RESEARCH TITLE

Implementation of Multiscale Poincaré in Early Detection System for Atherosclerosis

A research summary of no more than 500 words containing: research background, research objectives, research method stages, targeted outcomes, as well as a description of the proposed research TKT.

SUMMARY

One potentially life-threatening disease is atherosclerosis. Initially, this disease is caused by injuries inside the arterial walls, resulting in the accumulation of deposits in the arteries that can lead to serious issues in the body, such as stroke, heart attack, and the possibility of death. There are several methods used to detect atherosclerosis early, including Flow Dilatation, Ultrasonic, Computer Tomography scan (CT-scan), and Magnetic Resonance Imaging (MRI). However, these methods are expensive and time-consuming. Therefore, Photoplethysmogram (PPG) can be an alternative solution to create a faster and more affordable early detection system for atherosclerosis.

The development of an early atherosclerosis detection system using PPG signal processing will be conducted in this research. Two groups, healthy and heart disease subjects, are separated for the study. The groups will be tested across various genders and ages. In this study, we apply PPG to obtain signals from subjects. The signals come from an optical sensor placed on the subject's wrist or/and finger. Then, to recognize and eliminate artifacts from the raw PPG signal, Fast Fourier Transform (FFT) Algorithm will be applied. This process is also used for feature extraction based on different frequency types. Finally, feature clustering from the PPG signal is performed by Multiscale Poincaré to determine the level of atherosclerosis. All PPG signal processing is done by MATLAB. The targeted output is an article published in the IJECE journal, with the expected publication year being 2024. The targeted TKT scale for this research is scale 3 to prove that the created system is capable of quickly and affordably detecting atherosclerosis.

Keywords maximum 5 keywords. Use a semicolon (;) as a separator and write in alphabetical order.

Multiscale Poincaré; Early Detection System; Photoplethysmogram; Atherosclerosis.

The research background is no more than 500 words containing: (i) the problem to be researched, (ii) the research objectives, and (iii) the urgency of the research. At the end of this background section, the reasons for selecting the research scheme are also explained.

BACKGROUND

Photoplethysmography (PPG) [1] is an optical sensor-based device known for its affordability, simplicity, and ease of use. This device holds significant potential as a valuable medical tool for the effective assessment of several cardiovascular diseases (CVD), including hypertension [2-4], diabetes [2], atherosclerosis [5], erectile dysfunction [6], and conditions associated with the coronary artery [7-9].

Atherosclerosis is a significant factor in cardiovascular disease (CVD), and the increase in

arterial stiffness and the progression of atherosclerosis are connected to a higher risk of severe cardiovascular events and mortality, especially in individuals with essential chronic diseases [10]. Assessing arterial stiffness is essential, and Photoplethysmography (PPG) offers numerous advantages due to the simplicity of its system and ease of application for this purpose.

In the assessment of the PPG system, addressing issues related to time consumption and data reduction is pivotal. Several methods have been proposed to tackle these challenges, and one such approach that capitalizes on the multiscale concept is multiscale entropy (MSE). Expanding on this concept, Multiscale Poincaré (MSP) has been developed to simplify the mapping used in assessing R–R intervals from Electrocardiography (ECG) signals in various diseases [11]. However, the application of this method to study other biomedical signals remains unclear. Despite numerous algorithms being suggested to enhance the original MSE's performance, especially in reducing computational time [12], there are still possibilities for further improvement.

As part of the study objectives, one goal is to assess the Poincaré plot, a straightforward calculation method, using PPG signals from both healthy and diabetic subjects. Another objective is to explore the feasibility of MSP in distinguishing similar subjects based on PPG amplitudes. Additionally, the study utilizes three parameters of Poincaré plot for comparison with MSP.

Additionally, there are two reasons why the research chooses this scheme. The first reason is that the research implements the MoU between two universities (UAD and NDHU). The second reason is that the researchers want to collaborate with other researchers from other countries to improve their skills and publications.

Literature review of no more than 1000 words by presenting the state of the art and road map in the field being studied. Charts and road maps are created in JPG/PNG format which are then inserted into this field. Relevant primary library/reference sources and prioritizing research results in scientific journals and/or the latest patents. It is recommended to use library sources from the last 10 years. Specifically for the PIPP scheme, the literature review focuses on findings from related patents that previously existed. This section must also include a table of related patent search results.

LITERATURE REVIEW

Poincaré plot

A simple method to analyse qualitative and quantitative signal is Poincaré plot that has three variables, which measure the short- and long-term variability of biological data. Most of the studies stated that the method was used to analyse the heart rate variability (HRV) [13]. However, more explorations to analyse the application of the method in other biomedical signals still have challenges [14].

Poincaré plot could be shaped from the delay time series of PPG pulse amplitudes (i.e. PPGA). The minor axis of the ellipse (SD1), the major axis of the map (SD2), and the SD1/SD2 ratio are the three indices in this plot that is related to the standard deviation (SD) of the short-

term PPGA and the long-term PPGA, respectively [15]. The three parameters are presented in (1), (2), (3).

$$SD1 = \sqrt{var(PPGA(i) - PPGA(i+1)/\sqrt{2})} \quad (1)$$

$$SD2 = \sqrt{var(PPGA(i) + PPGA(i+1)/\sqrt{2})} \quad (2)$$

Therefore, the SSR be able to define by

$$SSR = SD1/SD2 \quad (3)$$

Multiscale Poincaré (MSP)

MSP is calculated from SSR by applying the fundamental function (τ) to each coarse-grained dataset. The multiple coarse-grained in dataset is described as follows by equation 4.

$$y_k{}^{(\tau)} = \frac{1}{\tau}\sum_{i=(k-1)\tau+1}^{k\tau} PPGA''_L(i) \quad , 1 \le k \le \frac{n}{\tau}, k \in integer \quad (4)$$

The range from which the SSR(τ) values are obtained was from 1 to 10 to calculate MSP_{SSR} in multiple scale as follow the equation below:

$$MSP_{SSR}(n) \triangleq \frac{1}{10}\sum_{\tau=1}^{10} SSR(n,\tau) \quad \text{n = 1000, 500, 250, 100} \quad (5)$$

Prior work

In previous studies, several methods have been presented in attempting to minimize the amount of data and speed up the processing. However, other enhancements remain potential, particularly in the saving of computational time. Poincaré plot with simplicity of calculation is applied to investigate the viability of MSP in differentiation of healthy and diabetic subjects. Therefore, the main aim of the study is implementation MSP to detect atherosclerosis.

Road map

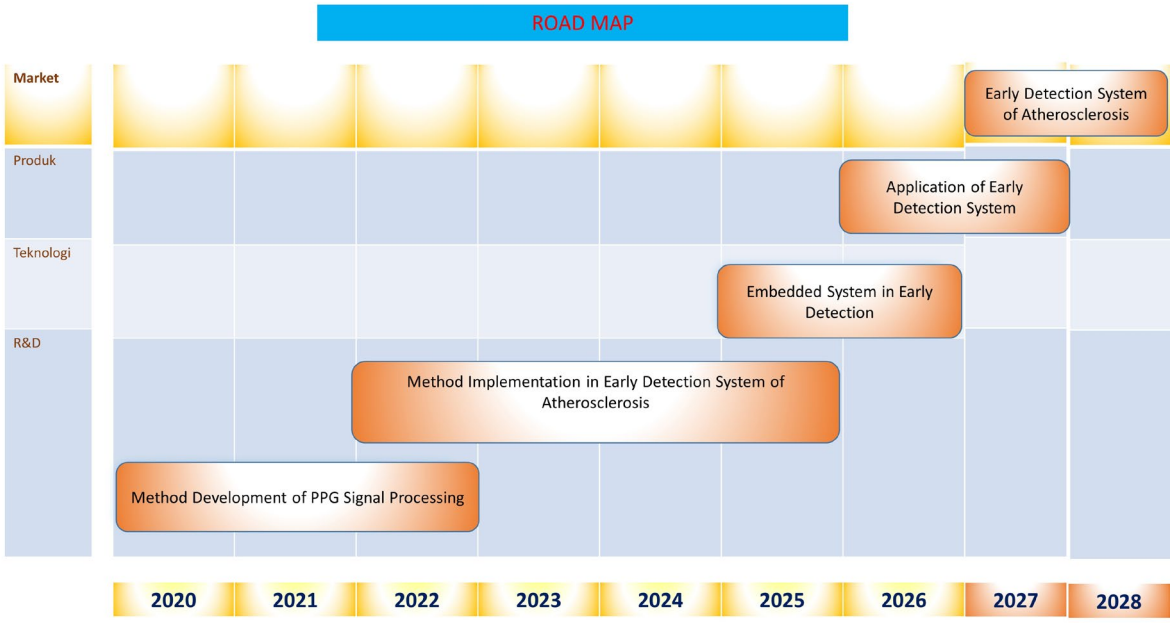

Figure 1. Research roadmap

Methods or ways to achieve the stated objectives are written in no more than 600 words, including: (i) population, sample, sampling technique, (ii) data collection methods, (iii) research design, (iv) research procedures, and (iv) data analysis. This section is equipped with a research flow diagram that describes what has been carried out and what will be done during the proposed time. The flow chart format can be a JPG/PNG file. The research chart must be made in its entirety with clear stages, starting from the beginning, what the process and outcomes are, and the targeted achievement indicators.

RESEARCH METHODS

Data Population

There are two parts in collecting PPG data in this study. In the first part, collecting PPG data from healthy and non-healthy subjects, the non-invasive optical instrument is used in left wrist and/or finger of each subject (sampling rate=500Hz). Before data acquisition is conducted, all subjects are asked to pass the blood sampling procedure to reduce latent inaccurate interpretations from the PPG sensor. All participants relaxe (5 minutes) in a silent and controlled temperature (25 ± 1 °C) room at a supine position.

Research Design

The research designs follow the steps:

1. PPG Signals Acquisition

There are several steps to collect the PPG signals. First of all, an optical sensor put in his or her finger and/or wrist. Secondly, the signals from the optical sensor are transferred to the high pass filter stage in order to pass signal frequency higher than 0.5 Hz then transmitted to the amplification module. After that, the first and the second stage of Butterworth low pass filter removed baseline variations and interferences in frequency lower than 10.6 Hz. Before the digital signals are stored to the memory unit for computation using the LabVIEW software, the analogue signal is digitalized using a specific instrument as part of the microcontroller such as Arduino board.

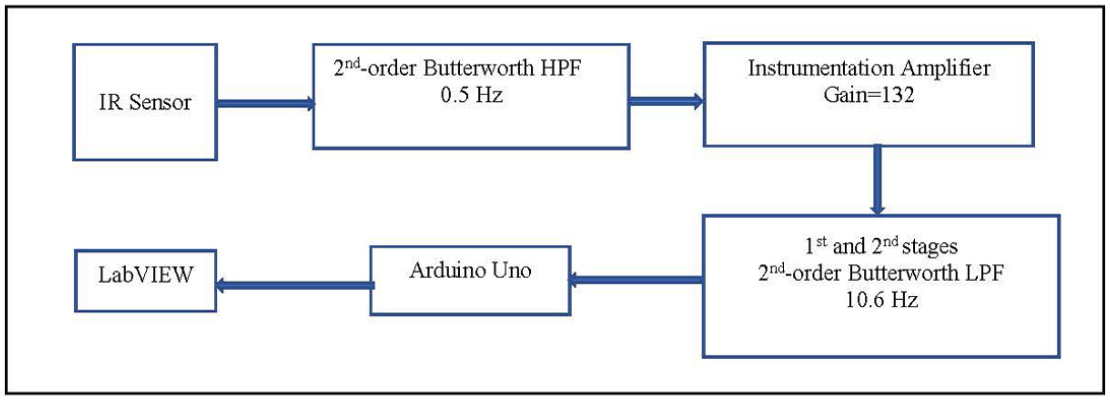

Figure 2. PPG Signals Acquisition

2. Calculation of PPG Signal Amplitudes

The converted signals were saved with no other digital filtering units in order to reduce time consuming after signals had been processed by ADC. Using the MATLAB software with special edition, then PPG signal is ready as an original of PPG pulse amplitudes (PPGA). PPGA coming from the PPG signals are displayed in **Figure 3**. The retrieved consecutive PPGA from left hand ($PPGA_L$) for each participant as shown in (6).

$$PPGA_L(N) = \{PPGA_L(1), \ldots, PPGA_L(i), \ldots, PPGA_L(N)\} \quad (6)$$

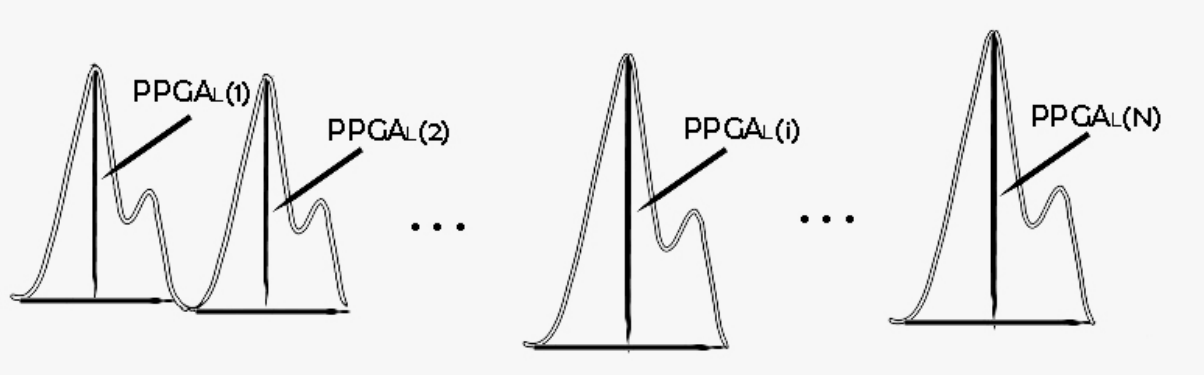

Figure 3. The samples of $PPGA_L$

3. Implementation of MSP

There are two steps to implement MSP. Firstly, we will apply the Poincare plot to classify the $PPGA_L$ between the healthy group and unhealthy group. Secondly, the MSP will be conducted to detect the level of atherosclerosis of two different groups.

4. Statistical Analysis

The SPSS version 22 is used as main software in analysing statistics data. The results presented in tables are expressed mostly in structure (mean ± standard deviation). Kolmogorov-Smirnov test is applied to show satisfactory in normal distribution. To compare two distinct clusters in continuous variables is applied a two-tailed t-test. Additionally, categorical variables are compared using the Fisher's exact test or the chi-square test to distinguish between the clusters.

Research Procedure

This research will be conducted as follows in Figure 4.

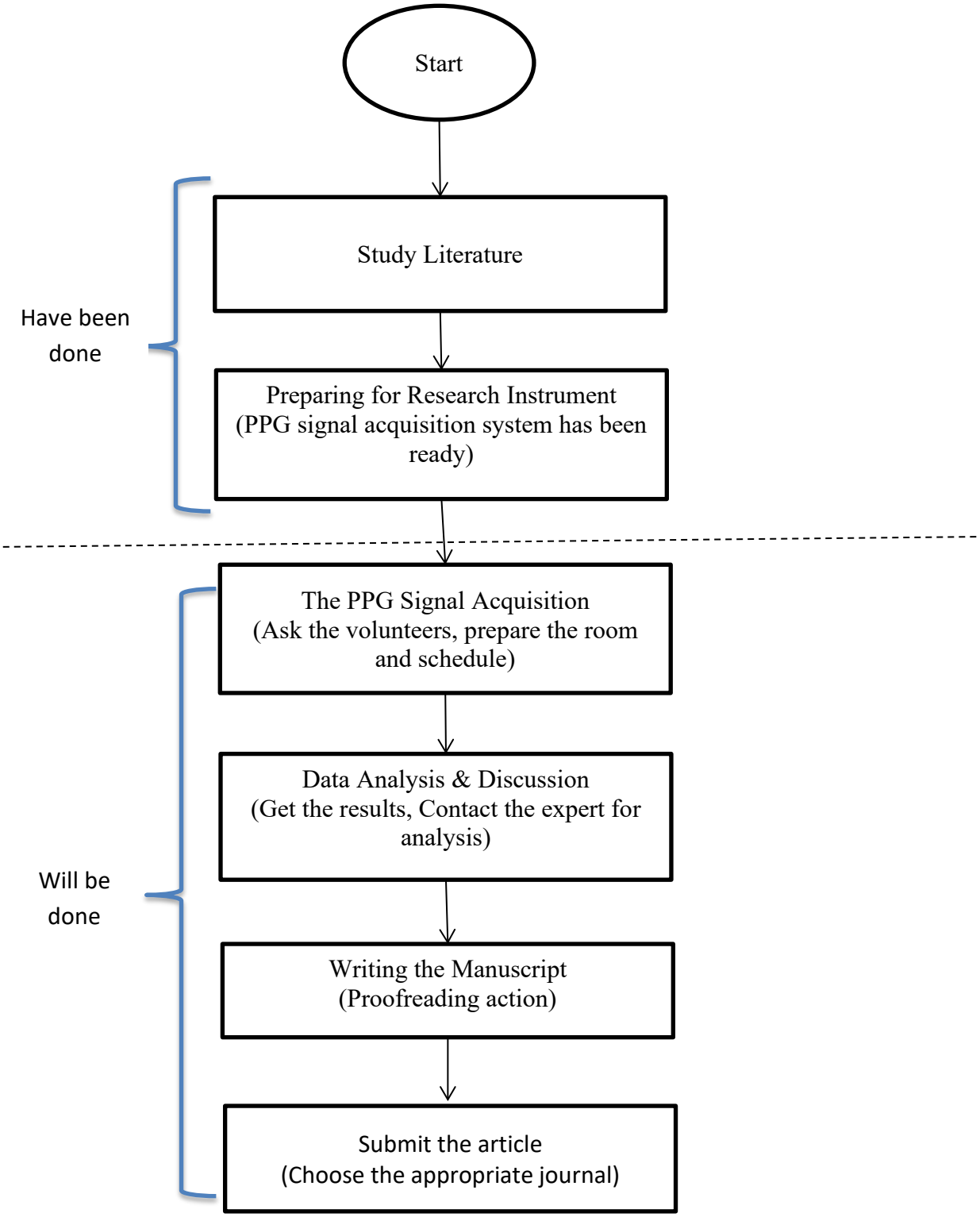

Figure 4. Research Procedure Flow chart

Write down the mandatory outputs and additional outputs that will be used from this research. The type of outcome is adjusted to the type of research

OUTPUTS TARGET

No	Output	Outer type	Outer Goals
1	Must	***Article***	***IJECE***
2	Addition		

The research schedule is prepared by filling in the following table directly, allowing for additional rows according to the number of activities.

RESEARCH SCHEDULE

No	Research Schedule	Month							
		1	2	3	4	5	6	7	8
1	Preparation	X							
2	Data collection		X	X					
3	Data analysis				X	X			
4	Writing Draft manuscript						X		
5	Submit the manuscript							X	
6	Progress report								X

Information:
The 1st month is the first month of the contract, the 8th month is the final period of the contract which is marked by uploading the final report and mandatory outputs and additional outputs, if any.

The bibliography is arranged and written based on a number system according to the order of citation. Only literature cited in the research proposal is included in the Bibliography. Minimum 15 references.

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Telah menyetujui atas revisi yang telah dilakukan oleh tim pengusul
Reviewer,

Dr. Moh. Toifur, M.Si.