IAIC Transactions on Sustainable Digital Innovation (ITSDI)
Vol. 2 No. 1 October 2020

p-ISSN: 2686-6285
e-ISSN: 2715-0461

8Remote Sensor Network Application For Monitoring System and Air Quality Classification

Albern Ace[1], Almero Rio[2]
Univercity Phoenix[12]
American Samoa
e-mail: albern08@yahoo.com , almero.rio@yahoo.com

To cite this document:
Ace, A., & Rio, A. . (2020). Remote Sensor Network Application For Monitoring System and Air Quality Classificatio. IAIC Transactions on Sustainable Digital Innovation (ITSDI), 2(1), 31-45.
DOI : https://doi.org/10.34306/itsdi.v2i1.350

Author Notification
20 October 2020
Final Revised
21 October 2020
Published
23 October 2020

Abstract

Indonesia is one of the nations putting resources into the modern area. Businesses influence the climate, outstandingly air quality. On the off chance that the air contamination ousted by modern fireplaces couldn't be handled appropriately, it would unfavorably influence human wellbeing. As of now, checking the air quality in certain zones just uses one apparatus. This is esteemed insufficient to depict the state of air quality in a given region. Then again, introducing more than one device would be extravagant. This exploration applied the idea of remote sensor organization (WSN) for air quality checking by introducing more than one sensor hubs in a specific area and one sink that demonstrations to gather information from the sensor hubs at that point sends them to the worker. Air quality information acquired by the sensor hubs were then ordered utilizing the grouping technique in information mining that is k-closest neighbor (K-NN). Preceding grouping utilizing K-NN, information standardization was performed, which creates a decimal scaling with great execution for air quality information. The k esteems utilized for the K-NN characterization are 5. The exactness of the framework is 94.28%, the accuracy is 85.16% and the review is 93.35%.

Keywords: *Wireless Sensor Network, Data Mining,Classification*

1. Introduction

1. Introduction Indonesia is one such country has a rapid development in the sector industry, it certainly affects environment including air quality [1]. According to Supraptini [2], air pollution is ejected from industrial area chimneys if not managed properly will have an impact bad on human health, among others affect the physiological status of the lungs, changes in the immune response, even causes death to living things. It has been described in government regulations the importance of air for life, so it is necessary function is preserved and maintained through air pollution control [3]. Hence, monitoring pollution levels air becomes an urgent matter. In Indonesia, currently only monitoring air quality using one tool only and within scope certain location, so it can't be describe the existing air quality conditions.

It takes more than one tool to be effective conduct monitoring within the scope of locations the. To overcome this, you can applying Wireless Sensor Network (WSN). WSN is a technology that performs processes sensing, control, and communication for monitoring environment in physical measurement [4]. WSN consists of several sensor nodes, as well as the base station which is implemented and can be mutually transmits data using a wireless network. Each sensor node uses a network module wireless in communication and easy applied to the environment [5]. There are several studies that have been reviewing the application of Wireless Sensor Network (WSN). In research that has been conducted by Iwan et al [6], air quality monitoring system built using WSN, with parameters used, namely temperature, humidity, carbon dioxide, and carbon monoxide. On this study [6], the data obtained was not carried out further processing for generate air quality classification information. Research conducted by Xu and Liu [7], namely monitoring water quality by using oxygen solubility parameters, water pressure, PH, and temperature with apply WSN. WSN application research with the title "Wireless Sensor Network System Design using Raspberry Pi and Arduino for Environmental Monitoring Applications ”[8] apply arduino and Xbee modules for wireless communication, it's just the Xbee module it has a fairly high cost inside procurement.

Other research that applies wireless sensor network and apply the concept Mining data classification among them, Laksono et al [9] apply a wireless sensor network to make weather predictions with using wind, temperature, and sensor parameters humidity, using the C4.5 method. In the research of Sugiarto and Sustika [10], the air quality data was classified with the features used, namely temperature, moisture, carbon dioxide, and carbon monoxide, then classification using the decision tree method. Saoudi et al [11], conducted research applying WSN to detect forest fires. Sensor node in this study [11] conducted monitoring temperature, humidity, light intensity, and intensity smoke, then classify the data on the server to find out if it happened forest fire or not by using Artificial Neural Network in data mining. In this study, an application based Wireless Sensor Network (WSN) for monitoring and online air quality classification, with use the LoRa module for communication between the sensor node and the base station which costs it quite affordable and a relative communication distance also large compared to several modules other wireless communication like Xbee. Distribution of sensor nodes is carried out at points certain

locations, for example near highways, housing, industrial areas, and so on with the parameters used in between carbon monoxide, ozone, and particulate levels in air. The value of this parameter is obtained from sensing process by sensors on a regular basis.

2. Research Method

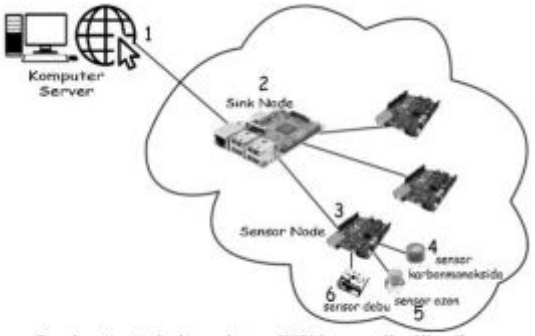
In this research, the concept will be applied wireless sensor network for monitoring systems and air quality classification, where the device built and used for monitoring levels of carbon monoxide (CO), ozone (O3), and particulate matter (PM10) in the air. Then from the results of the monitoring (sensing) will carried out environmental air quality classification, whether good, moderate, or unhealthy. For process classification is used one of the existing techniques in data mining, namely the K-Nearest Neighbor method. Data analysis The data used in this study is the value data of the carbon parameter monoxide (CO), ozone (O3), and airborne particulates (PM10). The data is used as data train for the classification process later. Three these parameters are in accordance with the decision of the head Bapedal Air Pollution Standard Index (ISPU) [12]. The data in this study were obtained from environmental service websites of several regions in Indonesia. Approach that can used for the classification process is used K-Nearest Neighbor (K-NN) algorithm. Algorithm K-NN was chosen because data levels of CO, O3, and PM10 which are monitored in the form of numbers, and the K-NN method in the data classification process using the proximity of the distance between the test data with every data contained in the training data. Here are some examples of air quality data formats in Table 1.

TABEL 1
DATA KUALITAS UDARA

Data ke	CO (PPM)	O3 (PPM)	PM10 (PPM)	Label
1	0,692692	8,175989	45,05	tidak sehat
2	0,83508	8,175989	67,78	tidak sehat
3	0,499352	8,138137	48,36	tidak sehat
4	0,947176	12,58099	29,45	tidak

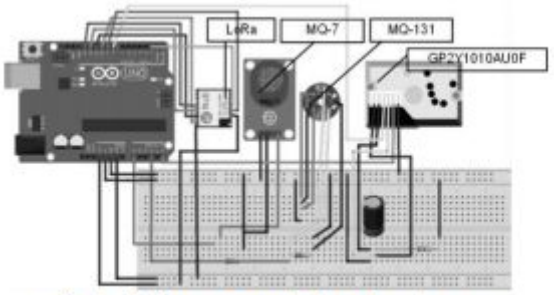
5	0,703906	12,08419	43,7	sehat tidak sehat
6	0,591964	9,898246	51,01	sedang
7	0,88617	9,794153	55,21	sedang
8	0,40288	8,086091	89,22	sedang
9	0,680368	13,57933	32,25	sedang
10	0,520717	3,345153	33,3	sedang
11	1,121146	4,807179	65,4	baik
12	0,373837	4,168429	10,29	baik
13	0,800799	1,47622	17,21	baik
14	0,780917	2,408321	15,86	baik
15	6,600995	99,42201	192,516	baik

System Architecture Design In this study, the wireless sensor architecture network (WSN) that is used consists of sinks nodes, sensor nodes, and server computers. Topology used in this research's WSN system namely the star topology where each sensor node directly connected to the sink. In Figure 1 is an implemented WSN architecture.



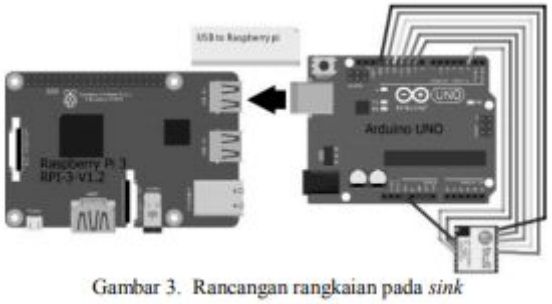
Gambar 1. Arsitektur sistem WSN yang diaplikasikan

Information: 1. Server computer that functions for monitoring and air quality classification 2. Sync is a mini computer using the device Raspberry Pi 3 Model B and plus Arduino. 3. The sensor node is a microcontroller device using Arduino Uno. 4. The MQ-7 sensor is used to measure levels of carbon monoxide gas. 5. The MQ-131 sensor is used to measure the levels of ozone gas (O3). 6. The GP2Y1010AU0F sensor is used for measure the level of dust particulates in the air. Error! Reference source not found 1 represents the WSN architecture implemented consisting of node components sensors, sink nodes, and server computers. Node sensors that function to take measurements environment related to air quality. Result sensor node measurements are sent to the sink. Sink nodes act to collect yield data sensing by sensor nodes for a while. Once the data is collected at the sink, the data is will be sent to the server computer for processing generate classifications and displays air quality Sensor Node The components used on the sensor nodes, namely arduino board to store source code program, the MQ-7 sensor for sensing CO, MQ-131 sensor for sensing O3, sensor sharp GP2Y1010AU0F to do PM10 sensing, and the LoRa module is used for communicate with sink. Figure 2 represents circuit design at the sensor node.



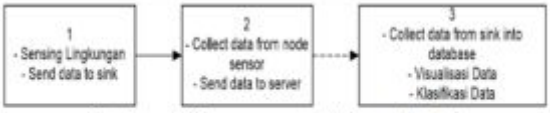
Gambar 2. Rancangan rangkaian pada *node* sensor

Sink The components used in the sink are boards The equipped Raspberry Pi 3 model B wifi module on board. The wifi module will be used to communicate with server computer to transmit quality data air. Then on the sink there is an Arduino Uno board equipped with LoRa module connected to the Raspberry Pi's USB port used to communicate in order to receive data from sensor nodes.



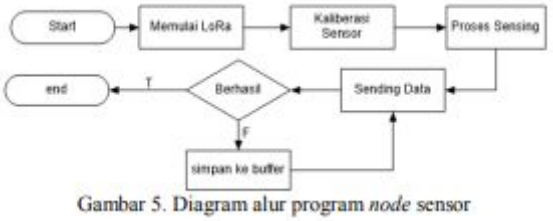
Gambar 3. Rancangan rangkaian pada *sink*

Sink The components used in the sink are boards The equipped Raspberry Pi 3 model B wifi module on board. The wifi module will be used to communicate with server computer to transmit quality data air. Then on the sink there is an Arduino Uno board equipped with LoRa module connected to the RaspbeProcess Design At this stage, process design is carried out for each component contained in a wireless sensor network (WSN) architecture applied to sensor nodes, sinks, and servers according to their respective functions. Figure 4 is a description of the design process.rry Pi's USB port used to communicate in order to receive data from sensor nodes.



Gambar 4. Rancangan rangkaian pada *sink*

Information : 1. The process device at the sensor node (Microcontroller). 2. The process device on the sink. 3. The process device on the server. Radio Frequency Network (LoRa). HTTP Request. Sensor Node The software on the sensor node is used for perform the air condition sensing process with take the values of the parameters CO, O3, and PM10. Figure 5 is a program flow diagram on microcontroller sensor nodes



Gambar 5. Diagram alur program *node* sensor

Figure 5 above is an instructional process program on the sensor node that performs the process measurement of the values of CO, O3, and PM10. Process sensing was carried out for 1 minute with data obtained ± 40 data, then calculated the value average. The value of the average obtained for 1 minute is then sent to sink. If the delivery is not made successful, the data is not transmitted it will stored in the buffer for a while, and will be sent during the shipping process next. Sink The software on the sink is used for collect data from sensor nodes, then sent to the server. Figure 6 is a diagram software flow on the sink.

Gambar 6. Diagram alur perangkat lunak pada *sink*

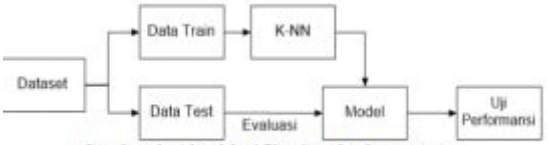
From Figure 6 above, the sink will receive data sent by the sensor nodes, then will be recorded the time when you first receive the data from the sensor node. The process of sending data to the server done every 1 hour from the time of receiving data the first time from the sensor node, this is done accordingly Regulation of the Head of Bapedal Decree No. 107 Years 1997. The sensor node sends data to each sink 1 minute, then the sink will have 60 data levels of CO, O3, and PM10 before data sent to the server. Of the 60 data.

the average value is calculated, then sent to the server. Sending data to the server using HTTP protocol. Server The software on the server receives data air quality of the sink. After receiving data from sink, the server will perform data classification accepted, then enter the data and results classification into the database available at server. The server computer will display air quality visualization. Figure 7 is a groove program from receiving data from the sink using the HTTP protocol to be accessed by the server.

Gambar 7. Diagram alur penerimaan data pada *server*

Based on Figure 7 above, the server will waiting for HTTP messages sent by sink which sends air quality data i.e. rate levels of CO, O3, PM10. When data is received by server, quality classification processing is performed air using the K-NN method. After the label is generated from the data sent by sink, labels are saved into database located on the server. In the process of classifying data on the server using the

concept of data mining, namely using the K-Nearest Neighbor (KNN) method. The data normalization stages were carried out in the form of equalization of scale or distance on each feature there is the training data and the data that will be classified, because of the data received by the server has a scale of each feature diverse. Distance standard (normalization) used namely z-score, min-max, and decimal scaling. From The 3 normalizations will be sought which one is has a performance level for data classification the good one. Error! Reference source not found. is the flow of classification using data mining.



Gambar 8. Alur klasifikasi pada *data mining*

The algorithm in K-NN is as below. a. Enter the value of k (amount of training data closest). b. Perform data normalization for equations the scale of each data parameter.

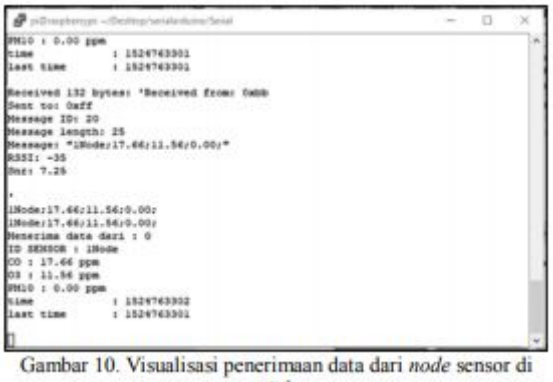
This study uses 3 variations normalization, namely:
-Z-score, the formula to use: v ′ = v - μ σ Where, v ′ = Standardized value; v = value of attribute; μ = average; σ = standard deviation. -Min-Max, the formula of the min-max normalization: v ′ = v - vmin vmax - vmin -Decimal Scaling, the decimal scaling formula: v ′ = v 10j Where j = the desired scaling value c. Calculates the shortest distance between data will be classified with each data there is in the training data using euclidean distance measurement. Euclidean distance equation: D (x, y) = √∑ (xi - yi) 2 n i = 1 d. Sort the data closest to the value of the smallest distance calculation. e. Choose the label with the most frequency.

3. Results and Analysis

Sensor Node Implementation Figure 9 is the device's print screen soft on the sensor nodes while performing the process sensing and sending data to the sink. From the picture below can be seen if the sensor node can sends data to sink then status delivery is 1 and if not then 0. Apart delivery status, the sensor node will display data sent by the sensor node to the sink.

Gambar 9. Visualisasi pengiriman data ke *sink*

Sink Implementation Below Figure 10 is a print screen the software contained on the sink. Sink will displays the data received from the sensor node.
Figure 11 is a visualization of the program when the sink sends data to the server. The data sent is sensor ID, time sensing, and the value of air quality parameters. After the data is successfully sent to the server, the server will give a JSON response to the data from the sink.



Gambar 10. Visualisasi penerimaan data dari *node* sensor di *sink*

Gambar 11. Visualisasi pengiriman data dari *sink* ke *server*

Server Implementation

Figure 12 is a visualization of monitoring data air quality by value parameter carbon monoxide (CO), ozone (O3), particulate dust (PM10), and the results of the air quality classification which is the result of its monitoring obtained by the sensor node.

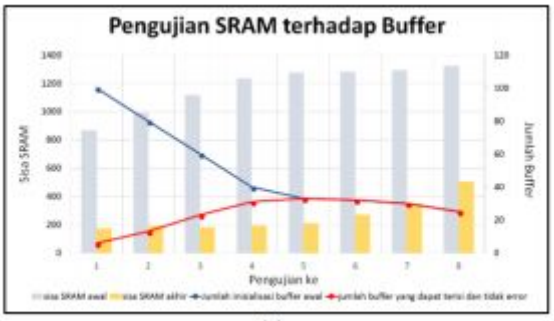
Gambar 12. Visualisasi data pada *server*

Testing the use of SRAM and Flash Memory Sensor Node

This test is carried out with a scenario, for know the remaining usage of SRAM and flash memory on arduino (sensor node) against variations in the number of buffer arrays used for store data when sensor nodes are unable reach or transmit data to the sink. This test is done to maximize arduino resource usage. SRAM on Arduino UNO of 2K bytes and flash memory 32K bytes

TABEL II
PENGGUNAAN SRAM DAN *FLASH MEMORY*

Jumlah inisialisasi *buffer* awal	sisa SRAM awal (*byte*)	sisa *flash memory* (*byte*)	jumlah *buffer* yang dapat terisi dan tidak *error*	sisa SRAM akhir (*byte*)	keterangan
100	864	19756	6	172	tidak sesuai
80	992	20102	13	192	tidak sesuai
60	1112	20102	23	181	tidak sesuai
40	1232	20102	31	192	tidak sesuai
33	1274	20102	33	208	sesuai
32	1280	20102	32	272	sesuai
30	1292	20102	30	346	kurang memaksimalkan *resource*
25	1322	20102	25	504	kurang memaksimalkan *resources*



(a)

(b)

Figure 13. Use of SRAM and flash memory
(a) Graph of remaining SRAM on Arduino versus variation number of buffers;
(b) Graph of remaining flash memory on Arduino compared to variations in the number of buffer arrays

From Table II and Figure 13 above can see the use of variations in the number of buffers effect on remaining SRAM and flash memory on arduino. If the remainder of the Arduino SRAM less than 200 bytes, arduino will experience system failure (system error). Number of buffers appropriate to maximize resources SRAM on Arduino is about 33 and 32 in number buffer.
LoRa Communication Distance Testing (SX1278) This test is done to find out the range of the LoRa module to do sending data from the sensor node to the sink. This test is carried out with a scenario with variations in distance between sensor nodes and sinks, and buffers filled array, the number of buffer array initialized numbering 33 (adjusted to previous tests in Table II Usage SRAM and flash memory).

TABEL III
PENGUKURAN JARAK LORA (SX1278)

Pengujian	Jarak (m)	Maksimal Buffer Terisi	keterangan
1	30	0	stabil
2	60	0	stabil
3	90	0	stabil
4	150	0	stabil
5	200	0	stabil
6	220	10	tidak stabil
7	240	33	gagal terkirim

In Table III above it can be seen at a distance less than 200 meters, sending data from the node sensor to the sink is stable. Then testing from a distance of 200 to less than 220 meters data transmission is not stable. Then in moment distances greater than or equal to 240 meters, data transmission is not possible.

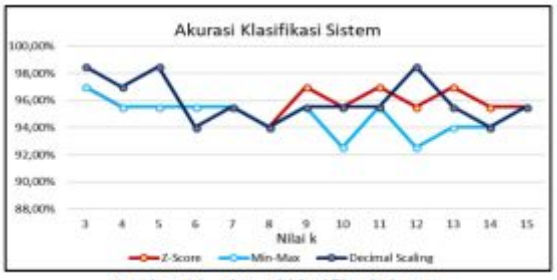
Data Missing Testing Handling) This test is performed to handle current data The sink cannot be reached or accessed by the node sensors, which can result from network instability between the sensor nodes and sink using the LoRa module. Scenario the test, the sensor node will carry out the process sensing up to 1 minute (in this study time sensing 1 minute). Then the amount of data obtained for 1 minute will be

searched average value (this is done for maximize the processing instructions on arduino), then sent to the sink. If The sink cannot be accessed by the sensor node, data will be stored in the buffer. Thing is intended so that the data is not lost when The sink cannot be accessed by the sensor node. amount The array used is 33 buffers (adjusted to the previous test table II Use of SRAM and flash memory). If the data contained in the buffer array has up to 33 data and sensing data by node the next sensor is generated when the sink is still not accessible, data on the old buffer array will be replaced with new sensing data. Moment sensor nodes can access the sink, then all the array in the buffer will be sent directly by sensor nodes to sinks one by one. Testing buffer function can be seen in Table III LoRa distance measurement (SX1278).

Testing the k value for the K-NN classification Testing the value of k on the K-NN is carried out for find out the value of k that corresponds to the level high accuracy. The k value test is performed with scenarios with variations in the value of k in the method K-NN with 3 types of normalization. Table IV is a test of the k value of the K-NN classification on the system. From Table IV, the k value for K-NN with normalization variations and Figure 14 Accuracy classification system, obtained several values of k for normalization the z-score has a degree of accuracy which were high, namely 3, 9, 11, 13 of 97.01%. The min-max normalization gets the k value has the highest accuracy, which is 3 of 97.01%. Decimal scaling normalization is obtained multiple k values with a high degree of accuracy namely 3, 5, and 12 amounting to 98.51%.

NILAI K UNTUK K-NN DENGAN VARIASI NORMALISASI

Nilai k	Normalisasi		
	Akurasi Z-Score	Akurasi Min-max	Akurasi Decimal Scaling
3	97,01%	97,01%	98,51%
4	95,52%	95,52%	97,01%
5	95,52%	95,52%	98,51%
6	95,52%	95,52%	94,03%
7	95,52%	95,52%	95,52%
8	94,03%	94,03%	94,03%
9	97,01%	95,52%	95,52%
10	95,52%	92,54%	95,52%
11	97,01%	95,52%	95,52%
12	95,52%	92,54%	98,51%
13	97,01%	94,03%	95,52%
14	95,52%	94,03%	94,03%
15	95,52%	95,52%	95,52%



Gambar 14. Akurasi klasifikasi sistem

Classification Accuracy Testing with K-Fold Cross Validation This test is done to determine the level stability results in accuracy, precision, and recall against the classification results generated by the system if tested with data train (train) and test data (test) which varies. From Table IV, test the value of k on K-NN prior to normalizing z-score accuracy the highest is obtained by using the k value for the K-NN classification is 11, the k value for the min-max normalization of 3, the k value for normalization of decimal scaling, namely 5. Table V is an evaluation of the performance of the classification system by using the 10-fold cross test validation.

TABEL V
EVALUASI PERFORMA KLASIFIKASI 10-*FOLD CROSS VALIDATION*

fold	*Z-Score*			*Min-Max*			*Decimal Scaling*		
	Akurasi	**Presisi**	***Recall***	**Akurasi**	**Presisi**	***Recall***	**Akurasi**	**Presisi**	***Recall***
1	100,00%	100,00%	100,00%	97,30%	97,50%	97,22%	100,00%	100,00%	100,00%
2	94,59%	95,24%	94,44%	94,59%	95,24%	94,44%	97,30%	97,50%	97,22%
3	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%
4	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%
5	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%
6	67,57%	49,36%	63,99%	64,86%	47,27%	60,86%	86,49%	61,33%	84,38%
7	78,38%	74,39%	81,94%	83,78%	77,97%	81,75%	78,38%	51,10%	66,87%
8	89,19%	87,25%	91,79%	83,78%	79,23%	87,62%	89,19%	83,33%	91,79%
9	97,30%	66,67%	97,37%	97,30%	66,67%	97,37%	97,30%	66,67%	97,37%
10	91,18%	88,46%	93,75%	88,24%	85,71%	91,67%	94,12%	91,67%	95,83%
Rata-Rata	**91,82%**	**86,14%**	**92,33%**	**90,99%**	**84,96%**	**91,09%**	**94,28%**	**85,16%**	**93,35%**

From Table V, cross-testing 10 times the validation that has been done, it is found that the normalization of the decimal scaling has a high level of added value and is relatively more stable than the normalization of z-score and min-max with an average level of accuracy of 94.28%, the precision is 85 , 16% and the recall is 93.35%.

4. Conclusion

Based on the results of the analysis and implementation on research on wireless sensor network applications for the monitoring system and quality classification In this air, several statements can be summed up as follows. Wireless sensor network application applied as a monitoring system and air quality classification designed with use the MQ-7 sensor to find out CO level, the MQ-131 sensor for know the level of O3 levels, and sensors GP2Y1010AU0F to find out the level dust particulates. Meanwhile, the LoRa module for wireless communication sensor node to the sink and HTTP protocol for sending data from sink to server. LoRa delivery distance testing was carried out to determine the maximum distance for sending data. In this study, the range was obtained maximum, which is 200 meters. This result is different with the one on the datasheet, which one the

range can be up to 10 km. To to handle missing data, buffer is used for stores temporary data when sensor nodes are not can access the sink to transmit data sensing results. For data handling when the sensor nodes are not can access the sink in sending the result data sensing, a buffer is needed to hold the data for a while. Test results against the amount of buffer that can be accommodated on arduino sensor nodes by maximizing resources there are 33 buffers. From the test results for performance classification using confusion matrix and 10-fold cross validation scenario, classification results generated by the system using K-Nearest Neighbor (K-NN) algorithm is a value accuracy, precision, and recall are affected by type of data normalization used. Normalization which has a high level of performance better in this study, namely normalization.

References

[1] T. Astuti, T. Parenta, and H. Paddu, “Peranan Kegiatan Industri Pengolahan Terhadap Pencemaran Lingkungan di Sulawesi Selatan,” Univ. Hasanudin, Makasar, vol. 3, no. 1, pp. 49–56, 2013.

[2] S. Supraptini, “Pengaruh Limbah Industri Terhadap Lingkungan Di Indonesia,” Media Penelit. dan Pengemb. Kesehat., vol. 12, no. 2 Jun, pp. 10–19, 2002.

[3] PERATURAN PEMERINTAH REPUBLIK INDONESIA NOMOR 41 TAHUN 1999 TENTANG PENGENDALIAN PENCEMARAN UDARA. 1999.

[4] K. Sohraby, D. Minoli, and T. Znati, Wireless Sensor Networks. 2007.

[5] M. Pule, A. Yahya, and J. Chuma, “A Wireless Sensor Network Solution for Monitoring Water Quality in Botswana,” 3rd Natl. Found. Sci. Technol. Dev. Conf. Inf. Comput. Sci., pp. 12–16, 2016.

[6] I. Muhammad, B. Sugiarto, and I. Sakti, “Rancang Bangun Sistem Monitoring Kualitas Udara Menggunakan Teknologi Wireless Sensor Network (WSN),” Inkom, vol. III, no. 1, pp. 90–96, 2009.

[7] Y. Xu and F. Liu, “Application of Wireless Sensor Network in Water Quality Monitoring,” 22017 IEEE Int. Conf. Comput. Sci. Eng. IEEE Int. Conf. Embed. Ubiquitous Comput., pp. 368–371, 2017.

[8] S. Ferdoush and X. Li, “Wireless sensor network system design using Raspberry Pi and Arduino for environmental monitoring applications,” Procedia Comput. Sci., vol. 34, pp. 103–110, 2014.

[9] H. Budi et al., “APLIKASI WIRELESS SENSOR NETWORK (WSN) SEBAGAI SISTEM,” vol. 1, no. 1, pp. 101–110, 2016.

[10] B. Sugiarto and R. Sustika, “Data Classification for Air Quality on Wireless Sensor Network Monitoring System Using Decision Tree Algorithm,” 2016 2nd Int. Conf. Sci. Technol., pp. 172–176, 2016.

[11] M. Saoudi, R. Euler, T. Kechadi, and A. Cuzzocrea, “Energy-Efficient Data Mining Techniques for Emergency Detection in Wireless Sensor Networks,” 2016 Intl IEEE Conf. Ubiquitous Intell. Comput. Adv. Trust. Comput. Scalable Comput. Commun. Cloud Big Data Comput. Internet People, Smart World Congr., pp. 766–771, 2016.

[12] Keputusan Kepala Bapedal No. 107 Tahun 1997 Tentang : Perhitungan Dan Pelaporan Serta Informasi Indeks Standar Pencemar Udara, no. 107. 1997.

[13] H. Electronic, “Mq-7 Gas Sensor,” MQ-7 Datasheet. 2006.

[14] Z. W. T. C. Electronics, “Ozone Gas Sensor （Model：MQ131 High Concentration）.” 2014.

[15] SHARP, “Application note of Sharp dust sensor GP2Y1010AU0F - Sheet No.: OPI3024EN,” 2010.