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PREFACE TO THE CONFERENCE PROCEEDINGS

On behalf of the conference committee, first of all, I would like to thank God Almighty for holding this activity. I also extend a warm welcome to all involved in our International Conference on Electrical, Computer Technology, and Information Engineering (ICEECIT).

As the General Chair of this conference, I am honored and would like to thank those who have played a part in this important event.

First of all, I would like to thank and appreciate the leadership of the University of Jember, who has been willing to provide funds and other facilities so that this event can be held. Second, I express my gratitude and appreciation to the IEEE Indonesia Section and the Power Energy System IEEE Indonesia Section Chapter for sponsoring this activity. Third, my thanks to the reviewers that have examined the papers so that only the ones that meet the quality can be published in conferences and proceedings. Fourth, thanks to the authors, moderators, and participants for collaborating in improving science and technology. Fifth, I express my highest gratitude and appreciation to my colleagues from the organizing committee and my students for their tireless efforts in managing this conference.

I realize that organizing this first conference still has several obstacles, although my team and I have tried our best to manage it as best we can.

Finally, I hope that our conferences and proceedings that have been published can significantly contribute to the welfare of humanity.

Prof. Dr. Ir. Bmbang Sujanarko, MM, IPM
ICEECIT General Chair

Prediction of LED Arrangement Illumination on Street Light Armature Using Random Forest Regression Method

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***Abstract*— LED's have a lifetime of up to 30 thousand hours. In addition, it has a level of effectiveness and efficiency of 80%-90%. The current problem is to determine the performance of the LED array arrangement using conventional methods so that the LED array arrangement must be made first and operated for testing. In this study, the LED array arrangement test determines each test sample's performance. Illumination prediction computations were performed on each sample using different test parameters. The prediction of illumination has a different predictive value in each test sample. The first and sixth samples have prediction accuracy below 95%. However, samples 2,3,4 and 5 have prediction accuracy above 95%. The interests of the current and temperature variables are 50% and 48%, while the voltage is only 3%. The value of R2, which is not by the research hypothesis, which is greater than 98%, is caused by the ability of the dependent variable, namely limited illumination. In addition, because the independent variables are less varied, they do not provide information on the dependent variable during the training data process. The low R2 value can also influence by the ability of the prediction test parameters formed.**

Keywords*— *LED, Prediction, Random Forest Regression.

I. Introduction

Conventional lamps such as sodium lamps emit only 30% of the light they need. So it is very inefficient to use; besides being expensive for the electricity bill, this lamp does not emit light as a whole [1]. Different from LED lamps which have advantages and disadvantages over conventional lamps. Relatively long lifetime with a durability of up to 30 thousand hours. LEDs also have an energy use efficiency of up to 80 to 90 %, much better than other types of lamps. In addition, LEDs also do not distort the surrounding color, so they are safer to use for public street lighting [2]. In fact, 70% to 85% of the power delivered to the LED circuit is converted to heat. So this causes a high temperature at each junction of the LED array. And will cause a decrease in lamp performance such as illumination and even cause damage to the LED. In addition, the lighting of the resulting LED array will decrease faster than the lifetime of the LED itself. So, in this case, thermal management on the armature is needed [3]. Research on the characteristics of temperature and current on the LED array conducted by Widjonarko showed the average LED array current increases by 21.12% and causes an increase in temperature in the circuit by 91.37% [4]. This causes a decrease in the illumination of the LED array by 4.82%. The voltage on the LED array circuit also decreased by about 0.52% [5]. This study aims to determine the performance of the LED array arrangement without making hardware first and only using input variables in the form of input temperature, current, and voltage using the random forest regression method. The random forest regression method is a suitable method to make a prediction; Primajaya and Sari's (2018) research that predicts rainfall using the random forest regression method produces prediction accuracy and accuracy of 99.45% [6].

II. Method

A. Random Forest Regression

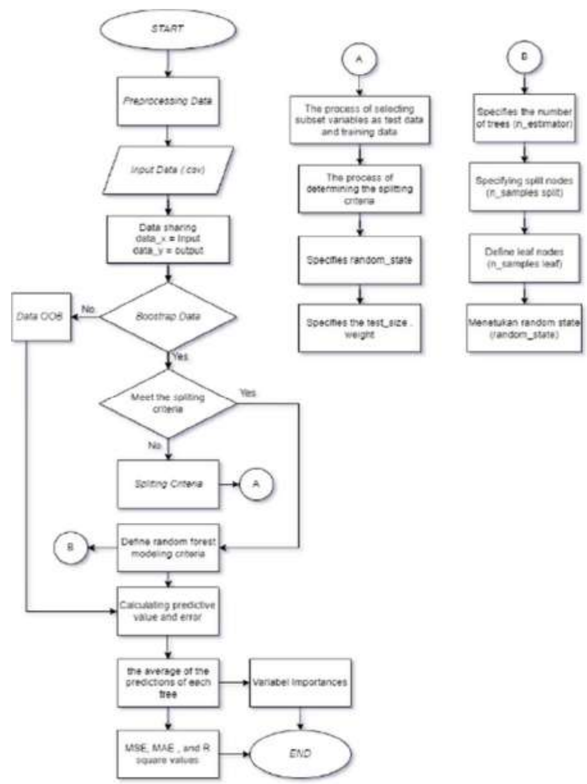

Fig. 1. Random Forest Regression Algorithm

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The research uses random forest regression because this method has the advantages of high accuracy, high efficiency, and high performance in dealing with many variables and has a faster computation time than other methods [7]. Prediction of the illumination of the LED array on the PJU armature, there are steps in data processing using the random forest regression method as follows:

- Before starting the first step, namely preparing (preprocessing) the data used as training data.
- Next, determine N_{tree}, the number of trees tested from variable parameter data.
- Then from the data train, it goes through the bootstrap stage. The data has been divided into train and test at this stage.
- OOB data will be included in the calculation, and errors from predictions to be processed are reprocessed into the bootstrap process.
- The stage of determining the formation of trees in a random forest on the results of bootstrap.
- To determine the value of the final prediction results using the prediction results from each tree will be aggregated. The following is the average mathematical equation for all tree predictions in a random forest:

$$\hat{Y}_i = \frac{1}{N_{tree}} \sum_{n=1}^{N_{tree}} \hat{Y}_i \qquad (1)$$

Keterangan

$\hat{Y}_i$: Final prediction result

N_{tree} : Total number of trees in random forest

$\hat{Y}_i$: The result of the prediction tree to n

B. Data Logger

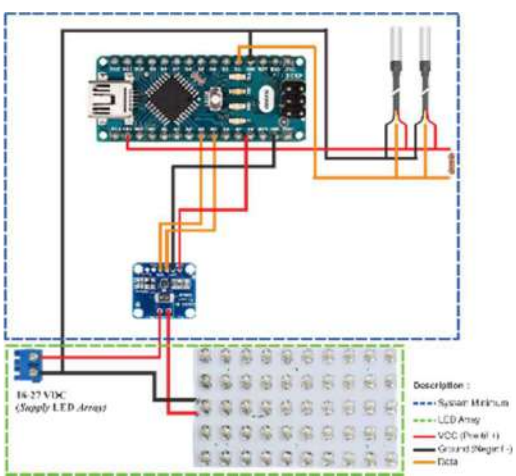

Fig. 2 Electrical Data Logger

Arduino nano for the control center of the test system. In addition to monitoring the system's temperature, current, and voltage when testing [8]. A data logger method is needed during testing to simplify the process of processing and storing data. So in the system's electrical circuit, there is PLX.dax which can monitor when testing the LED array arrangement. The data read by the sensor will be recorded into Microsoft excel in real time using PLX.dax.

C. Test Design

The research was conducted using the LED module array design with an array configuration of 6x3. In addition, the arrangement of each sample will have a varying array distance of 6 variations. For a total of LED chips, all samples have the same number of 18 LED chips arranged in a series-parallel. The purpose of this LED array variation is to produce the best distance so that the LED performance is also excellent

TABLE I. LED ARRAY SPECIFICATIONS

Sample	Dimensions		Jarak Chip LED	
	L (mm)	W (mm)	H (mm)	V (mm)
1	147	55	20	20
2	198	55	30	20
3	248	55	40	20
4	144	75	20	30
5	196	75	30	30
6	244	75	40	30

L : Length ; W : Width ; H : Horizontal ; V : Vertikal

Fig. 3 Array LED PCB design (H :20 ; V : 20)

Fig. 4 armature design test

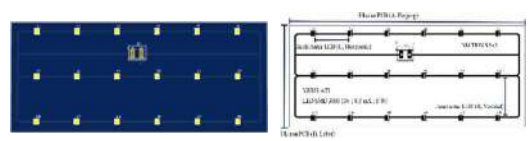

Fig. 5 Illumination and Temperature Test

In the general street lighting armature used for the lantern or housing of the LED array had designed to provide an air gap for air circulation generated on the LED array. Temperature and illumination tests are conducted on each sample to determine its characteristics.

D. Block Diagram

In general, street lighting armatures for lanterns or housings of LED arrays; are to provide air gaps for air circulation in the LED arrays.

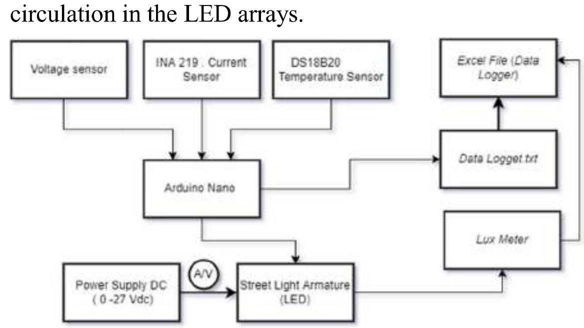

Fig. 6 Block Diagram

III. RESULTS AND DISCUSSION

The research begins with testing the electrical components used in the research testing process. That is to produce accurate data from the sensor readings used. The sensors used to process the research data logger are the INA219 sensor and the DS18B20 temperature sensor. Sensor calibration is essential because it will affect the LED module array illumination data. For the INA219 sensor calibration process, the value reading compares between the Arduino IDE serial monitor and the multimeter measuring instrument [9]. However, it is different from the calibration of the DS18B20 temperature sensor; namely, the reading compares with a digital thermometer which is already accurate according to SNI. The illumination prediction data will be processed using the random forest regression method using the open-source Kaggle platform.

A. INA219 Calibration

After calibration, the test produces a comparison value between the current reading on the INA219 sensor, and the resulting value is an average error of 0.42% or an MAE (Mean Absolute Error) value of 0.417 mA. From the value of the regression results obtained the appropriate current reading value and has a relatively small error value.

TABLE II. CURRENT CALIBRATION OF INA219

No	Reference Voltage (V)	INA219 Sensor Value (mA)	Multimeter Value (mA)	Percent error (%)	MAE (mA)
1	1	9.49	9.57	0.84%	0.080
2	2	18.68	18.56	0.64%	0.120
3	3	27.03	27.03	0.00%	0.000
4	4	36	35.92	0.22%	0.080
5	5	45.26	45.22	0.09%	0.040
6	6	55.32	55.14	0.33%	0.180
7	7	64.65	64.46	0.29%	0.190
8	8	74.09	73.93	0.22%	0.160
9	9	84.3	83.91	0.46%	0.390
10	10	95.074	94.71	0.38%	0.364
11	11	104.49	104.14	0.33%	0.350
12	12	114.16	113.72	0.39%	0.440
13	13	123.46	122.89	0.46%	0.570
14	14	133.02	132.41	0.46%	0.610
15	15	142.91	142.23	0.48%	0.680
Eror (%)				0.42%	0.417

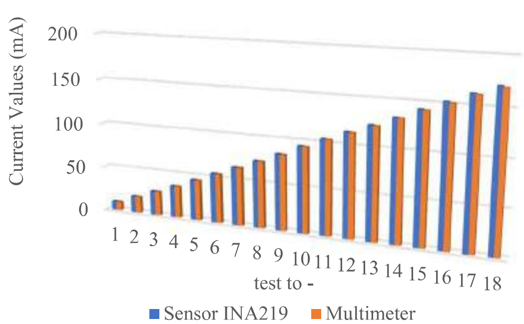

Fig. 7 Comparison of reading the current value of INA219 with multimeter calibration results.

In testing the INA219 sensor voltage, the readings from the calibration INA219 sensor so that the percent error value is 1.09% and the mean absolute error (MAE) is 0.090 volts. Based on the linear regression results, the INA219 sensor has a reading corresponding to a relatively small error.

TABLE III. VOLTAGE CALIBRATION INA219 SENSOR

No	Reference voltage (V)	Sensor voltage value INA219 (V)	Multimeter Voltage (V)	*Error* (%)	MAE (V)
1	1.00	0.80	0.79	1.88%	0.015
2	2.00	1.85	1.84	0.81%	0.015
3	3.00	2.81	2.77	1.39%	0.039
4	4.00	3.70	3.64	1.57%	0.058
5	5.00	4.63	4.59	0.86%	0.040
6	6.00	5.66	5.56	1.77%	0.100
7	7.00	6.67	6.60	1.05%	0.070
8	8.00	7.57	7.49	1.06%	0.080
9	9.00	8.50	8.45	0.59%	0.050
10	10.00	9.29	9.20	0.97%	0.090
11	11.00	11.06	10.92	1.27%	0.140
12	12.00	11.70	11.59	0.94%	0.110
13	13.00	12.83	12.70	1.01%	0.130
14	14.00	13.89	13.73	1.15%	0.160
15	15.00	14.84	14.72	0.81%	0.120
16	16.00	15.87	15.75	0.76%	0.120
17	17.00	16.87	16.73	0.83%	0.140
18	18.00	17.90	17.75	0.84%	0.150
Eror (%)				1.09%	0.090

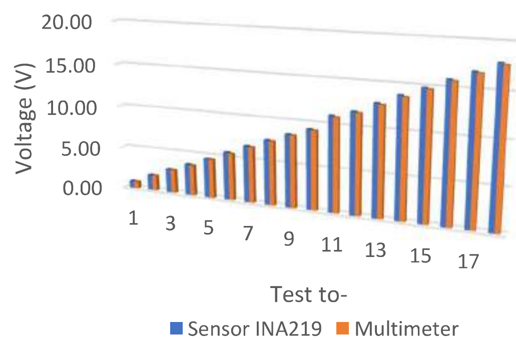

Fig. 8 Comparison of reading the voltage value of INA219 with multimeter calibration results.

B. Calibration DS18B20 Sensor

The temperature sensor test uses a smoothing technique for a more stable sensor reading. Retrieval of valid data is taken with ten iterations and then determines the average of the data. The average value of the ten iterations uses as the temperature reading value on the DS18B20 sensor [10]. That aims to get a stable temperature value and has a relatively small error when testing with the LED module array load.

TABLE IV. DS18B20 SENSOR CALIBRATION RESULTS

No	Sensor reading value DS19B20 (°C)	Nilai thermometer (°C)	Error (%)	MAE
1	76.08	76	0.11%	0.08
2	70.68	71	0.45%	0.32
3	70.19	70.4	0.30%	0.21
4	68.72	68.8	0.12%	0.08
5	67	67.3	0.45%	0.3
6	65.77	66	0.35%	0.23
7	64.54	64.7	0.25%	0.16
8	63.31	63.7	0.62%	0.39
9	62.09	62.5	0.66%	0.41
10	61.1	61.5	0.65%	0.4
Error Average			0.39%	0.258

The percent error value is smaller when compared to the DS18B20 temperature sensor before calibration. The percent error value after calibration is 0.39%, with a mean absolute error of 0.258°C.

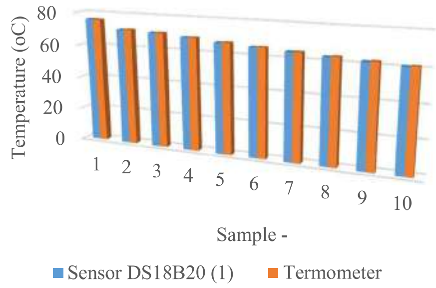

Fig. 9 DS18B20 Sensor calibration

C. Illumination prediction using random forest regression

- Test sample 1

In test sample 1, the parameter n_estimator is equal to 100, n_sample split is equal to 6, min_sample_leaf is equal to 4, and random state is valued at 40 and has a low predictive accuracy with R2 of 0.821 or 82.1% with an accuracy of forecasting model (MSE) of 0.0032 and the level of accuracy (MAE) of 0.020. The low R2 value can also influence by the ability of the prediction test parameters formed.

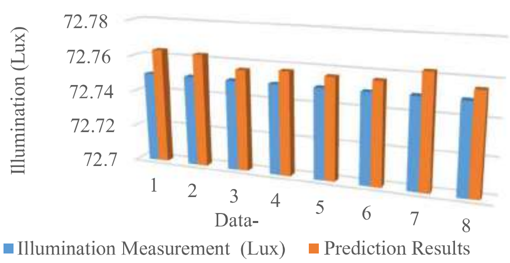

Fig. 10 Comparison of illumination measurement and prediction of first test sample

- Test sample 2

At the R2 value of the second sample test with the prediction test parameters n_estimator equal to 500, n_sample split equal to 2, min_sample_leaf equal to 1, and random state worth 40 have the best value in the test sample test of 0.993 or 99.3%. This parameter has a perfect level of accuracy with an MAE value of 0.0008 and has good predictive accuracy with an MSE value of 0.0004.

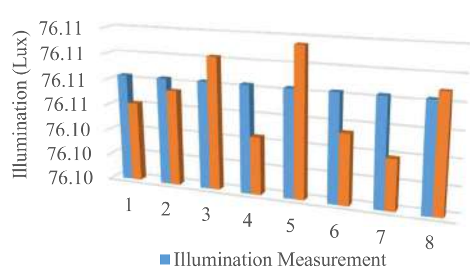

Figure 11 Comparison of illumination measurement and prediction of second test sample

- Test Sample 3

The prediction of the third sample with the highest R2 value of 99.6% has the correct illumination prediction accuracy. So by using these parameters, it can be used as a reference for testing the LED array module illumination prediction.

- Test sample 4

In the 4 test sample, the value of R2 with the test parameter n_estimator is equal to 50, n_sample split is equal to 10, min_sample_leaf is equal to 4, and the random state is worth 40 has a small R2 value (not close to value = 1) so that the level of accuracy with the model parameter is the prediction result. The R2 value is 0.901 or 90.1%. That is indicated by the MSE and MAE values, 0.0054 and 0.027.

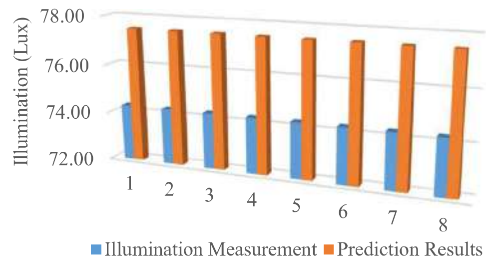

Fig. 12 Comparison of illumination measurement and prediction of third test sample

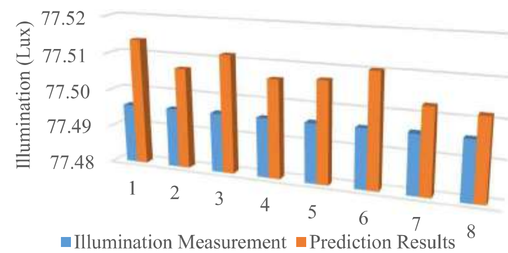

Fig. 13 Comparison of illumination measurement and prediction of fourth test sample

- Test sample 5

The fifth sample prediction test with the highest R2 value of 99.3% has the correct illumination prediction accuracy. So by using these parameters can be used as a reference for testing the LED array module illumination prediction, which has almost the same data variation. With only 50 trees, the results of prediction accuracy and good accuracy indicate that the fifth test sample data has less variation in input data, so in testing, predictions to avoid the bootstrap process, the data is not good.

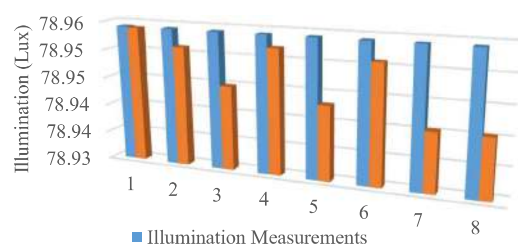

Fig. 14 Comparison of illumination measurement and prediction of fifth test sample

- Test sample 6

The 6th sample prediction test with the highest R2 value of 95.1% has the correct illumination prediction accuracy. In the sixth sample, there is a lack of varied data on the input voltage value because when testing, it uses a constant voltage, so the test parameter value is enough to use 50 trees with split bootstrap data 6.

The varying distance between LED chips causes the effect of the difference in the illumination value of each sample. So that the heat generated by each LED chip will increase the current due to the more excellent resistance on the LED chip. This phenomenon results in power dissipation and a decrease in efficiency, so the illumination value in the LED module array will also decrease. This

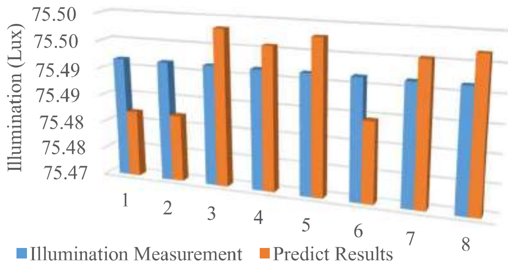

Fig. 15 Comparison of illumination measurement and prediction of sixth test sample

analysis by studying the degradation system using the SPD (Spectral Power Distribution) method proves that the degradation of the LED array module arrangement is caused by the current and temperature values. So that the quality of the lighting strength (illumination) gets worse under conditions of high temperature and high current values [11]. The temperature and current values of the LEDs are essential to qualify and optimize the LED array design. LED brightness depends on both current and temperature. LED connection temperature depends on heat sources such as injection current and ambient temperature [12]. This experiment uses the random forest regression method to determine the illumination prediction on the LED armature arrangement of street lights. The random forest regression method has many advantages, such as high accuracy, high efficiency, and high performance in handling significant variables [13]. In designing the parameters of the random forest regression method, several steps are carried out: preprocessing data, tree formation (bootstrap, stopping criteria, variable separation), calculating predictions, and the average prediction of each tree formed. The following is an explanation of the design of the random forest regression method in carrying out the computational process.

D. *Variable Importances*

In this study, the current and temperature variables had high weights, namely 50% and 48%, respectively. That is because the two variables affect the performance of the LED array arrangement and data processing with random forest regression. Meanwhile, the value of the voltage variable, which acts as the control variable in the study, has a lower weight than the current and temperature weights, which is 3%.

IV. Conclusion

The conclusion of the research is the result of testing and data processing. Following are the conclusions of the research. The performance of random forest regression in the LED array illumination prediction research is influenced by several factors. So that each test samples 1 and 6 has predictive data whose accuracy level is below the research target, which is <98.5%. These factors are varied data values for research variables, some trees, minimum split, and a minimum and random state built on random forest regression. However, in the test sample that has a lot of varied data, test samples 5, 4, 3, and 2 have a predictive value with R2 above 98.5%. So that in the test sample, the accuracy and precision of the prediction value is very high compared to the sample tests 1 and 6. In this case, it can be concluded that in determining the variation of the data, it is very important to make predictions using the random forest regression method. In the random forest regression method, a variable's weight importance determines the LED array illumination prediction result. Each weight that the variable has a different value. In this study sequentially, the current and temperature variables have high consequences, namely 50% and 48%. That is because the two variables affect the performance of the LED array arrangement and data processing with random forest regression. Meanwhile, the value of the voltage variable, which acts as the control variable in the study, has a lower weight than the current and temperature weights, which is 3%.

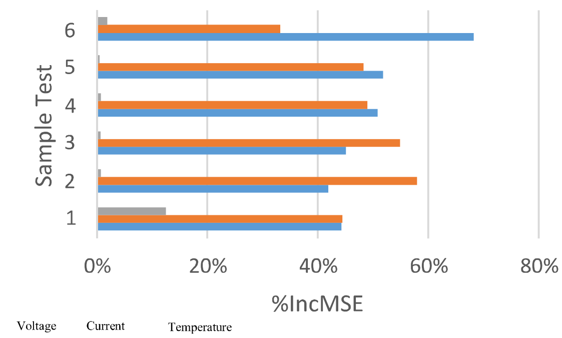

Fig. 16 Percentage of Variable Importance

VI. References

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