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A PROTOTYPE OF LOW COST WEATHER STATION FOR DATA SPATIAL AND TEMPORAL ANALYSIS

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Abstract. *This study aims to design a Weatherlink station that can be used not only for monitoring weather conditions but also to obtain the relationship of data readings between sensors at a relatively low cost. The sensor designed for the development of the Weatherlink station consists of a Rain Gauge, a temperature and humidity sensor (DHT22), an air pressure sensor (BMP280), a wind speed sensor (Anemometer), a wind direction sensor (Wind Vane) and a light intensity sensor (LDR). The Weatherlink station prototype, which in this study is called an End Device, for testing, is installed in two different locations (End Device A and End Device B). The data from sensors on each End Device shows the same trend despite the differences in values at some particular time caused by the position of the prototype. The results of this study can later implement to predict rainfall based on temporal and spatial data.*
Keywords: Rainfall prediction, Extreme learning machine, Spatial analysis, Correlation

1. **Introduction.** Indonesia is a country that has a diversity of climate that is influenced by rainfall patterns, such as the monsoonal pattern. The amount of rainfall is high in the tropics due to many factors, each of which is interrelated. The first factor that is influential and considered the most important is the presence of ITCZ (Inter Tropical Convergence Zone), namely the influence of the location of a meeting area of wind that forms a rain-producing cloud around the area and its extended coverage covers a large area with almost all year presence. The second factor is the relief of the surface of an area. An increase in the orographic is very efficient in producing rain, especially if there is a monsoon wind that is pushed up through the hills as it does in the ocean. The third factor is tropical cyclones as zones with high rainfall associated with storm paths. The fourth factor is related to convergence and change in trade wind direction when approaching the tropics [1].

A high amount of rainfall can bring the potential for natural disasters such as floods, landslides, cold lava flows, and flash floods. The high rainfall in some areas will also cause areas that were once shaken by tectonic earthquakes to be prone to landslides [2]. Floods and landslides in Indonesia have claimed losses, both property, and casualty. Additionally, floods and landslides cause damage to facilities and infrastructure, obstruction of transportation routes, and even influence the environment in the future, such as erosion, the emergence of landslide-prone points, and even the emergence of germs in flooded areas. To avoid this, disaster prevention, or known as disaster mitigation, is necessary. One

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of the efforts to mitigate floods and landslides is to predict rainfall. Weather data from prediction data is used to reduce the harmful risks that potentially caused by the weather.

Weatherlink station is a weather observation device that obtains weather forecast information for an area or place with several parameters such as temperature, air pressure, humidity, wind speed, wind direction, and rainfall. Several studies related to weather station design have been conducted. Rasal and Rana in 2016 used Raspberry Pi to support the performance of the Weather Monitoring System that was developed [3]. Weather Station, with a weather prediction system, was developed by Fowdur et al. in 2017. K-nearest neighbor is used as a data clustering algorithm. Overall, the system was developed with Raspberry Pi3 and Arduino microcontrollers that run on the cloud and an artificial intelligence algorithm embedded for its predictions [4]. Another weather station design was also introduced by Espitia et al. 2017. The advantage of the design was that of a relatively low price by using three sensors, namely temperature, pressure, and humidity. The sensor test results obtained a confidence value of 95% [5].

The focus of research related to the rainfall prediction algorithm was also carried out by Safar, Ndzl and Kagalidis. The data used is short term localized data in the tropical regions of North Malaysia. Some methods of Artificial Neural Networks (ANN) used are Bayesian Regularization (BR), Levenberg-Marquardt (LM), and Scaled Conjugate Gradient (SCG). Among the 3 ANN methods in this study, LM provides better performance than the other two methods [6].

Research by utilizing artificial intelligence methods to predict the weather has been done in recent years. Sofian et al. developed two models of ANN algorithm for monthly rainfall prediction, namely Backpropagation Neural Network (BPNN) and Radial Basis Function Neural Network (RBFNN). Total data of 238 months (1994-2013) is used as input data. This study shows that the RBFNN architecture with 0.001 error goals gives the best results with the value of MSE (Mean Square Error) = 0.00072 and $R = 0.98$ at the training stage, and MSE = 0.00092 and $R = 0.86$ at the testing stage [7]. In addition, research on rainfall prediction using artificial intelligence by considering both temporal or spatial aspects (the influence of parameters from other locations or other stations) has also been conducted. Indrabayu et al. developed a system that can predict rain in the Makassar area based on spatial data from Ambon and Palembang with 30 minutes sampling resolution for 2015 and 2016. This study estimates rain in Makassar using parameters of temperature, humidity, visibility, and dew point in Ambon and Palembang uses the Extreme Learning Machine (ELM) algorithm. The research results obtained an accuracy of 98.37% for 2015 and 98.62% for 2016 [8]. Research using temporal spatial data was also carried out by Ruan and Lu. The Self Adaptive Spatial-Temporal Correlation (SASTC) algorithm model was introduced in 2018. The simulation process is demonstrated by comparing the performance of the model with the Analog Digital Converter (ADC) algorithm. The performance of SASTC is proven to reduce the amount of data transmission in the network and save energy consumption from data transmission. However, this study was limited to test the performance of the algorithm and has not been implemented in a real sensor network [9].

Therefore, in this study, a weather station system is designed, which involves sensors of temperature, rainfall, humidity, wind speed, and air pressure that utilize the Internet of Things technology in the process of communication between nodes. The data obtained in each End Device will be seen as correlations to become input data by utilizing the artificial intelligence algorithm. The algorithm will be embedded to develop the weather station. However, this research will focus on designing a multi-node weather station architecture model with a combination of sensors to predict rainfall in short term data. The structure of this paper is as follows. In Section 2, the proposed system is described. In Section 3, the results are discussed. And finally, Section 4 concludes the paper and discusses the future work.

2. Proposed System. The design of rainfall prediction systems based on the spatial data is shown in Figure 1. Weatherlink Station (WS), which in this study is called the End Device, will be placed in a different location. The End Device consists of several sensors, Arduino, and LoRa, as shown in Figure 2. Data from the sensors on the End Device will be sent to the gateway every ±60 seconds at a frequency of 915 MHz. Data received by the gateway will be processed in Raspberry and then sent into the database server; the Raspberry Pi acts as a server. Data on the server will then be input data

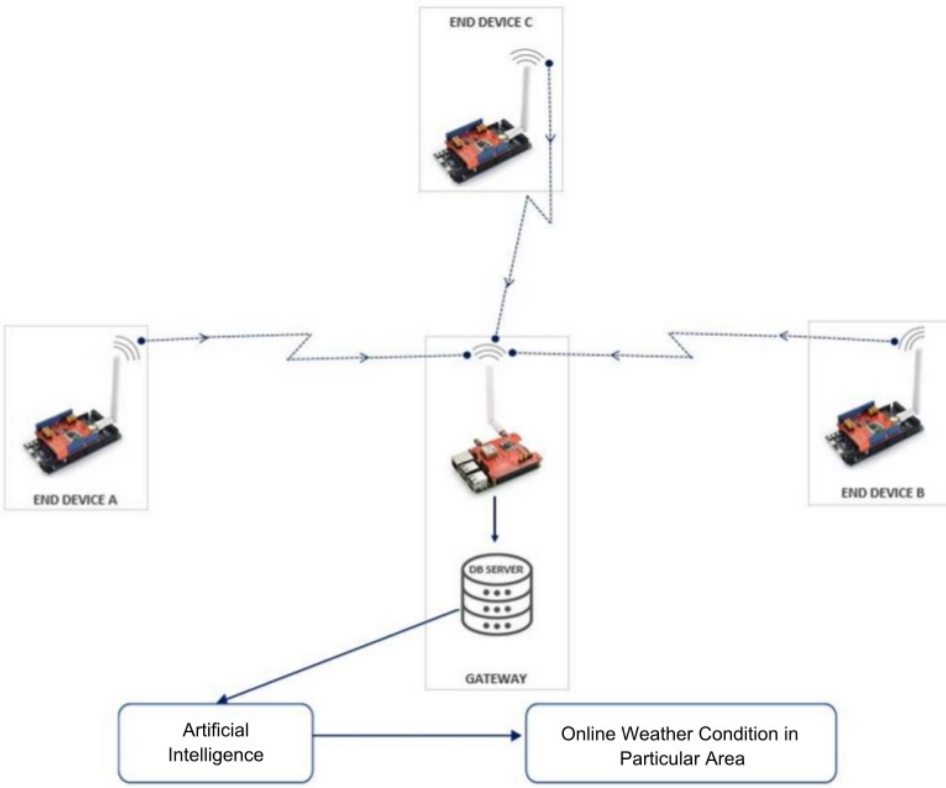


FIGURE 1. System design

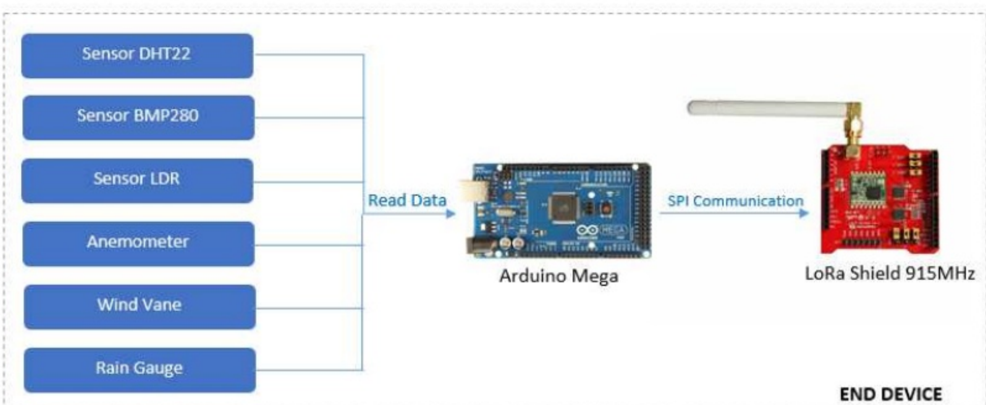


FIGURE 2. End Device illustration

for the association system based on spatial data from End Devices that will be processed using artificial intelligence methods.

The End Device consists of six sensors, as illustrated in Figure 2. Arduino Mega functions to measure and read data from the sensor. Data that has been received by Arduino will be sent to the LoRa Transmitter using the Serial Peripheral Interface (SPI) line every ±60 s.

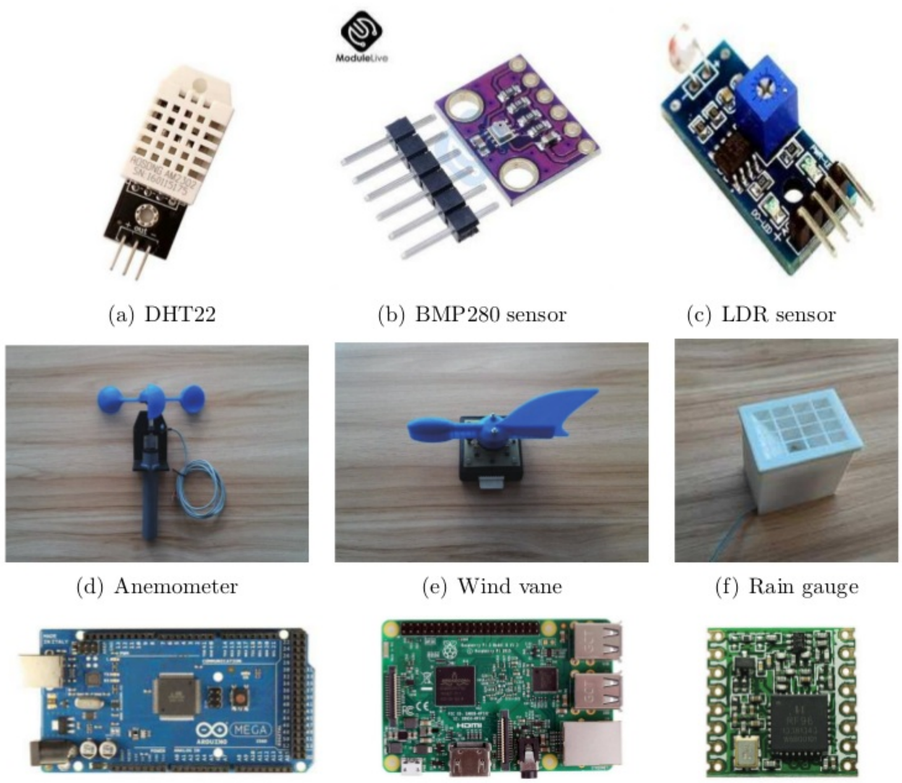
The components used in this study are described as follows and shown in Figure 3.

1) DHT22 is a sensor measuring humidity and relative temperature with digital output. In this project, humidity has an output with a relative unit of humidity (%), while temperature has an output with a unit of Celsius (°C). This sensor has three pins, which are VCC, DATA, and GND. DHT22 uses 5 V power, suitable for 0-100% humidity readings with 2-5% accuracy while for temperature readings both for -40 to 80°C with an accuracy of ±0.5°C.

2) BMP280 sensor measures air pressure (Pa), by using the I2C communication line to Arduino Mega. The power needed is 3.3 V.

3) LDR sensor in this project is used to measure light intensity (Lux). The module used already has a potentiometer to adjust the sensor sensitivity. There are four pins, namely VCC, GND, Analog Output, and Digital Output. The power used is 5 V, while the output data used is Analog.

4) Anemometer, in this project is used to measure angina velocity (m/s). The power supply used is 5 V. The working principle of this anemometer is to use an optical sensor



(a) DHT22 (b) BMP280 sensor (c) LDR sensor

(d) Anemometer (e) Wind vane (f) Rain gauge

(g) Arduino Mega 2560 (h) Raspberry Pi3 (i) LoRa Transceiver

FIGURE 3. Components of Weatherlink prototype

to capture light passing through each gap in the rotary encoder. Rotary encoder has 18 slits.

5) Wind Vane, in this project is used to detect wind direction. The working principle of this wind vane uses eight magnetic sensors, each of which represents each direction of the compass, with the resulting output digital, and the power used is 5 V.

6) Rain gauge, in this project is used to measure the intensity of rain (mm/minute).

7) Arduino Mega 2560, in this project is used as a microcontroller for all sensors used.

8) Raspberry Pi3, in this project is used as a gateway.

9) LoRa Transceiver, in this project, is used as a media for data transmission between End-Devices and gateways using 915 MHz frequency.

All components in Figure 3 are assembled to obtain a Weatherlink station prototype as shown in Figure 4.

(a) End Device A

(b) End Device B

Figure 4. End Device

3. **Results and Discussion.** The system is designed by applying the concept of the low-cost weather station with a combination of rainfall sensor (Rain Gauge), temperature and humidity sensor (DHT22), air pressure sensor (BMP280), wind speed sensor (Anemometer), wind direction sensor (Wind Vane) and light intensity sensor (LDR). The data results for each End Device show a correlation, which are shown in Figures 5-7. However, the light intensity data shown in Figure 5 is different at certain times because the weather station's position is not the same.

Figure 6 shows the plot results of two End Devices readout data for the temperature sensor in Celsius. The temperature difference is insignificant. There is a deviation due to the relative position of the weather station to the sun. As with humidity, the position of the sensor is influential on the measurement results as shown in Figure 7.

4. **Conclusions.** The design of the Weatherlink station can be used not only for monitoring weather conditions but also to obtain the relationship of reading data between sensors at a relatively low cost. The sensor designed for the development of the Weatherlink station consists of a Rain Gauge, a temperature and humidity sensor (DHT22), an air pressure sensor (BMP280), a wind speed sensor (Anemometer), a wind direction sensor (Wind Vane) and a light intensity sensor (LDR). The results of the sensor readings on each End Device show the same trend even though there are differences in values at specific times caused by the position of the prototype. The sensor readings from the

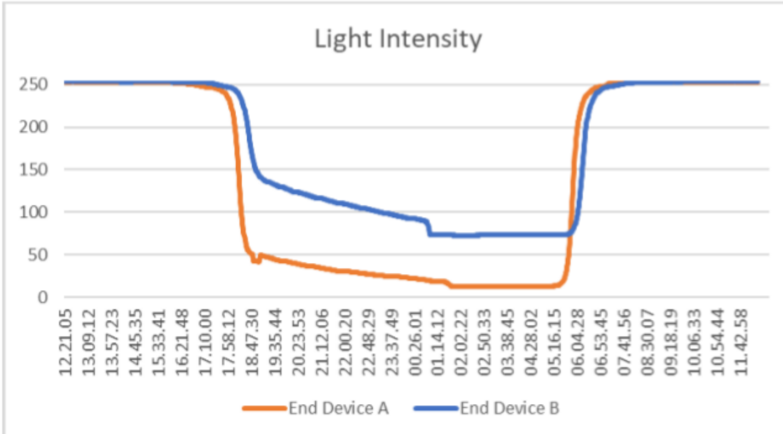


FIGURE 5. Light intensity graph for 24 hours

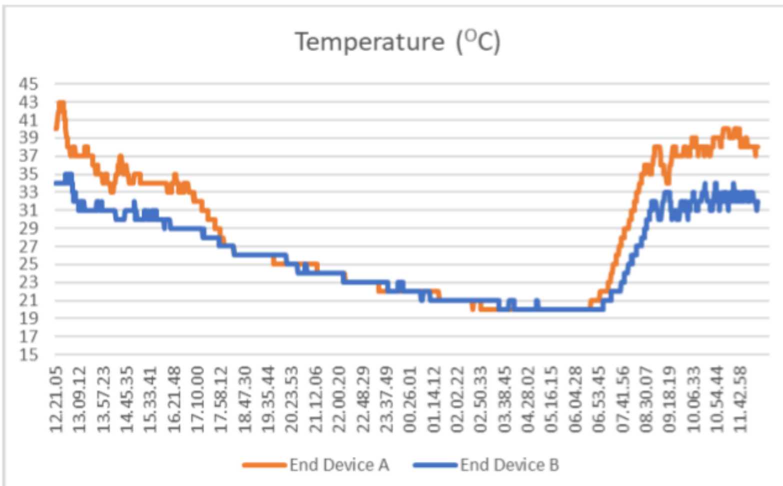


FIGURE 6. Temperature data graph for 24 hours

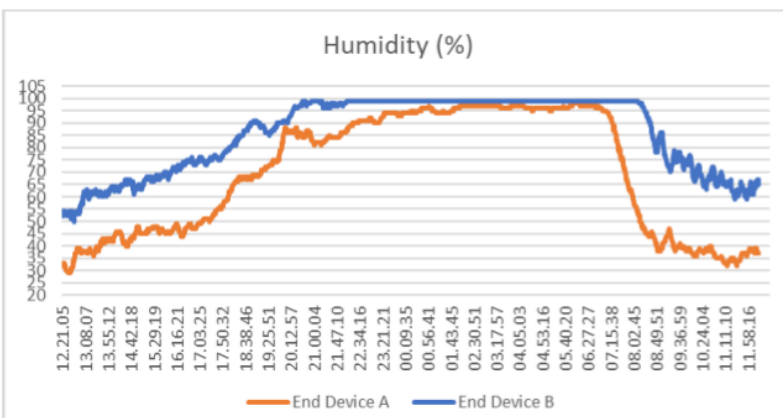


FIGURE 7. Humidity data graph for 24 hours

developed Weatherlink station indicate the correlation between the 2 End Devices. The significant difference that occurs in the sensor reading process is due to the condition of the surrounding environment and the position of the sensor placement. The results of this study can later implement to predict rainfall based on temporal and spatial data.

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REFERENCES

[1] M. P. Byrne, A. G. Pendergrass, A. D. Rapp and K. R. Wodzicki, Response of the intertropical convergence zone to climate change: Location, width, and strength, *Current Climate Change Reports*, vol.4, no.4, pp.355-370, 2018.

[2] A. S. Arsjad and B. Riadi, Potential risk of longsor natural disaster related to extreme weather in Ciamis district, Jawa Barat, *Jurnal Ilmiah Geometri*, vol.19, no.1, pp.57-63, 2013.

[3] M. V. Rasal and J. G. Rana, Raspberry Pi based weather monitoring system, *International Journal of Advanced Research in Computer and Communication Engineering*, vol.5, no.10, pp.119-122, 2016.

[4] T. Fowdur, Y. Beeharry, V. Hurbungs and V. Bassoo, A framework for a real-time cloud-based weather forecasting system for Mauritius, *International Journal of Mechatronics, Electrical, and Computer Technology*, vol.7, no.26, pp.3563-3581, 2017.

[5] G. P. Espitia, A. C. Pinto, F. Estevez and D. C. Pinto, Design of a low cost weather station for detecting environmental changes, *Revista Espacio*, pp.1-22, 2017.

[6] N. Z. Mohd-Safar, D. Ndzl, I. Kagalidis, Y. Yang and A. Zakaria, Short-term localized weather forecasting by using different artificial neural network algorithm in tropical climate, in *Proc. of SAI Intelligent Systems Conference (IntelliSys) 2016. IntelliSys 2016. Lecture Notes in Networks and Systems*, Y. Bi, S. Kapoor and R. Bhatia (eds.), Cham, Springer, 2016.

[7] I. M. Sofian, A. K. Affandi, I. Iskandar and Y. Apriani, Monthly rainfall prediction based on artificial neural networks in backpropagation and radial basis function, *International Journal of Advances in Intelligent Informatics*, vol.4, no.2, pp.154-166, 2018.

[8] Indrabayu, S. Aditama, A. A. Prayogi, S. Pallu, A. Achmad and I. S. Areni, Spatial-temporal approach for predicting rainfall in tropical country, *ICIC Express Letters*, vol.13, no.2, pp.113-118, 2019.

[9] J. Ruan and Z. Lu, A self-adaptive spatial-temporal correlation prediction algorithm to reduce data transmission in wireless sensor networks, *International Journal of Innovative Computing, Information and Control*, vol.14, no.3, pp.997-1013, 2018.

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