Heart Rate Monitoring System Abnormal Using a Microcontroller

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Abstract. The heart is an organ of the human body that plays an important role in blood circulation and is one of the bases for knowing the physical health of every human being. The heart rate monitoring system used by health institutions is quite good but it costs a lot of usages. In the design carried out by researcher produced a tool that can detect all ages process for 60 seconds. The results after heart rate detection provide condition information and BPM (Beat Per Minute) of the heart. This tool uses a pulse sensor as a heart rate detector with a 3x4 keypad as input for age data and is displayed on a 16x2 LCD with the results of heart conditions and BPM. During testing, the researcher tested approximately 20 respondents as counted tests to put their data in a comparison table. From the results of tests that have been done are classified into two systems testing. The final result of manually testing produces a relative error percentage of 2.40%. While testing, by comparison, using a stethoscope produces a relative error percentage of 1.65%.

Keywords: Ages, BPM, heart rate, pulse sensor

INTRODUCTION

The heart is a muscular organ cavity that pumps the blood through blood vessels by repetitive rhythmic contractions (Kemenkes RI, 2016). The heart is one of a human organ in the blood circulation system. This organ is in the chest cavity sized as big as a fist weighed approximately 300 grams (Purba and MenKes, 2013).

In 2012, the World Health Organization (WHO) estimated that 17.5 million people in the world died due to cardiovascular disease (Tribun Medan, 2017). Cardiovascular disease (heart disease) is a condition in which narrow or blockage of blood vessels causing heart attack, chest pain or stroke (Samiadi, 2016). WHO predicted that this occurred in 31% of 56.5 million deaths around the world.

According to the Sample Registration System (SRS), Coronary Heart Disease (CHD) was the highest cause of death at all ages after stroke, with the number reaching 12.9 per-cents of the mortality rate (Tribun Medan, 2017). While in 2013 according to the Ministry of Health in 2013, 39 per-cents of heart patients in Indonesia were aged 44 years and under. In detail, 22 per-cents of them were aged 15 – 35 years, during which time is a productive period in human life (Hanifan, 2016).

In this case, it is explained that the sharia is maintained to keep human from harming himself, namely guarding oneself in regulating lifestyle, especially maintaining health (Rofi'i et al., 2011). Maintaining healthy body health is recommended in Islam, including from maintaining a diet, exercising, and checking routine health.

In this case, related to "Maqasid Sharia" related to "Hifdzu-n-Nafsi. Likewise, including "Hifdzu-l- Mal", because it can save economically in the design of tools to use. With the cost and quality savings obtained, users can save a portion of their assets.

In the initial stages of a medical examination, medical check-ups usually are carried out before a person's illness is diagnosed. The medical check-up done at the hospital for the first time is to diagnose the patient's heartbeat. A method that is most commonly used in knowing body condition is based on the number of heart pulse. By knowing the number of heartbeats, heart condition can be identified.

The most common method to find out a person's heart rate is to feel the blood pulse. Measuring the heart in this way is not accurate. In medicine, a stethoscope is a tool to listen to the heart and breathing sounds. This tool is used to hear blood flow in the arteries and 'vein'.

The researcher designed alternatives for these tools using microcontroller devices. The research that is conducted is intended to monitor the heart rate. By knowing the heart rate, it be can determine the health condition of a certain person can be provided information about the state of a person's heart in the form of fast or slow cardiac impulse. The heart rate of children with adults is usually different, as well as between the heart rate of healthy and sick people. Heart rate is measured in Beat per Minute or BPM.

The heart rate monitoring system is designed by the researcher the users in detecting the number of heartbeats and can minimize costs. The results of the pulse sensor measurement can be viewed via an Arduino Uno R3 microcontroller and 16x2 LCD (Liquid Crystal Display). If the heart rate is normal, it provides information on "Normal". Whereas if the heart rate is below the average specifications available, then "Denyut Lambat". Likewise, when the heart rate exceeds the average specification, it shows "Denyut Cepat". With this tool, it is expected to be able to know the health

conditions with the parameters above, at least in the initial stages of the examination.

MATERIALS AND METHODS

The research method is a step in carrying out research from the beginning to the end of the study in order to obtain various knowledge related to the research that takes place. The method to be used in this study is a Waterfall model. Each process model represents a certain perspective, thus only providing partial information about the process.

In this waterfall model, taking activities in the form of basic process specifications, development, validation and evolution represent each of the separate phases, namely requirements analysis, design, implementation, system testing and maintenance (Sommervile, 2011). In Figure 1 explains how the waterfall model works.



Figure 1. Waterfall process model.

Figure 1 describes the basic steps in defining device development. The researcher explains the basic steps involved in the ongoing research process:

Requirements Analysis

In the requirements analysis, the researcher provides information about the usefulness of the device to be designed later. Explanations that be carried out based on observation and documentation so that the design results can be used.

Design

The design system process allocates requirements for designing devices in building the overall system in the form of architecture. In the design of this device, researcher display hardware design, system diagram flow, Use Case Diagram, and system flowchart.

Implementation

In this process, the design of the device begins with the use of Arduino IDE software to manage the system to be carried out. The researcher also assembled the design in the form of Arduino Uno R3, Pulse Sensor, 16x2 LCD, 3x4 Keypad and LED.

System Testing

After the implementation process is complete, the next step is to test the system in functionalist testing until the overall design test. In testing, the researcher explained the results of functionalist testing with several tables as a more detailed explanation, as well as testing the overall design.

The last process in the waterfall process method is the maintenance process. In this stage, the researcher does not use the maintenance process to detect errors. Because of the time limit that is on the researcher, the limitations of the research that took place and were less conducive to this study.

Hardware design

This research tool uses a pulse sensor as a sensor that detects the heart rate and is converted into analogue graph data. The 3x4 keypad is useful for entering age which is a reference in the data processing. Data be processed by Arduino Uno receive signals from pulse sensors, read data, calculate data and send data to the viewer. After the data is processed from Arduino Uno, the results are displayed on the LCD and also on the LED. The following in Figure 2 show the hardware design.



Figure 2. Hardware design.

Implementation of design system results

The design of the tool from this study is to be able to read the heart rate for one minute by displaying the heart rate process (BPM) and heart condition after reading the sensor. The purpose of implementing the system is to implement a design that has been analyzed systematically so that the design is as expected. In Figure 3 has been shown the results of designing a heart rate detector.



Figure 3. Results of a series of heart rate detection devices.

Testing

The overall testing of the heart rate detector is done to prove that the tool can run properly as it functions without any obstacles. The process of testing the heart rate detector as a whole has several stages, these stages are as follows:

- 1. Turn on the button on the footswitch 2 first.
- 2. The user first pastes the index finger on the pulse sensor as a pulse sensor reading object.
- 3. The user enters age data when the age data input command has appeared.
- 4. The user reconfirms the system whether the age data entered is correct or not, by pressing the '*' (star) button if the age data is correct and the '# '(fence) button, if the age data entered, is incorrect. If the age data entered is incorrect, the system returns to the command to enter age data.
- 5. After confirmation of age, data is complete and correct, the reading process of the system run. Users wait for the process of reading the system for 60 seconds.
- 6. During the printing process, users can view timer data and BPM data on the 16x2LCD.
- 7. Graph data of the heart rate reading process can be

seen if the heart detector is connected to a laptop or PC that has Arduino IDE installed and opens the program code from the heart rate detection system. Then the user opens the serial plotter on the Arduino IDE before the system starts, the graph data be visible when the system is reading the heart rate process.

- 8. If it has been 60 seconds, the results come out on the 16x2 LCD by providing condition and heart BPM information.
- 9. The program is complete.
- 10. If the user wants to read again, then the user presses the '*' button to immediately read the heart rate again with the index finger still attached to the pulse sensor and press the '#' button if the user enters the age data again.

Here are the limitations in a situation:

- Air temperature,
- Body position,
- Emotions,
- Body size,
- The side effect of the drug.

No	Username	Age (Year)	Manual Measured Heart Rate (BPM)	Measured Heart Rate Sensor (BPM)	An Absolute Error by Manual	Measured Heart Rate Stethoscope (BPM)	An Absolute Error by Stethoscope
1	Nizam	1	128	134	6	130	4
2	Dafa	2	125	130	5	128	2
3	Nabila	4	95	99	4	98	1
4	Fayyad	5	106	110	4	105	5
5	Lulu	6	96	99	3	98	1
6	Wawa	10	85	88	3	86	2
7	Lubna	12	90	94	4	90	4
8	Reva	14	90	90	0	90	0
9	Afiqah	14	97	98	1	96	2
10	Lazuardi	24	95	97	2	97	0
11	Fuad	24	96	97	1	95	2
12	Hasyim	23	74	74	0	72	2
13	Agung	23	76	77	1	77	0
14	Ahmad	30	86	86	0	86	0
15	Hasan	35	82	85	3	83	2
16	Imam	35	88	90	2	89	1
17	Bukhori	44	90	92	2	92	0
18	Patminingsih	54	98	98	0	98	0
19	Pak Kin	58	94	96	2	95	1
20	Mbah Kif	63	72	75	3	73	2
Total				1909	46	1878	31
Average Relatif Error				95,45	2,3	93,9	1,55
Average Relative Error Percentage				2,40	%	1.65	%

Table 1. Heart Rate Measurement Results.

Table 1 is the data from the testing results of a microcontroller-based heart rate detector with several people as users that be presented.

Table 1 is the result of testing the tools that researcher have designed with a comparison of manual detection and detection using a stethoscope. The results of testing tools with manual testing get a percentage error value of 2.40%. While testing tools with a stethoscope get a percentage error value of 1.65%.

Based on experimental data, pulse sensors can detect and measure minute heart rate (BPM). Measurements are made in the age range found in Table 1 with users at rest. The data obtained then calculated absolute errors and relative error percentages. Calculation of absolute error percentage and relative error can be seen in the following formula:

Information:

Estimated Value = Measured heart rate sensor. Expected Value = Manual measured heart rate = Measured heart rate stethoscope.

Calculation of absolute error in the difference calculation manually as follows:

Absolute error calculation on the difference calculation with a stethoscope as follows:

The next formula is the formula to find the relative error calculation as follows:

$$Relative Error = \frac{Absolute Error}{Actual Value}$$
(2)

Information:

Absolute Error = Absolute error by manual = Absolute error by stethoscope. Actual Value = Total users.

The following is a calculation of the total measurement using a heart rate sensor:

$$Relative \ Error = \frac{1909}{20} = 95.45$$

The following is a calculation of the total absolute error manually:

Relative Error =
$$\frac{46}{20} = 2.3$$

The following is the calculation of the total measurement using a stethoscope:

Relative Error =
$$\frac{1878}{20} = 93.9$$

The following is a calculation of the total absolute error using a stethoscope:

Relative Error
$$=$$
 $\frac{31}{20} = 1.55$

The final calculation formula is to look for the percentage of relative errors to find out the final result:

Relative Error Percentage (3)
$$= \frac{Measured Actual}{Actual Value} \times 100\%$$

Information:

Measured Actual = Absolute error by manual= Absolute error by stethoscope. Actual Value = Measured by a sensor= Measured by stethoscope.

There are the percentages of relative error calculations with sensor proportions with manual calculations:

Relative Error Percentage =
$$\frac{2.3}{95.45} \times 100\%$$

= 2.40 %

Here are the percentages of relative error calculations with sensor proportions from stethoscope calculations:

Relative Error Percentage =
$$\frac{1.55}{93.9} \times 100\%$$

= 1.65 %

The results of testing the tools that have been designed are divided into two parts, namely the results of testing tools with manual calculations and testing tools with a stethoscope. The first result by comparison with testing by manual calculation results in an average relative error of 2.40%. The second result compared with testing instruments with a stethoscope produces an average relative error of 1.65%.

CONCLUSIONS

Based on the design of the heart rate detection system that has been made, it is explained about conclusions from the results of the design. The researcher explains the essence of the results of the research for better development after this research. The conclusions that can be taken in designing a monitoring system for heart rate detection devices are:

- 1. Detection using a tool that has been designed by researchers can be used at all ages with a resting heart condition.
- 2. This detection system reads the heart rate at the fingertips for 60 seconds by entering the user's age first, after confirmation of a successful age, the

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