Signal and Image Processing Letters
Vol. 3., No. 2, 2021, pp. 17-23
ISSN 2714-6677
https://simple.ascee.org/

Design a Heart Rate Counter Based on the Atmega328 Microcontroller Displayed Via Smartpone

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ARTICLE INFO

Keywords
Smartphone
Bluetooth
Pulse Heart Sensor
Arduino
Serial monitor

ABSTRACT

In today's era, technological advances are experiencing a rapid impact on human life as well as smartphones that trigger and influence technological developments in the health sector. The process of monitoring human heart rate can be known by its pulse that can be done by everyone by utilizing technological developments. The purpose of this study was to determine the design of a pulse response detection research test kit with a heartbeat sensor and display data through a smartphone. Using a pulse heart sensor attached to one person's fingertip to detect the pulse rate signal, then the sensor reading data is received by the smartphone via an analog pin (AO), forwarded via Bluetooth and displayed on the serial monitor application in the smartphone, then it will be processed into BPM (beats per minute) so that it can find out the pulse ticking signal displayed on the smartphone. Based on the results of the simulation carried out, the results of testing the tool on the heart rate sensor were able to detect the pulse rate signal response. A person's pulse rate when doing sports activities beats quickly compared to the pulse before doing sports activities, because when doing sports activities the heartbeat pumps blood to all parts of the body quickly. After testing, the tool can detect the number of pulses a person can work normally ranging from 90 to 100 Beat Per Minute (BPM) and indicates that the tool can work properly.

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1. Introduction

One of the most important organs in the human body is the heart. The heart functions to pump blood throughout the body [1]. A person's delay in knowing the condition of the disease can increase the risk of death each year. Therefore, a tool is needed that can find out whether a person's health is normal or not in a faster and easier way, one of which is a device that can detect the pulse [2].

In adults the normal heart rate is 60-100 per minute. If it exceeds the normal limit, it can be fatal such as heart disease. To detect the pulse, a sensor is needed that is attached to the surface of the skin on the fingertips, namely using a pulse sensor. Pulse sensors can work by utilizing light. When this sensor is placed on the surface of the skin, most of the light is absorbed or reflected by organs and tissues (skin, bones, muscles, blood), but part of the light will pass through fairly thin body tissues. The running Pulse sensor can be connected to an analog pin of 0, continuously every (2ms) reading of the measured heart rate sensor [3] [7].

Arduino is one of the microcontroller boards based on ATmega328. Arduino has open source advantages that other microcontroller boards do not have. C language is a special language used for

Arduino programming, where the program can be downloaded in various versions, one of which is using USB. In addition, in the Arduino board itself there is already a loader which makes it easier when programming a microcontroller di in the Arduino. Whereas on most other microcontroller boards that still need a separate loader circuit to insert programs into the microcontroller programming. Programs written in C language will be compiled, then *hex files will be downloaded into the ATmega328 IC chip [4] [9].

Bluetooth is a wireless communication technology that operates in the 2.4 GHz unlicensed ISM (Industrial, Scientific, and Medical) frequency band [5]. Bluetooth HC-05 has a maximum speed of 1 Mbps can be used as a link between the sensor, Arduino, and smartphones. The sensor reading data sent can be displayed through the serial monitor application on a smartphone in the form of the number of beat pulses per minute (BPM), so that the pulse checking process becomes more practical and easy to use [10].

2. Research Methods

The object of this research is to calculate the number of pulse beats per minute in a person. The variable that can be measured is the number of pulses per minute to compare with several conditions, namely before and after exercise. This can be done because when the sensor detects the number of pulses in a person with different sports conditions, it will produce a different number of pulses. From several journals that discuss the design of heart rate measuring devices, the value of the average error rate for heart rate device designs from several of these journals ranges from 1.414% to 4.104% [6].

2.1. System Design

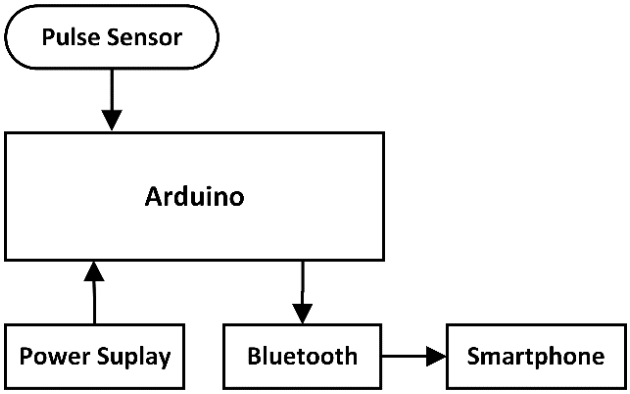


Fig. 1. Hardware design

Fig. 1. is the hardware design in this research. Description of the block diagram, namely:

1. Pulse sensor as a pulse detector which will later send input data to Arduino as the brain of the program and process it
2. Then the data input is processed on Arduino which will later be processed as data input in the form of a BPM (Beats Per Minutes) numerical value
3. And then the input data signal is sent via Bluetooth and will be displayed on the Android smartphone application.

The block diagram on this system has 3 main parts, namely, input, microcontroller, and output. The input section of this system consists of a series of pulse sensor heart rate as a marker of the presence of a beat that is received and integrated by the LED when the pulse rate is detected. Then the data enters the Arduino Uno R3 to be converted into digital data and processed so that it can display information on the heart rate value and then transferred by Bluetooth then displayed the data input in the android monitor serial application / output.

2.2. Algorithm

The thing that needs to be done before creating a program is to create a flowchart as a guide for writing a program. The flowchart can be seen in Fig. 2.

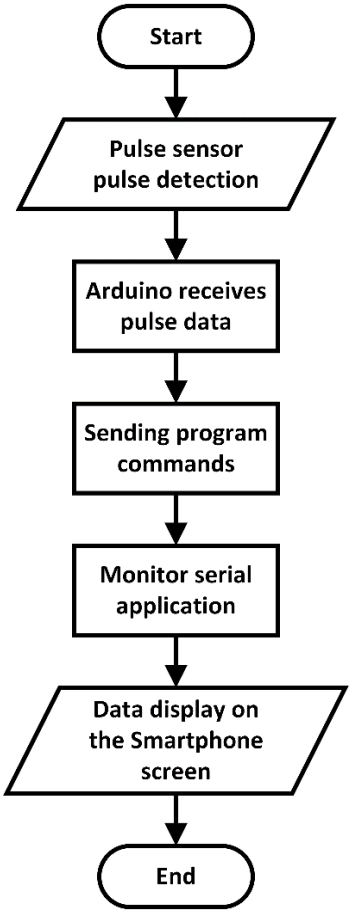


Fig. 2. Process flowchart on microcontrollers

In this study, the number of pulse beats of a person in BPM (Beat Per Minute) units that work under normal conditions and before and after exercise. This Pulse Sensor combines a simple heart rate sensor with amplification and noise cancellation using 4 mA power at 5 V voltage allowing precise data reading and reliable. The Arduino receives data and will be processed via program commands and forwarded using the Serial Monitor to display the pulse data that has been tested by displaying the data on Android smartphones.

2.3. Calculation Formula

The pulse sensor is designed to measure IBI (Interbeat Interval). IBI is the time interval of the heart rate in milliseconds as soon as the heart beats. BPM (Beatper Minute) derives each beat from the average of every 10 times IBI [8]. When the microcontroller is turned on and running with a pulse sensor connected to analog pin 0 continuously (every 2ms) it can read the sensor value based on the measured heart rate from the fingertip, using equation (2).

$$Average\ fingertip\ pulse\ rate = \frac{Number\ of\ finger\ pulse\ beats}{lots\ of\ experimental\ data} \quad (2)$$

The result of the average number of pulse beats on the fingertip object of the inner pulse beat each minute is 76.7 times the pulse beats. In the calculation of the tool, the result is concluded with normal circumstances.

3. Results And Discussion

3.1. Tool Testing Under Normal Conditions

Data on the test results of the tool in a normal / conscious state can be seen in Table 1.

Table 1. Tool test results under normal circumstances

No	Name	Number of pulse beats Heartbeat of People Normal			
		1	2	3	Average
1.	Nice Dwi Setiawan	76	77	85	79.3
2.	Pandhu Wicaksono	83	78	95	85.3
3.	Dawn Juna Shantika	80	78	87	81.6
4.	Andri Hidayat	78	80	83	80.3
5.	Safri Zuman	76	86	80	80.6
6.	Ilham Fathurrahman	77	70	80	75.6
7.	Arif Ardiansyah	68	88	98	84.6
8.	Andra Primary	77	80	87	81.3
9.	Ibn Fajar Nugroho	85	79	89	84.3
10.	Anton Maulana Joseph	70	78	90	79.3

Based on the results of the data from the experiment above, it can be seen that the average number of pulse beats per minute under normal circumstances for each person has a difference ranging from 70 to 90 Beats Per Minute (BPM). The difference in the number of pulse beats can be seen in Fig. 3.

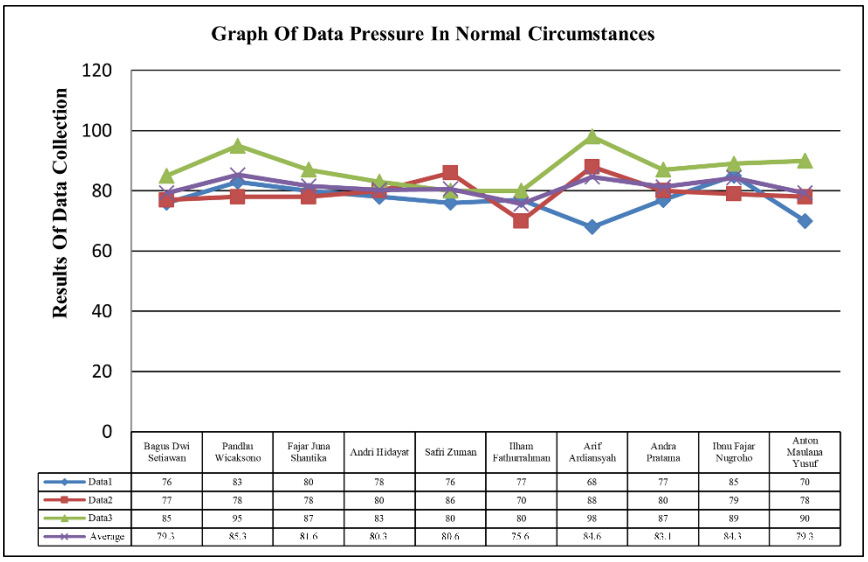


Fig. 3. Graph of tool testing under normal conditions

Fig. 3 displays a graph of the pulse rate of 10 people under normal conditions. The graph shows that there are changes caused by the influence of a pulse that works well.

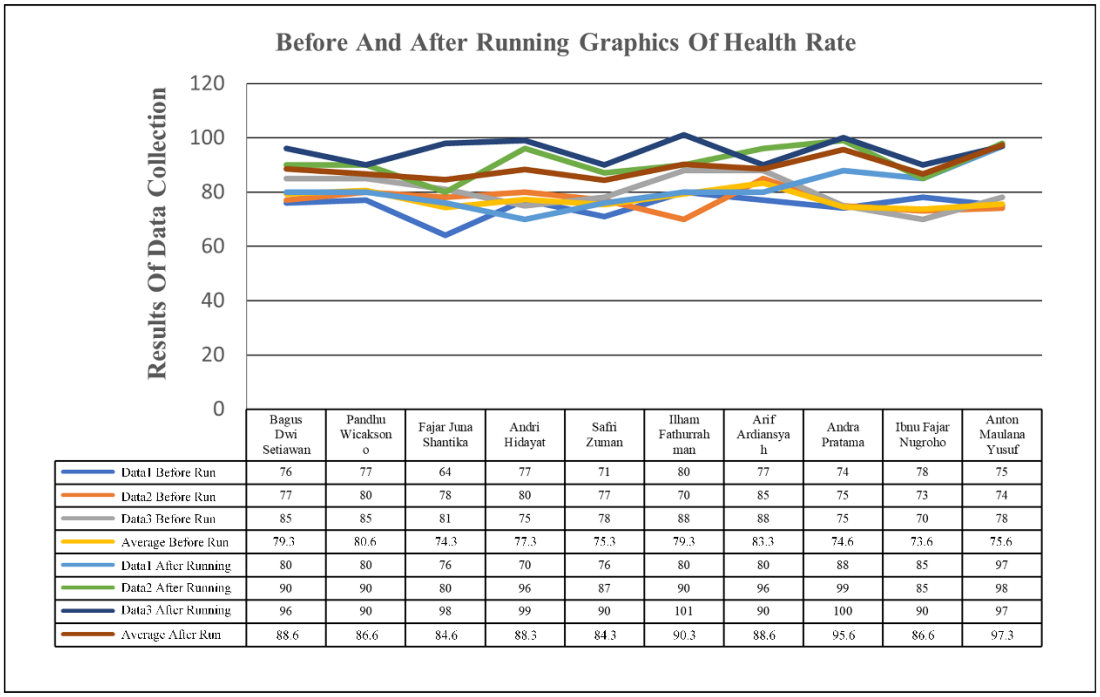
3.2. Tool Testing in a State of Push Up

Data on the results of testing the tool before and after the Push Up can be seen in Table 2.

Table 2. The results of testing the tool in the state before and after the Push Up

No	Name	Number of pulse beats							
		Before Push Ups				After Push Ups			
		1	2	3	Average	1	2	3	Average
1.	Nice Dwi Setiawan	76	77	80	77,7	81	90	96	89.7
2.	Pandhu Wicaksono	83	72	71	75,3	91	89	95	91.7
3.	Dawn Juna Shantika	64	78	73	71,7	76	101	101	92.7
4.	Andri Hidayat	77	80	75	77,3	84	96	99	93.0
5.	Safri Zuman	71	79	78	76,0	76	87	90	84.3
6.	Ilham Fathurrahman	86	71	69	75,3	88	90	97	91.7
7.	Arif Ardiansyah	88	73	77	79,3	90	104	105	99.7
8.	Andra Primary	74	75	75	74,7	88	99	98	95.0
9.	Ibn Fajar Nugroho	78	73	69	73,3	91	97	101	96.3
10.	Anton Maulana Joseph	75	74	78	75,7	97	98	97	97.3

Based on Table 2 from the experiment above, it shows the number of pulse beats per minute of each person can be calculated and get two different treatments namely, in normal circumstances (before push up) ranges from 64 to 90 Beats Per Minute (BPM). In the condition after the Push up was done 3 times it had an increase in the BPM value which increased with the highest value of 97 Beats Per Minute (BPM) which caused the pulse to beat faster than before.



	Bagus Dwi Setiawan	Pandhu Wicaksono	Fajar Juna Shantika	Andri Hidayat	Safri Zuman	Ilham Fathurrahman	Arif Ardiansyah	Andra Pratama	Ibnu Fajar Nugroho	Anton Maulana Yusuf
Data1 Before Run	76	77	64	77	71	80	77	74	78	75
Data2 Before Run	77	80	78	80	77	70	85	75	73	74
Data3 Before Run	85	85	81	75	78	88	88	75	70	78
Average Before Run	79.3	80.6	74.3	77.3	75.3	79.3	83.3	74.6	73.6	75.6
Data1 After Running	80	80	76	70	76	80	80	88	85	97
Data2 After Running	90	90	80	96	87	90	96	99	85	98
Data3 After Running	96	90	98	99	90	101	90	100	90	97
Average After Run	88.6	86.6	84.6	88.3	84.3	90.3	88.6	95.6	86.6	97.3

Fig. 4. Graph of Effect of Activity Before and After Running

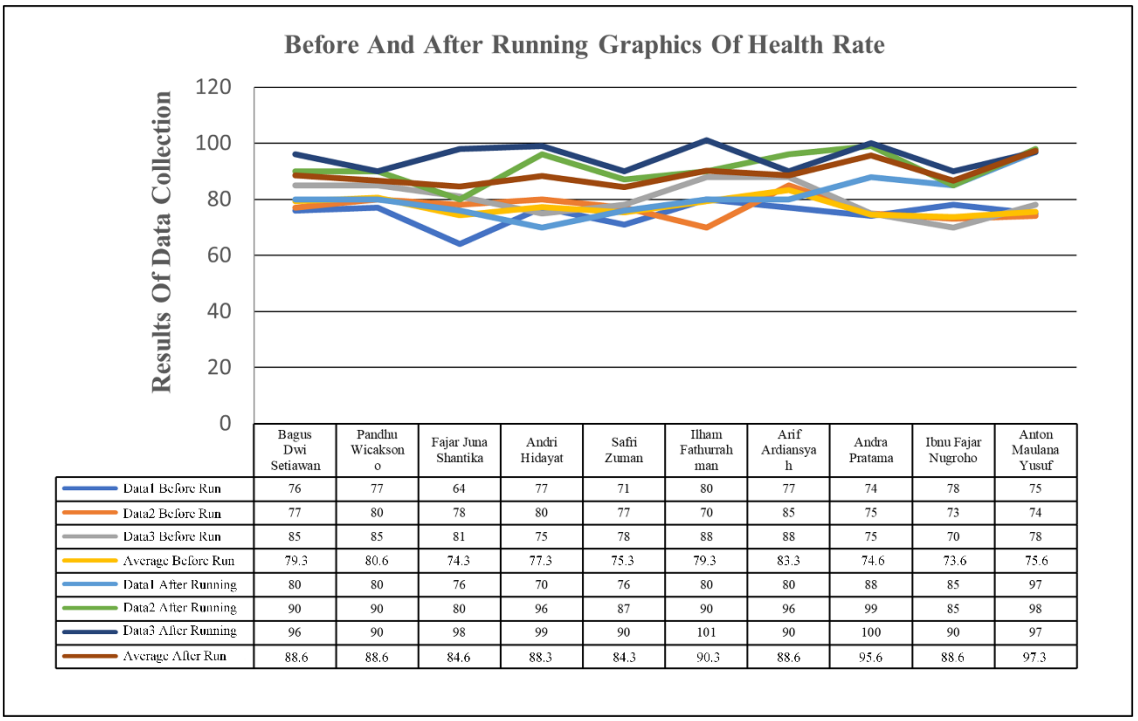
Fig. 4 shows that the difference between a person before and after doing a push-up activity shows an increase in graph values from normal conditions.

3.3. Testing of Equipment In Running State 100

Table 3. Results of testing the tool before and after running 100 meters

No	Name	Number of pulse beats							
		Before running				After the run			
		1	2	3	Average	1	2	3	Average
1.	Nice Dwi Setiawan	76	77	85	79,3	80	90	96	88,6
2.	Pandhu Wicaksono	77	80	85	80,6	80	90	90	86,6
3.	Dawn Juna Shantika	64	78	81	74,3	76	80	98	84,6
4.	Andri Hidayat	77	80	75	77,3	70	96	99	88,3
5.	Safri Zuman	71	77	78	75,3	76	87	90	84,3
6.	Ilham Fathurrahman	80	70	88	79,3	80	90	101	90,3
7.	Arif Ardiansyah	77	85	88	83,3	80	96	90	88,6
8.	Andra Primary	74	75	75	74,6	88	99	100	95,6
9.	Ibn Fajar Nugroho	78	73	70	73,6	85	85	90	86,6
10.	Anton Maulana Joseph	75	74	78	75,6	97	98	97	97,3

Based on Table 3 from the experiment above, it shows the number of pulse beats per minute of each person is calculated and gets two different treatments, that is, in normal circumstances it ranges from 60 to 90 Beats Per Minute (BPM). In the condition after running 100 meters has an increase in the value of BPM which increases with the highest value of 99 Beats Per Minute (BPM). caused by the state of a person's stamina is different.



	Bagus Dwi Setiawan	Pandhu Wicaksono	Fajar Juna Shantika	Andri Hidayat	Safri Zuman	Ilham Fathurrahman	Arif Ardiansyah	Andra Pratama	Ibnu Fajar Nugroho	Anton Maulana Yusuf
Data1 Before Run	76	77	64	77	71	80	77	74	78	75
Data2 Before Run	77	80	78	80	77	70	85	75	73	74
Data3 Before Run	85	85	81	75	78	88	88	75	70	78
Average Before Run	79.3	80.6	74.3	77.3	75.3	79.3	83.3	74.6	73.6	75.6
Data1 After Running	80	80	76	70	76	80	80	88	85	97
Data2 After Running	90	90	80	96	87	90	96	99	85	98
Data3 After Running	96	90	98	99	90	101	90	100	90	97
Average After Run	88.6	88.6	84.6	88.3	84.3	90.3	88.6	95.6	88.6	97.3

Fig. 5. Graph of effect of activity before and after running

Fig. 5 above shows that the graph of the difference between a person who before and after doing the 100 meter running activity shows that the graph value has increased from normal conditions.

4. Conclusion

The results obtained in the entire test, the pulse response detection system by utilizing a heart beat can monitor a person's pulse very easily, then it can be analyzed and displayed on the Android smartphone monitor screen. So, with a tool like this is in accordance with the research objectives. Based on the results of observations, comparison of data between several people obtained conclusions. The pulse display occurs when the sensor is attached to the fingertip and when the LED on the Arduino flashes then it also appears on the Android monitor screen with the help of sending data with Bluetooth media. In designing a test tool using a pulse sensor as a sensor, this pulse signal consists of an optical pulse sensor that is equipped with an IR LED and a photodetector, so that the results obtained will be better and more accurate. The resulting picture of the number of pulses using the Pulse sensor varies for a person because it is influenced by several factors, including before and after carrying out activities. Then the difference in the output between the pulse before and after doing the activity lies in the number of pulse beats, for the normal number of pulse beats before and after activity ranges from 60 to 80 Beats Per Minute (BPM) while the pulse rate after activity ranges from 90 to 100 Beats Per Minute (BPM).

References

[1] S. Trivedi and A. N. Cheeran, "Android based health parameter monitoring," *2017 International Conference on Intelligent Computing and Control Systems (ICICCS)*, Madurai, India, 2017, pp. 1145-1149, doi: 10.1109/ICCONS.2017.8250646.

[2] L. A. Ramalho *et al*., "Development of an Intelligent Platform Management controller for the Pulsar IIb," *2015 IEEE Nuclear Science Symposium and Medical Imaging Conference (NSS/MIC)*, San Diego, CA, USA, 2015, pp. 1-2, doi: 10.1109/NSSMIC.2015.7581788.

[3] B. Dong, V. Prakash, F. Feng and Z. O'Neill, "A review of smart building sensing system for better indoor environment control," *Energy and Buildings*, vol. 199, pp. 29-46, 2019.

[4] S. Karthikeyan, T. Sankar, M. Vijayakarthick, T. Ravi and B. Rajasekar, "Role of IOT in Healthcare using Smart Textiles," *2020 International Conference on Power, Energy, Control and Transmission Systems (ICPECTS)*, Chennai, India, 2020, pp. 1-6, doi: 10.1109/ICPECTS49113.2020.9337054.

[5] M. M. Ali, S. Haxha, M. M. Alam, C. Nwibor and M. Sakel, “Design of Internet of Things (IoT) and Android Based Low Cost Health Monitoring Embedded System Wearable Sensor for Measuring SpO 2, Heart Rate and Body Temperature Simultaneously,” *Wireless Personal Communications*, vol. 111, pp. 2449-2463, 2020.

[6] E. Calilung *et al*., "Design and Development of an Automated Compression Mechanism for a Bag-Valve-Mask-Based Emergency Ventilator," *2020 IEEE 12th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM)*, Manila, Philippines, 2020, pp. 1-6, doi: 10.1109/HNICEM51456.2020.9400150.

[7] W. Makni, N. Ben Hadj, H. Samet and R. Neji, "Design simulation and realization of solar battery charge controller using Arduino Uno," *2016 17th International Conference on Sciences and Techniques of Automatic Control and Computer Engineering (STA)*, Sousse, Tunisia, 2016, pp. 635-639, doi: 10.1109/STA.2016.7952093.

[8] S. M. R. Islam, D. Kwak, M. H. Kabir, M. Hossain and K. -S. Kwak, "The Internet of Things for Health Care: A Comprehensive Survey," in *IEEE Access*, vol. 3, pp. 678-708, 2015, doi: 10.1109/ACCESS.2015.2437951.

[9] M. Patil, A. Madankar and P. D. Khandait, "Heart Rate Monitoring System," *2019 5th International Conference on Advanced Computing & Communication Systems (ICACCS)*, Coimbatore, India, 2019, pp. 574-576, doi: 10.1109/ICACCS.2019.8728501.

[10] S. P. Preejith, A. Alex, J. Joseph and M. Sivaprakasam, "Design, development and clinical validation of a wrist-based optical heart rate monitor," *2016 IEEE International Symposium on Medical Measurements and Applications (MeMeA)*, Benevento, Italy, 2016, pp. 1-6, doi: 10.1109/MeMeA.2016.7533786.