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Discrete Wavelet Transform (DWT) and Entropy features to monitoring Happy Hypoxia based on Photopletysmograph Signal

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Abstract

Happy hypoxia is a disease that is becoming a new phenomenon in covid-19 cases in 2020. Happy hypoxia is a condition where the patient experiences a decrease in oxygen saturation in the brain or there is only about <90% saturation in the brain. Several studies have been carried out to detect happy hypoxia. with many types of implementations. Existing research projects generally use Discrete Fourier Transform (DFT) signals. However, the results show that the accuracy of detecting happy hypoxia is still low. This study provides a solution to the problems above, by proposing a happy hypoxia detection system based on the entropy feature and the Discrete Wavelet Transform (DWT) feature combined with a classifier based on K Nearest Neighbor (KNN). The method used in this study is the Hybrid Wavelet and Entropy Features method, by utilizing the data obtained to convert the data template into data with a photopletysmography signal template, then the data will be collaborated with Python-based data processing to get the accuracy value by applying this method. Discrete Wavelet Transform and Entropy Features. The experimental results show that the proposed system has 98% accuracy for Discrete Wavelet Transform and 98% accuracy for Entropy Features.

Keywords: Happy Hypoxia, Entropy Features, Signal Photoletsymogram, Hybrid Wavelet

I. Introduction

Several studies on happy hypoxia based on photopletysmogram signals with various methods in their application such as Photoplethysmography (PPG)-based human pulse detection on video using Discrete Fourier Transform (DFT) [2], The pathophysiology of "happy" hypoxemia in COVID-19. Respiratory Research [3] and Happy Hypoxia Early Detection Tool in IoT Based for COVID-19 Patients Using SpO2 Sensor, Body Temperature and Electrocardiogram (ECG) [4] and Smartphone pulse oximeter: a solution for early detection of happy hypoxia [8], Denoising of EEG , ECG and PPG signals using wavelet transform [11] as well as research such as the use of smartphone communication devices for medical needs were also carried out in research A fetal ECG monitoring system based on the android smartphone [12]. Hypoxia based on tool

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design without measuring the accuracy of the research results. In this study the authors make a design from previous research by utilizing photopletysmogram signals with KNN-based data processing which is implemented with signal processing methods based on Discrete Wavelet Transform (DWT) and Entropy Features. sample data was taken from a hospital in the city of Medan, with the use of both methods, an accuracy value of 98% was obtained for KNN based on Discrete Wavelet Transform and also 81% for KNN based on Entropy Features. The accuracy value above is the value in the first sample where the repeat value is accuracy is done 8 times. based on the problems above, this final project is a happy hypoxia monitoring design based on Discrete Wavelet Transform and feature entropy by utilizing photopletysmogram signals.

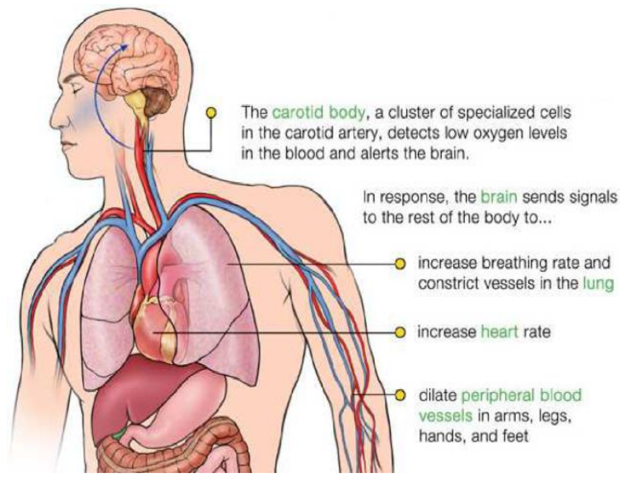


Fig. 1. Happy Hypoxia Symptom on Human Body

II. LITERATURE REVIEW

Fig. 2 shows a flow chart illustrating the research methodology. The research process is as follows: literature review, algorithm design, algorithm testing, and prototype design applied the proposed algorithm but if the prototype does not reach an accuracy rate of 85% then the step will return to the algorithm testing process, if testing produces an accuracy value of 85% then the process continues to testing and analytics of the developed prototype.

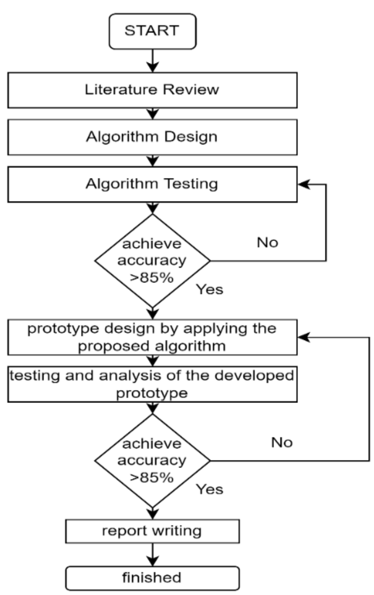


Fig. 2. Flowchart Research Framework

The design stages in this study include: (1) study of literature; (2) Algorithm Design; (3) Algorithm Test; (4) Implementation of the algorithm; (5) Testing and Analysis of the developed Prototype; (6) Report writing; (7) analysis and discussion

A. K-Nearest Neighbor (KNN)

KNN classifier is to classify unlabeled observations by assigning them to the class of the most similar labeled examples. Characteristics of observations are collected for both training and test dataset. There are two important concepts in the above example. One is the method to calculate the distance between sweet potato and other kinds of food [14].

$$D(p,q) = \sqrt{(p_1 - q_1)^2 + (-q_2\ )^2 + 7 \dots + (p_{\Pi} - q_n)^2} \quad (1)$$

where p and q are subjects to be compared with n characteristics. There are also other methods to calculate distance such as Manhattan distance

B. Photopletysmograph

The principles of PPG have been reviewed previously and briefly explained here. Light travels through biological tissues to be absorbed by various substances, including pigments in the skin, bones, and arterial and venous blood. Most changes in blood flow occur primarily in the arteries and arterioles (but not in the veins). For example, arteries contain more blood volume during the systolic phase of the cardiac cycle than during the diastolic phase.

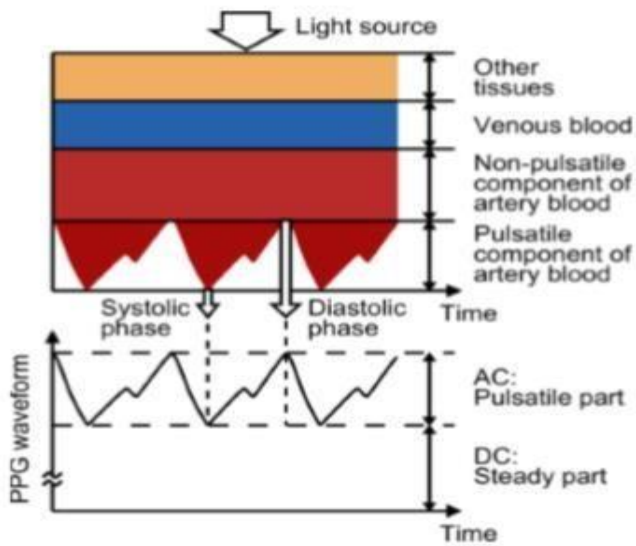


Fig. 3. Variation of Light Absorption by Tissue Body

PPG sensors optically detect changes in blood flow volume (i.e., detect changes in light intensity) in the microvascular layer of tissue through reflection from or transmission through the tissue. Figure 3 shows an example of a photoplethysmographic waveform, consisting of direct current (DC) and alternating current (AC) components. The DC component of the PPG waveform corresponds to the transmitted or reflected optical signal detected from the tissue and depends on the tissue structure and the average blood volume of arterial and venous blood.

III. RESEARCH METHOD

Research methods are designed to monitor people with hypoxia, the authors use the photopletsymogram method with the application of hybrid wavelets and entropy features as a supporting tool in conducting a monitoring analysis of Hypoxia Syndrome. Photoplethysmography (PPG) is a simple optical technique used to check the volume of blood in the peripheral circulation. This is a low-cost, non-invasive method that makes measurements on the surface of the skin. This technique provides valuable information regarding our cardiovascular system.

A. Data

In this experiment data in this experiment was taken from medical data originating from the Hj. Adam Malik general hospital in the city of Medan and some testing data was taken from databases on open sites such as Bidmc where the data was processed into data to maximize the data to be obtained in a Discrete Wavelet transform and also Entropy Features to get the best accuracy value.

TABLE I
DATA PATIENT FROM HAJI ADAM MALIK MEDAN

No	Initial Name	Age	Blood Pressure (BP)	Respiration Rate (RR)	Heart Rate (HR)	Saturate Oxygen (SpO2)
1	M.Hut	62	122/66	36	132	83%
2	D.Gin	43	103/10.8	14	145	98%
3	SAH	60	105/71	20	110	98%
4	M.SYA	31	97/74	32	97	99%
5	A SIB	55	103/80	28	71	97%
6	R ER	61	142/83	30	122	84%
7	SA LU	37	123/78	24	87	99%
8	ADA	44	134/89	20	112	97%
9	SA Gin	77	124/85	14	75	97%
10	EF IB	63	130/50	20	99	96%
11	SUK	69	140/80	24	99	97%
12	SUB	51	130/90	20	70	98%
13	RO Gin	45	200/120	30	75	98%
14	AS RI	58	200/135	32	104	91%
15	HAZ RO	27	108/62	32	112	95%
16	SAH NAP	65	120/70	20	50	97%
17	MA EL	6	-	20	72	92%
18	MU HA	18	110/70	20	84	99%
19	BU SI	66	124/70	20	71	97%
20	SU PER	67	156/101	18	98	98%

B. Discrete Wavelet Transform

Wavelets are a family of derivatives of single functions that are translated and dilated. The general form of the wavelet function is:

$$\psi^{n,h} - |U|^{-1/2}\Psi\left(\frac{t-b}{a}\right) \quad (1)$$

Ψ is called the mother wavelet and is used to get all of its derivatives. The general choices for a and b are a = 2m, b = n2m, n, m Z, where n and m are the scales and translation indices, so we get

$$\psi_{m,n}(t) = 2^{-2}\,\psi(2^{-m}t - n) \qquad (2)$$

Discrete Wavelet Transform not only uses wavelet function, but also uses image smoothing function. The scale function is dilated and translated as the wavelet function equation, so that it is obtained

$$\phi_{m,n}(t) = 2^{-m/2}\phi(2^{2}\,t - n) \qquad (3)$$

C. Entropy Features

Entropy method, the entropy value shows randomness of the gray degree distribution of a image, random degree distribution the gray, the higher the entropy value generated. Entropy for image, the higher the value of entropy, the complex of the image. Tendency of entropy and energy the opposite. Entropy also represents the amount of information contained in distribution data. Entropy is a statistical measure of randomness which can be used for characterizes the texture of the input image. [5] It can be seen from the entropy formula as follows:

$$entropi = -\sum_{i=\underline{o}}^{l-1} P(i)\; log\; log\; \big(P(i)\big) \qquad (4)$$

D. Scenario

1) Denoising Signal

Noise reduction (denoising) is a fundamental part of digital image processing, Digital image processing is one of the important elements in image analysis. Denoising is a noise-crime technique found in the image and retains important information. Image denoising can be done by various methods, for example by a filtering process, wavelet analysis, and fractal method.

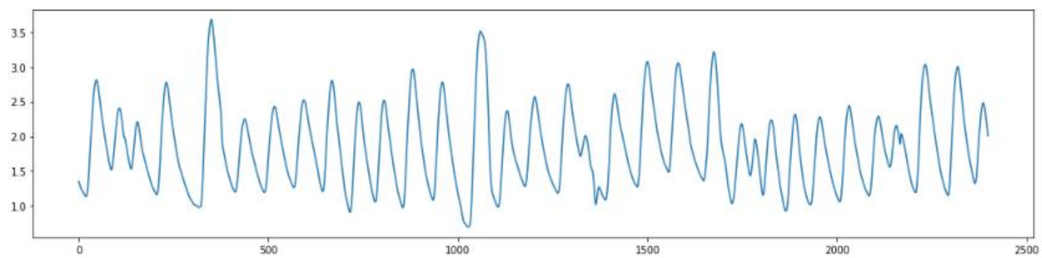
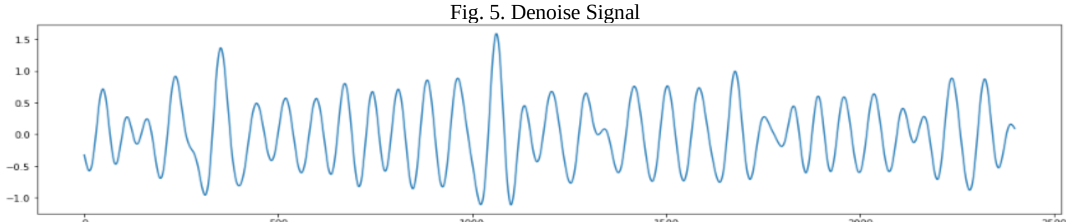


Fig. 4. Original Signal

Fig. 5. Denoise Signal



Based on the denoise process above, we can conclude that there has been a formation of an original signal with a significant comparison.

2) Cleaning Signal

The purpose design of the signal cleaning process aims to divide the data value after the denoising process is carried out where the data will be divided into two model signals namely Atrial Fibrillation (AF) and normal (N).

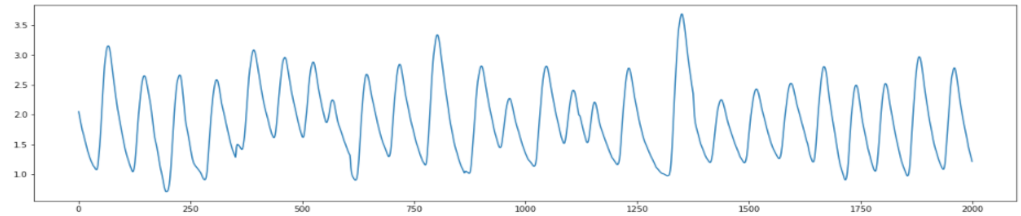


Fig. 6. Atrial Fibrillation (AF) Signal

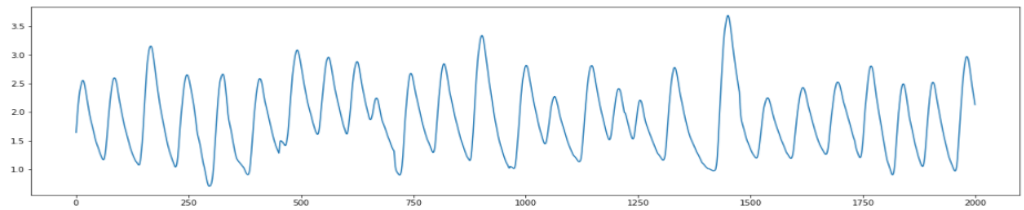


Fig. 7. Normal (N) Signal

Atrial Fibrillation and normal data which aims to carry out the process of absorption of entropy feature extraction and Discrete Wavelet Transform in the search for accuracy by utilizing the K-nearest Neighbor Algorithm

3) Features Extraction

In the design of the data feature extraction process that has been denoising and cleaning, the feature extraction process is carried out so that the data can be implemented into the data analysis process so that the process of finding the accuracy value can be carried out.

4) K Nearest Neighbor on Discrete Wavelet Transform and Feature Entropy

Based on the process of applying KNN to Discrete Wavelet Transform and entropy features, the value of the results of denoising and cleaning is implemented into a Java-based programming language, so that the accuracy value of the two methods is obtained.

IV. RESULTS AND DISCUSSION

A. Patient sample data collection scheme using a mobile phone

Currently most Android Smartphone devices are being developed that can be used for all needs. Through the Smartphone application, the user's heart rate data can be monitored by others for certain needs, in addition heart rate data can be stored on the Smartphone for certain needs

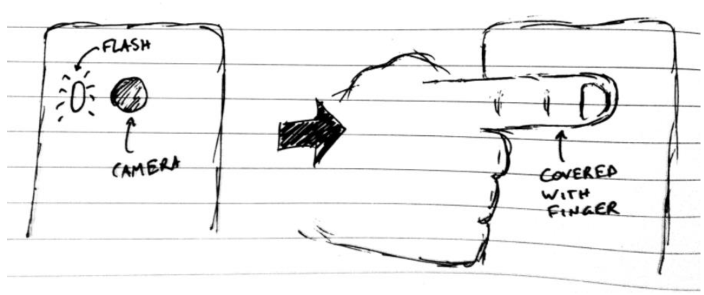
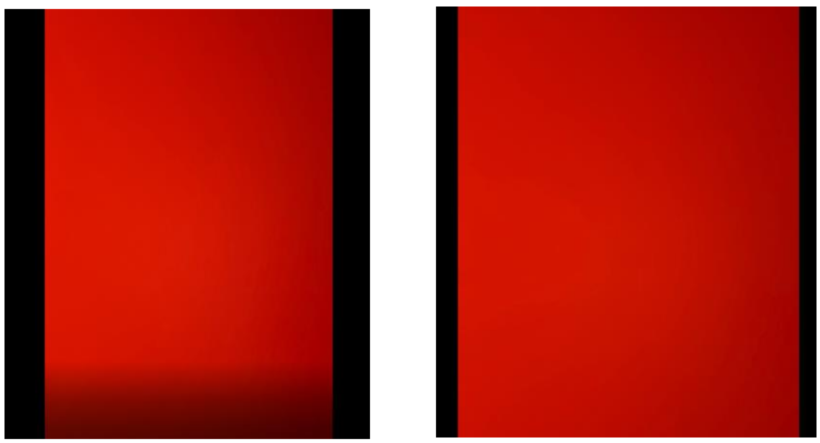


Fig. 8. Photoleysmogram on Mobile

Before we can extract the sample of data, we must record it.

1. Open your camera app on your phone and prepare to record video (don't start the recording yet, though).
2. Turn on the flash.
3. Place your finger such that it covers both the flash and camera, like in the image below. Note that you need to adjust this based on your flash/camera layout. Just make sure your finger covers both.
4. Record a video of at least 20 seconds.
5. Save video to computer/ Google Drive to be accessible to this script

Fig. 8. Show a picture of taking the blood rate using a camera and flash smartphone, there are two models of testing resting1 and active1 sample testing.



(Resting1) **(Active1)**

Fig. 9. Blood Rate of The Test Results Video

The results of the blood measurement above are the use of components from placing a finger between the middle rear camera, the flash position is turned on, causing the blood flow in the index finger to be detected by the HP camera.

B. Discrete Wavelet Transform Using K-Nearest Neighbor

In this section, we execute the signal denoise process that we have done to get the accuracy value which will later be processed by the KNN method.

TABLE II
ACCURACY K-NEAREST NEIGHTBOR DISCRETE WAVELET TRANSFORM

	Precision	Recall	F1-score	Support
AF	0.98	1.00	0.99	108
N	0.00	0.00	0.00	2
Accuracy			0.98	110
Macro Avg	0.49	0.50	0.50	110
Weighted Avg	0.96	0.98	0.97	110

The accuracy for the data value of the train results above is 0.98% taken from the accuracy value in the F1-Score table

C. Entropy Feature Using K-Nearest Neighbor

In this section, we execute the signal denoise process that we have get the accuracy value which will later be processed by the KNN method.

TABLE III
ACCURACY K-NEAREST NEIGHBOR ENTROPY FEATURES

	Precision	**Recall**	**F1-score**	**Support**
AF	0.81	1.00	0.89	79
N	1.00	0.05	0.10	20
Accuracy			0.81	99
Macro avg	0.90	0.53	0.49	99
Weighted avg	0.85	0.81	0.73	99

The accuracy for the data value of the train results above is 0.81% taken from the accuracy value in the F1-Score table

D. Discussion

This study refers to Farid Suryanto [2], who previously classified pulse detection with a photoplethysmograph signal using a discrete Fourier transform. The results of his research succeeded in measuring the value of bitrate per second by utilizing the results of the image. Based on this research, the author felt challenged to monitor hypoxia using the entropy feature and Discrete Wavelet Transform signal. This study refers to Farid Suryanto, who previously classified pulse detection with a photoplethysmograph signal using a discrete Fourier transform. The results of his research succeeded in measuring the value of bitrate per second by utilizing the results of the image. Based on this research, the author felt challenged to monitor hypoxia using the entropy feature and Discrete Wavelet Transform signal.

TABLE IV
THE RESULT DATA ACCURACY OF ENTROPY FEATURES AND DISCRETE WAVELET TRANSFORM

No	**Discrete Wavelet Transform**	**Entropy Feature**
1	0,98%	0,81%
2	0,98%	0,98%
3	0,92%	0,93%
4	0,95%	0,90%
5	0,93%	0,86%
6	0,90%	0,93%
7	0,97%	0,90%
8	0,98%	0.97%

Based on the results of the experiments above, it can be concluded that the value of Discrete Wavelet Transform gets a more stable value in each experiment, for the value generated by feature entropy gets a relatively variable value.

V. CONCLUSION

Based on the research that has been done, then it can be said that Design Photoplethysmography (PPG) to count *Accuracy* with K-Nearest Neighbor by based PLETH and II data successfully built and working well. Most heart rate detection results the highest score of accuracy is an average error of 0.98% with using Discrete Wavelet Transform data, then for the result of Entropy Features it has result 0,81%. based on the results of the tests that have been carried out, conclusions can be drawn:

1. The denoising process on a signal serves to neutralize a signal
2. The denoising process can be enabled in the creation of a new dataset that will be used in processing a dataset to become a dataset that will be used in processing data accuracy
3. Utilization of features on a cellphone can be used as a scientific work processing
4. the best experimental process in the Discrete Wavelet Transform Process gets an accuracy value of 0.98%
5. the best experimental process in the Entropy Feature process gets an accuracy value of 0.98%
6. Implementation of smartphones is an example used to get data from the patient not the best result to get the data

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