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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 condition where patients experience decreasing oxygen saturation in their brains. In worst cases, Happy hypoxia can reduce the patient's consciousness and even death. Covid-19 has increased cases of happy hypoxia. Several studies have been conducted to detect happy hypoxia. Existing research projects generally use photoplethysmography signals. However, the results show that the accuracy of happy hypoxia detection is still low. This study provides a solution to the above problems, by proposing a happy hypoxia detection system based on entropy features and Discrete Wavelet Transform (DWT) features that are combined with a classifier based on K Nearest Neighbor (KNN). The method used in this research is as below Hybrid Wavelet and Entropy Features method. Experiments on the proposed system have been carried out using data on Covid-19 patients from Haji Adam Malik Hospital in Medan. The experimental results show that the system proposed has an accuracy of 87%, sensitivity of 90%, and specificity of 85%.

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

I. Introduction

At the end of August 2020, there was news about an unusual symptom of people with COVID-19, it’s called happy hypoxia. This has been discussed a little in the previous article but will be discussed more deeply in this article. Happy hypoxia has a most formal name in medical science, namely silent hypoxia or silent hypoxemia. An event or condition that is well known in the medical world can be due to several medical conditions. Currently, there are COVID19 (C19) patients showing these symptoms, happy hypoxia has become famous. Covid-19 has increased cases of happy hypoxia. Several studies have been conducted to detect happy hypoxia. Existing research projects generally use photoplethysmography signals. However, the results show that the accuracy of happy hypoxia detection is still low. This study provides a solution to the above problems, by proposing a happy hypoxia detection system based on entropy and Discrete Wavelet Transform (DWT) features that are combined with a classifier based on K Nearest Neighbor (KNN)

Oxygen saturation is a value that indicates the level of oxygen in the blood. This value is very influential on various functions of organs and body tissues. Measurement of oxygen saturation values can be done in 2 ways, namely by blood gas analysis (AGD) or using an oximeter. The principle of physical distance in SpO2 detection on existing oximeters has not been applied to solve this problem, the study developed a tele-oximeter based on photoplethysmograph (PPG) signals to serve SpO2 for Covid patients. Machine learning is used to improve SpO2 level accuracy.

In engineering design in monitoring people with hypoxia, the authors use the photopletsymogram method with the application of hybrid wavelets and entropy features as supporting tools in analyzing the monitoring of Hypoxia Syndrome. Photoplethysmography (PPG) is a simple optical technique used to detect volumetric changes in 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 the cardiovascular system.

Recent technological advances have revived interest in this technique, which is widely used in clinical physiological measurement and monitoring The photoplethysmogram makes use of low-intensity infrared (IR) light. When light travels through biological tissues, it is absorbed by bone, skin pigment, and venous and arterial blood. Because light is more strongly absorbed by the blood than the surrounding tissue, changes in blood flow can be detected by the PPG sensor as changes in light intensity. The voltage signal from the PPG is proportional to the amount of blood flowing through the blood vessels. Even small changes in blood volume can be detected using this method, although they cannot be used to measure blood counts.

II. LITERATURE REVIEW

Research on measuring oxygen pressure in the human body has long been carried out in research and so far in the medical world, the tool that has been created is the oximeter an oil for measuring oxygen pressure in the blood. Based on many related articles such as Entropy and Hybrid wavelet according to the author, it is very rarely used in its application in happy hypoxia analysis. Overall the author's theoretical design is summarized from several sources of articles that have no comparative value between the author's work and other scientific works. The hope of making this scientific work is to create a new system design to combine feature entropy and hybrid wavelets for monitoring happy hypoxia.

In this design, the author refers to the scientific work of Farid Suryanto [2] entitled "HUMAN PULSE DETECTION BASED ON PHOTOPLETHYSMOGRAPHY (PPG) ON VIDEO USING THE DISCRETE FOURIER TRANSFORM (DFT) ". Signal photoplethysmography is very closely related to the application of telemedicine and it is very interesting if research is carried out with a combination of other diseases in the medical world.

where the scientific work produces a heart rate value of 4 data results which have the following comparisons:

TABLE I
STATISTICAL DATA FOR 4 HR MEASUREMENT METHODS USING 60-SECOND DURATION VIDEOS

Statistik	M1	M2	M3	M4
Mean of Error (BPM)	2.46	2.83	5.50	4.77
Standart Deviation of Error (BPM)	1.17	2.49	1.89	2.44
Pearson's Correlation coefficient	0.97	0.95	0.90	0.85
Success Rate	85%	71%	28%	42%

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.

Recent technological advances have revived interest in these techniques, which are used in clinical physiological and medical measurements The photoplethysmogram makes use of low-intensity infrared (IR) light. When light travels through biological tissues, it is absorbed by bone, skin pigments, and venous and arterial blood. Because stronger light is absorbed by the blood which helps the surrounding tissue, changes in blood flow can be detected by the PPG sensor as changes in light intensity. The voltage signal from the PPG is proportional to the amount of blood flowing through the blood vessels. Even small changes in blood volume can be detected using this method, although they cannot be used to measure blood counts.

Fig. 1 shows a flow chart illustrating the research methodology. The research process is as follows: literature review, algorithm design, algorithm testing, and prototype designapplyinglied 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.

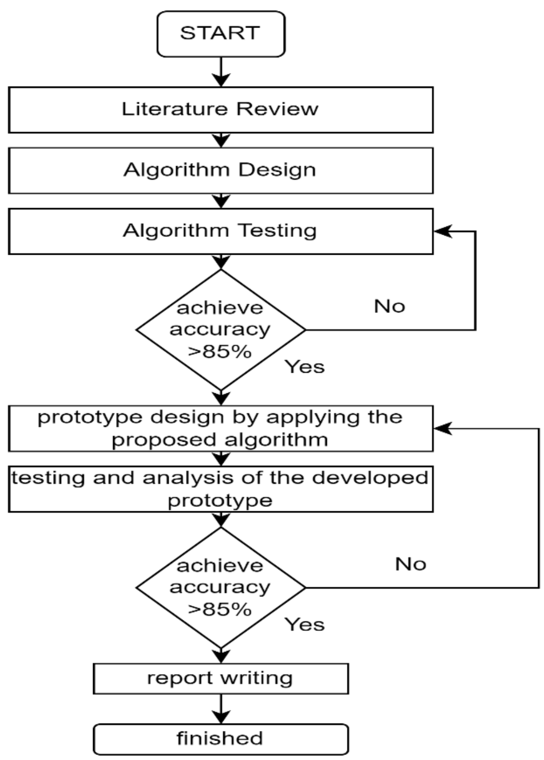


Fig. 1. Flowchart Research Framework

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. Smartphone Usable

Currently, many 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 other people for certain needs, besides that heart rate data can be stored on the Smartphone for certain needs. Android Smartphone design connected to Arduino Pro Mini using Bluetooth. Smartphone application design is carried out through the MIT App Inventor free smartphone application provider website.

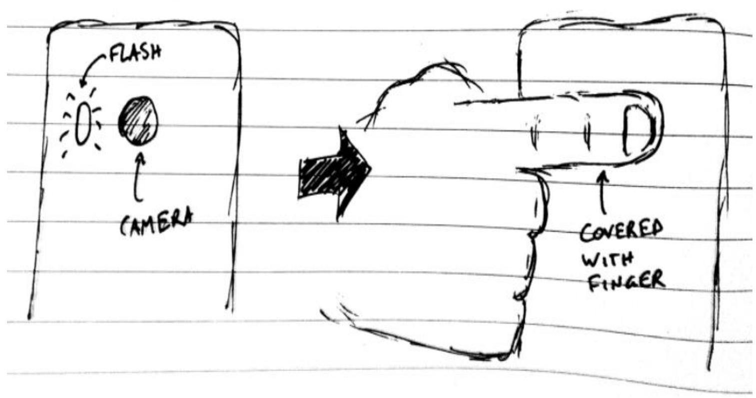
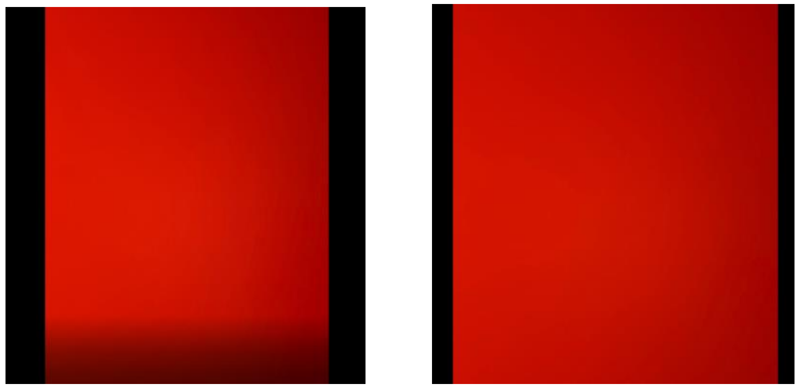


Fig. 2. Photoleysmogram on Mobile

Before we can extract the heart rate, we must record it.

- Open your camera app on your phone and prepare to record video (don’t start the recording yet, though).
- Turn on the flash.
- 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.
- Record a video of at least 20 seconds.
- Save video to computer/ Google Drive to be accessible to this script

Figure. 3. 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. 3. Snippet 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.

```
[8]
#Overall results laid out with their error rate as well
print(overall_results)

[77.0, 70.0, 70.0, 85.0, 75.0]
```

Fig. 4. Colab Result Heart Rate with Mobile Camera

The results obtained from the 5 classifications of data collection obtained from one object are shown in Figure 7 above. Result of [77.0, 70.0, 70.0, 85.0, 75.0] . All definitions of the data are measured in the form of the Bpmthe Scale.

B. Photopletysmograph

The principles of PPG have been reviewed previously [2–4], and are briefly described here. Light travels through biological tissue to be absorbed by a variety of substances, including pigments in skin, bones, and arterial and venous blood. Most of the changes in blood flow occur mainly in the arteries and arterioles (but not in veins). For example, arteries contain more blood volume during the systolic phase of the cardiac cycle than during the diastolic phase.

PPG sensors optically detect changes in blood flow volume (i.e., detected changes in light intensity) in the microvascular layer of tissue through reflection from or transmission through the tissue. Figure 2.3 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.

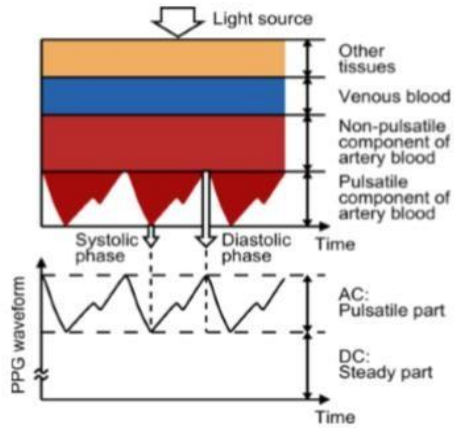


Fig. 5. Variation of Light Absorption by Tissue body
(Source: Tamura T. , et.al. , 2014)

C. 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:

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

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 scale and translation indices, so we get

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

Discrete Wavelet Transform not only uses wavelet function, but also uses image smoothing function [6]. The scale function is dilated and translated as the wavelet function equation, so that it is obtained

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

Many theory of revolution analysis states that -1 = Vm Wm. This means that 1 is orthogonal's complement to in -1. There is a vector in the vector -1, so the vector and -1 have a different time space [5]. To connect the vector, a filter t with a scale function is used and a filter l with a wavelet function so that,

$$t = \sum\nolimits_{n} h(n)\sqrt{2\phi(2t-n)} \qquad (4)$$

$$l = \sum\nolimits_{n} y(n)\sqrt{2\psi(2l-n)} \qquad (5)$$

The process of decomposing a signal into approximations and details, such as the projection of x to Vm and Wm. This process can be obtained by passing the coefficient on a filter through a sub-sampling process.

IV. Results And Discussion

A. Result

Data used in this study were the 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 process. wavelet transform and also hybrid wavelet to get the best accuracy value .

TABLE II
DATAS PATIENT FROM HAJI ADAM MALIK MEDAN

No	Initial Name	Age	Blood Pressure (BP)	Respiration Rate (RR)	Heart Rate (HR)	Saturasi Oksigen (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%
21	HI SIM	70	157/67	18	75	96%
22	DE BA	30	98/55	22	120	95%
23	HE SI	53	133/73	20	63	98%
24	JOH	57	100/60	40	120	98%
25	WIN	32	130/80	22	76	98%

After doing the data calling step, we convert the dataset into the form of Photopletysmograph data by only utilizing the values of the Respiration rate, heart rate and Oxygen Saturation.

TABLE III
CONVERTING NORMAL DATA TO PHOTOPLETYSMOGRAPH DATA

Times (s)	RESP	II	V	AVR	PLETH
0,000	0,28390	0,19990	0,59531	0,54985	1,3060
0,008	0,27339	0,26002	0,58016	0,53519	1,2903
0,016	0,26313	0,31476	0,54008	0,50000	1,2747
0,024	0,25214	0,32991	0,50000	0,47019	1,2590
0,032	0,24139	0,36510	0,45992	0,45992	1,2444

B. Denoising Signal

Noise reduction (denoising) is an important and 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 retain important information. Image denoising can be done by various methods,for example by filtering process, wavelet analysis, and fractal method.

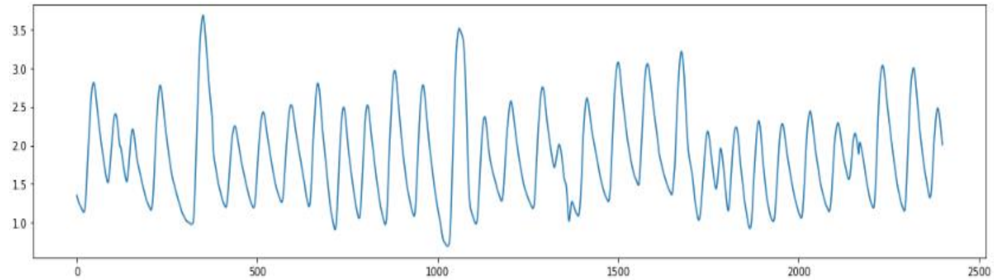


Fig. 6. Original Signal

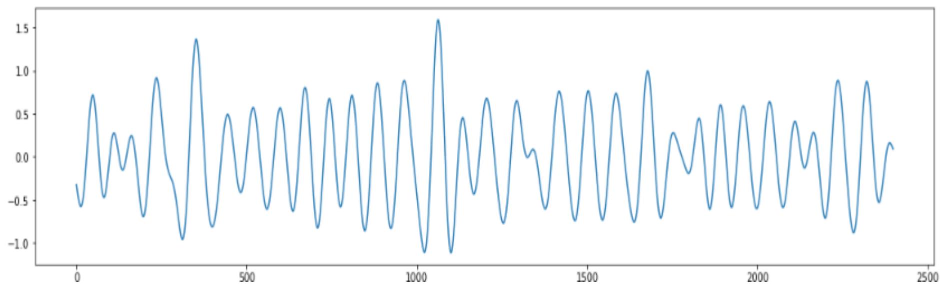


Fig. 7. Denoise Signal

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

C. 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 signal namely Atrial Fibrillation (AF) and normal (N).

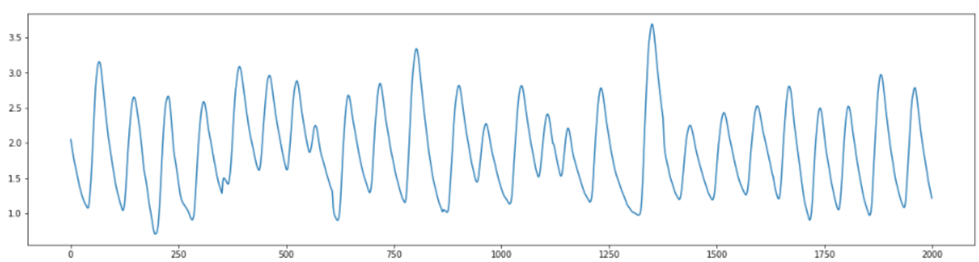


Fig. 8. Atrial Fibrillation (AF) Signal

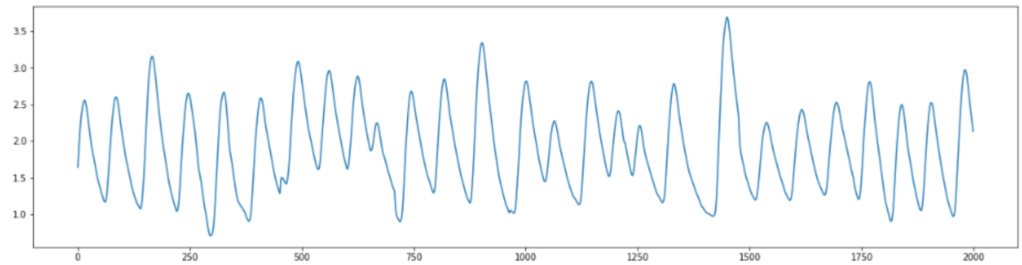


Fig. 9. Normal (N) Signal

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-neirest Neighbor Algorithm

D. Discrete Wavelet Transform Using K-Nearest Neightbor

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.

	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

Fig. 8. Acurracy K-Nearest Neightbor Discrete Wavelet Transform

From the relative error data, it can be calculated the relative error The resulting accuracy is 0,98 %.

E. Entropy Feature Using K-Nearest Neightbor

	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

Fig 9. Accuracy K-Nearest Neightbor Entropy Feature

From the relative error data, it can be calculated the relative error The resulting accuracy is 0,81 %.

F. Discussion

This study refers to Farid Suryanto [2], who previously classified pulse detection with a photopletysmograph 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 photopletysmograph 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 DATAS 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 Neightbor by based **PLETH** and **II** datas 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 Wavelete Transform datas,than 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 pro0cess 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%

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