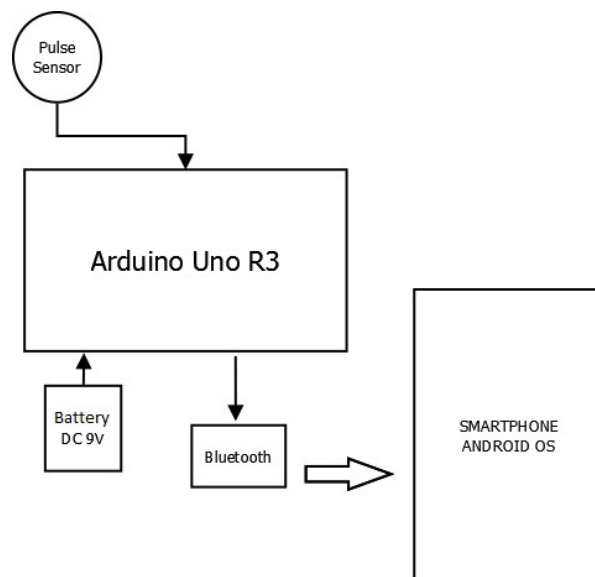


Figure 7. Diagram block of application

Pulses the sensor will detect the human heartbeat and then the data is processed by the Arduino Uno R3. When the heart rate calculation process has been completed, data send via Bluetooth to the Android Smartphone.

Flowchart applications heart rate monitoring system can be seen in Figure 8. Application is started by entering the "Name" and "Age" which will be used as a data processing heartbeat. Furthermore bluetooth will be connected automatically with 'Heartbeat Detector Tool'. Bluetooth activation flowchart is shown in Figure 9. Then performed the data based on the selected gender. Details of the process data is shown in Figure 10. If the heartbeat detector can read the data, the results will be displayed on android devices. measurements can be repeated by pressing the repeat button.

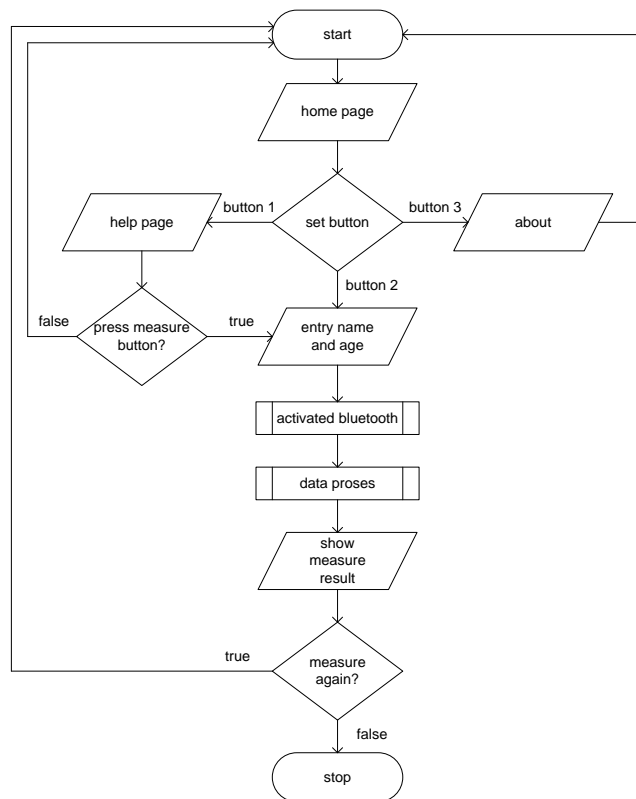


Figure 8. Flowchart application

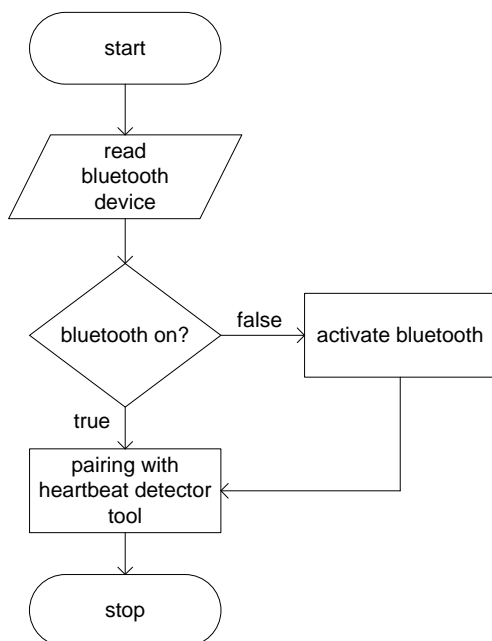


Figure 9. Bluetooth activation flowchart

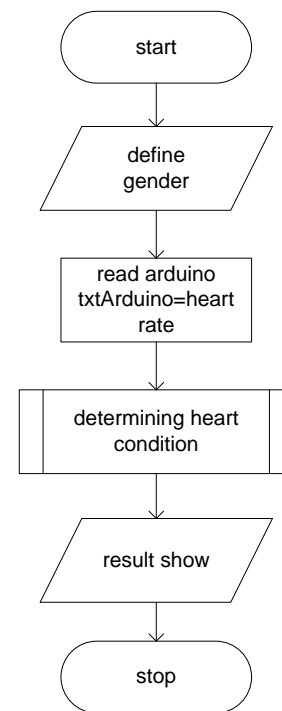


Figure 10. Processing heart rate data

Determination of heart condition depend on two variables were included, namely age and gender as well as the results of detection of heart rate readings. Starting with the reading age is entered. Furthermore, based on the age, heart rate readings compared to the table to determine if the heart is in good condition, pretty or ugly. This process is shown in figure 11 and figure 12. Figure 11 shows the flowchart for the determination of heart conditions over 18 years. While figure 12 to under 18 years old. Each age group has a different standard of heart rate in determining the condition of the heart.

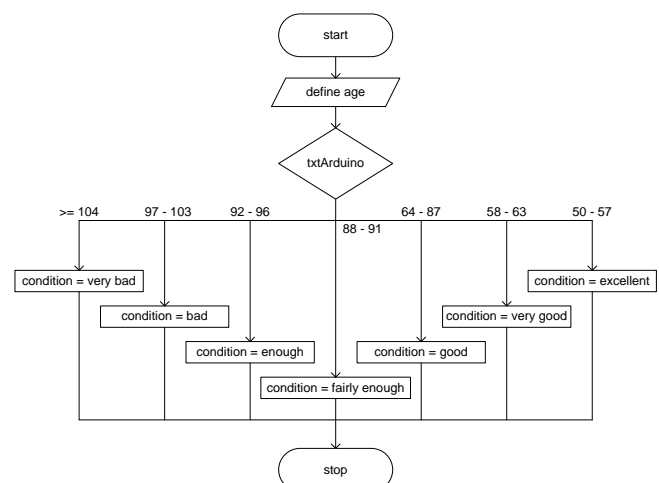


Figure 11. Determine heart condition for age over 18

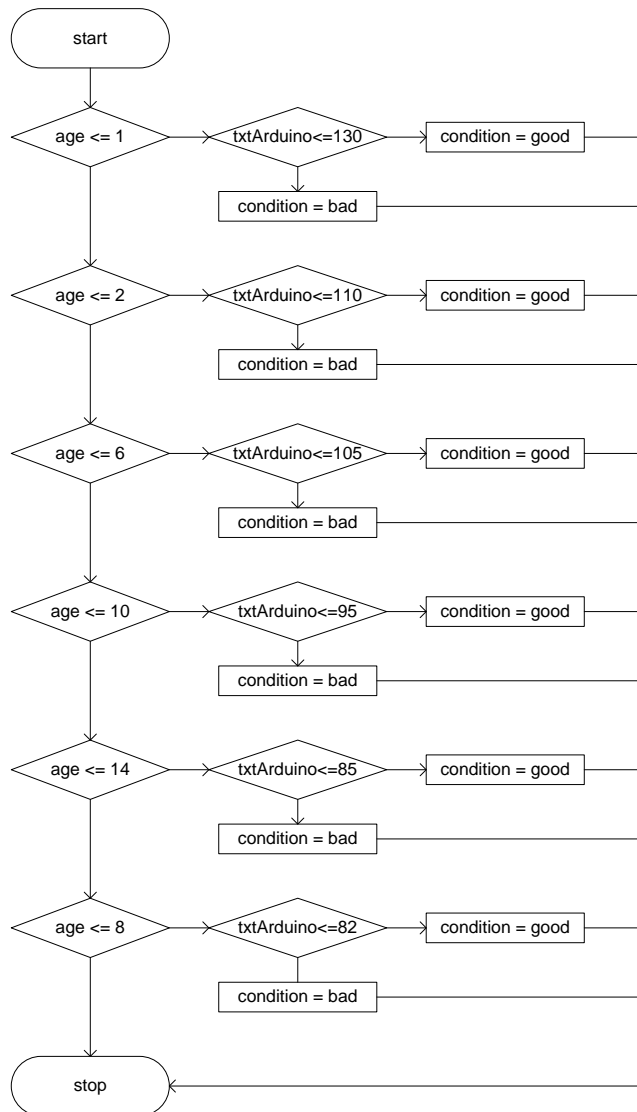


Figure 12. Determine heart condition

VI. RESULTS

The result is a tool that is used to detect heart rate-based Arduino Uno R3 and an android-based application that is used to display the number of heartbeats and heart conditions are detected by Arduino. Figure 13 is a heartbeat detector based Arduino. Operation is to put a finger on the pulse sensor and Arduino will automatically read and process the catch pulse sensor. This data is then sent via Bluetooth to android devices.

Display on android devices is shown in Figure 14. When the application is first run to check whether the Bluetooth is in a condition on. If not then display an instruction to turn on bluetooth. Look at figure 14 appears only if an active Bluetooth device.

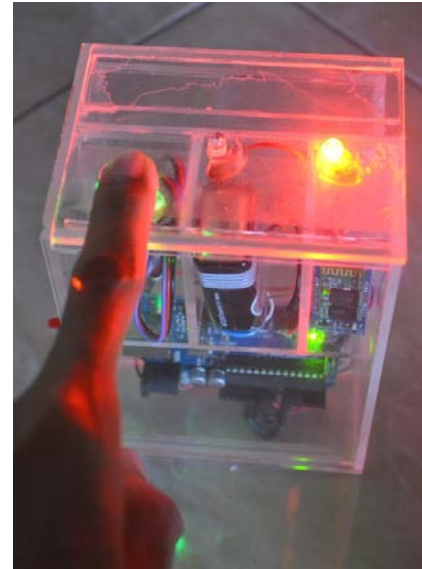


Figure 13. Heartbeat detector tools



Figure 14. View of heart rate monitoring system based on android system

Operation of the application to detect the heart rate is click calculation button. The next display is a form to enter their name and age. By pressing the button, the application will display a new page that is used to show the result on heart rate and heart condition. This is shown in Figure 15 and Figure 16.

Testing tools and comparison with manual measurement of heart rate is shown in Table III. Tests conducted on 10 people at random with age and gender diverse. From these data shows that of the 10 trials, 8 trials gave similar results and 2 times there is a difference with an average difference of 1.45%.

Tests for heart conditions also done shows for 10 people at random. The results are shown in Table IV. Seen from the table that in 10 trials the appearance of heart conditions in accordance with the standards used, based on the number of heartbeats that can be read.

Figure 15. Form to input name and age

Figure 16. View of the heart rate result

VII. CONCLUSION

The conclusion that can be drawn from this research is :

- In the Data Acceptance Testing showed that the maximum error of 1.45%.
- Testing Conditions on appointment results conducted on 10 people: 4 people under 18 years, 3 men over 18 years and 3 women over 18 years. All experiments showed a heart rate corresponding to the referenced table.

REFERENCES

- [1] A. Ramalingam, P. Dorairaj and S. Ramamoorthy, "Personal Safety Triggering System On Android Mobile Platform", International Journal of Network Security & Its Applications (IJNSA), July 2012, pp. 179 – 197.
- [2] J. M. Bharathi, S. Hemalatha, V. Aishwarya, "Advancement in Mobile Communication using Android", International Journal of Computer Applications, 2010, pp. 95 – 98.
- [3] Pearce, Evelyn Pearce, "Anatomy and Physiology for Paramedics", Gramedia, 2007.
- [4] Prasetyo, Didik Dwi, "150 JAVA Programming Secrets", Elex Media Komputindo, 2012.
- [5] S. Holla, M. M. Katti, "Android Based Mobile Application Development And Its Security", International Journal of Computer Trends and Technology, 2012, pp. 486 – 490.
- [6] S. Lee, "Creating and Using Databases for Android Applications", International Journal of Database Theory and Application, June 2012, pp. 99 – 106.
- [7] Suprianto, Dodit, and R. Agustina, "Programming Android Application", MediaKom, 2012.
- [8] WHO, "Avoiding heart attacks and strokes", 2012.

TABLE IV. COMPARATION BETWEEN MANUALLY CHECK AND HEART RATE WITH ANDROID APPLICATION

Sample	Heart Rate Calculation		Difference	
	Manually	Application Data	Total	Percentage
1	66	66	0	0%
2	69	70	1	1.45%
3	68	68	0	0%
4	71	71	0	0%
5	74	73	1	1.35%
6	62	62	0	0%
7	63	63	0	0%
8	70	70	0	0%
9	81	81	0	0%
10	64	64	0	0%

TABLE V. HEART RATE WITH ANDROID APPLICATION BASED ON AGE AND SEX

No	Name	Age	Sex	Heart rate (Bpm)	Condition
1	Wisnu Reswara	2	Man	80	Good
2	Firmansyah	13	Man	99	Bad
3	M. Taufiq	21	Man	69	Good
4	Suryadi Pudy A.	21	Man	66	Good
5	Supadi Ws	52	Man	70	Good
6	Astri Amaya	3	Woman	75	Good
7	Diah Arum	5	Woman	72	Good
8	Galuh Wahyu	21	Woman	67	Good
9	Wahyu Tutik	28	Woman	94	Enough
10	Waginah	65	Woman	65	Good