Design of a High Sea Wave Sensor System in Puger Beach

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Abstract

Indonesia is an archipelagic country that has a very wide sea area. Thus, Indonesian sea has a huge potential of natural resources that can be utilized to grow the nation's economy. There are many occupations and efforts that can be done to increase the income from the sea and also to conserve it. Fishery is one of the most effective way to gain the sea resources; however, fishery is limited by the weather condition on the sea. This is also a problem that happened in Puger Beach. Puger Beach is located in the south Jember and it faces the Hindia Ocean, which means the weather condition is more dangerous for fishermen than other part of coastal. To ensure the safety of the fishermen, the weather condition on the sea must be evaluated and predicted before the fishery. This study aims to design a system to provide fishermen in Puger Beach an information about sea and beach weather condition which consist of wave height prediction, wind speed, temperature, humidity and weather prediction. The wind speed is obtained from self-designed anemometer system, the temperature is measured using LM35 sensor, and the humidity is assessed using DHT22. The wave height in the sea was predicted by calculating the wind speed value and effective average fetch value using neural network algorithm. The weather on the sea and on the beach were predicted by rain and light sensor. This weather prediction would be classified into three different results, namely raining, cloudy and bright. After some experiments, the result showed that the device can provide the information needed for fishermen and it has a high sensing accuracy. The humidity measurement had an average error of 1.1%, the temperature measurement had 1.42% average error, and 2.37% for the wind speed measurement. The wave height measurement system worked out and found the average wave height in Puger Beach 0.37 meters.

1. INTRODUCTION

The increasing weather variability, intensity of cyclone, and sea wave due to global warming occurred in many parts of the world. In Indonesia, cyclone and high sea wave usually occur in the transition between rainy and dry season. Both cyclone and high sea wave impact community welfare in the form of damages and losses. Since there is still no technology to stop the occurrence of both cyclone and high sea wave, the effort to minimize the damages and losses can be mitigated through community preparedness, timely warning, and effective response [1]. Hence, an effective warning system for cyclone and high sea wave need to be designed to increase disaster resilience of community.

Community with high disaster resilience can adapt successfully to disaster and adopt strategies which include means for further increasing their disaster resilience, one of which is disaster warning system [2]. Disaster warning system can be effective or ineffective, or somewhere between these two extreme point. However, an effective one has two main features, first it provides timely meteorological forecasts; second, it gives a well-disseminated warning [3].Currently, information on marine weather conditions in Indonesia has been provided by Indonesian Bureau of Meteorology, Climatology, and Geophysics

through website. However it is not easily accessible to all and the information provided is not in real time. Based on the previous definition of an effective disaster warning system, the current warning system for cyclone and high sea wave in Indonesia is not effective since it cannot provides timely meteorological forecast and well-disseminated warning. Thus in Indonesia, the need for system that provides accurate and timely information is increasingly high, since such system can help in reducing the potential losses and damages from disaster and increases community disaster resilience.

Hence, the main purpose of this study is to design a system which gives an accurate prediction on weather condition, cyclone and high sea wave utilizing weather sensor. Similar studies have been conducted by [1], [2], [5], [6], [7], [8], [9], and [10], in which they include climate and weather parameters. Another study by Coastal Engineering Research (1984) designed a system providing weather prediction for fisherman, however the accuracy of resulting prediction has not been tested. Specifically, the purpose of this study is to design a warning system utilizing data from weather sensors to predict the occurrence of cyclone and high sea wave and test the accuracy of prediction from the system.

2. METHOD

The system consists of three main components, namely (1) Sensors; (2) Arduino Uno; (3) Laptop. The working of the system represented by block diagram which is shown in Figure 1. The methods of design were as follows: defining the objective, identify the components, identify the data sources and indicators, design data processing system, and testing the system. Based on the block diagram, Arduino Uno is used to read both analog and digital data gathered from each sensor. The first sensor, anemometer, utilized to gather data on windspeed and then Arduino Uno converted this data to wave height by finding the value of angle of fetch [2] [3] as shown in Figure 2 (a). Then the next step is to calculate and forecast the windspeed based on data gathered from anemometer using neural network, as shown in Figure 2 (b). The second sensor, DHT22, is utilized to collect temperature and humidity data. The third and fourth sensors, LDR and rain sensor, were utilized to detect weather condition. LDR is utilized to detect clear or cloudy weather, while rain sensor is utilized to detect the existence of rain. All data pertaining to each sensor will be processed by Arduino Uno to get values wich correspond to the actual conditions. Then, the data from Arduino Uno will be transferred to laptop to be further processed using visual studio 2012 and presented as weather information system containing information on windspeed, air temperature and humidity, wave height, and weather condition and suggestion for fisherman safety based on wave height also included, like shown in Figure 3 (a). The forecasting system has a dimension of 41 cm in length, 19 cm in width, and 38 cm in height. The system consists of: (1) Anemometer sensor, (2) Rain sensor, (3) light sensor, (4) DHT22 sensor, (5) Laptop, (6) Arduino Uno. The physical appearance of the system is shown on Figure 3 (b).
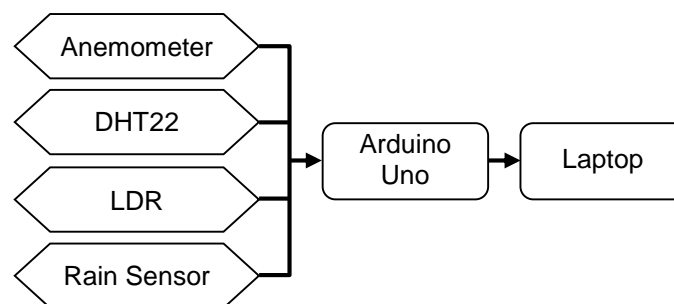

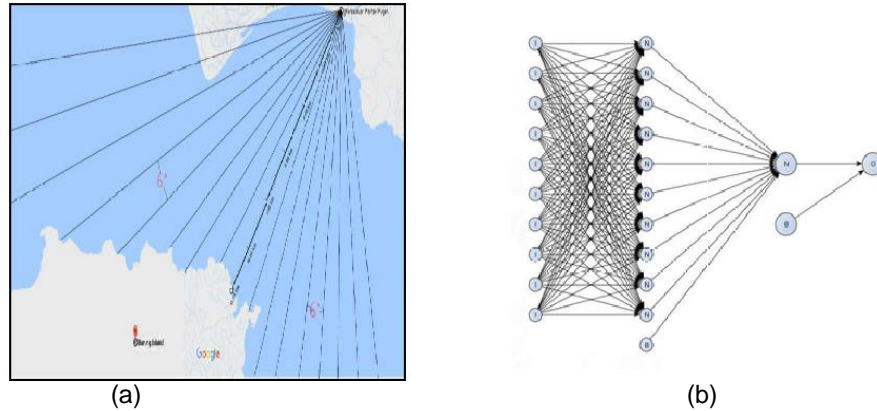*Figure 1. The proposed weather forecasting system*

| (a) | (b) |

Figure 2. (a) Determination of fetch angle, (b) Neural network structure of the proposed system
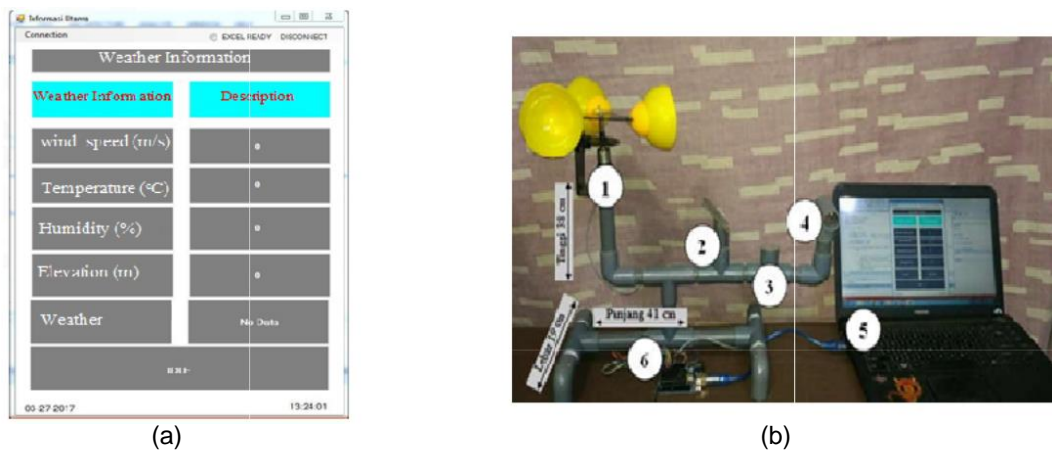

| (a) | (b) |

Figure 3. The designed system; (a) weather information system, (b) the physical appearance

3. RESULTS AND DISCUSSION

Tests to determine the accuracy of the system were consisted of (1) testing the accuracy of each sensor separately, and (2) testing the accuracy of the overall system.

3.1 Anemometer Test

In this system, the anemometer sensor was constructed using encoder and a series of opto interrupt created using MOC70T3 sensor. Encoder will interrupt the infrared from MOC70T3 sensor, then the sensor will produce pulses to indicate whether the infrared interrupt ted or not. The encoder used in this system is spherical and has 22 holes. The output of opto interrupt in the form of pulses, can be calculated by microcontroller which then be converted into wind speed. The wind speed generated is then compared to the result from calibrated tool to determine its accuracy. Error (%) was obtained from:

$$Percent\ Error = \frac{(Anemometer\ reading - Calibrating\ tool)}{Calibrating\ tool} \qquad (1)$$

The test result shown in Table 1.

Table 1. Anemometer test result

No	Calibrating tool (m/s)	Anemometer (m/s)	Error %
1	0	0	0
2	0.5	0.53	6
3	1.6	1.6	0

Table 1. Anemometer test result (continued)

No	Calibrating tool (m/s)	Anemometer (m/s)	Error %
4	1.7	1.75	2.9
5	1.8	1.79	0.5
6	2	2.09	4.5
7	2.1	2.05	2.4
8	2.2	2.13	3.2
9	2.3	2.28	0.9
10	2.4	2.44	1.6
11	2.5	2.59	3.6
12	3.1	3.01	2.9
	Average Error		2.375

3.2 DHT22 Sensor Test

To test the accuracy of DHT22 sensor in measuring air temperature and humidity, a comparison between the measurement result from DHT22 sensor and the result of manual measurement of air temperature and humidity using thermometer and hygrometer was conducted. The result of the test shown in Figure 4 (a) for temperature and figure 4 (b) for humidity. From both result shown in figure 7 and figure 8, the average error from temperature test is 1,42% while the average error from humidity test is 1,1%.
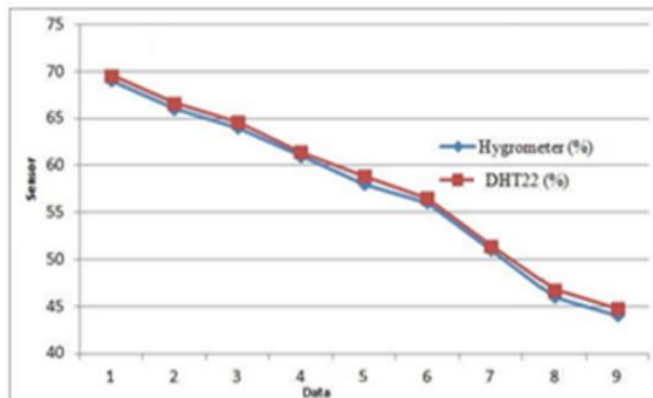
(a)
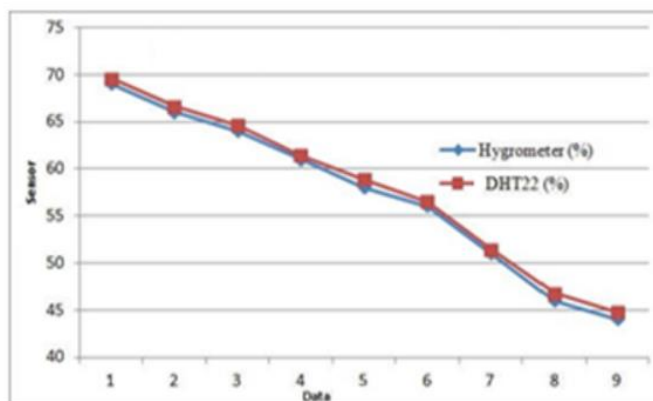
(b)

Figure 4.The result of DHT22 Sensor Test on (a) temperature and (b) humidity

3.3 LDR and Rain Test

To test the accuracy of LDR sensor in predicting clear and cloudy weather, the comparison of the actual weather condition and the reading of the sensor was conducted. LDR sensor will give an ADC value less than 600 when the weather is clear and an ADC value greater than 600 when the weather is cloudy. Based on the test, LDR sensor gives an accurate reading of the actual weather condition. The result of the test shown in Table 2. The same procedure as that on LDR sensor test was used in testing the accuracy of rain sensor. Rain sensor will give an ADC value less than 600 when the actual weather is rainy and an ADC value greater than 600 when it is not.

*Table 2. The ADC value based on LDR and Rain Sensor Test*

No	ADC Value	Actual Weather
1	< 600	Clear
2	≥ 600	Cloudy

3.4 Neural Network Test

Neural network test conducted in three stages, (1) training data, to obtain the best model; (2) validation, to test whether the best model obtained actually good; (3) testing, to evaluate the result of the model. Based on Figure 5 (a), the best mean squared error obtained when epoch value is 462. To determine the response of output and target i training, validation and test stages to time, the test like shown in Figure 5 (b) is conducted. To forecast wave height using windspeed through neural network, the actual data gathering was conducted. The data gathering in this study conducted in two days when the sea wind blows starting at 9 a.m. to 4 p.m. local time. The comparison between windspeed and wave height shown in Figure 6.
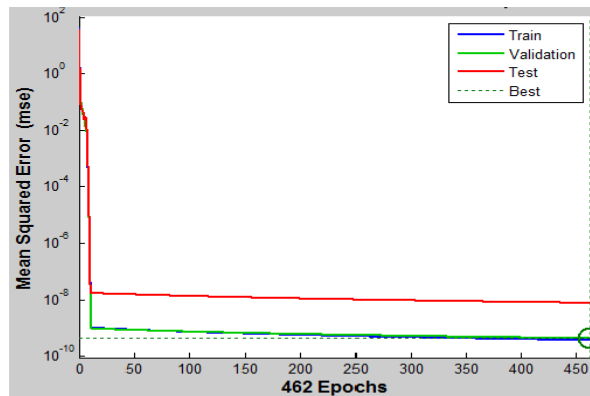
(a)
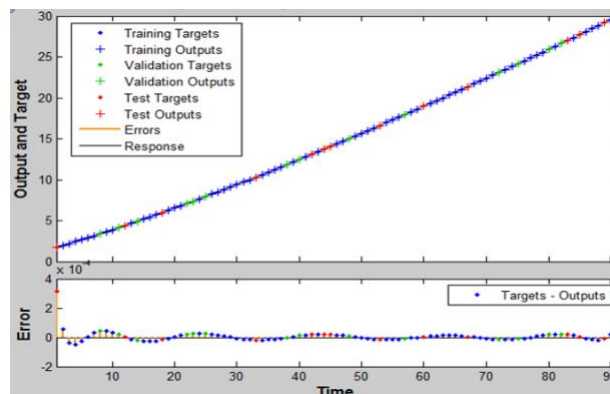
(b)

Figure 5.The result of DHT22 Sensor Test on (a) temperature and (b) humidity
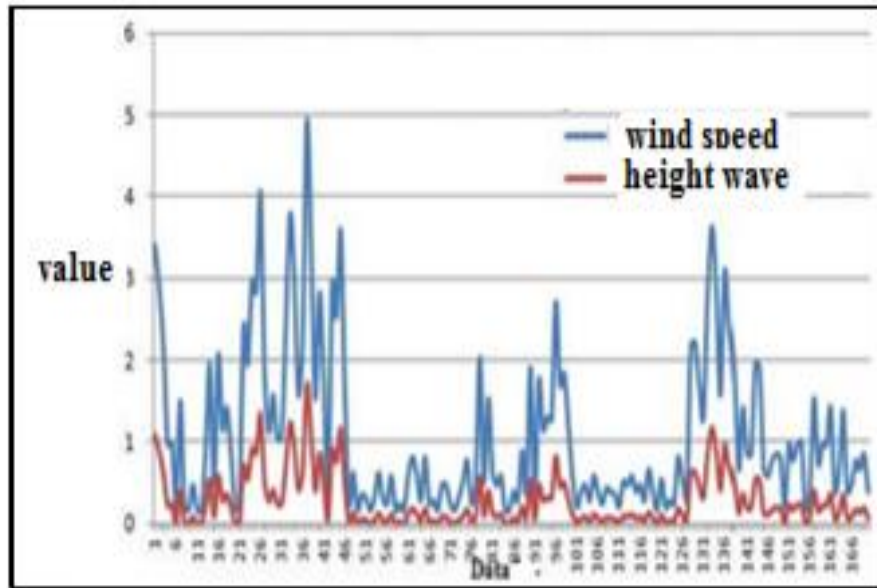
Figure 6.The result of measurement on wind speed and height wave

3.5   Overall System Test

The final test of the system was conducted to give information of coast actual weather. The test conducted in 2 days in Puger Coast, 40 meter high. The data gathered when the sea wind blows between 9 a.m. and 4 p.m. local time, the data gathered on 5 minutes interval. The data shown in Table 4 is data gathered on hourly interval.

Table 3. Neural Network Test Result

Stage	Samples	MSE	Regression
Training	70 %	3.66349×10^{-10}	9.99999×10^{-1}
Validation on	15 %	4.27994×10^{-10}	9.99999×10^{-1}
Testing	15 %	7.68634×10^{-9}	9.99999×10^{-1}

Table 4. Overall System Test Result

No	Time	Wind speed (m/s)	Temperature (C)	Humidity	Wave height (m)	Weather	Warning
1	09.00	3.39	27.9	85.8	1.09	cloudy	safe
2	10.00	0.88	26.2	92.5	0.21	cloudy	safe
3	11.00	2.82	25.3	95.1	0.87	cloudy	safe
4	12.00	14.91	25.7	93.7	1.72	cloudy	beware
5	13.00	0.15	25.7	92.1	0.01	cloudy	safe
6	14.00	0.57	25.6	92	0.12	cloudy	safe
7	15.00	0.3	25.1	92.7	0.05	cloudy	safe
8	16.00	0.15	24.7	94.6	0.01	cloudy	safe
9	17.00	0.38	24.8	95.6	0.07	cloudy	safe
10	18.00	1.83	24.8	94.2	0.51	cloudy	safe
11	19.00	0.34	25	93	0.06	cloudy	safe
12	20.00	0.19	25	92.8	0.02	cloudy	safe
13	21.00	2.89	25.3	90.8	0.9	cloudy	safe
14	22.00	0.57	24.8	93.2	0.12	cloudy	safe
15	23.00	0.72	23.9	98.5	0.16	cloudy	safe
16	24.00	0.38	23.9	98.8	0.07	cloudy	safe

4. CONCLUSION

The result of the tests shows that anemometer sensor and DHT22 are able to give accurate information on windspeed, air temperature, and humidity. The tests also give an acceptable error level or both anenometer sensor and DHT22. The error of anemometer is 2,7%, and DHT22 error for temperature and humidity measurement are 1,42% and 1,1% respectively. Using neural network, the wave height can be forecasted by windspeed. The system shows that a "beware" warning category issued at windspeed of 14,91 m/s and wave height of 1,72 m, on cloudy weather at 12 a.m.

ACKNOWLEDGMENTS

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