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Exploration of Biomechanical and Biooptical Sensors on Cardiac Monitor on Carotid Pulse

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ABSTRACT Cardiovascular diseases are a significant global health concern, often requiring timely and accurate monitoring for effective management. Traditional heart monitoring devices face limitations, such as inadequate real-time data and suboptimal accuracy. This study aims to enhance the detection of carotid pulse signals by comparing the performance of two sensor types: piezoelectric sensors and SEN0203 sensors. The methodology involved designing a cardiac monitoring device that integrates both sensors to simultaneously capture carotid pulse and phonocardiograph (PCG) signals. Data collection was conducted on 10 respondents, where both sensors were applied alternately to the carotid artery, and the signals were analyzed using an oscilloscope. The results demonstrated that the piezoelectric sensor outperformed the SEN0203 sensor in terms of signal clarity and amplitude. Specifically, the average amplitude of the carotid pulse recorded by the piezoelectric sensor was 5.3 mV, while the SEN0203 sensor recorded an average amplitude of only 3.2 mV. Additionally, the correlation analysis revealed a strong relationship between the carotid pulse and PCG signals, with a correlation coefficient of 0.87, indicating a high degree of reliability in the measurements obtained from the piezoelectric sensor. In conclusion, the findings of this study suggest that piezoelectric sensors are more effective for monitoring carotid pulse signals compared to SEN0203 sensors, providing clearer and more reliable data. This advancement in sensor technology has the potential to improve early detection of cardiovascular abnormalities, leading to better patient outcomes. Future research should focus on the development of portable monitoring devices that incorporate these sensors, facilitating widespread clinical application and enhancing the overall quality of cardiovascular care.

INDEX TERMS Carotid Pulse, Cardiac Monitor, Piezoelectric, SEN0203

I. INTRODUCTION

Cardiac Monitor is a tool to monitor patients identified as having heart defects[1][2][3]. One method to detect early heart disease related to heart valve abnormalities can be done with auscultation techniques[4][5][6]. Auscultation is a technique of listening to heart sounds using an Electric Stethoscope[7][8][9][10]. In fact, the electrical and mechanical activity of the heart also involves the process of blood pressure in flowing blood through the heart valves to the heart chambers and lungs[11][12][13]. Blood pressure here is represented by the Carotid Pulse[14][15][16][17]. Carotid Pulse is a recording of carotid artery pressure signals, recording is done with leads on the neck and is an alternative in seeing blood pressure

signals[18][19][20]. This carotid pulse is also useful for Phonocardiography (PCG)[21][22] and can be helpful in identifying the second heart sound (S2) and its components. Carotid Pulse provides information about indications of variations in blood pressure signals in the arteries and the volume of each heart beat[23][24][25][26]. Once made a Pulmonary Parenchyma Abnormality Detection tool based on the Power Spectra Density of Lung Sound with the Welch Method by Kemalasari, et al in 2011, but only displayed a PC G signal graph. When testing the tool, the results were not optimal because the signal results were truncated[12]. Then in 2011 Dian Hera once made a Phonocardiography (PCG) tool . based on Personal Computer, but only displays PCG signal

graphs and has a weakness, [27] namely graphic display. The signal displayed on the PC is not real-time data but data that has been buffered and then displayed, so from the weakness of both tools. In 2016, Nurul & Aisy developed a Cardiac Monitor Based on Personal Computer PCG and ECG Parameters, by displaying both signals simultaneously or simultaneously, but has not added carotid pulse parameters. So in 2017 Samsul Anwar made a Carotid Artery device Via Bluetooth, but the signal produced still has noise [28]. Then in 2019 Rosyida & Risa developed a tool entitled Design and Build Cardiac Monitor ECG, PCG and Carotid Pulse Parameters by displaying signals simultaneously with Carotid Pulse signals but the tool has not yet Portable [29]. In 2021, Amalia Rizki developed a tool entitled Design and Build Cardiac Monitor Using Piezoelectric Sensors [30], but there are weaknesses that have not conducted further research on carotid pulse signals. From the results of the identification above, the author plans to make a tool "EXPLORATION OF BIOMECHANICAL AND BIOOPTICAL SENSORS ON CARDIAC MONITOR DEVICES (CAROTID PULSE)" by displaying the Carotid Pulse signal which will simultaneously be displayed with the PCG signal to obtain results and data. Diagnosis on carotid arterial examination is more accurate and faster.

II. MATERIALS AND METHOD

The following are the materials and methods needed in this study, as follows:

A. DATA COLLECTION

The author will test both sensors and take data with the aim of knowing the capabilities of the tool that has been designed.

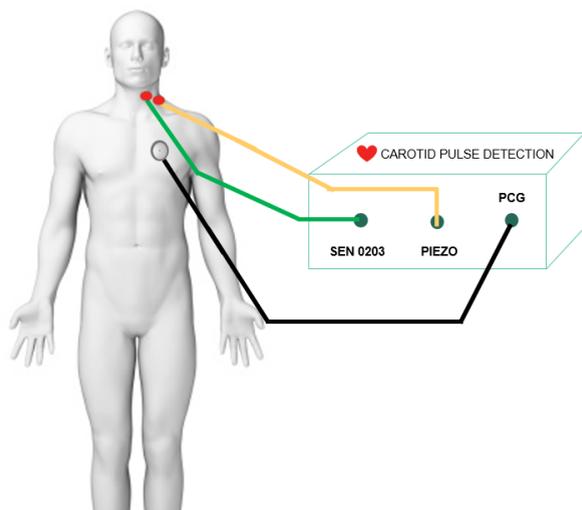


FIGURE 1. Mechanical diagram of laying parameters on a designed tool

In testing both sensors, namely Piezoelectric sensors and SEN0203 use oscilloscopes to test the performance of both sensors. In addition, this tool will also be taken data on respondents to measure the correlation between carotid pulse and phonocardiograph (PCG) which aims to determine the

performance of the two sensors in measuring the correlation of the two parameters.

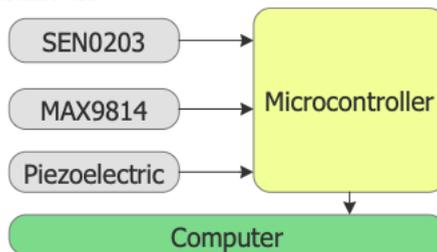


FIGURE 2. Block Diagram of Tool System, using a microcontroller and displayed on a Personal Computer

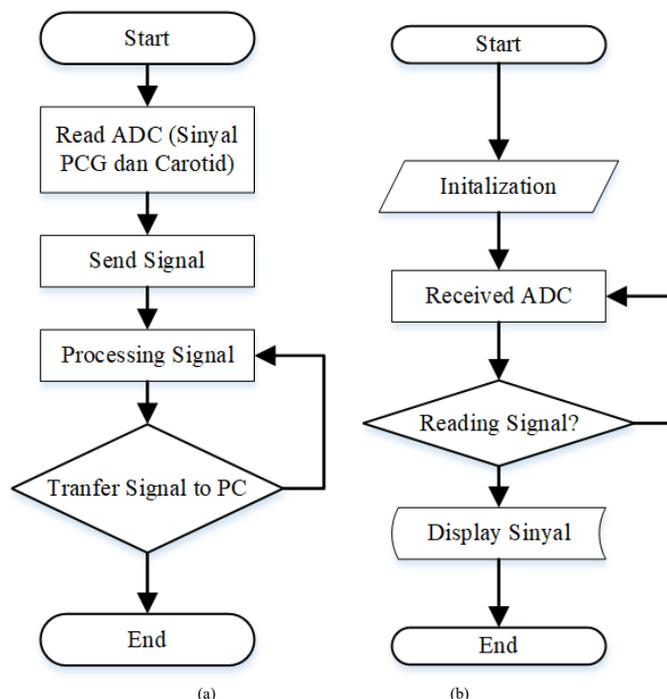


FIGURE 3. Arduino flowchart (a) and PC flow chart (b)

FIGURE 2 shows a system-wide block diagram. From the MAX 9814 sensor output and SEN0203 will be processed in the microcontroller program, the output of piezoelectricity will be received by the piezoelectric module, then it will be read by the microcontroller which will enter the Arduino analog pin which will process from analog data into digital data. Digital data from Arduino will be received by Personal Computer via USB cable which then the data will be processed using Visual Studio Code software. Processing in Visual Studio Code is used to display Carotid Pulses in real time.

And the flow chart shown in FIGURE 3 namely (a) Arduino flow chart, (b) PC flow chart. For (a) When the device is activated it initiates the initialization of ADC data from the carotid sensor consisting of piezo and SEN0203 detect the carotid signal from the MAX9814 sensor used to detect heart sound signal. After Initialization is complete, the program will

read ADC data to processed to the microcontrollers, there is process of converting analog signal from reading ADC data to digital data so that it can be processed. Once read, the program will provide a code sending heart sound signal to the Personal Computer via USB cable to be received on the personal computer. Whereas (b) when the microcontroller sends data, it will command the program on the PC to perform the initial initialization. After the initial initialization is done, the next process is to receive ADC data by encoding the data so that it can be distinguished for the processing process, if "NO" then the program will return to the ADC data receiving process Carotid Pulse, if "YES" then the data will be processed in the Visual Studio Code program to be displayed in real time and simultaneously or simultaneously. On the graphic display , the program will start displaying Carotid Pulse .

B. DATA ANALYSIS

The average value of measurement is obtained using the following equation:

$$X = \frac{X1+X2+\dots+Xn}{n} \tag{1}$$

The equation above shows that "N" represents the amount of data obtained, "X1" indicates the first measurement and "Xn" indicates the Nth measurement. Furthermore, standard deviation is a value that indicates the degree (degree) of variation in a data group or standard of elevation from its average. The formula for the deviation mark (SD) is shown in the equation:

$$SD = \sqrt{\frac{\sum(Xi - X)^2}{n - 1}} \tag{2}$$

where "xi" is the percentage of the value in question, "x" indicates the average of the measurement results, and "n" indicates the total number of measurements. System errors are displayed as %error. The smaller amount of difference between the averages of each piece of data is Error. Erro pointed out the possibility that the module is not compliant or does not meet the standards it should be. Equation (3) displays the error formula :

$$ERROR = \frac{(Xn - X)}{Xn} \times 100\% \tag{3}$$

where "xn" above represents the measuring value of the calibrator. Meanwhile, the value determined by the module is the symbol "x".

C. RESULT

In this study, the oscilloscope has tested both sensors, namely piezoelectric and SEN0203 so that the sensor is stated to work as expected. And data has been taken on patients so that the following results were found: FIGURE 3 and FIGURE 4 show the results Measurements on respondents were carried out by

placing piezoelectric sensors and SEN0203 sensors on the carotid artery alternately during data retrieval. Data collection has been carried out on 10 respondents and analyzed the results of data collection in the form of the average obtained.

The correlation graph shown shows a difference in the carotid pulse signal produced, where the carotid pulse recorded by the piezoelectric sensor looks more dicrotic notch than that recorded by the SEN0203 sensor.

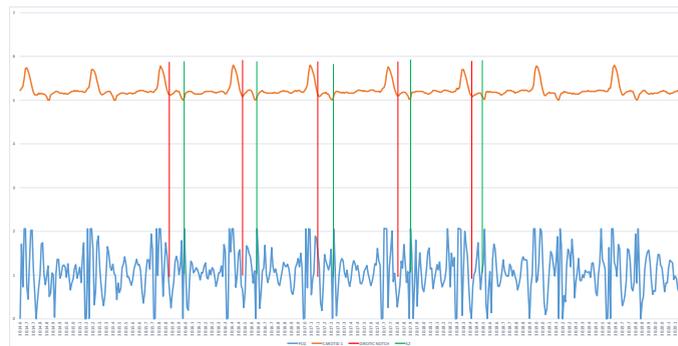


FIGURE 5. Correlation Graph of S2 Phonocardiograph with Dicrotic Notch Carotid Pulse (Piezoelectric Sensor)

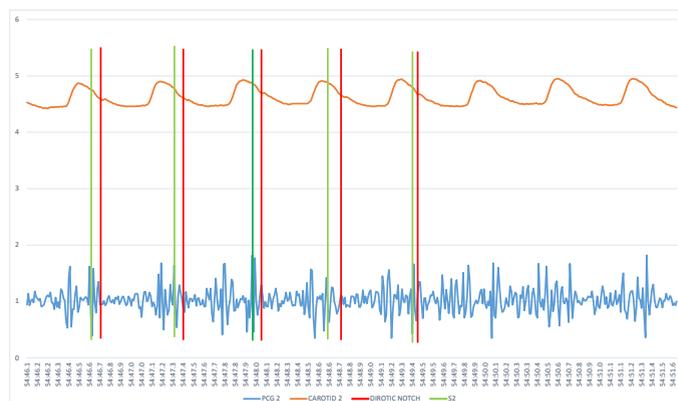


FIGURE 3. Correlation Graph of S2 Phonocardiograph with Dicrotic Notch Carotid Pulse (SEN0230 Sensor)

Based on the results of data collection on 10 respondents who aimed to measure the correlation between dicrotic notch (carotid pulse) and phonocardiograph (PCG) using piezoelectric sensors and SEN0203 results have been found in TABLE 1

TABLE 1
Average Results of S2 and Dicrotic Notch Interval Measurements in 10 Respondents

Responden	Interval S2 dan Dicrotic Notch (s)	
	PIEZOELEKTRIK	SEN0203
1	0.11	0.13
2	0.17	0.052
3	0.124	0.098
4	0.136	0.13

5	0.17	0.106
6	0.144	0.152
7	0.144	0.044
8	0.104	0.044
9	0.146	0.148
10	0.142	0.064
AVERAGE	0.139	0.0968

The measurement results of 10 respondents showed that the average result of measuring the correlation between dicrotic notch on carotid pulse and S2 on phonocardiograph (PCG) using piezoelectric sensor was 0.139s greater than using SEN0203 sensor with an average of 0.0968s. It was found that the use of piezoelectric sensors in measuring the correlation of dicrotic notch on carotid pulses with S2 on phonocardiograph (PCG) was better than SEN0203 sensors.

D. DISCUSSION

The overall working system begins when the tool is activated, the tool starts the initialization of ADC data from the carotid sensor consisting of piezoelectricity and SEN0203 will detect carotid signals from the MAX9814 sensor used to detect heart sound signals. After initialization is complete, the program will read the ADC data to be processed to the microcontroller. In microcontrollers, there is a process of converting analog signals from reading ADC data to digital data so that it can be processed. Once read, the program will provide a code for sending heart sound signals to the Personal Computer via a USB cable to be received in the Visual Studio Code program to be displayed in real time and simultaneously or simultaneously. On the graphic display, the program will start displaying the Carotid Pulse. Before measuring the tool on respondents, it is necessary to test the sensor first with the aim of knowing whether the sensor works as expected. After that testing is carried out, the tool can be tested on 10 respondents.

This measurement on respondents is carried out with the aim of comparing the performance of the two sensors when applied or used directly to respondents. In addition, to determine the relationship between phonocardiograph (PCG) and carotid pulse. In this measurement, some data are taken, namely S2 on the phonocardiograph (PCG) and dicrotic notch or D wave on the carotid pulse signal which is a wave that causes the closure of the aortic valve. And from the data of the 10 respondents will get the average interval between S2 and dicrotic notch.

E. CONCLUSION

Based on the above research that has been explained, it can be concluded that piezoelectric sensors and SEN0203 sensors can be used in detecting carotid pulses. the results of the carotid pulse readings from the piezoelectric sensor and the SEN0203 sensor state that there is a relationship between the carotid pulse and the phonocardiograph (PCG). The use of piezoelectric sensors can be expressed better in showing the correlation between carotid pulses and phonocardiographs than

the use of SEN0203 sensors

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