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Performance Evaluation of the Transfer Learning Model in Car Vehicle Detection

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ABSTRACT

Congestion is a common problem that occurs in big cities. It is necessary to make an ITS (Intelligent Transportation System) using computer vision to monitor street density by counting the number of passing vehicles. The basis of vehicle counting is vehicle detection. This study will compare the performance of vehicle detection models in order to make it easier to determine which model is suitable for implementation. The dataset used is the Vehicle Detection Image Set. The models used are InceptionV3, Xception, MobileNet, MobileNet V2, VGG 16, VGG 19, Efficientnet (B7), and Efficientnet V2 (L). The results show that Inception, Xception, Mobilenet, and VGG19 are the models with the highest test accuracy. The VGG 16 model has the shortest training duration while the Efficientnet V2 (L) has the longest training duration.

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1 INTRODUCTION

Congestion is a common problem that occurs in big cities today. An imbalance between the quantity and size of existing roads and the increasing number of vehicles from year to year is one of the causes of this problem. The Central Statistics Agency (BPS) notes that in 2022 there will be 143,797,227 units of motorized vehicles where this number will continue to grow (see this link below): https://www.bps.go.id/indikator/indikator/view_data_pub/0000/api_pub/V2w4dFkwdFNLNU5mSE95Und2UDRMQT09/da_10/1.

Meanwhile, in the same year, BPS noted that the total length of roads in Indonesia was 548,423 km (see https://www.bps.go.id/). Based on data compiled by Tomtom (see https://www.tomtom.com/traffic-index/jakarta-traffic/), Jakarta is the 46th most congested city in the world in 2021 with a congestion rate of 34%. If you look at the previous 2 years, this figure is the smallest number. In 2019 the level of congestion in Jakarta reached 53%, while in 2020 it decreased to 36%.

Various policies have been put in place to overcome this problem, one of which is a traffic monitoring policy to monitor the level of traffic density by counting each vehicle on the road. The conventional method of counting vehicles in traffic monitoring is done using sensors, such as pneumatic tubes, magnetic sensors, inductive loops, etc [1]. However, this conventional method requires a fairly high cost coupled with the cost of maintenance. In addition, this method is difficult to install and less flexible. Therefore, it is necessary to create an Intelligent Transportation System (ITS) using computer vision to calculate vehicles on the highway [2]. One of the basics in ITS is the vehicle detection process. Before vehicles are counted and their density determined, the system first detects whether these objects include vehicles such as cars, trucks, buses, etc. or non-vehicles.

Research conducted by H. Song et al. [3] regarding Vision based Vehicle Detection and Counting System using Deep Learning in Highway Scenes. In this study using a dataset created by researchers taken from video monitoring of highways in Hangzhou, China. The dataset consists of 3 categories, namely cars, buses and trucks with a total of 11,129 images. First of all, the image will be extracted and segmented using Gaussian Mixture Modeling. The vehicle detection process uses YOLOv3 Darknet-53. The results showed that the method created could produce a precision value of 88%, 89% recall, average IOU 71.32%, and mAP 87.88%. This method has a price that is not too high and high stability.

Research conducted by Y. Chen and Z. Li [4] regarding An Effective Approach of Vehicle Detection Using Deep Learning. In this study using the BDD100K dataset consisting of six categories, namely cars, buses, pedestrians, trucks, motorbikes, and bicycles. The model used is YOLOv3. Results show that the model has a MAP value of 72.8. The model can detect cars well but for the bus category it is slightly poor and it is performing very poorly in the truck category.

Research conducted by [5] regarding Vehicle Type Detection Based on Deep Learning in Traffic Scene. In this study using the MIT and Clatech vehicle dataset with the ZF and VGG16 models. Samples will be trained using the RPN network which will then be entered into the Fast-RCNN network until the network converges. The results show that the ZF model with a total of 3052 data obtained the accuracy values for each category for buses, minibuses and SUVs of 79.9%, 73.9% and 68.3%. Whereas the VGG16 model with the same amount of data and categories obtained accuracy values of 82.3%, 74.8% and 70.1%. In the ZF model with a total of 5042 data, the accuracy values for each category for buses, minibuses and SUVs were

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84.0%, 81.0% and 73.7%. Whereas the VGG16 model with the same amount of data and categories obtained accuracy values of 84.4%, 83.8% and 78.3%.

Research conducted by [6] regarding A Multi-Task Faster RCnn Method for 3d Vehicle Detection Based on A Single Image. This study uses the KITTI dataset using the Faster R-CNN and RPN methods. Faster R-CNN is used as the base network and ResNet-50 backbone network. The results show that the method is feasible and can be used in vehicle detection, especially in autonomous driving vehicles.

Research conducted by A. Wang [7] regarding the Vehicle Recognition Algorithm Based on Improved YOLOv3. The dataset used is video monitoring. In this study using the YOLOv3 method with the Darknet-53 model. YOLOv3 will be enhanced by using Dpow3x332 and residual blocks to perform feature extraction. The results show that after the method is improved, the loss value can be seen in distinguishing large and small vehicles. The loss value is 0.0006 for small vehicles and 0.00012 for large vehicles which is ¼ times smaller than the previous method.

The architecture used in this study is the Convolutional Neural Network (CNN) using InceptionV3, Xception, MobileNet, MobileNet V2, VGG 16, VGG 19, Efficientnet (B7), and Efficientnet V2 (L) as the model. The dataset used is the Vehicle Detection Image Set. This dataset consists of 17760 images containing both vehicles and non-vehicles. This study contributes to comparing the level of accuracy of each model. Readers will be able to analyze various existing models to determine which model is best for the research they are conducting. This research is useful as a basis for further research as well as a basis for other research related to. In addition, the results of this study can be implemented and integrated with existing vehicle detection hardware in everyday life. This paper starts with an Introduction which explains the background of the problem, objectives, objectivity, and literature review Then proceed with the method which discusses the stages of research. Third, there are Results and Discussion which discuss the results of the research and discuss them with several previous studies. Finally, the last section contains the conclusions of the research that has been carried out from beginning to end.

2 METHODS

In general, the method of this research consists of several steps including Data Acquisition, Splitting Dataset, Data Augmentation, Model Training, Model Testing, and Evaluation as shown in **Figure 1**. Training uses a computer with GPU RTX 2080 SUPER, Intel i7 9700K CPU, and 32GB RAM.

2.1 Data Acquisition

At this stage, the data collection process is carried out to create a dataset. However, this time the researchers did not manually create datasets but used public datasets that are already available on the internet. The dataset used is the Vehicle Detection Image Set obtained from Kaggle (see https://www.kaggle.com/datasets/brsdincer/vehicle-detection-image-set). This dataset consists of 17760 images containing both vehicles and non vehicles. The dataset consists of 2 classes, namely the non vehicles class and the vehicles class. In the non-vehicles class there are 8968 pictures and in the vehicles class there are 8792 pictures. The outline of the whole project described in **Figure 1.**, which include their parts: knowledge-database provided by experts in different fields; software-agent uploaded by developers who access to our server; and client-part which usually occur in factories.

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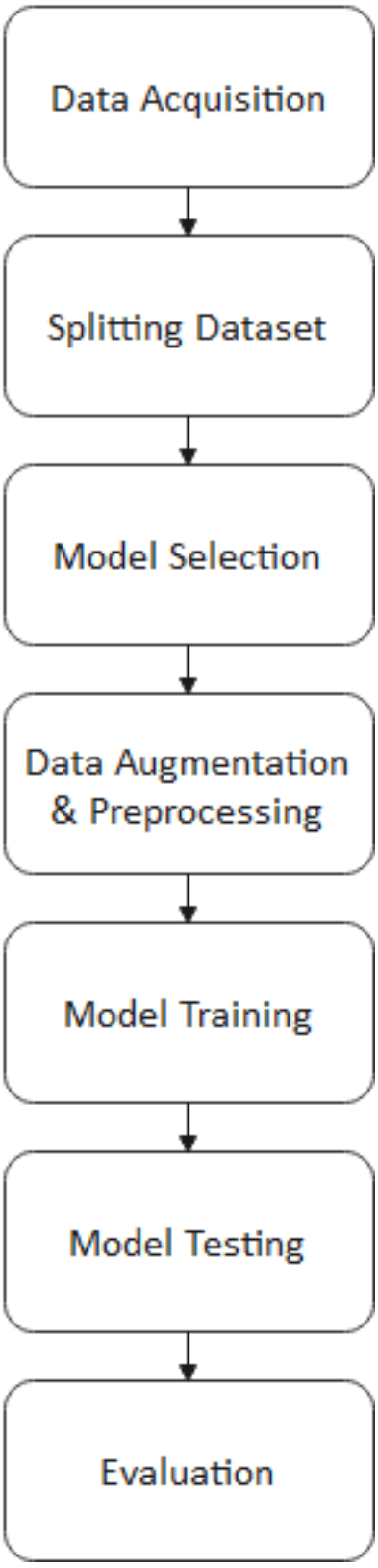


Figure 1. Research Flowchart.

2.2 Splitting Dataset

The dataset will be divided into 2 parts, namely the training set and the testing set using the train test split function in the Scikit-learn library. As much as 90% of the data will be used for training data and 10% for testing data.

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2.3 Model Selection

At this stage the researcher chooses which models will be used. There are 8 models that will be used. The model is obtained from the transfer learning model available in tensorflow. These models include.

2.3.1 Inception V3

Specifically, the Inception V3 model includes three parts: basic convolutional block, enhanced Inception module, and classifier. The basic convolutional block, which replaces the convolutional with a max-pooling layer, is used for feature extraction. The upgraded Inception module is designed on the basis of Network In-Network, where multiscale convolutions are performed in parallel and the convolution results of each branch are further combined. The use of a classifier makes the training results more stable and the gradient convergence obtained is better and the problem of overfitting is reduced [8][9].

2.3.2 Xception

Xception is part of the CNN architecture which is based on deep separable convolution layers. Xception is an acronym for Extreme Inception. The Xception architecture consists of 36 convolutional layers. The 36 convolutional layers are organized into 14 modules, all of which have linear residual connections around them, except for the first and last modules [10][11].

2.3.3 MobileNet

MobileNet is based on convolution layers which can be separated in depth except for the first layer which is full convolution layer [12-14]. In total there are 28 layers in this architecture. All layers are followed by a batchnorm and non-linear ReLU except for the last layer which is fully connected and included in the softmax layer for classification.

2.3.4 MobileNet V2

Process on MobileNet V2 starts with feature extraction using Conv2D with 3x3 kernel. The results from Conv2D will enter the bottleneck layer. The bottleneck layer consists of 3 convolution processes, namely 1x1 convolution, 3x3 depthwise convolution, and 1x1 pointwise convolution [12-15]. In this study, the architecture used is the same as the MobileNet V2 architecture in general, but Flatten and Dropout layers are added to reduce the level of overfitting. In addition, for the last layer, the activation function that originally used softmax was changed to sigmoid because the dataset is a binary class, not a multiclass.

2.3.5 VGG 16

VGG 16 architecture consists of a convolutional layer, max pooling layer, fully connected layer, and softmax layer [16][17]. VGG 16 uses ReLU for its activation function. In this study the architecture used is the same as the VGG 16 architecture in general but added Flatten and Dropout layers to reduce the level of overfitting. In addition, for the last layer, the activation function that originally used softmax was changed to sigmoid because the dataset is a binary class, not a multiclass.

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2.3.6 VGG 19

VGG 19 architecture consists of 19 layers with 16 convolutional layers, 3 fully connected layers, 5 max pooling layers and 1 softmax layer [16-18]. In this study the architecture used is the same as the VGG 19 architecture in general but added Flatten and Dropout layers to reduce the level of overfitting. In addition, for the last layer, the activation function that originally used softmax was changed to sigmoid because the dataset is a binary class, not a multiclass

2.3.7 EfficientNet (B7)

The EfficientNet architecture is based on the reverse bottleneck MBConv architecture previously introduced in MobileNet V2. It's called an inverted bottleneck because the incoming MBConv block consists of layers that expand then shrink like a compressed channel. This design contains deep convolutions [19][20]. In this study, the architecture used is the same as the EfficientNet architecture in general but added Flatten and Dropout layers to reduce the level of overfitting. In addition, for the last layer, the activation function that originally used softmax was changed to sigmoid because the dataset is a binary class, not a multiclass.

2.3.8 EfficientNet V2

The EfficientNet V2 architecture uses MBConv and adds fused-MBConv to the initial layer. EfficientNet V2 has a smaller expansion ratio and kernel size but has many layers [21]. In this study the architecture used is the same as the EfficientNet V2 architecture in general but added Flatten and Dropout layers to reduce the level of overfitting. In addition, for the last layer, the activation function that originally used softmax was changed to sigmoid.

2.4 Data Augmentation and Preprocessing

The data augmentation stage aims to increase the amount of training data so that the existing data is more diverse. Each image will be flipped horizontally and vertically. In addition, the image will be rotated by 20° and rescaled with a ratio of 1./255. At the data preprocessing stage, each label in the image will be converted into a numeric using a label encoder.

2.5 Model Training, Testing, Evaluation

Each existing model will be trained using training data. The model will be trained sequentially until the model produces a good accuracy value. After the model is trained, then model testing will be carried out using testing data. Models that have been trained and tested will be evaluated. Evaluation of the model uses several parameters, namely the value of accuracy, precision, recall, f1-score, and AUC.

3 RESULTS AND DISCUSSION

From the experimental results in this study, the results obtained from the model were evaluated. The results obtained are accuracy, recall, precision, F1, and AUC, and training duration for each model, as shown in **Figure 2**.

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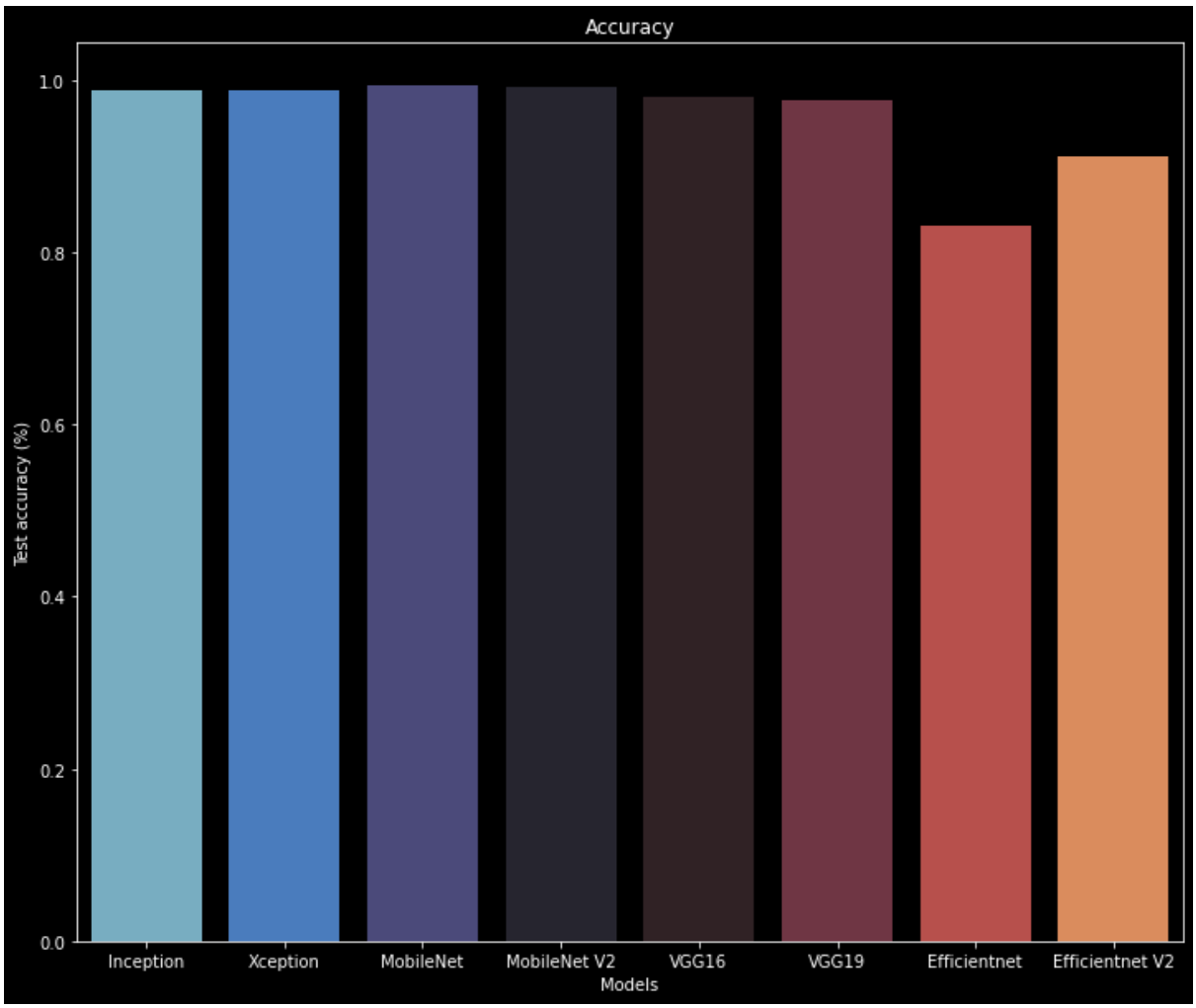


Figure 2. Graph of Comparison of Accuracy Values Between Models.

Inception, Xception, Mobilenet, and VGG19 are the models with the highest test accuracy. Mobilenet V2, Efficientnet (B7), and Efficientnet V2 (L) experience overfitting with training accuracy reaching 98% and above but test accuracy is far below that value. The VGG16 and VGG19 models have poor accuracy during training but the results on test accuracy are much better. Mobilenet V2 and VGG16 are the fastest models in completing training.

VGG16 was the fastest model in training with a training time of 02:12, then followed by VGG19 with 04:04 minutes, MobileNet V2, with 03:39 minutes, MobileNet with 07:17 minutes, Inception with 07:23 minutes, and Xception in 07:23 min. Efficientnet (B7) and Efficientnet V2 (L) are the longest models with a training time of 51:14 minutes and 01:28:41 hours.

Efficientnet V2 (L) has a Recall value of 29%. Efficientnet (B7) has better performance but not perfect with a Recall value of 76%. VGG 16 also has a Recall value that is less than perfect at 78%. MobileNet V2 has a good Recall value with a value of 99% but a bad precision value with a value of 55%, as shown in **Figure 3**.

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Table 1. Table of accuracy values and length of training.

Model	Training Accuracy (%)	Test Accuracy (%)	Recall (%)	Precision (%)	F1 (%)	Training Time (Hours)
Inception	0.976870	0.985360	0.989819	0.980942	0.985360	0:07:23
Xception	0.987418	0.981419	0.988688	0.974359	0.981471	0:08:43
MobileNet	0.978213	0.972973	0.990950	0.956332	0.973333	0:07:17
MobileNet V2	0.997266	0.992117	0.998869	0.555346	0.713824	0:03:39
VGG16	0.573127	0.894144	0.789593	0.997143	0.881313	0:02:12
VGG19	0.720506	0.972973	0.990950	0.956332	0.973333	0:04:04
Efficientnet (B7)	0.991751	0.878378	0.764706	0.988304	0.862245	0:51:14
Efficientnet V2 (L)	0.988911	0.650901	0.298643	1.000000	0.459930	1:28:41

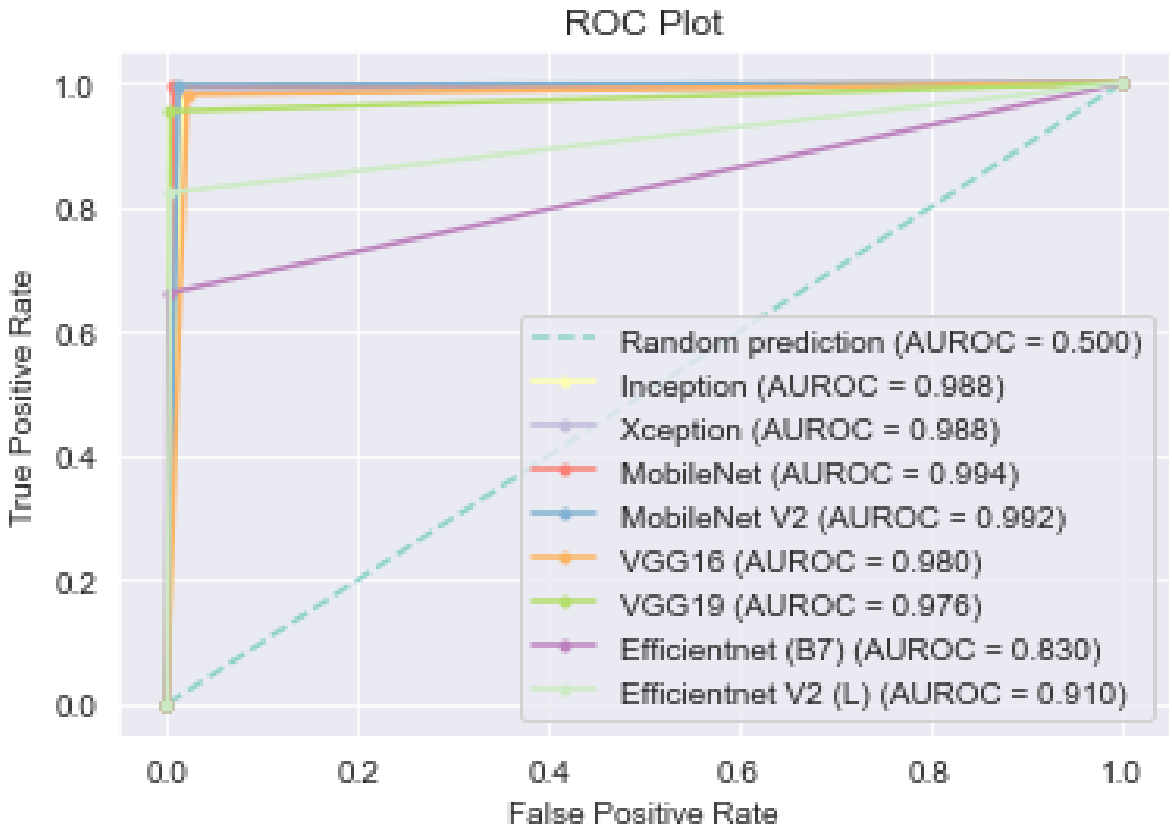


Figure 3. ROC Every Model.

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From the picture above it can be seen that the two models Efficientnet has a False Negative case on 3 True vehicles images. VGG16 and Mobilenet V2 also have a False Positive case on one of the different True non vehicles images. The Inception, Xception, Mobilenet, and VGG 19 models have no False Positive or False Negative cases in the image above.

Based on the test results above, each model has different training duration and accuracy values. There is no correlation between training duration and accuracy. This is because it can be seen that some models with a short training duration have a high accuracy value, while others have a fairly low accuracy value. Likewise with models with a long enough duration, some have high accuracy values, some are quite low. As shown in **Figure 4**.



Figure 4. Testing Model.

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Models other than Efficientnet (B7) and Efficientnet V2 (L) have a short training time because the model accepts a lower resolution than the Efficientnet model. Models that have a fairly good accuracy value and also have a shorter training time have many advantages. The relatively short training time makes inferences faster so that they are easier to apply in small devices that can be used in the field, such as CCTV cameras. Another advantage is that the model iteration is faster and easier. Faster model training will make it easier to iterate changes and optimize model performance.

The InceptionV3, Xception, MobileNet, MobileNet V2, VGG 16, and VGG 19 models were introduced earlier than the Efficientnet (B7) and Efficientnet V2 (L) models. Therefore, it can be seen that the 5 models have a fairly good level of accuracy as seen in the InceptionV3, VGG 16, and VGG 19 models, which experienced an increase in the accuracy value during testing when compared to the accuracy value during training.

Even though Xception, MobileNet, and MobileNet V2 experienced a decrease in the level of accuracy during testing. This is different from the Efficientnet (B7) and Efficientnet V2(L) models. This model was introduced recently, namely in 2019 and 2021 by M Tan with the advantage of a faster training duration.

However, this is inversely proportional to the results of our tests. Although the Efficientnet (B7) and Efficientnet V2 (L) models have quite good training accuracy values, they have quite a long training duration and worse test accuracy values than the other models.

Even though the Efficientnet (B7) and Efficientnet V2 (L) models have quite good training accuracy values, they have quite a long training duration compared to the other models. To find out the causes of the performance of the Efficientnet (B7) and Efficientnet V2 (L) models, which have a long testing duration but poor accuracy results, this research cannot yet be proven because they are outside the scope of the research.

4 CONCLUSION

In our project, we use the vibration monitoring method to make the machine diagnosis. Some energy harvesters are used to collect power from rotation machines, and our laboratory constructed an autonomous vibration sensor that consumes the power collected by these energy harvesters instead of external power supply, such as batteries and AC power supply. To implement the planning agent, we use PDDL (Planning Domain Description Language) technique and utilize the inference engine of PPDL to do the planning jobs.

To implement the planning agent, we use the PDDL technique to set up the inheritance relationship among different agents. After involving the inheritance feature, it can improve the efficiency of searching and extendibility of our multi-agent system.

5 AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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6 REFERENCES

[1] Li, S., Chang, F., and Liu, C. (2020). Bi-directional dense traffic counting based on spatio-temporal counting feature and counting-LSTM network. *IEEE Transactions on Intelligent Transportation Systems, 22(*12), 7395-7407.

[2] Azimjonov, J., and Özmen, A. (2021). A real-time vehicle detection and a novel vehicle tracking systems for estimating and monitoring traffic flow on highways. *Advanced Engineering Informatics, 50*(1), 1-14.

[3] Song, H., Liang, H., Li, H., Dai, Z., and Yun, X. (2019). Vision-based vehicle detection and counting system using deep learning in highway scenes. *European Transport Research Review, 11*(1), 1-16.

[4] Chen, Y., and Li, Z. (2022). An effective approach of vehicle detection using deep learning. *Computational Intelligence and Neuroscience, 2022*(1)*,* 1-9.

[5] Li, Y., Song, B., Kang, X., Du, X., and Guizani, M. (2018). Vehicle-type detection based on compressed sensing and deep learning in vehicular networks. *Sensors, 18*(12), 1-15.

[6] Arora, N., Kumar, Y., Karkra, R., and Kumar, M. (2022). Automatic vehicle detection system in different environment conditions using fast R-CNN. *Multimedia Tools and Applications, 81*(13), 18715-18735.

[7] Gai, W., Liu, Y., Zhang, J., and Jing, G. (2021). An improved tiny YOLOv3 for real-time object detection. *Systems Science and Control Engineering, 9*(1), 314-321.

[8] Al Husaini, M. A. S., Habaebi, M. H., Gunawan, T. S., Islam, M. R., Elsheikh, E. A., and Suliman, F. M. (2022). Thermal-based early breast cancer detection using inception V3, inception V4 and modified inception MV4. *Neural Computing and Applications, 34*(1), 333-348.

[9] Lin, C., Li, L., Luo, W., Wang, K. C., and Guo, J. (2019). Transfer learning based traffic sign recognition using inception-v3 model. *Periodica Polytechnica Transportation Engineering, 47*(3), 242-250.

[10] Chen, B., Liu, X., Zheng, Y., Zhao, G., and Shi, Y. Q. (2021). A robust GAN-generated face detection method based on dual-color spaces and an improved xception. *IEEE Transactions on Circuits and Systems for Video Technology, 32*(6), 3527-3538.

[11] Polat, Ö. Z. L. E. M. (2021). Detection of COVID-19 from chest CT images using xception architecture: a deep transfer learning based approach. *Sakarya University Journal of Science (SAUJS), 25*(3), 813-823.

[12] Jing, J., Wang, Z., Rätsch, M., and Zhang, H. (2022). Mobile-unet: an efficient convolutional neural network for fabric defect detection. *Textile Research Journal, 92*(1), 30-42.

[13] Kulkarni, U., Meena, S. M., Gurlahosur, S. V., and Bhogar, G. (2021). Quantization friendly mobilenet (QF-mobilenet) architecture for vision based applications on embedded platforms. *Neural Networks, 136*(1), 28-39.

[14] Ghosh, T., Abedin, M. M. H. Z., Chowdhury, S. M., Tasnim, Z., Karim, T., Reza, S., Saika, S., and Yousuf, M. A. (2020). Bangla handwritten character recognition using MobileNet V1 architecture*. Bulletin of Electrical Engineering and Informatics, 9*(6), 2547-2554.

[15] Wibowo, A., Adhi Hartanto, C., and Wisnu Wirawan, P. (2020). Android skin cancer detection and classification based on MobileNet V2 model. *International Journal of Advances in Intelligent Informatics, 6*(2), 135-148.

[16] Pardede, J., Sitohang, B., Akbar, S., and Khodra, M. L. (2021). Implementation of transfer learning using VGG16 on fruit ripeness detection. *International Journal of Intelligent Systems and Applications, 13*(2), 52-61.

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p- ISSN 2829-4157 e- ISSN 2829-4149

[17] Rangarajan, A. K., and Purushothaman, R. (2020). Disease classification in eggplant using pre-trained VGG16 and MSVM. *Scientific Reports, 10*(1), 1-11.
[18] Mateen, M., Wen, J., Nasrullah, N., Song, S., and Huang, Z. (2018). Fundus image classification using VGG-19 architecture with PCA and SVD. *Symmetry, 11*(1), 1-12.
[19] Chowdhury, M. E., Rahman, T., Khandakar, A., Ayari, M. A., Khan, A. U., Khan, M. S., Al-Emadi, N., Ibne Reaz, M. B., Islam, M. T., and Ali, S. H. M. (2021). Automatic and reliable leaf disease detection using deep learning techniques. *AgriEngineering, 3*(2), 294-312.
[20] Ali, K., Shaikh, Z. A., Khan, A. A., and Laghari, A. A. (2022). Multiclass skin cancer classification using EfficientNets–a first step towards preventing skin cancer. *Neuroscience Informatics, 2*(4), 1-10.
[21] Rizal, S., Ibrahim, N., Pratiwi, N. K. C., Saidah, S., and Fu'adah, R. Y. N. (2020). Deep learning untuk klasifikasi diabetic retinopathy menggunakan model efficientnet. *ELKOMIKA: Jurnal Teknik Energi Elektrik, Teknik Telekomunikasi, and Teknik Elektronika, 8*(3), 693-705.

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Smart Pet Feeder on Cat Food Portions Using Mamdani's Fuzzy Logic Inference System

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ABSTRACT

This is a system that can help cat owners provide the right amount of food for their cats. This system uses the Mamdani fuzzy logic inference system method which can process input in the form of information about the cat's body weight and make a decision about the amount of food to be given to the cat. This system is integrated with a smart pet feeder called FoodyPet which can dispense food according to the decision made by the system. By using this system, cat owners can easily provide the right amount of food for their cats and maintain their cat's health. In addition, this system can also help cat owners automatically schedule their cat's meal times so they don't have to worry about forgetting to give food to their cats. This system consists of several main components, namely Arduino UNO as a microcontroller that runs all data processing processes, an loadcell as a tool to measure the cat's body weight, an ultrasonic sensor as a tool to measure the level of food in the tank, and an LCD display used to display information about the food portion to be given to the cat. This system is also equipped with a buzzer that will signal the cat owner when the food is ready to be given to the cat.

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1. INTRODUCTION

Cats are animals that can be kept and are one of the most popular and widely kept pets today [1]. Cat owners come from various age groups and different backgrounds, therefore various problems arise in the procedures for raising and caring for cats at home. The problem that often occurs is that it is difficult for cat owners to provide food when leaving their pet cat for a long time and the portion of food that is not ideal can cause the cat to be malnourished or even obese [2]. So many pet feeder products were created beforehand to make it easier for cat owners.

IoT is a concept that is widely used in smart pet feeder systems [3][4] not only that, but also in other fields such as [5]. The use of the IoT concept makes it easier for cat owners to send orders to the smart pet feeder to provide food to their pet cats using a mobile application [6][7]. Unfortunately, most existing smart pet feeders do not pay attention to the ideal portion of food given to the pet cat itself [8]. To solve this problem, a system is needed that can regulate the ideal portion of a cat's meal. There are so many algorithms that can be used to design the system, one of which is Fuzzy Logic. [9]

Fuzzy logic is an artificial intelligence field that is intended to create intelligent systems [10] and is a mathematical framework utilized for managing uncertainty and imprecision in reasoning and decision-making. Unlike classical logic, which is based on binary true/false values, fuzzy logic permits various degrees of truth and membership in a set.[11] Membership functions are assigned to variables in fuzzy logic, which determine the extent to which an input value belongs to a specific set. These membership functions may be defined using linguistic terms such as "very high," "high," "medium," "low," and "very low."[12] Fuzzy logic finds numerous applications in areas such as artificial intelligence, control systems, and decision-making. It is particularly advantageous in managing complex systems that contain high levels of uncertainty or when accurate mathematical models are unavailable, as depicted in **Figure 1.**

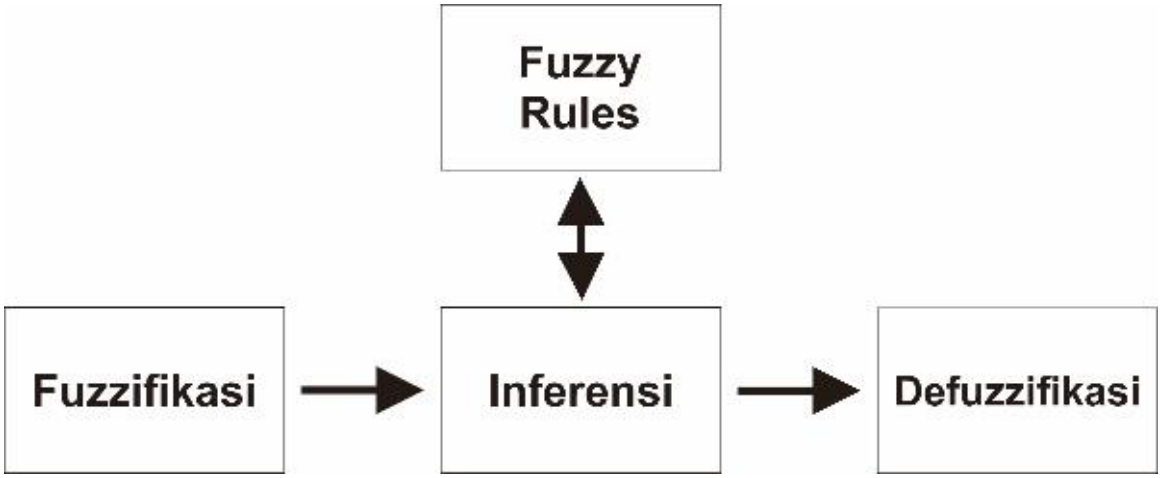


Figure 1. Fuzzy Logic Block Diagram.

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The way of working in Fuzzy Logic has a value of fuzzyness or gray between right and wrong and has a reasoning system that is similar to intuition or human feelings so that it can be used for systems that require a reasoning process [13]. One method in Fuzzy Logic that has a higher level of accuracy than other methods is the Mamdani Inference System method [14]. Researchers need several components to realize the system such as a microcontroller which is used as the main component and control center in the designed system. The microcontroller used is Arduino UNO ATmega328. Arduino UNO is a microcontroller board based on the ATmega328. The microcontroller is a single board electronic device with open source or open source nature [15] which is very easy to use both in terms of hardware and software as shown in **Figure 2**.



Figure 2. Arduino UNO ATmega328.

The Arduino UNO board comes equipped with 14 digital input/output pins (with 6 of them capable of being used as PWM outputs), 6 analog inputs, a 16MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It has everything necessary to support the microcontroller and only requires a connection to a computer via USB cable or an AC-DC adapter or battery to operate.[16]

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The control system for the smart pet feeder that was designed is outfitted with servo motors, RTC, ultrasonic sensors, load cells, and buzzers. Servo motors are vital components used in several industries that require precise position control, such as numerically controlled machines, robotics, automation, and other mechanisms where quick and accurate start and stop functions are needed [17]. The microcontroller commands the servo motors to rotate.

The Real Time Clock (RTC) utilized in the control system is a module that serves as a timer and is composed of electronic chips. These chips can function with clocks in general and calculate seconds, minutes, and hours with great accuracy, and store these calculations in real-time [18]. The RTC in the control system acts as a time store to prevent it from continuously changing when the system is not powered [19]. The ultrasonic sensor is used to measure the percentage of leftover food in the system. Ultrasonic sensors operate by reflecting sound waves and are used to detect the distance or presence of a specific object using sound waves ranging from 20 kHz to 2 MHz [20]. The ultrasonic sensor consists of two components: the transmitter and the receiver.

2. METHODS

The tool design method of this system planning consists of block diagrams, flowcharts and interrelated mechanical designs. In addition to hardware, the system is also equipped with fuzzy logic to run effectively according to user needs.

2.1. Working Principle and Block Diagram

The working principle of the Arduino microcontroller-based smart pet feeder system which is equipped with several components works with 9V power which functions to move the servo as a food gate down and turn on several important components such as load cells, ultrasonic sensors, buzzers, and LCDs. The microcontroller is connected directly to the RTC (Real Time Clock) which functions as a cat feeding schedule, ultrasonic sensors which function to measure the remaining volume of cat feed, buzzer as an alarm when the feed is finished, and LCD which will display information on feeding time and remaining feed in the smart FoodyPet pet feeder. When the cat steps on the loadcell, the microcontroller will receive a signal to move the servo motor and open the feed gate and the cat can immediately enjoy the food without waiting for the owner to feed it conventionally.

The first step is to design a Cat Food Portion Control System on the Arduino UNO-Based Smart Pet Feeder FoodyPet Using the Mamdani Fuzzy Logic Inference System Method, namely by making a block diagram. The purpose of making the block diagram is as an initial planning for making the system as shown in **Figure 3.**

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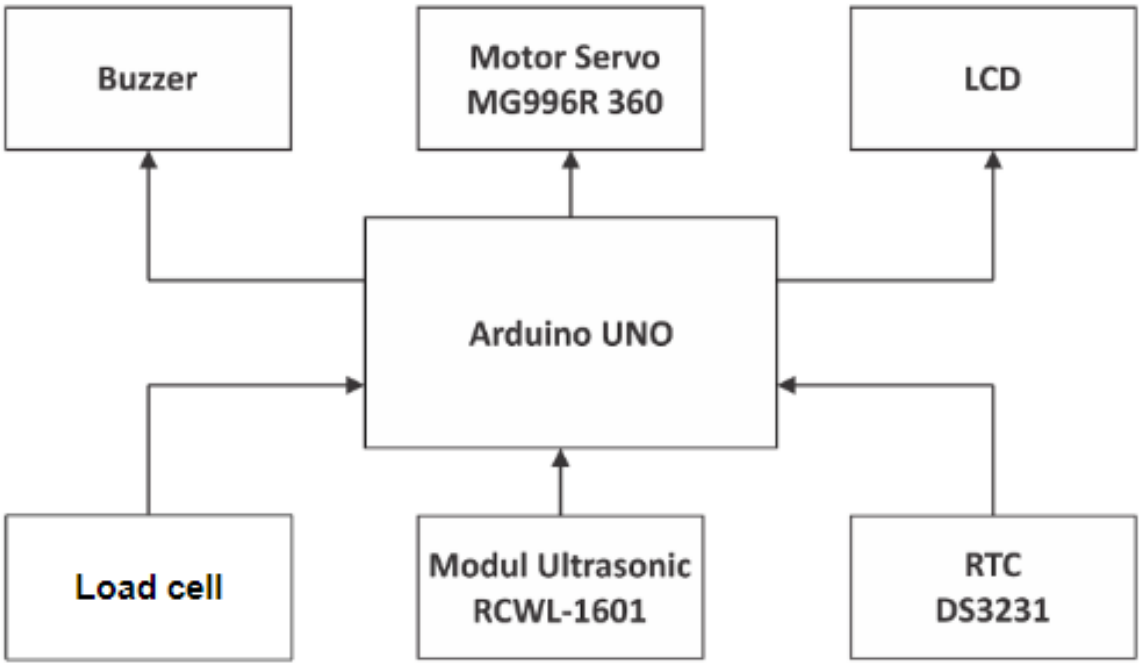


Figure 3. Proposed System Block Diagram.

There are three input components and three output components. The load cell will weigh the cat's body weight so that the portion of the cat's feed will be adjusted according to the cat's body weight assisted by fuzzy logic.

2.2. Wiring Diagram

All components that have been designed and designed are then connected according to the pins needed. The design of this wiring diagram is done using the Tinkercad simulator which is depicted in **Figure 4.**

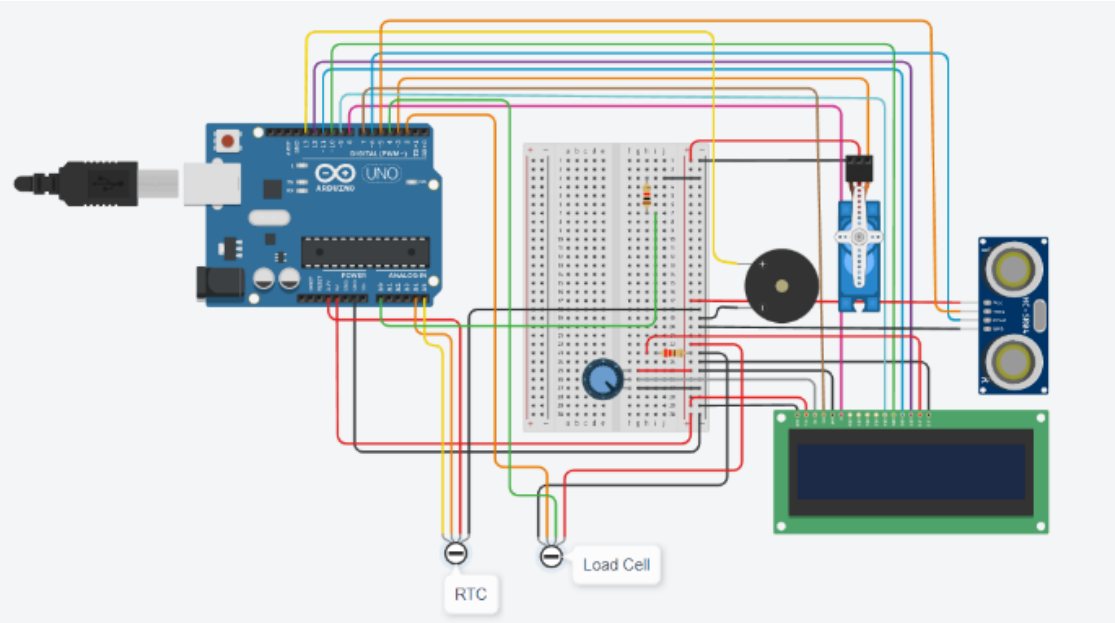


Figure 4. Proposed Wiring Diagram.

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2.3. System Flowchart

Flowcharts or can also be referred to as flowcharts in the system will be made with the working principle of the tool to be produced. The flowchart starts from when the system is turned on until the final process in the system, depicted in **Figure 5.**

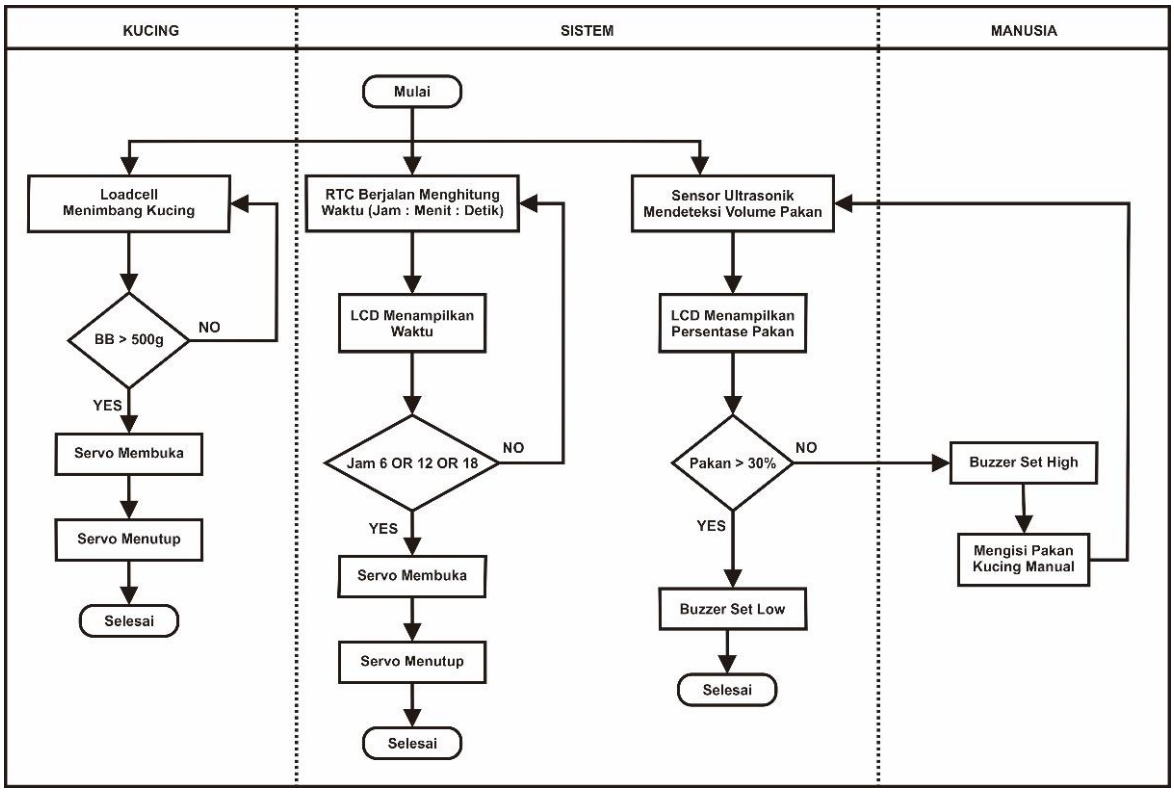


Figure 5. Proposed flowchart system.

3. RESULTS AND DISCUSSION

To determine whether the tool works according to design it is necessary to do testing. However, before testing is carried out, it is necessary to implement fuzzy logic on the system that has been made.

3.1. Variables and Fuzzy Sets

Fuzzy variables are variables that are operated and used to temporarily store input values into crisp values in a fuzzy system. There are 2 interrelated attributes in the fuzzy set, namely linguistic values and numerical values. This system has 3 fuzzy variables used, which include 2 input variables and 1 output variable. Variables and fuzzy sets can be seen in **Table 1.** as follows.

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Table 1. Variables and Fuzzy Sets.

Variable Fuzzy	Variable Name
Variable input	Body Weigh
	Time
Variable output	Meal portion

3.2. Membership Functions

Based on the variables and fuzzy sets that have been determined, there are membership function equations and their curves that will be used in the ideal cat food portion control system.

1) Equation and membership curve of variable body weight

There are 4 linguistic values that are owned by the weight variable, including {small, normal, large, obese}. The linguistic value can be seen in the membership function in **Figure 6.** and Equation [1-4] as follows:

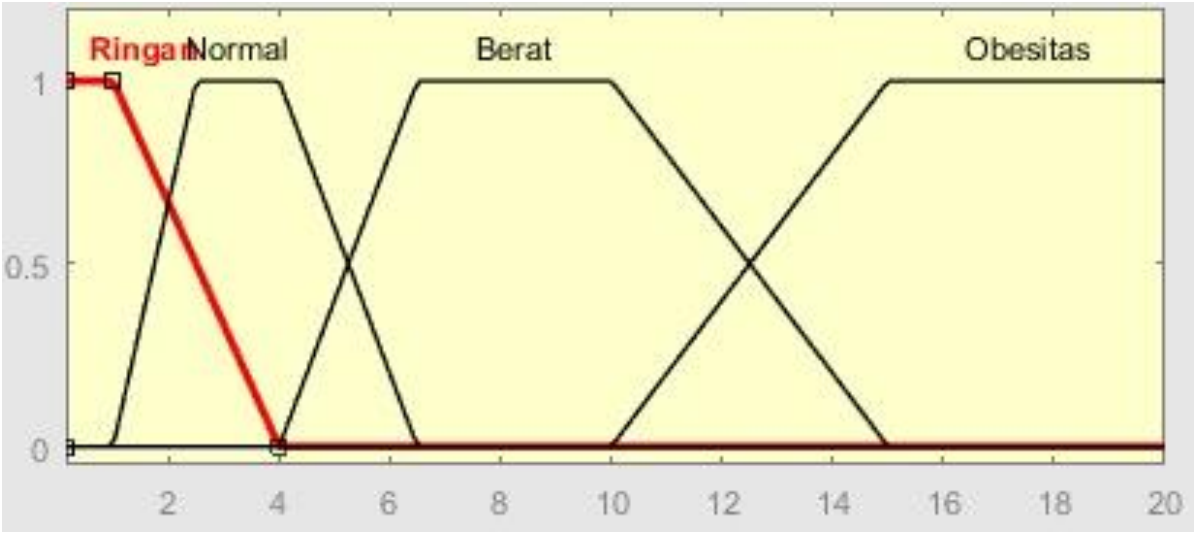


Figure 6. Member Function Weight Curve.

$$\mu\, Ringan\,[x]\begin{cases} 0; & x \geq 4 \\ \dfrac{4-x}{4-1}; & 1 < x < 4 \\ 1; & x \leq 1 \end{cases} \quad (1)$$

$$\mu\, Normal\,[x]\begin{cases} 0; & x \leq 1, x \geq 6{,}5 \\ \dfrac{x-1}{4-1}; & 1 < x < 4 \\ \dfrac{6{,}5-x}{6{,}5-4}; & 4 < x < 6{,}5 \\ 1; & x = 4 \end{cases} \quad (2)$$

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$$\mu\, Berat[x]\begin{cases} 0; & x \le 4, x \ge 15 \\ \dfrac{x-4}{6{,}5-4}; & 4 < x < 6{,}5 \\ \dfrac{15-x}{15-10}; & 10 < x < 15 \\ 1; & 6{,}5 < x < 10 \end{cases} \quad (3)$$

$$\mu\, Obesitas\,[x]\begin{cases} 0; & x \le 10 \\ \dfrac{x-10}{15-10}; & 10 < x < 15 \\ 1; & x \ge 15 \end{cases} \quad (4)$$

2) Equation and time variable membership curve

There are 3 linguistic values that are owned by the time variable, including {morning, afternoon, evening}. The linguistic value can be seen in the membership function in **Figure 7.** and Equation [5-7] as follows:

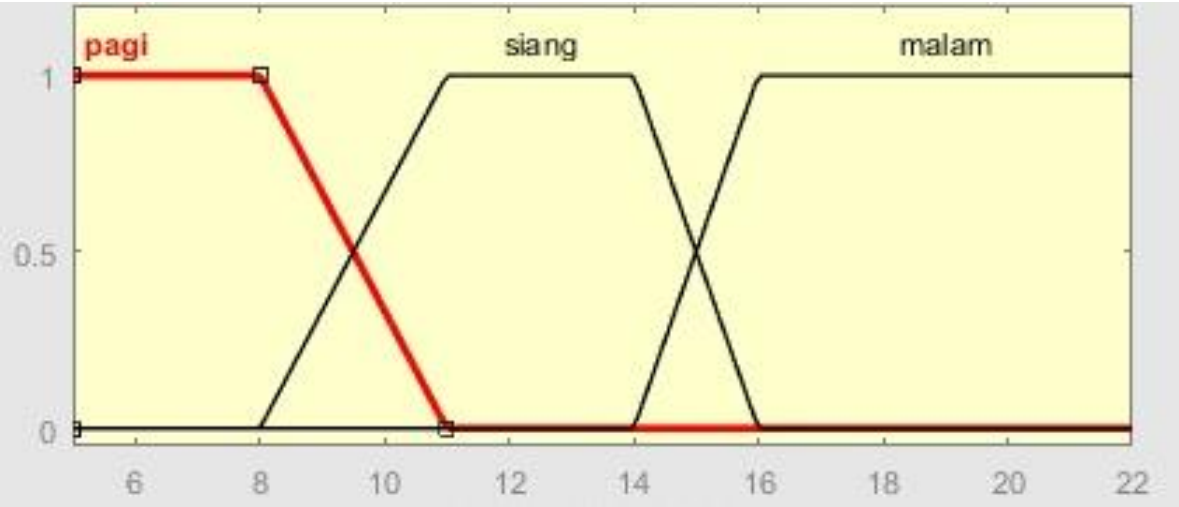


Figure 7. Time Member Function Curve.

$$\mu\, Pagi\,[x]\begin{cases} 0; & x \ge 11 \\ \dfrac{11-x}{11-8}; & 8 < x < 11 \\ 1; & x \le 8 \end{cases} \quad (5)$$

$$\mu\, Siang\,[x]\begin{cases} 0; & x \le 8, x \ge 16 \\ \dfrac{x-8}{11-8}; & 8 < x < 11 \\ \dfrac{16-x}{16-14}; & 14 < x < 16 \\ 1; & 11 < x < 14 \end{cases} \quad (6)$$

$$\mu\, Malem\,[x]\begin{cases} 0; & x \le 14 \\ \dfrac{x-14}{16-14}; & 14 < x < 16 \\ 1; & x \ge 16 \end{cases} \quad (7)$$

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3) Portion membership equations and curves

There are 3 linguistic values that are owned by the portion variable, including {Little, Moderate, Many}. The linguistic value can be seen in the membership function in **Figure 8.** and Equation [8-10] as follows:

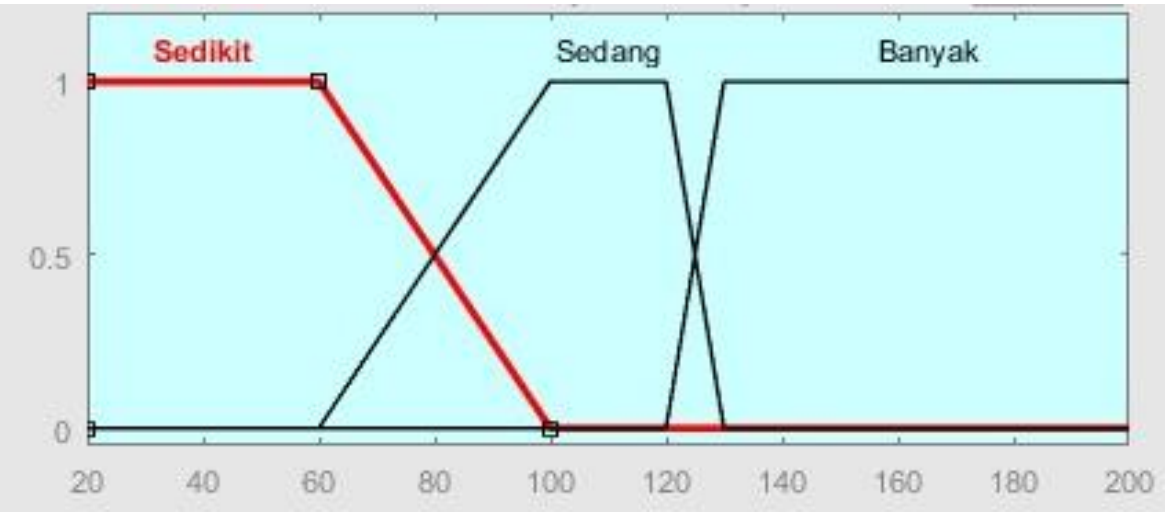


Figure 8. Feed Portion Member Function Curve.

$$\mu\, Sedikit\,[x]\begin{cases} 0; & x \geq 100 \\ \dfrac{100-x}{100-60}; & 60 < x < 100 \\ 1; & x \leq 60 \end{cases} \tag{8}$$

$$\mu\, Sedang\,[x]\begin{cases} 0; & x \leq 60, x \geq 130 \\ \dfrac{x-60}{130-60}; & 60 < x < 130 \\ \dfrac{120-x}{120-100}; & 100 < x < 120 \\ 1; & 100 < x < 120 \end{cases} \tag{9}$$

$$\mu\, Banyak\,[x]\begin{cases} 0; & x \leq 120 \\ \dfrac{x-120}{130-120}; & 120 < x < 130 \\ 1; & x \geq 130 \end{cases} \tag{10}$$

3.3. System Testing

System testing is carried out to ensure that all components work as they should. There are five components tested, namely the ultrasonic sensor, load cell, RTC, LCD, and buzzer. Each component is tested ten times on a regular basis to show the level of accuracy the component runs. At the end of the test, a thorough test will also be carried out when all the components have been combined into one final prototype.

1) Ultrasonic Sensor Testing

Ultrasonic sensors in this study are used to measure the height of food contained in food tanks. The results of the tests carried out in **Table 2.** as follows:

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Table 2. Ultrasonic Sensor Testing.

Testing Number	Persentage Real	Persentage Ultrasonic
1	50%	50%
2	78%	0%
3	80%	80%
4	30%	100%
5	30%	30%
6	0%	0%
7	100%	100%
8	100%	0%
9	48%	48%
10	93%	93%

Based on the test data contained in the ultrasonic sensor testing table in **Table 2.**, it can be seen that of the ten tests carried out, seven tests got accurate results and three tests got distorted results. The accuracy rate of using ultrasonic sensors is 70%. This indicates that the ultrasonic sensor is running quite well.

2) Loadcell Testing

The load cell in this study is used to measure the weight of the cat's meal and trigger the servo motor to move. The results of the tests carried out in **Table 3.** as follows:

Table 3. Loadcell Testing.

Testing Number	Detected Massa
1	Yes
2	Yes
3	No
4	Yes
5	Yes
6	Yes
7	Yes
8	Yes
9	Yes
10	Yes

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Based on the test data contained in the loadcell testing table in **Table 3.**, it can be seen that of the ten tests carried out, nine tests triggered the servo to move and one test did not detect any mass above the loadcell. The accuracy rate of using ultrasonic sensors is 90%. This indicates that the loadcell is running well.

3) Real-Time Clock (RTC) Testing

The RTC or real time clock in this study is used to measure real time so that the portion of food is in accordance with the time. The results of the tests carried out in **Table 4**. as follows:

Table 4. Real-Time Clock (RTC) Testing

Testing Number	Accurate Real-Time
1	Yes
2	Yes
3	Yes
4	Yes
5	Yes
6	Yes
7	Yes
8	Yes
9	Yes
10	Yes

Based on the test data contained in the RTC testing table in **Table 4.** , it can be seen that of the ten tests performed, all tests showed accurate real-time results. The level of accuracy from the use of ultrasonic sensors is 100%. This indicates that the RTC is running very well.

4) LCD Testing

LCD or liquid-crystal display in this study is used to display information and become the interface of foodypet. The results of the tests carried out in **Table 5.** as follows:

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Table 5. LCD Testing.

Testing Number	LCD Displays Information Accurately
1	Yes
2	Yes
3	Yes
4	No
5	No
6	Yes
7	Yes
8	No
9	Yes
10	Yes

Based on the test data contained in the LCD testing table in **Table 5**, it can be seen that of the ten tests carried out, nine tests showed that the LCD displayed information as it should and one test showed inappropriate results. The accuracy rate of using the LCD is 70%. This indicates that the LCD is running well.

5) Motor Servo Testing

The servo motor in this study is used to open and close the feed exit hole from the tank. The following are the results of the tests that have been carried out shown in **Table 6.**

Table 6. Motor Servo Testing.

Testing Number	Servo Motor Moves
1	Yes
2	Yes
3	Yes
4	Yes
5	Yes
6	Yes
7	Yes
8	Yes
9	Yes
10	Yes

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Based on the test data contained in the servo motor testing table in **Table 6**, it can be seen that of the ten tests carried out, all tests showed that the servo motor moved as it should. The level of accuracy from using a servo motor is 100%. This indicates that the servo motor is running very well.

6) Buzzer Testing

The buzzer in this study is used to issue a sound as a form of warning when the food in the tank shows a percentage below 30%. The following are the results of the tests that have been carried out in **Table 7.**

Table 7. Buzzer Testing.

Testing Number	Tank Percentage	Buzzer is sounding	Buzzer is silent
1	76%	No	Yes
2	26%	Yes	No
3	0%	Yes	No
4	93%	No	Yes
5	29%	Yes	No
6	50%	No	Yes
7	12%	Yes	No
8	14%	Yes	No
9	90%	No	Yes
10	64%	No	Yes

Based on the test data contained in the buzzer testing table in **Table 7.**, it can be seen that of the ten tests carried out, all tests showed that the buzzer turned on and off according to the settings. The accuracy rate of using the buzzer is 100%. This indicates that the buzzer is running very well.

3.4. Compilation of Program Code

The preparation of the program code is done by entering the program code into the Arduino Uno through the Arduino IDE software. Before implementing into the tool, the program code is tested first using the Tinkercad simulator.

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3.5. Design Result

The results of the final FoodyPet prototype design can be seen in **Figure 9.** The entire system is stored in a different place from the storage tank. The ultrasonic sensor is placed above the food tank to measure the percentage of available food and the LCD is placed in front of the tool to make it easier for users to see food depicted in **Figure 9.**



Figure 9. FoodyPet Prototype Design Results.

4. CONCLUSION

Based on the results of this discussion, it can be concluded that the problem that often occurs in cat maintenance is the difficulty for cat owners to provide food to their cats when they are not at home and the portion of food that is not suitable can cause cats to be malnourished or obese. To solve this problem, we need a system that can regulate the ideal portion of a cat's meal, which uses the Fuzzy Logic algorithm. One method in Fuzzy Logic that has a higher level of accuracy is the Mamdani Inference System method. Researchers needed several components to realize the system, including the Arduino UNO ATmega328 microcontroller, which is an easy-to-use, open-source microcontroller board based on the ATmega328.

To ensure that the designed system is effective in regulating cat food portions, researchers will conduct trials on the system using several variables as input, such as cat body weight, cat age, and cat activity. The results of the trial will be used to determine the appropriate portion of food for the cat. In addition, researchers will also develop a mobile application that can be

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used by cat owners to send commands to the system and monitor the cat's food portion. Thus, this system is expected to provide convenience for cat owners in providing appropriate food to their pet cats and avoid malnutrition or obesity problems.

In addition, the designed system will also be equipped with a notification feature to cat owners if cat food runs out or if there is a disturbance in the system. This feature will help cat owners to always monitor the condition of cat food and refill it immediately if needed. Thus, this system is expected to provide convenience and comfort for cat owners in caring for their pet cats.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

6. REFERENCES

[1] Rahmalisa, U., Mardeni, M., Helmi, R., dan Linarta, A. (2020). Pemberi makan otomatis pada kucing menggunakan raspberry pi berbasis android. *Jurnal Teknologi dan Open Source, 3*(2), 298-308.

[2] Tribudiman, A., Rahmadi, R., dan Fadhila, M. (2021). Peran pet attachment terhadap kebahagiaan pemilik hewan peliharaan di kota Banjarmasin. *Jurnal Al-Husna, 1*(1), 60-77.

[3] Khoiroh, S. H., Ridwan, M., dan Maftukhah, S. (2022). Penerapan logika fuzzy pada rancang bangun alat pakan kucing otomatis dan monitoring sisa pakan dengan aplikasi Blynk. *Jutis (Jurnal Teknik Informatika), 10*(2), 206-218.

[4] Devitasari, R., dan Kartika, K. P. (2020). Rancang bangun alat pemberi pakan kucing otomatis menggunakan mikrokontroler nodemcu berbasis internet of thing (IoT). *Antivirus: Jurnal Ilmiah Teknik Informatika, 14*(2), 152-164.

[5] Suteddy, W., Atmanto, D. A., Nuriman, R., and Ansori, A. (2022). Prototype application of crowd detection system for traditional market visitor based on iot using RFID MFRC522. *Jurnal Teknologi Informasi Universitas Lambung Mangkurat (JTIULM), 7*(1), 23-30.

[6] Valendio, B. J., Susilawati, S., dan Sembiring, Z. (2022). Perancangan prototype pemberi pakan kucing otomatis berdasarkan umur berbasis sms gateway. *Jurnal Ilmiah Teknik Informatika dan Elektro (JITEK), 1*(2), 57-65.

[7] Samsugi, S., Neneng, N., dan Suprapto, G. N. F. (2021). Otomatisasi pakan kucing berbasis mikrokontroller intel galileo dengan interface android. *J-SAKTI (Jurnal Sains Komputer dan Informatika), 5*(1), 143-152.

[8] Afrizal, M. R. (2022). Smart pet feeder menggunakan ESP8266 nodeMCU dan Blynk app berbasis smartphone. *Jurnal Ilmiah Indonesia, 7*(12), 19436-19448.

[9] Saputro, R., dan Suhendi, H. (2021). Sistem monitoring dan automatic feeding hewan peliharaan menggunakan android berbasis internet of things. *eProsiding Teknik Informatika (PROTEKTIF), 1*(1), 1-12.

[10] Aldisa, R. T., dan Soleha, P. A. (2022). Penerapan metode fuzzy logic pada tempat pemberi pakan kucing menggunakan sensor HC-SR04. *JURIKOM (Jurnal Riset Komputer), 9*(5), 1569-1574.

DOI: https://doi.org/10.17509/coelite.v2i1.56926
p- ISSN 2829-4157 e- ISSN 2829-4149

[11] Gusman, A. P., dan Kurniawan, H. (2018). Fuzzy logic dalam menganalisa pengaruh konsep halal tourism terhadap perilaku masyarakat sumatera barat. *Jurnal Matematika UNAND, 7*(2), 235-242.
[12] Setia, B. (2019). Penerapan logika fuzzy pada sistem cerdas. *Jurnal Sistem Cerdas, 2*(1), 61-66.
[13] Prayudha, J., Pranata, A., dan Al Hafiz, A. (2018). Implementasi metode fuzzy logic untuk sistem pengukuran kualitas udara di kota Medan berbasis internet of things (IoT). *JURTEKSI (Jurnal Teknologi dan Sistem Informasi), 4*(2), 141-148.
[14] Situmorang, E., and Rindari, F. (2019). Decision support system for selection of the best doctors in sari mutiara hospital using fuzzy tsukamoto method. *Jurnal Teknik Informatika CIT Medicom, 11*(2), 45-50.
[15] Mahardika, P. S., and Gunawan, A. N. (2022). Modeling of water temperature in evaporation pot with 7 DS18B20 sensors based on atmega328 microcontroller. *Linguistics and Culture Review, 6*(S3), 184-193.
[16] Ismailov, A. S., and Jo'Rayev, Z. B. (2022). Study of arduino microcontroller board. *Science and Education, 3*(3), 172-179.
[17] Tahir, N. H. M., Mohamad, S. N., Azimi, F. H., Aw, S. R., Tarmizi, W. F. W., and Zain, M. L. M. (2022). Development of real time cat auto feeder dispenser using arduino. *International Journal of Synergy in Engineering and Technology, 3*(1), 52-57.
[18] Ginting, R. C., Ishak, I., dan Yakub, S. (2021). Implementasi real time clock (RTC) pada robot line follower untuk vacuum cleaner berbasis arduino. *Jurnal Teknisi, 1*(1), 8-12.
[19] Mubarok, S., Wahyudi, D. W. D., Octaviany, D., dan Karno, K. (2018). Pemanfaatan modul RTC berbasis arduino mega sebagai penentu variabel nutrisi pada sistem kontrol hidroponik. *TRANSISTOR Elektro dan Informatika, 3*(1), 5-8.
[20] Marwan, M., Rifqan, R., dan Syamsudin, F. (2019). Karakterisasi sifat fisik batupasir daerah Jantho dan Krueng Raya menggunakan uji gelombang ultrasonik. *POSITRON, 9*(1), 8-12.

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Determination of Priorities for the Development of Small and Medium Enterprises in the Province of South Sulawesi Using the Weighted Product Model

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ABSTRACT

Small and Medium Enterprises (SMEs) are a sector that plays a vital role in running the national economy. The South Sulawesi Provincial Office of Industry as a regional government organization is tasked with administering affairs in the industrial sector of the South Sulawesi Province. In terms of developing SMEs, the South Sulawesi Provincial Industry Service has the right to determine priority industries that have the potential to be developed. The decision-making process at the South Sulawesi Industry Office is still experiencing several obstacles. This is due to the decision making does not use an objective method. In order to help solve this problem, we need a system that can be used to determine industrial development priorities. This research builds a web-based decision support system software regarding priority setting for SMEs development in South Sulawesi Province using the weighted product model. A method that will find a concluding solution by considering industry weights and criteria. This study uses the implementation of the data management subsystem using MySQL. Meanwhile, the implementation of the model management subsystem uses the weighted product model and the dialog management subsystem uses a website interface that can assist the South Sulawesi Provincial Office of Industry in determining priorities for the development of SMEs.

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1. INTRODUCTION

Economic development that leads to industrialization can encourage economic growth and create jobs for the community. In the history of the development of economic development, the process of the industrial revolution began in the 18th century in England. With the first discovery, namely cotton weaving, after that new innovations in the form of processing engines, trains, steam engines, and steam power ships. These developments led to the spread of industrialization to other countries, increased international trade and led to the industrial revolution.

According to the Regulation of the Minister of Industry of the Republic of Indonesia [1], Industry is all forms of economic activity that process raw materials and/or utilize industrial resources to produce goods that have added value or higher benefits, including industrial services.

The industrial classification for each region or country is different. The more advanced the level of industrial development in an area, the more industrial classifications and the more complex the nature of its activities. Based on the business scale, industry can be divided into small, medium and large industries.

Small and Medium Enterprises (SMEs) are a sector that plays a vital role in running the national economy. South Sulawesi as one of the main corridors of economic development, especially in the eastern part of Indonesia. According to the Head of the South Sulawesi Industry Service, Ahmad Akil, SMEs are one of the contributors to economic growth in South Sulawesi that needs to be developed, with the presence of SMEs in South Sulawesi it is very helpful in creating jobs, although there are still various problems that need to be fixed, such as access to capital, promotion and sales [2].

The South Sulawesi Provincial Office of Industry as a local government organization is tasked with administering affairs in the industrial sector of the South Sulawesi Province. In terms of developing SMEs, the South Sulawesi Provincial Industry Office has the right to determine priority industries that have the potential to be developed. However, in determining priorities the South Sulawesi Provincial Industry Service must be objective so that the decision is truly appropriate and accountable so that it does not harm anyone.

The decision-making process at the South Sulawesi Industry Office is still experiencing several obstacles. This is due to the decision making does not use an objective method. In order to help solve these problems, we need a system that can be used for prioritization. The use of decision support systems in industry is nothing new. Research has been carried out on decision support systems in determining priority for SMEs development in Karo District using the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method [3]. While research using the Weighted Product model method has been carried out research on the decision-making system for granting credit to BMT Muamalah Sejahtera Kendari. This study produced a decision support system for granting credit, where the implementation of this system showed that Weighted Product model in the process of rating new customer credit has the same results, if the method is calculated manually [4].

Qualified technological developments and with reference to the problems above, it is very appropriate to apply a method to assist the South Sulawesi Industrial Service in making decisions in providing support to SMEs. Several methods are often preferred to be applied because they are more suitable and able to handle certain data well [5].

In this study, the method applied is the Weighted Product model to help set a priority for various SMEs in South Sulawesi Province.

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2. METHODS

This study uses a design and creation approach. The design and creation method is a combination of system development and research. We chose this type of research because in addition to conducting research on this title, we also developed a decision support system for setting priorities for the development of SMEs in South Sulawesi Province. The system development approach used is Rapid Application Development (RAD) which is a system development method that can reduce software development time. RAD is divided into 3 stages [6], namely:

1) Requirement Planning is the stage of determining system features, objectives and constraints through consultation with the South Sulawesi Provincial Office of Industry.
2) System Design. In this stage, the system architecture is formed based on specific requirements and describes the basic abstraction of the system and its relationships.
3) Implementation. At this stage PHP will be used as a programming language [7]. The program code is prepared according to the Weighted Product model procedure. The activity carried out is to build a system that can determine the development priorities of SMEs in South Sulawesi Province according to the needs and design of the system that has been made.

In general, the steps taken in this study were processing the data including attributes and alternatives by using the Weighted Product model to rank them so as to obtain priority results for the development of SMEs.

2.1. Weighed product

Weighted Product model is one of the Multi Criteria Decision Making (MCDM) methods which is a decision making technique from several existing alternatives according to the desired criteria. Basically the application of the Weighted Product model is more efficient because the time needed in the calculation is shorter [8].

The use of the Weighted Product model in a decision support system is nothing new, in previous research a scholarship recipient system at SMKN 4 Jeneponto was designed [9]. In this study, evaluating several alternatives based on the following four criteria: parents' income, grades, number of siblings and distance traveled between home and school. The Weighted Product model multiplies the criteria values to get a score.

In the Weighted Product model, the values of the criteria are taken into account to determine alternative preference scores. By using multiplication to connect attribute ratings so that the rating of each attribute is raised to the first power of the attribute weight [10]. The stages of the Weighted Product model are as follows [11-15]:

1) Determine the criteria and alternatives, thus the criteria will be used as a reference in making decisions and alternatives.
2) Give weight to each criterion according to the level of importance.
3) Normalize the weights [16-20], where $\sum w_j = 1$. w_j is a rank with a positive value for cost criteria and a negative value for benefit criteria. The equation [1] for normalizing weights is as follows:

$$w_j = \frac{w_j}{\sum w_j} \quad (1)$$

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4) Determine the value of the vector S, after normalizing the weights, then calculate the value of the vector S with the Equation [2] below:

$$S_i = \prod_{j=1}^{n} a_{ij}^{w_j} \quad (2)$$

Information:

S_i = Alternative preferences (Vector S)
n = Number of criteria
j = Criteria Value
a_{ij} = Variable value of the alternative on each criterion
i = Alternate value

5) Determine the value of vector *V* using the Equation [3] below:

$$V_i = \frac{\prod_{j=1}^{n} a_{ij}^{w_j}}{\prod_{j=1}^{n} (x_j^*)^{w_j}} \quad (3)$$

6) Do a ranking based on the largest value based on the calculation of the Weighted Product model, the best value is the largest of all alternatives.

3. RESULTS AND DISCUSSION

The research used a dataset of 1,117 SMEs from South Sulawesi Province in 2021. The SMEs data is also referred to as an alternative which will later be processed using the Weighted Product model to determine priority for SMEs development. The calculation steps for determining priority for SMEs development using the Weighted Product model are as follows:

1) Determining alternatives and criteria as the basis for determining development priorities. This criterion becomes a reference for calculating the Weighted Product model. The criteria used are labor, investment, production capacity, production value and raw material value.
2) Giving weight to each criterion, there are five criteria with each value and weight in the following table according to the level of importance. The Weight of Each Criterion can be seen in **Table 1.**

Table 1. Weight of Each Criterion

Criteria code	Information	Weight
C1	Labor	2
C2	Investment	3
C3	Production capacity	5
C4	Production value	5
C5	Raw material value	4

3) Normalize the weights using Equation (4) with the proviso that the exponential value

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is positive for the cost and a negative value for the benefit criterion. The following is the result of weight normalization:

$$w_1 = \frac{2}{19} = 0.1$$

$$w_2 = \frac{3}{19} = 0.2$$

$$w_3 = \frac{5}{19} = 0.3 \quad (4)$$

$$w_4 = \frac{5}{19} = 0.3$$

$$w_5 = \frac{4}{19} = 0.2$$

The normalization calculation results are obtained as **Table 2**. below.

Criteria	Labor	Investment	Production capacity	Production value	Raw material value	Total
Weight	2	3	5	5	4	19
Normalization	0.1	0.2	0.3	0.3	0.2	1
Weightage	-0.1	0.2	0.3	0.3	-0.2	

4) After normalizing the weights, then calculating the value of vector *S* with Equation (5), the following is the calculation:

$$S_i = 10^{-0.1} \times 1{,}000{,}000{,}000^{0.2} \times 1{,}000{,}000{,}000^{0.3} \times 3{,}000{,}000{,}000^{0.3} \times 117{,}000{,}000^{-0.2}$$

$$S_i = 0.7943 \times 63.0957 \times 251.1886 \times 696.8453 \times 0.0243$$

$$S_i = 213{,}550 \quad (5)$$

So from the example of 6 cases of SMEs, the results of calculating the *S* vector for each alternative are as shown in **Table 3**.

Table 3. Vector *S* Calculation Results

Alternative	Enterprise names	C1	C2	C3	C4	C5	Vector *S*
A1	Barata Sejahtera	0.7248	49.5934	386.3445	465.1879	0.0219	141,263
A2	CV. Tirta Rumaju	0.9330	43.1736	344.9989	559.1248	0.0154	119,716
A3	UD. Anugrah Alam Nusantara	0.6849	90.2880	283.6791	566.0143	0.0149	148,208
A4	Ujung Loe Bangunan	0.7943	63.0957	251.1886	696.8453	0.0243	213,550
A5	PT. Bawakaraeng Lestari	0.8232	78.5872	51.2497	587.6716	0.0599	116,648
A6	PT. Lumpue Indah	0.8513	39.6906	261.5338	575.3426	0.0223	113,551

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Determine the value of vector V using Equation (6) as follows.

$$V_i = \frac{10^{-0.1} \times 1{,}000{,}000{,}000^{0.2} \times 1{,}000{,}000{,}000^{0.3} \times 3{,}000{,}000{,}000^{0.3} \times 117{,}000{,}000^{-0.2}}{213{,}550 + 141{,}263 + 116{,}648 + 148{,}208 + 113{,}551 + 119{,}716 + 123{,}682 + 151{,}333 + 136{,}964 + 175{,}497}$$

$$V_i = \frac{213{,}550}{1{,}440{,}412} \tag{6}$$

$$V_i = 0.1483$$

So that from the case examples of 6 SMEs, the results of calculating the vector *V* for each alternative are as shown in **table 4**.

Table 4. Vector *V* Calculation Results

Alternative	Vector *S*	Vector *V*
A1	141,263	0.0981
A2	119,716	0.0831
A3	148,208	0.1029
A4	213,550	0.1483
A5	116,648	0.0810
A6	113,551	0.0788

5) Perform ranking based on the greatest value. From the results of the calculations above, it results that the alternative A4 or Ujung Loe Bangunan is the first priority for SMEs development.

3.1. Use Case

Use case diagram is an illustration that describes the interaction relationship between the user and the activities running on the system. The use case of this research is shown in **Figure 1** as follows.

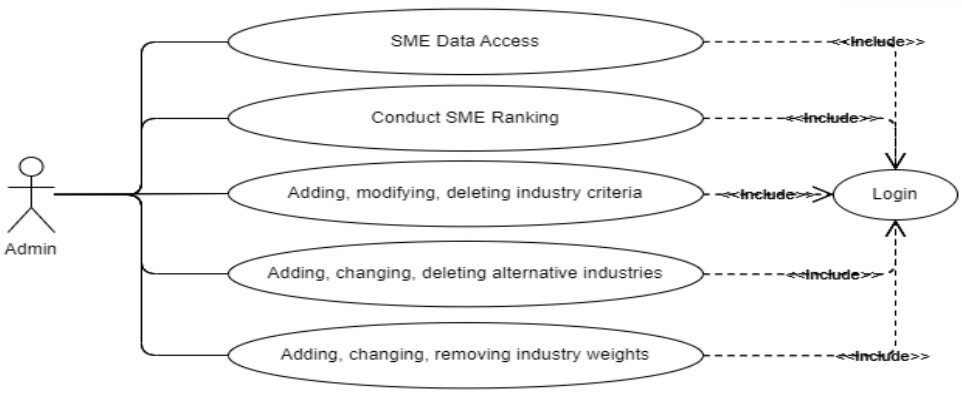


Figure 1. Use Case Diagram.

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3.3. Flowchart

The system in this study was carried out in several stages according to the flowchart in **Figure 2.**

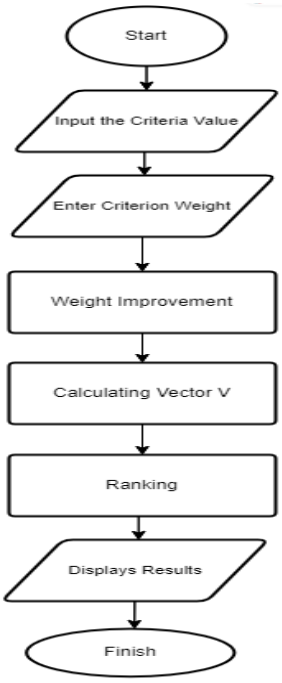


Figure 2. Flowchart.

3.4. Implementation

The main display of the SMEs development determination system can be seen in **Figure 3.** The homepage display will appear the first time when this system is run.

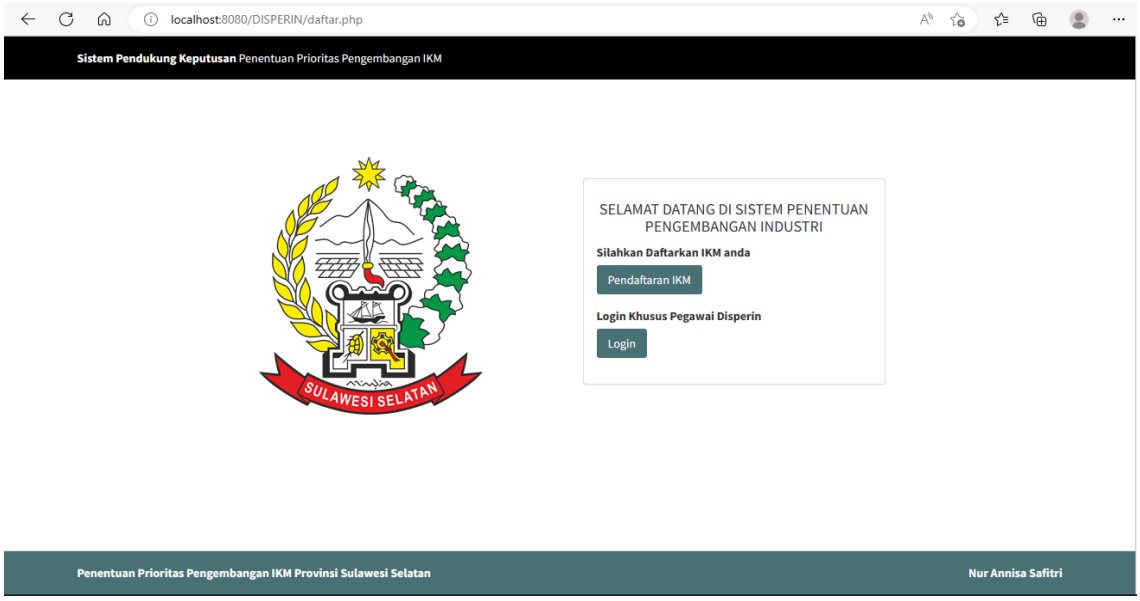


Figure 3. Homepage Interface.

When logging in as an employee, the home menu will appear for the first time. On the home menu there is an information display in the form of criteria, weights, industry

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alternatives and a map display of featured SMEs. The home menu has two feature options: alternative changes and ranking features.

The alternative change feature will display alternative industry data along with vector values S and vector V. On this page there are services for editing, deleting tick, searching and adding value data. The alternative change feature is used to input alternative or SMEs data.

The Ranking feature consists of seven sub-features: graph, preference value, type of criteria, weight, rating, edit criteria and registration. The sub-chart feature displays a graph of priority industries as well as the percentage of workforce, investment value, production capacity and production value in South Sulawesi Province. Preference values display preference value data from each industry weight and there are services to edit, delete tick data, search, and add value data. The types of criteria display industry criteria data along with the types of criteria, which are worth the costs and benefits and there are also services for editing, searching, deleting tick data and adding criteria data. Weights display weight value data and weight results from each industry criteria and there is also edit, delete tick data, search and add value data. The ranking displays alternative data reports that have been ranked based on the value of vector v and the criteria for each industry. Edit criteria displays alternative industry data along with criteria and values and on this page there are services for editing, deleting tick data, searching and adding value data. Registration displays data on SMEs that have registered to apply for industrial assistance. Based on its characteristics, decision support systems can adapt at any time and are flexible so that this system provides services for adding, editing, deleting criteria and industry weights. This service is useful in order to assist users in the process of making industry priority decisions.

The use of the Weighted Product model in this system can help users make decisions in determining SMEs that have the potential to be developed based on predetermined criteria and weights. Based on data from 1,117 SMEs in South Sulawesi Province, the result was that Ujung Loe Bangunan had a vector value of V of 0.016, followed by Barata Sejahtera with a vector value of V of 0.01. The Weighted Product Result can be seen in **Figure 4** and **Figure 5.**

Alternatif	Kriteria					P. Alternatif	P. Relatif
	Tenaga Kerja	Nilai Investasi	Kapasitas Produksi	Nilai Produksi	Bahan Baku		
UJUNG LOE BANGUNAN	0.7848	26	127	312	0.02	16461.39	0.0166
BARATA SEJAHTERA	0.7126	22	186	219	0.0179	11299.44	0.01139
PT. BAWAKARAENG LESTARI	0.8148	31	32	269	0.0516	11194.93	0.01129
UD. ANUGRAH ALAM NUSANTARA	0.6714	35	142	260	0.012	10354.09	0.01044
PT.LUMPUE INDAH	0.8442	18	132	264	0.0183	9822.46	0.00991

Figure 4. Weighted Product Model Rating Results.

Apart from being in tabular form, this system is equipped with graphical visualization so that it can make it easier for users to analyze and understand the results of this model.

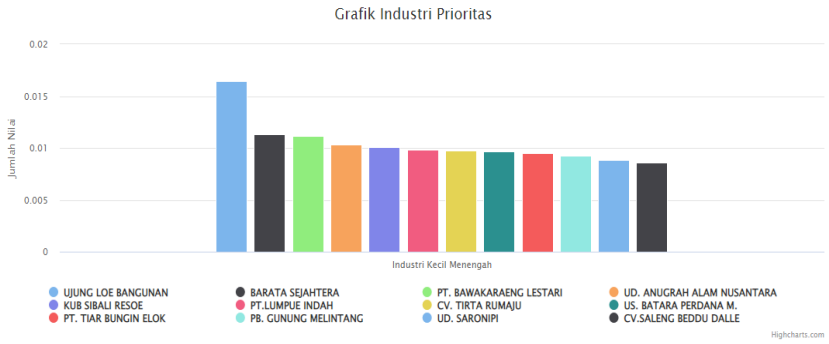


Figure 5. Graph of Weighted Product Model Rating Results.

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4. CONCLUSION

Based on the results of the research and system for determining the priority for the development of SMEs using the Weighted Product model above, the conclusions are as follows:

1) Use of the Weighted Product model to determine priorities and determine decisions by considering the weights and criteria.
2) This decision support system uses the PHP programming language with the implementation of the MySQL data processing subsystem which can assist the South Sulawesi Provincial Office of Industry in determining priority for SMEs development.
3) Alternative data, criteria and weights become dynamic assessment parameters, which can be added or subtracted according to user needs according to the characteristics of the decision support system.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

6. REFERENCES

[1] Wongkar, B. C., Liando, D., dan Kawung, E. (2019). Implementasi kebijakan pengarusutamaan gender di dinas perindustrian dan perdagangan daerah provinsi sulawesi utara dalam program pengembangan industri kecil dan menengah tahun 2018. *Jurnal Administrasi Publik, 5*(86), 70-81.

[2] Prijanto, W. J., dan Prasetyanto, P. K. (2020). Potensi usaha kecil mikro (UKM) dalam meningkatkan pertumbuhan ekonomi. *Jurnal REP (Riset Ekonomi Pembangunan), 5*(1), 97-117.

[3] Sembiring, A. A., Sembiring, A. S., dan Siregar, S. R. (2018). Sistem pendukung keputusan penentuan prioritas pengembangan industri kecil menengah di kabupaten karo mengunakan metode topsis. *Informasi dan Teknologi Ilmiah (INTI), 5*(3), 269-274.

[4] Jalil, A., Ningrum, I. P., dan Muchtar, M. (2017). SPK pemberian kredit menggunakan metode wp (weighted product) pada BMT Mu'amalah sejahtera kendari. *Jurnal Semantik., 3*(1), 173-180.

[5] Salman, N., dan Sari, M. (2020). Pengaruh penyetelan hyperparameter terhadap kinerja prediksi random forest pada pendeteksian spam. *Jurnal INSTEK (Informatika Sains dan Teknologi), 5*(2), 149-158.

[6] Pricillia, T. (2021). Perbandingan metode pengembangan perangkat lunak (waterfall, prototype, RAD). *Jurnal Bangkit Indonesia, 10*(1), 6-12.

[7] Sadali, M., dan Putra, Y. K. (2020). Sistem informasi berbasis web SMA al-mukhtariyah mamben lauk berbasis php dan mysql dengan framework codeigniter. *Infotek: Jurnal Informatika dan Teknologi, 3*(1), 79-83.

[8] Arifin, S. R., & Mintamanis, J. C. (2018). Decision support system for determining thesis supervisor using a weighted product (WP) method. *Jurnal Online Informatika, 3*(2), 80-85.

DOI: https://doi.org/10.17509/coelite.v2i1.57083
p-ISSN: 2829-4157 e-ISSN: 2829-4149

[9] Taha, S., dan Tahir, T. (2017). Sistem pengambilan keputusan penerima beasiswa di SMKN 4 jeneponto dengan menggunakan metode weighted product. *Jurnal INSTEK (Informatika Sains dan Teknologi), 2*(2), 61-70.

[10] Ramadiani, R., Ramadhani, B., Arifin, Z., Jundillah, M. L., and Azainil, A. (2020). Decision support system for determining chili land using weighted product method. *Bulletin of Electrical Engineering and Informatics, 9*(3), 1229-1237.

[11] Sahabuddin, M., and Khan, I. (2021). Multi-criteria decision analysis methods for energy sector's sustainability assessment: robustness analysis through criteria weight change. *Sustainable Energy Technologies and Assessments, 47*(1), 1-12.

[12] Aminudin, N., Sundari, E., Shankar, K., Deepalakshmi, P., Fauzi, R. I., and Maseleno, A. (2018). Weighted product and its application to measure employee performance. *International Journal of Engineering and Technology, 7*(226), 102-108.

[13] Wardhani, A. K., and Lutfina, E. (2020). Application culinary decision support system in Kudus city with weighted product method based on mobile phone. *Journal of Computer Science and Engineering (JCSE), 1(*1), 10-16.

[14] Goswami, S. S., Behera, D. K., and Mitra, S. (2020). A comprehensive study of weighted product model for selecting the best laptop model available in the market. *Brazilian Journal of Operations and Production Management, 17*(2), 1-18.

[15] Solikhun, S. (2017). Perbandingan metode weighted product dan weighted sum model dalam pemilihan perguruan swasta terbaik jurusan komputer. *Klik-Kumpulan Jurnal Ilmu Komputer, 4*(1), 70-87.

[16] Odu, G. O. (2019). Weighting methods for multi-criteria decision making technique. *Journal of Applied Sciences and Environmental Management, 23*(8), 1449-1457.

[17] Abdel-Basset, M., Gamal, A., Son, L. H., and Smarandache, F. (2020). A bipolar neutrosophic multi criteria decision making framework for professional selection. *Applied Sciences*, *10*(4), 1-22.

[18] Keshavarz-Ghorabaee, M., Amiri, M., Hashemi-Tabatabaei, M., Zavadskas, E. K., and Kaklauskas, A. (2020). A new decision-making approach based on fermatean fuzzy sets and WASPAS for green construction supplier evaluation. *Mathematics*, *8*(12), 1-24.

[19] Rangaiah, G. P., Feng, Z., and Hoadley, A. F. (2020). Multi-objective optimization applications in chemical process engineering: tutorial and review. *Processes*, *8*(5), 1-33.

[20] Yang, L., Li, Y., Wang, J., and Sherratt, R. S. (2020). Sentiment analysis for e-commerce product reviews in chinese based on sentiment lexicon and deep learning. *IEEE access*, *8(1)*, 23522-23530.

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Comparison Analysis of Bubble Sort and Insertion Sort Algorithm on the Selection of a Shop According to the Criteria

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ABSTRACT

In choosing a place to open a business was very important and must be considered. One of the suitable places to open a business was a kiosk. This study aimed to facilitate the public in determining the location of the sales kiosk. This was motivated by the limitations and speed in accessing information about the location of the kiosk. In this study, there was a process system for comparing execution time analysis using the Bubble Sort and Insertion Sort algorithms based on the criteria that had been provided. There were criteria that could be selected by users, including the location of the sales kiosk, the area and the available kiosk rental price per year. So that this research system could overcome community problems in terms of limitations and the speed of accessing information that was less efficient about the location of the sales kiosk. After the implementation and analysis of execution time on sales kiosk data as many as 10 places in the C++ programming language using Codeblocks, the results obtained were the use of the Insertion Short algorithm, the use of the Insertion Sort algorithm was more effective in sorting the kiosk places according to the criteria provided.

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Bubble Sort,
Decision Support System,
Execution Time Efficiency,
Insertion Sort.
Kiosk Selection,

1. INTRODUCTION

For people who are wanting to open a business by looking for a previous place, this is the start of running their business. The choice of business location is a factor that must be considered. One of the suitable places to be used as a place of business is a kiosk. Kiosk is a small shop that was built as a place of business for people who want to start a business. Usually, kiosks are used to sell a variety of goods. Besides being used to sell goods, the kiosk can also be used as a place to eat, for example a café

The density of the population is increasing, especially in urban areas, so it is not easy to find a place of business for people who want to start a business. There are several problems encountered when looking for a place of business that suits your taste, this causes limitations and inefficient time in finding information about the place of business you want to use for business.

Technological developments are now developing very rapidly, the use of information and communication technology in finding information about places of business, especially sales kiosks, is easy to do. So that it can be used as a solution to solve the problems that occur. The design system for the utilization of information and communication technology is designed using a process of comparing execution times in sorting information regarding the criteria that have been provided starting from the smallest to the largest. The available criteria include the location of the kiosk, the size and price of the kiosk rental per year, so that it can provide an overview for people who are looking for a selling kiosk.

Completeness of information is the most important part of a system, because it will make it easier for users to use. To be able to obtain better and faster data access, it is expected that data processing will also be better. Sequencing data plays an important role which is considered by many so that problems especially regarding processing will be better and faster to solve [1]. There are various solving procedures for solving data sorting problems or it can be called a sorting algorithm.[5]

The designed technology and information can provide an overview of society in general, and to the kiosk seeker. The system is designed using the process of searching and selecting the appropriate kiosk by showing the latest, detailed and complete information on prices, facilities, and location. In determining the place of business this factor is the most important factor because it can adjust the finances that we have. Especially in this day and age, it's hard to find a place of business that is cheap and has facilities according to what we want, right.

Therefore, here we are designing a system which will later bring up kiosks with rental prices and an area according to the wishes of people who want to start a business. By utilizing this system, it will make it easier for people who want to choose a kiosk according to the criteria that have been provided. And later it will display kiosks with rental prices and area from smallest to largest.

The process of searching for data can be optimized if it is stored in a sequential way, which is the importance of sorting. One important aspect of optimizing the speed of the sorting process is the level of efficiency. If the algorithm has high efficiency, then the process will make a faster time and can process more detailed data. There are several factors that are considered in deciding the community to choose the location of the kiosk. The aspects that most determine the location of the kiosk are the perception of the rental price, public facilities, and location.

In this research, there is a process analysis system for comparing the execution time of the sorting algorithm, namely using the Bubble Sort and Insertion Sort algorithms in the C++

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programming language using CodeBlocks Software [2]. This study aims to determine the sorting algorithm that has a faster level of execution time efficiency of sorting data. So that it can build a decision support system for selecting kiosks in the community so that it becomes a solution in finding sales stalls quickly and efficiently.[4]

The purpose of this research is to build a decision support system for choosing a kiosk. Where later will compare the 2 algorithms based on execution time.[6] The sorting algorithm that has the highest efficiency will result in a faster execution time. The results will later prove which algorithm is more efficient in finding kiosk data in the Jakarta area. Maybe this system can be useful for people who want to start a business and can also help people find kiosks according to the criteria they want.

2. METHODS

In this study, data analysis was conducted using a dataset consisting of 10 sales kiosks. The kiosks were categorized based on three criteria: area, kiosk rental price per year, and kiosk location. To analyze and compare the data, two sorting algorithms, namely bubble sort and insertion sort, were implemented using the C++ programming language. These sorting algorithms were utilized to arrange the kiosks based on the specified criteria, allowing for a systematic comparison and evaluation of the kiosk data.[7]

2.1. Research Stages

This research comprises several stages, as illustrated in **Figure 1**. These stages involve a literature review, design and development, manufacturing and assembly, testing and evaluation, and data analysis. The diagram provides a concise overview of the sequential steps followed in this study, serving as a roadmap for the research process.

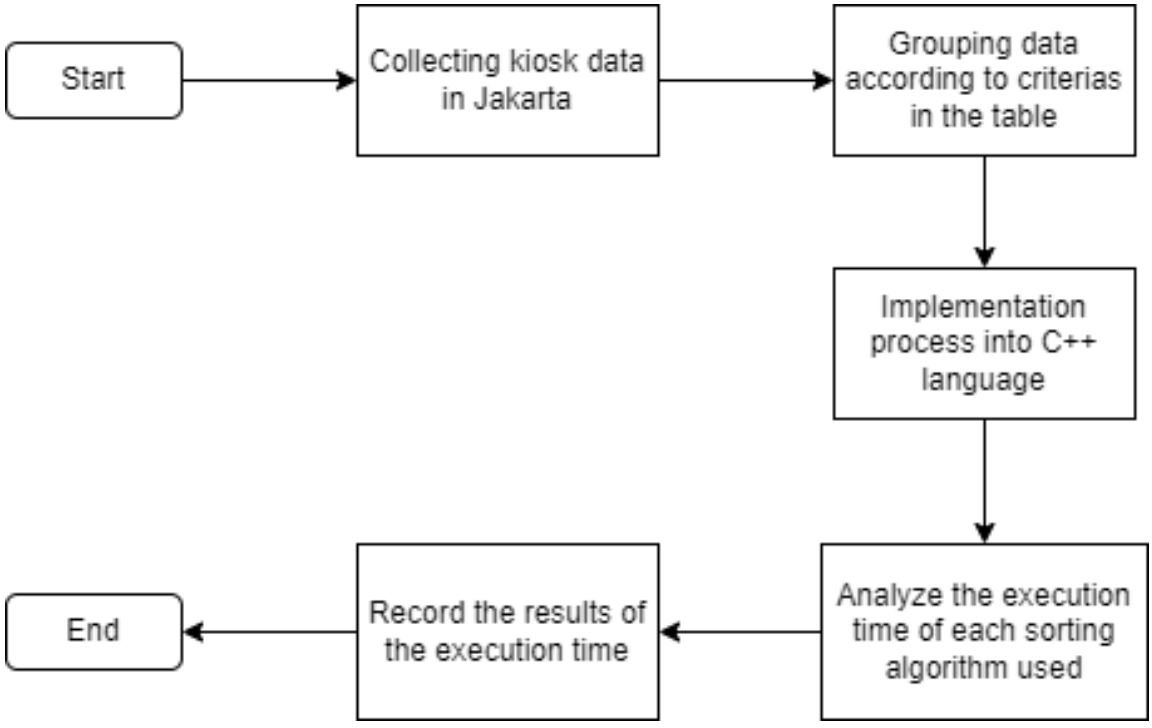


Figure 1. Research Stages.

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2.2. Data Collection

During the data collection process, we gathered information from research results using the Google search engine. The data was sourced from a specific website, namely https://www.99.co/id/sewa/kiosk, which provides listings for kiosk rentals. By accessing this website, we obtained relevant data related to kiosk rental information, including details such as prices, locations, and available amenities. This data served as a valuable resource for our research, allowing us to analyze and evaluate kiosk rental trends and patterns.

From the results of collecting search data for kiosks in Jakarta, there were 10 sales kiosk data, shown in **Table 1.**

Table 1. Kiosk Data in Jakarta.

KIOSK DATA IN JAKARTA				
No.	**Kiosk Name**	**Area (m^2)**	**Rent Cost/Year (Rp.)**	**Location**
1.	Kios Gading Nias	2	18.000.000	North Jakarta
2.	Kios PGC	5	3.900.000	East Jakarta
3.	Kios Palmerah	24	55.000.000	West Jakarta
4.	Kios Pondok Labu Cilandak	30	40.000.000	South Jakarta
5.	Kios Tanah Abang Blok B	4	25.000.000	Central Jakarta
6.	Kios Pasar Laris	6	15.000.000	West Jakarta
7.	Kios Kelapa Gading	8	30.000.000	North Jakarta
8.	Kios Pasar Senen	12	50.000.000	Central Jakarta
9.	Kios Ujung Menteng	36	1.800.000	East Jakarta

2.3. Data Processing

Once the data has been collected, the subsequent step involves processing the gathered information into structured data tables. These tables are organized and grouped based on predetermined criteria, including the kiosk name, area of the kiosk building, kiosk rental price per year, and the location of each kiosk (**Table 1**). By categorizing the data according to these criteria, we can effectively organize and analyze the information, enabling us to identify patterns, trends, and insights related to kiosk rentals. This data processing stage is crucial in facilitating further analysis and decision-making based on the collected data.

2.4. Implementation to C++ programming language

The implementation process of the sorting algorithms in the C++ programming language utilizes the CodeBlocks software for development. This software provides a user-friendly environment for writing, compiling, and executing the code.[8] The implementation involves comparing the data of 10 kiosks based on the criteria of annual rental prices and kiosk building areas. The data table is then subjected to the execution of both the Bubble Sort and Insertion Sort algorithms, which are widely used for sorting tasks. By measuring and comparing the execution time of these algorithms, we can evaluate their efficiency and performance in sorting the kiosk data effectively. This analysis will provide valuable insights into the effectiveness of different sorting approaches and assist in optimizing the sorting process for future implementations.

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2.4.1. Insertion Sort (Kiosk Building Area)

On the first menu in the programming that has been made is the command used to sort the smallest to largest values in the kiosk building area data using the Insertion Sort algorithm:

```
void insertionLuas(kios arr[], int n)
{
   int j;
   kios key;
   for(int i = 1; i<n; i++) {
      key = arr[i];
      j = i;
      while(j > 0 && arr[j-1].luas>key.luas) {
         arr[j] = arr[j-1];
         j--;
}
      arr[j] = key;
      for(int k = 0; k<n; k++){
          cout << arr[k].luas << " ";
       }
       cout << endl;
     }
}
```

Figure 1. Insertion Sort (Kiosk Building Area).

2.4.2. Insertion Sort (Kiosk Rental Cost Per Year)

Furthermore, on the second menu in the programming that has been made is the command used to sort the smallest to largest values in the kiosk rental cost data per year:

```
void insertionHarga(kios arr[], int n)
{
   int j;
   kios key;
   for(int i = 1; i<n; i++) {
      key = arr[i];
      j = i;
      while(j > 0 && arr[j-1].harga>key.harga) {
         arr[j] = arr[j-1];
         j--;
      }
      arr[j] = key;
      for(int k = 0; k<n; k++){
          cout << arr[k].harga << " ";
      }
      cout << endl;
    }
}
```

Figure 2. Insertion Sort (Kiosk Rental Cost Per Year).

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2.4.3. Bubble Sort (Kiosk Building Area)

On the third menu in the programming that has been made is the command used to sort the smallest to largest values in the data for the area of the next kiosk building using the Bubble Sort algorithm:

```
void bubbleLuas(kios arr[], int n)
{
   int i, j;
   bool swapped;
   for (i = 0; i < n-1; i++)
   {
     swapped = false;
     for (j = 0; j < n-i-1; j++)
     {
        if (arr[j].luas > arr[j+1].luas)
        {
           swap(&arr[j], &arr[j+1]);
           swapped = true;
        }
        for(int k = 0; k<n; k++){
              cout << arr[k].luas << " ";
         }
         cout << endl;
     }
     if (swapped == false)
                              break;

   }
```

Figure 3. Bubble Sort (Kiosk Building Area).

2.4.4. Bubble Sort (Kiosk Rental Cost Per Year)

Furthermore, on the second menu in the programming that has been made is the command used to sort the smallest to largest values in the kiosk rental cost data per year:

```
void bubbleLuas(kios arr[], int n)
{
   int i, j;
   bool swapped;
   for (i = 0; i < n-1; i++)
   {
     swapped = false;
     for (j = 0; j < n-i-1; j++)
     {
        if (arr[j].luas > arr[j+1].luas)
        {
           swap(&arr[j], &arr[j+1]);
           swapped = true;
        }
        for(int k = 0; k<n; k++){
              cout << arr[k].luas << " ";
         }
         cout << endl;
     }
     if (swapped == false)
                              break;

   }
```

Figure 4. Bubble Sort (Kiosk Rental Cost Per Year).

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2.5. Result Analysis

Analyze the execution time of the two sorting algorithms. The analysis process is obtained from the results of the execution time data of the insertion sort and bubble sort algorithms which are calculated using units of seconds based on 10 sales kiosk data in Jakarta which have been grouped based on predetermined criteria.

3. RESULTS AND DISCUSSION

After analyzing the execution time of the insertion sort and bubble sort algorithms, record the execution results of the two sorting algorithms. In a comparison of the execution time results of Insertion sort and Bubble Sort on the area of the kiosk building, the results are obtained.

In the criteria for the area of the kiosk building (**Figure 2**. and **Figure 3.**) the results of implementation into the C++ programming language using CodeBlock Software show the sorting steps for the area of the kiosk building based on the sorting method of the two sorting algorithms. **Figure 2** shows the 9 process steps for sorting data in the Insertion Sort algorithm for the area of the kiosk building. Furthermore, **Figure 4** shows the 42 process steps for sorting data in the Bubble Sort algorithm for the area of the kiosk building. This shows that the comparison of the data sorting process is longer than Bubble Sort than Insertion Sort.

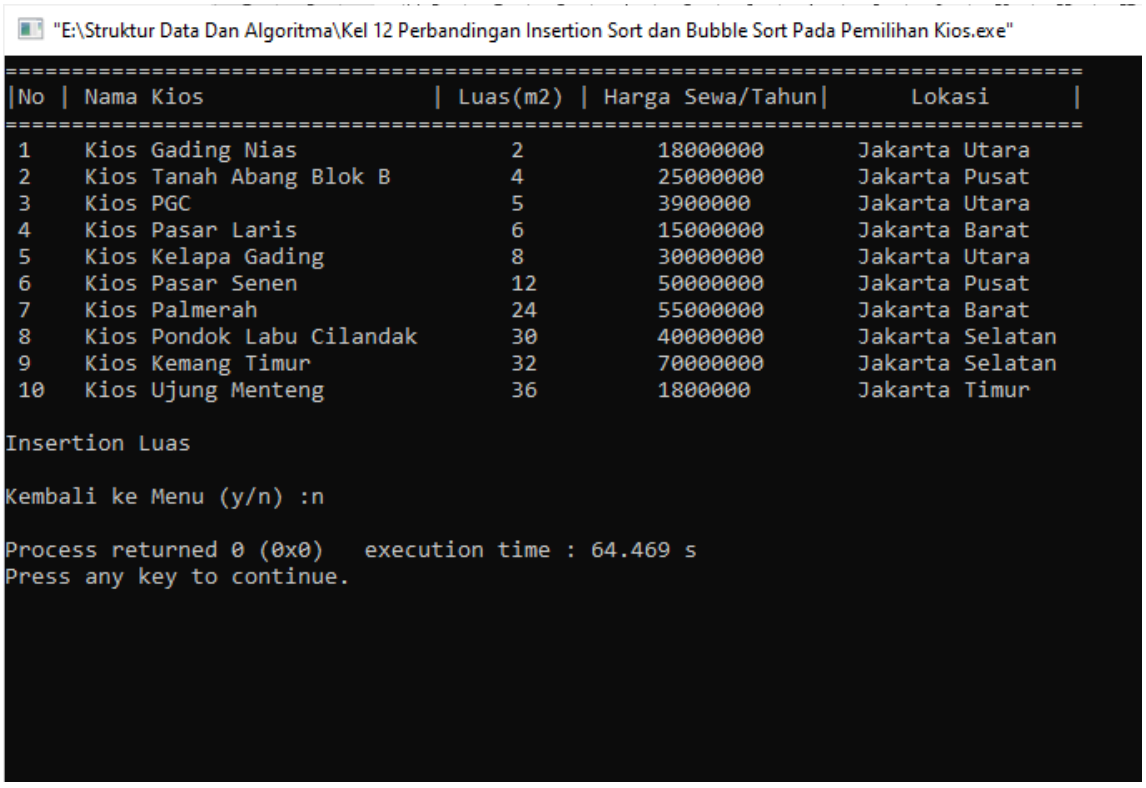


Figure 5. Process Steps for Ordering Insertion Sort Kiosk Building Area.

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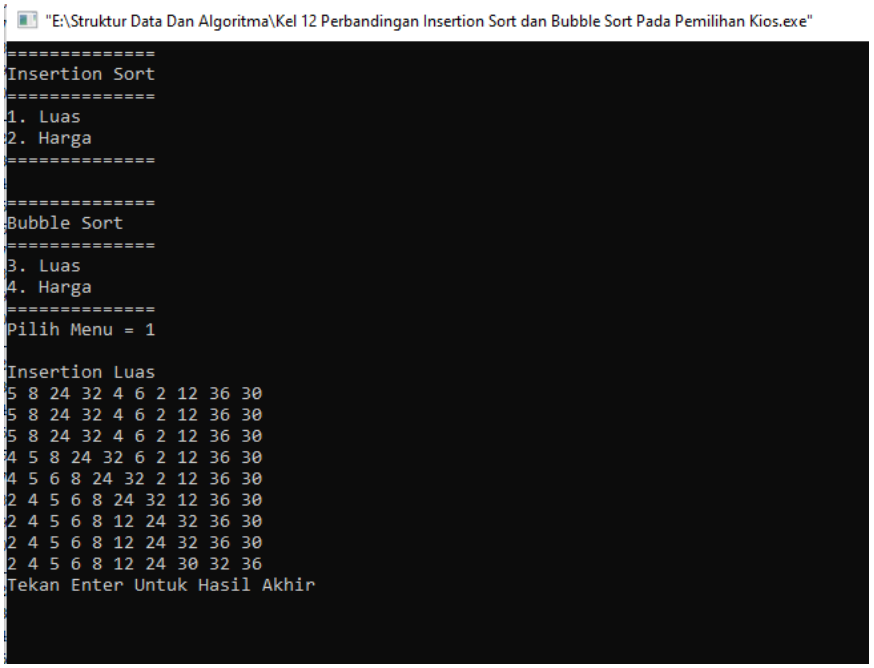


Figure *6*. Result of Execution Time of Insertion Sort Kiosk Building Area.

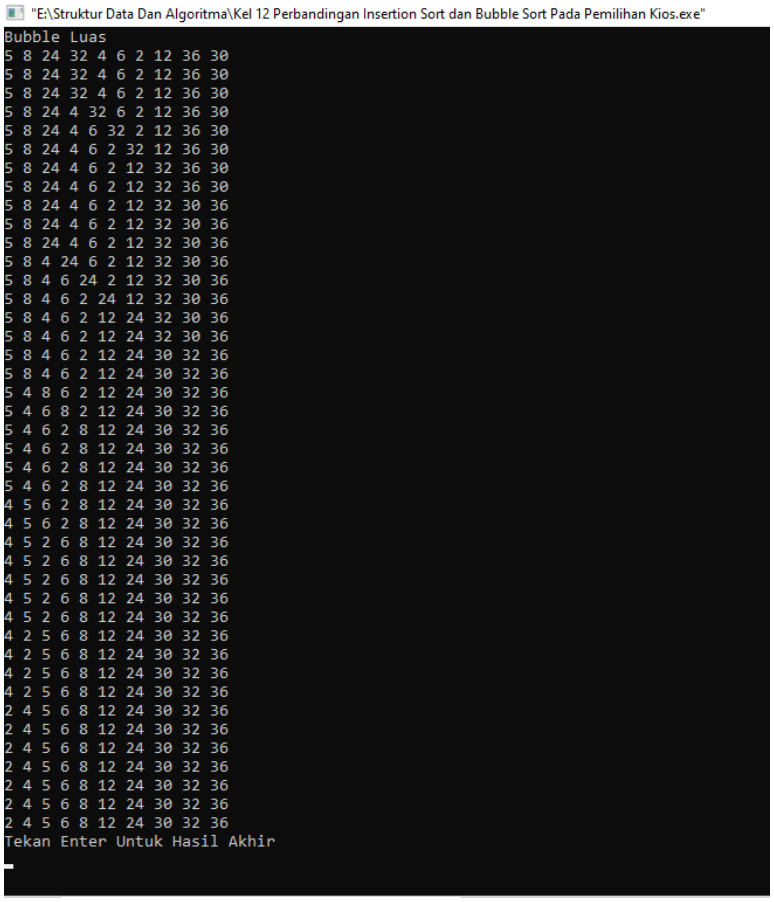


Figure 7. Bubble Sort Sequencing Process Kiosk Building Area.

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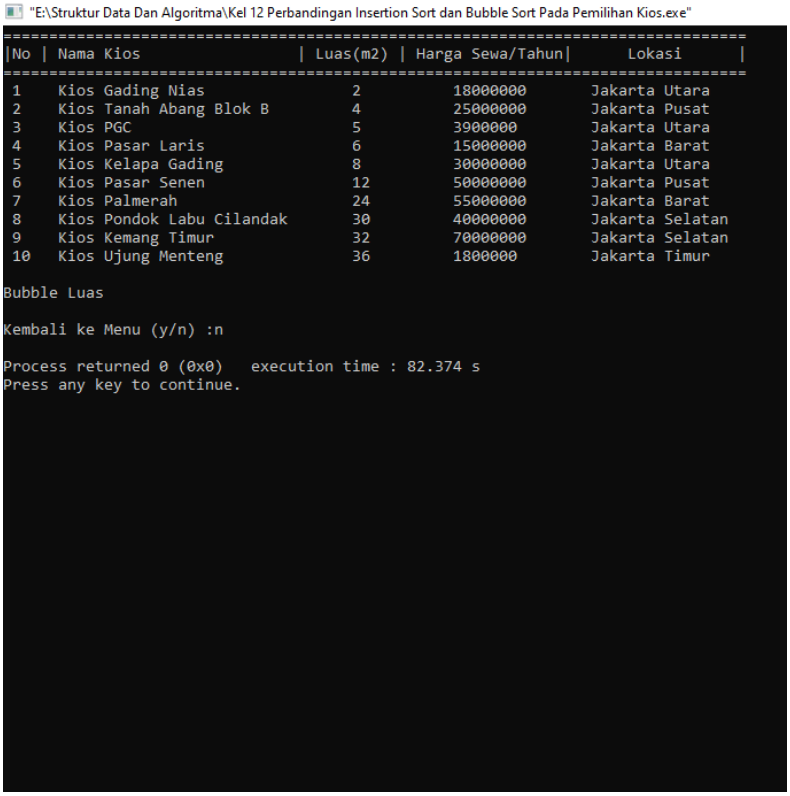


Figure 8. Results of Bubble Sort Execution Time Kiosk Building Area.

After the data on the building area of the kiosk has been sorted based on the sorting steps of the Insertion Sort and Bubble Sort algorithms. The results show that the Gading Nias Kiosk in North Jakarta is smaller with an area of 2 m2 and the Ujung Menteng Kiosk in East Jakarta is larger with an area of 36 m2.

Then in **Figure. 2.** and **Figure. 4.** show the results of the execution time of each of the two sorting algorithms. Furthermore, the results of the execution time are recorded on the area of the kiosk building from the two sorting algorithms **Table 2**.

In Insertion Sort, the results of the execution time were recorded as 64,469 s, while Bubble Sort was 82,3274 s, this shows that the execution time of the Insertion Sort algorithm in sorting data on the size of the kiosk building is faster than Bubble Sort.

In the criteria for kiosk rental prices per year **Figure 6.** and **Figure 8**. the results of implementation into the C++ programming language using CodeBlock Software show the steps for sorting kiosk rental prices per year based on the sorting method of the two sorting algorithms. **Figure 6.** shows the 9 process steps for sorting data in the Insertion Sort algorithm for the area of the kiosk building. Furthermore, **Figure 4** and **Figure 5.** shows the 45 process steps for sorting data in the Bubble Sort algorithm at the kiosk rental price per year. This shows that the comparison of the data sorting process is longer than Bubble Sort than Insertion Sort.

After the data on the kiosk rental price per year has been sorted based on the sorting steps of the Insertion Sort and Bubble Sort algorithms. The results show that the Ujung Menteng Kiosk in South Jakarta is smaller, with an annual rental price of 1,800,000 and the East Kemang Kiosk in South Jakarta is larger, with a price of 70,000,000.

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Table 2. Execution Time Result Kiosk Building Area.

Execution Time (s)	
Insertion sort	Bubble sort
64.469 s	82.3274 s

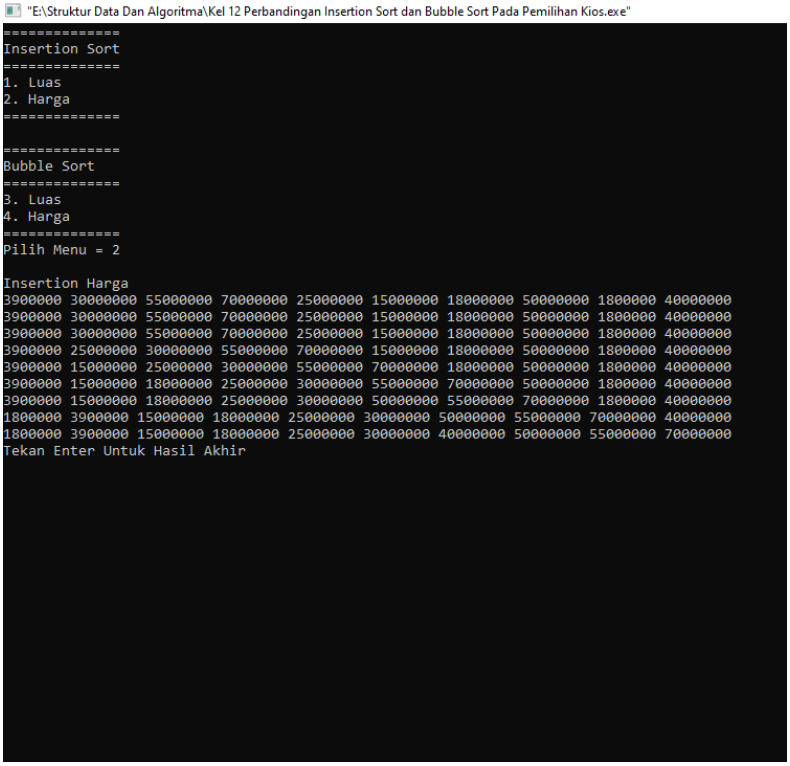


Figure 9. Insertion Sort Sequence Process Kiosk Rental Cost Per Year.

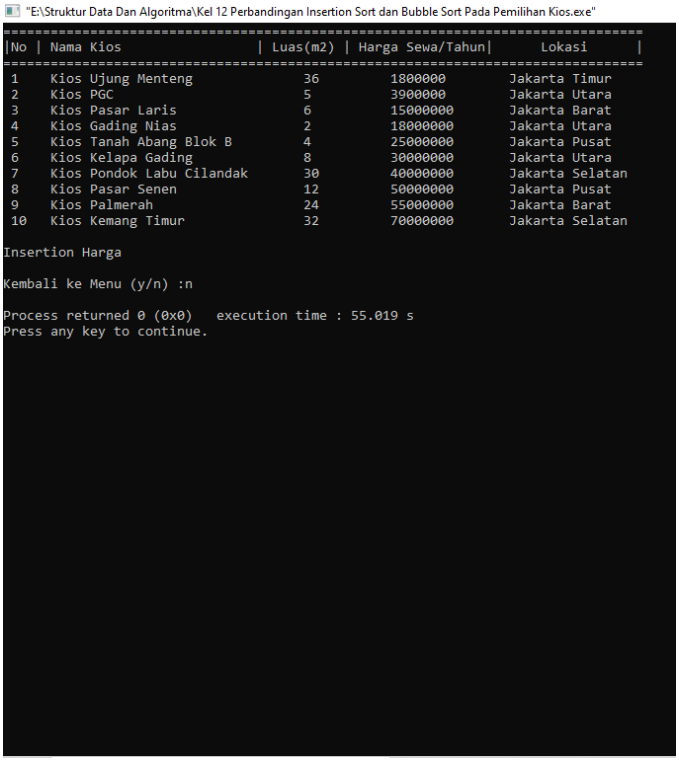


Figure *10*. Result of Execution Time of Insertion Sort Kiosk Rental Cost Per Year.

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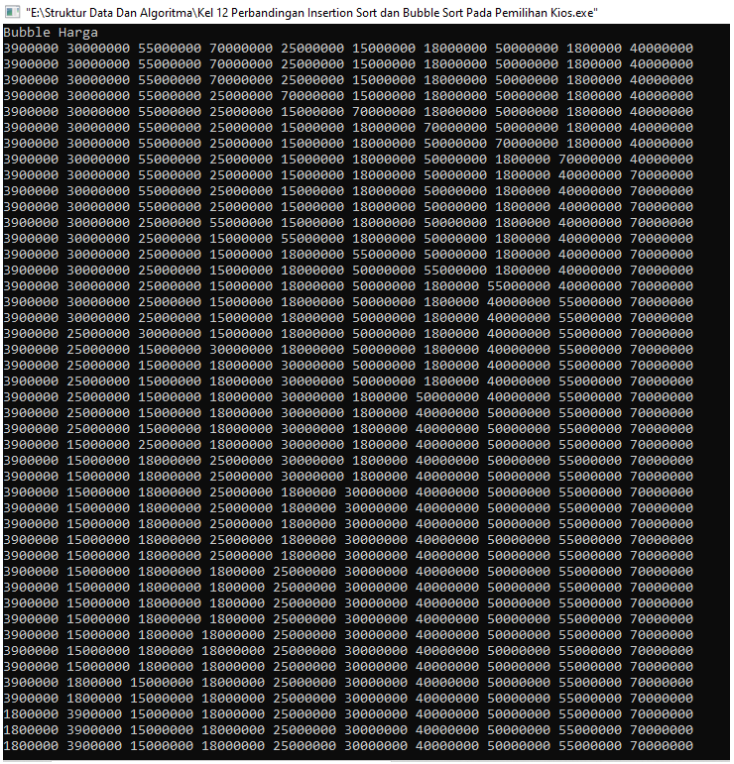


Figure *11*. Bubble Sort Sequencing Process Kiosk Rental Cost Per Year.

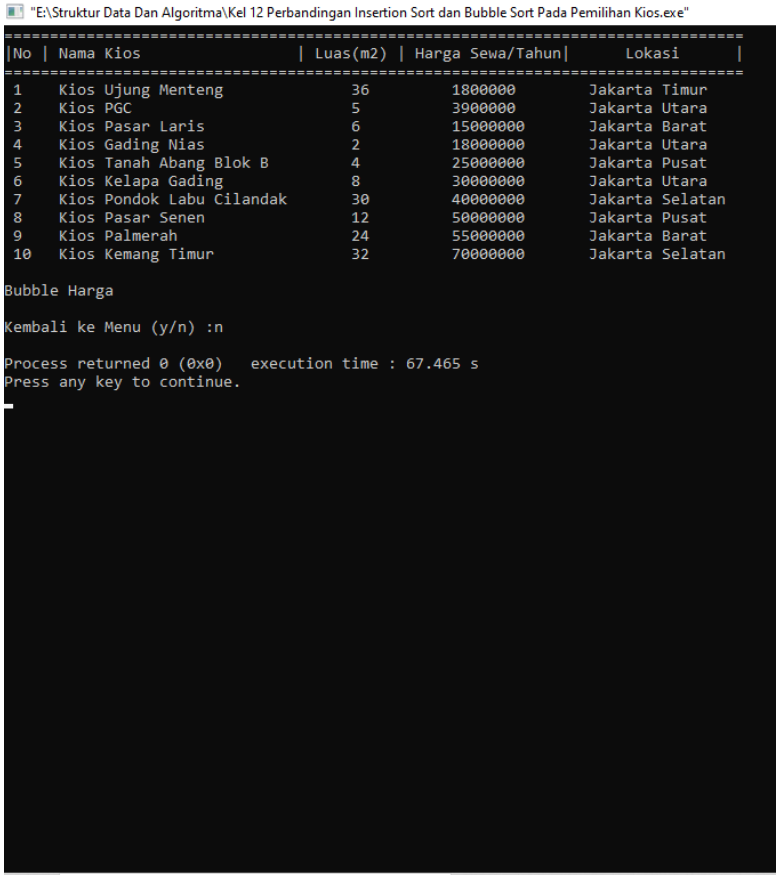


Figure 12. Results of Bubble Sort Execution Time Kiosk Rental Cost Per Year.

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Table 2. Results of Execution Time Kiosk Rental Cost Per Year

Waktu Eksekusi (s)	
Insertion sort	Bubble sort
55.019 s	67.465 s

After the data on the building area of the kiosk has been sorted based on the sorting steps of the Insertion Sort and Bubble Sort algorithms. Then in Figures 7 and 9 show the results of the execution time of each of the two sorting algorithms. Furthermore, the results of the execution time are recorded at the kiosk rental prices per year from the two sorting algorithms (Table 3).

In Insertion Sort, the results of the execution time were recorded as 55,019 s, while Bubble Sort was 67,465 s. This shows that the execution time of the Insertion Sort algorithm in sorting data on the size of the kiosk building is faster than Bubble Sort.

Based on the results of the data kiosk that has been implemented in the C++ programming language above, it can be seen that the insertion sort algorithm is faster and more effective than the bubble sort algorithm in sorting data. The time difference is quite a lot, around 10-15 seconds. It can also be seen that the results of bubble sort are longer than insertion sort.

4. CONCLUSION

After conducting an experiment by collecting 10 kiosk data with the criteria of area, price, and location, it can be seen from the criteria for the area of the Ujung Menteng kiosk being the largest kiosk with an area of 36 m2 and the Gading Nias kiosk being the smallest kiosk with an area of 2 m2, on the price criteria for Kemang kiosks Timur is the most expensive stall with a price of 70 million per year and the Ujung Menteng kiosk is the cheapest stall with a price of 1.8 million per year.

In the comparison of execution time it can be concluded that the insertion sort algorithm is faster than the bubble sort algorithm. The insertion sort algorithm's sorting is also less, whereas in bubble sort the sorting is quite long. Based on this research, it can be seen which algorithm is more efficient in execution time and it can also be seen which sequence is less. And the execution results are quite fast and can work well. Maybe in the future it will provide other features such as adding distance to kiosks, facilities, location placement, and images and others. By adding this feature, it will make it easier for the public to choose a kiosk according to their wishes, criteria, needs and convenience of a kiosk for those who want to start their business. Hopefully the system that has been created can be useful for people who want to start a business and are looking for kiosks with criteria that match what they want.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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6. REFERENCES

[1] Sunandar, E. (2019). Perbandingan metode selection sort dan insertion sort dalam pengurutan data menggunakan bahasa program java. *PETIR (Jurnal Pengkajian dan Penerapan Teknik Informatika), 12*(2), 172–178.

[2] Sitepu, R. R., Yusman, M., dan Febriansyah, F. E. (2017). Implementasi algoritma bubble sort dan selection sort menggunakan arraylist multidimensi pada pengurutan data multi prioritas. *Jurnal Komputasi*, *5*(1), 81-87.

[3] Vakulenko, Y., Oghazi, P., and Hellström, D. (2019). Innovative framework for self-service kiosks: Integrating customer value knowledge. *Journal of Innovation and Knowledge*, *4*(4), 262-268.

[4] Saputra, D. Y. R., Andryana, S., dan Sholihati, I. D. (2021). Analisis perbandingan algoritma bubble sort dan selection sort pada sistem pendukung keputusan pemilihan tempat kost berbasis IOS (iphone operating system). *JIPI (Jurnal Ilmiah Penelitian dan Pembelajaran Informatika)*, *6*(2), 318-324.

[5] Anggreani, D., Wibawa, A. P., Purnawansyah, P., dan Herman, H. (2020). Perbandingan efisiensi algoritma sorting dalam penggunaan bandwidth. *ILKOM Jurnal Ilmiah*, *12*(2), 96-103.

[6] Rahayuningsih, P. A. (2016). Analisis perbandingan kompleksitas algoritma pengurutan nilai (sorting). *EVOLUSI: Jurnal Sains dan Manajemen*, *4*(2), 1-12.

[7] Gunawan, I., Sumarno, S., dan Tambunan, H. S. (2019). Penggunaan algoritma sorting bubble sort untuk penentuan nilai prestasi siswa. *Sistemasi*, *8*(2), 296-304.

[8] Umar, M. F., Munir, E. U., Shad, S. A., and Nisar, M. W. (2014). Enhancement of selection, bubble and insertion sorting algorithm. *Research Journal of Applied Sciences, Engineering and Technology*, *8*(2), 263-271.

[9] Kardono, S. S. (2016). Arsitektur e-kios di Surabaya. *Jurnal Komunika: Jurnal Komunikasi, Media dan Informatika*, *5*(1), 37-44.

[10] Hariri, R. H., Fredericks, E. M., and Bowers, K. M. (2019). Uncertainty in big data analytics: survey, opportunities, and challenges. *Journal of Big Data*, *6*(1), 1-16.

[11] Jouin, M., Gouriveau, R., Hissel, D., Péra, M. C., and Zerhouni, N. (2016). Particle filter-based prognostics: review, discussion and perspectives. *Mechanical Systems and Signal Processing*, *72*(1), 2-31.

[12] Tan, Z., Li, H., and He, X. (2021). Optimizing parcel sorting process of vertical sorting system in e-commerce warehouse. *Advanced Engineering Informatics*, *48*(1), 101-279.

[13] Maramba, I. D., Jones, R., Austin, D., Edwards, K., Meinert, E., and Chatterjee, A. (2022). The role of health kiosks: scoping review. *JMIR Medical Informatics*, *10*(3), 1-21.

[14] Fan, M., Ammah, V., Dakhan, S. A., Liu, R., Mingle, M. N., and Pu, Z. (2021). Critical factors of reacquainting consumer trust in e-commerce. *The Journal of Asian Finance, Economics and Business*, *8*(3), 561-573.

[15] Kusumasari, B., and Alam, Q. (2012). Bridging the gaps: the role of local government capability and the management of a natural disaster in Bantul, Indonesia. *Natural Hazards*, *60*(1), 761-779.

[16] Maalaoui, A., Ratten, V., Heilbrunn, S., Brannback, M., and Kraus, S. (2020). Disadvantage entrepreneurship: decoding a new area of research. *European Management Review*, *17*(3), 663-668.

DOI: https://doi.org/10.17509/coelite.v2i1.57091
p- ISSN 2829-4157 e- ISSN 2829-4149

[17] Friess, E., and Boettger, R. K. (2021). Identifying commonalities and divergences between technical communication scholarly and trade publications (1996–2017). *Journal of Business and Technical Communication*, *35*(4), 407-432.

[18] Chin, J. T. (2020). Location choice of new business establishments: understanding the local context and neighborhood conditions in the United States. *Sustainability*, *12*(2), 1-17.

[19] Kimelberg, S. M., and Williams, E. (2013). Evaluating the importance of business location factors: the influence of facility type. *Growth and Change*, *44*(1), 92-117.

[20] Choi, J. O., Chen, X. B., and Kim, T. W. (2019). Opportunities and challenges of modular methods in dense urban environment. *International Journal of Construction Management*, *19*(2), 93-105.

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Verticulture Plant Monitoring System Using Internet of Things Based on Blynk Application

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ABSTRACT

The development of technology is now very rapid. One of them is the use of the internet of things in various fields. One of the applications of technology that is developing in the world including in Indonesia is in agriculture. In this field, there is a model of how to grow plants verticulturally that utilizes limited land. In agriculture, the verticulture cropping technique known as vertical cropping requires optimal soil moisture through proper watering. So an automatic monitoring process is needed to measure soil moisture, air humidity to plant temperature. In this study focused on optimizing the automatic monitoring system using the blynk application compared to ordinary monitoring. This research also encourages further exploration of the use of micro controllers and internet of things technology in agriculture.

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Monitoring system,
NodeMCU,
Vertikultur.

1. INTRODUCTION

Food availability is a staple considering that the longer the population increases. One form of increasing food sufficiency is by utilizing yard land outside the original agricultural land. In urban areas, the problem faced is limited land area [1]. Limited ownership of yard land is a result of the increasing price of land in urban areas. One way of cultivation that the community can apply to limited land conditions is vegetable cultivation with verticulture techniques [2].

In the process of verticulture cultivation, watering is one of the treatments that need to be done[3]. Providing sufficient water is an important factor for plant growth, because water affects soil moisture[4]. Crop production is inseparable from soil moisture which is influenced by water availability where this soil moisture will affect the plant growth process[5]. Not precisely the process of watering plants will cause production results not to be optimal or can even make plants die. Watering is traditionally considered less effective and inefficient because it does not save time and tends to be excessive in meeting water needs. If too much water at the time of watering will result in higher moisture in the soil which causes the plant to rot [6]. To deal with these problems, the development of technology allows us to create a system where the system will work automatically and we can monitor the state of our plants without worrying about plants will lack water or excess water[7].

The technology is the internet of things with the support of three important parts: mechanics, hardware (electronics) and control algorithms. The three parts interact with each other and cannot be separated into one system [8]. One of the electronic circuits that can be used for controllers is a micro controller. A micro controller is a small computer that includes a micro processor, memory, input/output lines, and other devices [9]. One such model is the NodeMCU ESP8266. NodeMCU is a micro controller board designed with ESP8266 Wifi chip that can be used to connect micro controller to Wifi network [10]. Micro controllers can run as desired when a program has been stored in it[11]. In running it, especially in the monitoring system, a sensor is needed[12]. Because the micro controller receives input from sensors, that is, information from the environment, and sends the output signal to the actuator, which can have an effect on the environment[13].

One of the sensors needed in this study is the YL sensor. This sensor is known as a soil moisture sensor[14]. This sensor operates by detecting moisture around the soil by displaying its temperature [15]. Another sensor is the DHT11 sensor which is a sensor module that can detect the temperature and humidity levels of an object with analog voltage output[16]. This information can be processed using a micro controller. DHT11 sensors typically feature accurate calibration for temperature and humidity readings [17]. The calibration data is stored in the OTP program memory, which is also known as the calibration coefficient [18]. Furthermore, the water flow sensor or known as the waterfall sensor. The sensor is made of plastic and has a rotor and Hall Effect sensor. The rotor will rotate as water flows through it[19]. This rotational speed will correspond to the amount of water flowing through the propeller [20]. In addition to sensors, blynk applications and supporters are also needed, power supplies, to several supporting tools to create a framework in building verticulture plant models.

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2. METHODS

In the implementation of system design, tools, meeting functional and non-functional needs, until the implementation of the system researchers use the prototype method. **Figure 1.** shows the diagram flow of the prototype method.

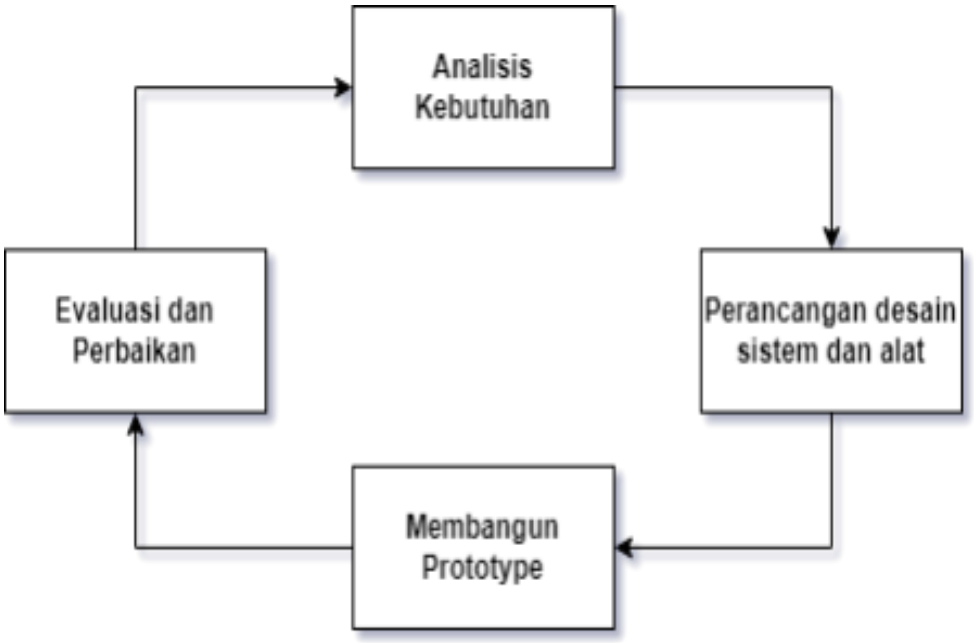


Figure 1. Prototype method.

2.1. Needs analysis

In this analysis, the author determines what needs are needed for the process of making the system in this study. Needs including functional and non-functional needs fall into this stage. The functional need in this study is that the system made must be able to read soil moisture, air humidity and temperature data on the media. Non-functional needs will be provided software and supporting hardware, internet access and location as well as ease of support for system use.

2.2 Design of systems and tools

In the design of systems and tools, researchers design systems and design tools to be built. In the process of making a hardware circuit system design and also a prototype architecture design on the system. The stage begins with designing the interface according to the functional needs of the software. This display design uses mock-up service provider software and uses flowcharts as system design. The interface design consists of mobile and web equipped with database design. Before designing an interface, the workflow of the system work flowchart must first exist. So that when designing the interface it will be easier to identify what kind of features are in the system later. **Figure 2.** shows the system workflow consisting of application and sensor needs.

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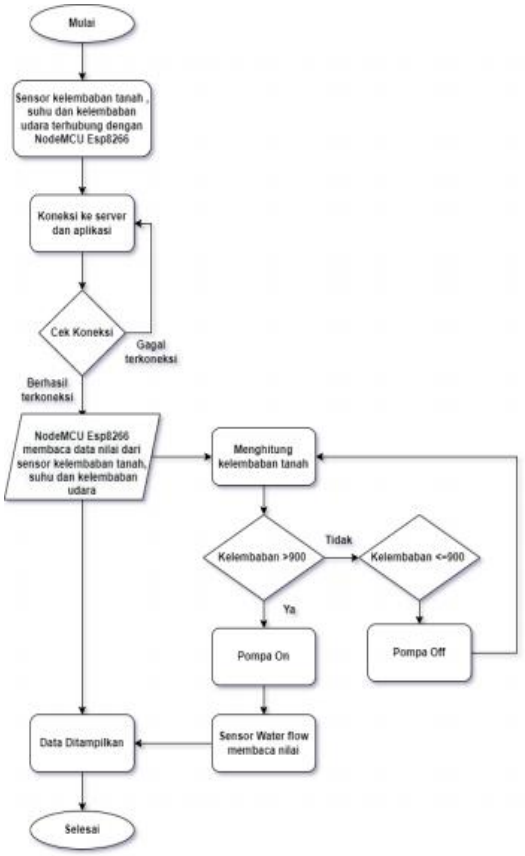


Figure 2. System workflow.

When data is displayed in the application, the application must contain the contents of the sensor consisting of soil moisture, temperature value and air humidity value of a medium. The sensor will later be connected to the Android mobile which will then be displayed to the screen through the intermediary blynk app. **Figure 3.** shows the system architecture of how the blynk app connects with sensors.

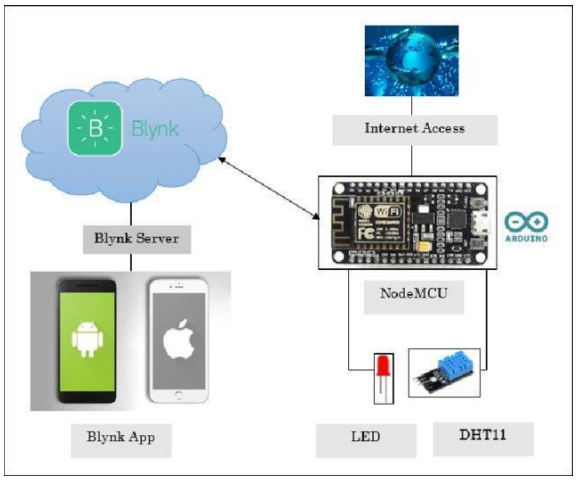


Figure 3. Bylnk app.

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After knowing the workflow of the system, proceed to know the flow of flowcharts and mobile interfaces. In the android flowchart, the system must display the main monitoring menu containing the results of sensor data. Mobile will read and display data through the mobile phone sent by sensors. The design of the mobile interface must match the state of the existing flowchart flow. The design should describe and display the actual state of the system. **Figure 4.** shows flowchart for design and mobile interface that will later be implemented in building a prototype.

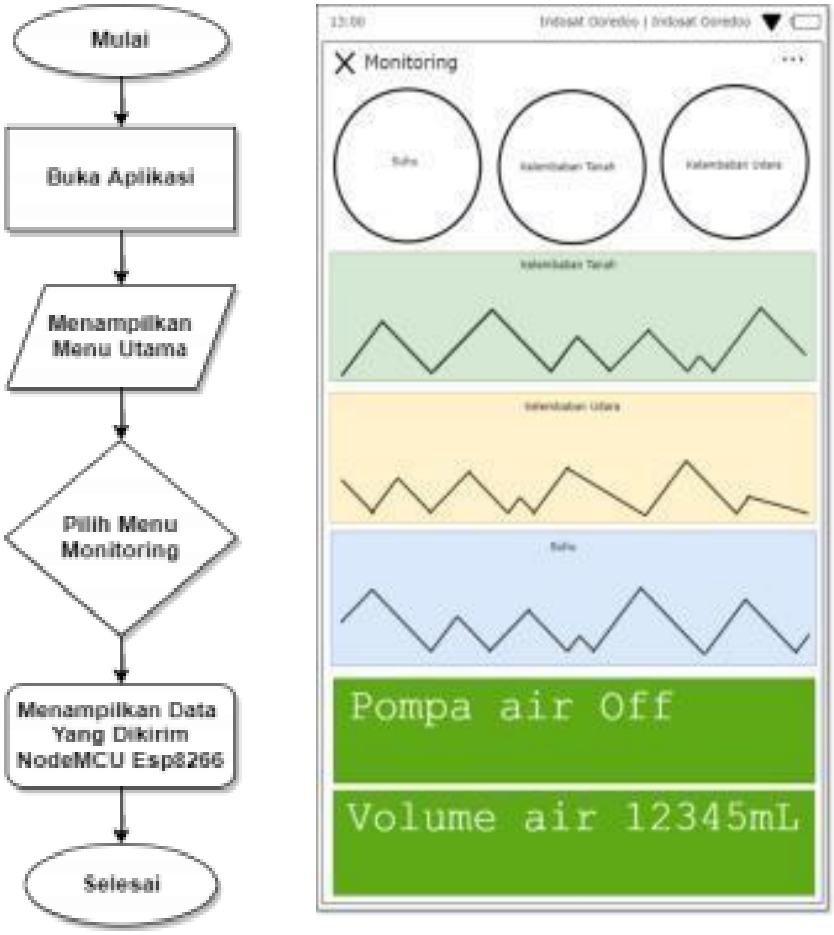


Figure 4. (Left) Android system workflow. (Right) Android interface.

Followed by the hardware design stage that combines all electronic components into one unit. Hardware design starts from assembling each component and continues to connect between a series of components with cables. **Figure 5.** shows the hardware design that will be implemented.

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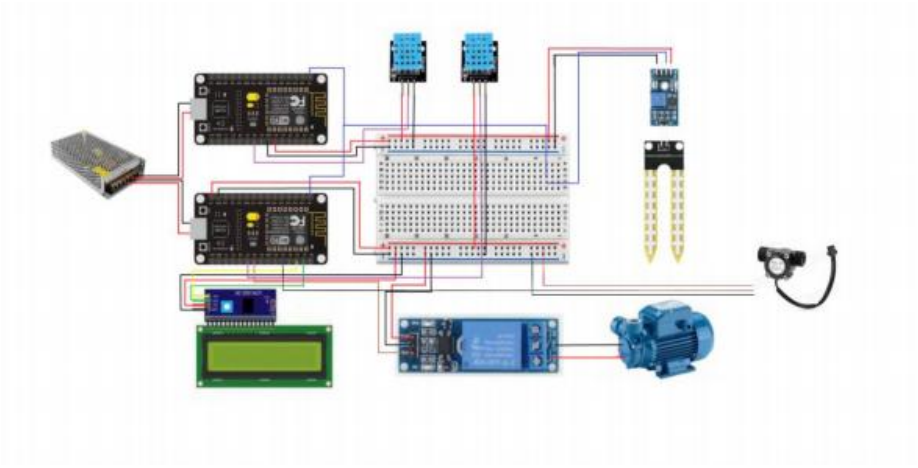


Figure 5. Hardware design.

Figure 6. shows the design of the skeleton of verticulture plants. At this stage combines the hardware design with the addition of a framework from the verticulture model plant.

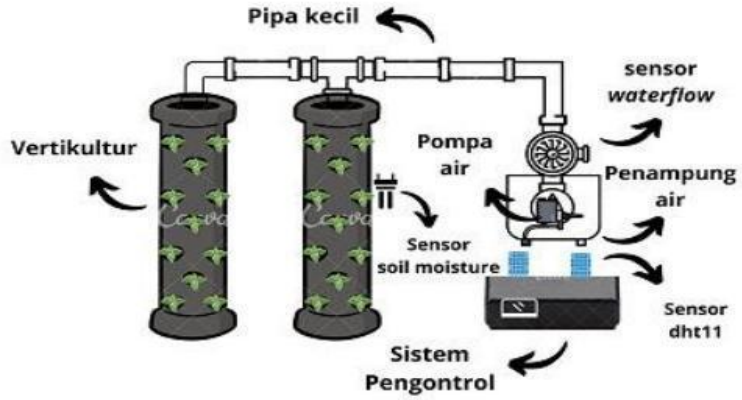


Figure 6. System architecture prototype.

2.3 Build a Prototype

This stage is a step to change from the design stage to the stage of building systems and assembling on hardware. At this stage, researchers first implement hardware components according to the needs and designs that have been designed before. After implementing the hardware components and completing the system prototype including the database in it, proceed with integrating software and hardware.

2.4 Evaluation

After all the previous stages have been carried out, the next stage is to evaluate through testing software and hardware systems. Whether the system is up and running or not. And it is connected to one another or not. This process is also the process of implementing a system that is ready to operate. So that if the system is not ready or there are still problems, immediate repairs will be made.

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3. RESULTS AND DISCUSSION

Research on prototype automatic sprinkler systems in plant cultivation verticulture based on the Internet of Things requires implementation on hardware, verticulture plant frameworks, and software. The following are the implementation results of all three.

3.1. Hardware Implementation

Hardware implementation is the execution process of the hardware design process into a system so that it can work as expected. **Figure 7.** shows the implementation of the system.



Figure 7. Hardware implementation.

Picture in **Figure 7.** is the last appearance of an automatic sprinkler system consisting of several components that have been made together, including soil moisture sensors, dht11 sensors, water flow sensors as data senders, 2 NodeMCU as system control centers, power supply as power supply, and others.

3.2. Implementation of System Architecture

The implementation of this prototype uses verticulture techniques which use 2 4 cm paralon pipes with water pipes on top. This pipe will later be given a water flow sensor that will calculate how much water flows through it. The water reservoir on this prototype is a glass water reservoir with a size of 50x30x20 cm which will be inserted 1 water pump into it. **Figure 8.** shows the whole implementation of the system along with the material that used in verticulture techniques.



Figure 8. Implementation of system architecture.

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The architecture of the system has been tested several times until the system is actually running validly. The system that is already running will be connected to the android system and the sensor test results will be displayed periodically. So there will be a test between each sensor that will be displayed for comparison.

3.3. Sensor Testing

Sensor testing is carried out with the aim of knowing whether the sensor used in the system can read data properly or not. Sensor testing is carried out by connecting all sensors to Nodemcu with the help of jumper cables. After all connected then open the ArduinoIDE software and select the serial monitor on the toolbar. Sensor testing is carried out on all sensors which include temperature sensors, air humidity sensors, soil moisture sensors, and water flow sensors, sensor test results are seen in the following figure and table.

a. Waterflow Sensor Accuracy Testing

In this test using a waterflow sensor as a counter for the discharge of water coming out of the pump. This test is carried out with the aim of determining the level of accuracy resulting from measuring water discharge without using a monitoring system and measuring water discharge using a monitoring system. This measurement is done by pumping water from the water reservoir through the waterflow sensor into a measuring cup as much as 1000 ml then matching the results of the two measurements. **Table 1.** shows the test results of the waterflow sensor.

Table 1. Waterflow sensor test results

No	Plan (ml)	Test result			
		With sensor (ml)	Error (%)	without sensor (ml)	Error (%)
1	1000	990	1 %	877	12,3 %
2	1000	1010	1 %	1217	21,7 %
3	1000	980	2 %	979	2,1 %
4	1000	1010	1 %	1057	5,7 %
5	1000	1010	1 %	1128	12,8 %
6	1000	950	5 %	1036	3,6 %
7	1000	1040	4 %	1130	13,0 %
8	1000	1020	2 %	1147	14,7 %
9	1000	990	1 %	866	13,4 %
10	1000	990	1 %	1145	14,5 %
11	1000	1000	0 %	1012	1,2 %
12	1000	1010	1 %	995	5 %
13	1000	990	1 %	997	3 %
14	1000	1000	0 %	987	1,3 %
15	1000	1000	0 %	1082	8,2 %
16	1000	990	1 %	979	2,1 %
17	1000	1030	3 %	989	1,1 %
18	1000	980	2 %	937	6,3 %
19	1000	1000	0 %	1119	11,9 %
20	1000	990	1 %	1173	17,3 %
Result		**Error Average (%)**	**1,4 %**	**Error Average (%)**	**8,2%**

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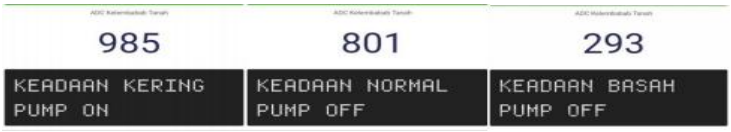
From **Table 1.**, it can be seen the results of testing waterflow sensors without a monitoring system and with a monitoring system on water with a volume of 1000 ml has an average percentage of error in discharge, which is 1.4% with sensors and 8.2% without sensors. From the table, it can be concluded that the accuracy obtained from testing the waterflow sensor to measure water discharge in measuring water discharge using a monitoring system is 98.6% and without a monitoring system is 91.8% in measuring water discharge using a monitoring system. This shows that in addition to spending energy and time to water, tests without sensors have more errors than tests using sensors.

b. Relay and pump testing

Relay and pump testing is carried out by connecting the relay to a pre-programmed NodeMCU digital pin. When soil moisture shows different ADCs then NodeMCU through digital pins will also give commands to different relays. This test can be seen directly and can also be seen through the LCD on the Android application. **Table 2.** shows the test results of the relay according to the values that read by the sensor.

Table 2. Relay and pump test results

Sensor	ADC	Circumstances	Reason	Effect	Relay
Soil moisture sensor	>900	Dry soil	Water-deficient soil can cause plants to lack nutrients and slow down the process of photosynthesis.	Make the plant wither, dry the tips of the leaves, it will even make the plant die	On
	>=600and <=900	Normal Soil	Sufficient soil will need water, not less water or excess water.	Make plants grow well and lush due to the process of photosynthesis	Off
	<600	Wet soil	Too much water soil can cause the condition of the roots to lack oxygen.	Makes the roots die, the leaves turn yellow and the stems become flabby	Off



From **Table 2.**, it can be concluded that the relay and pump testing on the automatic sprinkler system runs according to the planned soil moisture test data.

c. Testing real time monitoring

At this stage, testing is carried out on the monitoring system to find out whether this system can display time in real-time or close to real-time with a slight delay. This test was carried out by observing 20 data which was then displayed on the homepage of the android application. **Table 3.** shows the test results with the average delay time of the system.

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Table 3. Test results and the delay time average

No	Temperature	Air humidity	Soil moisture	Time	Delay (seconds)	Real-time description
1	26.20	69	711	23:31:10	1	fix
2	26.20	69	716	23:31:12	2	delay
3	26.20	69	715	23:31:14	2	delay
4	26.20	69	711	23:31:15	1	fix
5	26.20	69	716	23:31:16	1	fix
6	26.20	69	717	23:31:18	2	delay
7	26.20	69	712	23:31:19	1	fix
8	26.20	69	717	23:31:21	2	delay
9	26.20	69	717	23:31:23	2	delay
10	26.20	69	712	23:31:24	1	fix
11	26.20	69	717	23:31:26	2	delay
12	26.20	69	718	23:31:28	2	delay
13	26.20	69	714	23:31:29	1	fix
14	26.20	69	716	23:31:31	2	delay
15	26.20	69	716	23:31:33	2	delay
16	26.20	69	711	23:31:34	1	fix
17	26.20	69	711	23:31:35	1	fix
18	26.20	69	712	23:31:37	2	delay
19	26.20	69	712	23:31:39	2	delay
20	26.20	69	708	23:31:40	1	fix
Delay average					1,55 seconds	

From **Table 3.**, it was found that the monitoring system in this study can be said to be close to real-time with the results of the time delay on the Android application is an average of 1.55 seconds.

3.4. Implementation of the android system

The implementation of the android application is the final result after carrying out the application design process along with the application interface. The display of the android application is useful as a medium for exposing information in the form of unit data, graphics or information in the form of text. The data can be displayed in the android application when the data that has been uploaded by NodeMCU is stored on the server. The display on this android application can be seen when the user has an account and also has access to open the application that has been created.

From the sensor test above, the sensor test results will be sent and received, then will be displayed by the android system. The display of data corresponds to the sensor and the results to be displayed are in real time. **Figure 9.** shows the implementation of the android application using Blynk that described the data view.

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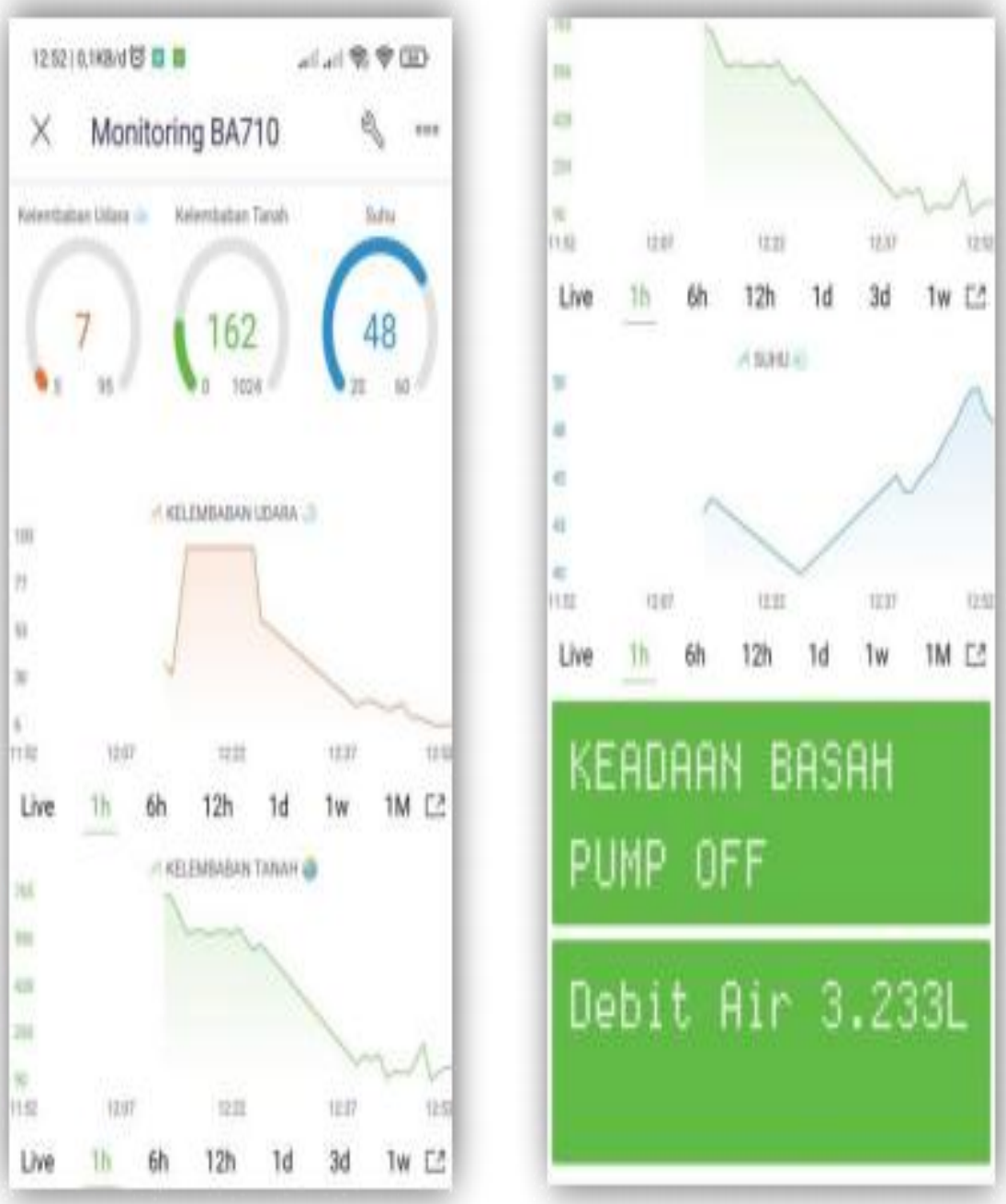


Figure 9. Android implementation.

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In tests carried out on the monitoring system on the homepage of the application built, the android application successfully displays the data that has been received from the micro controller. **Table 4.** shows the test results of the android application using the Black Box software testing method.

Table 4. Android testing.

Variable Test Data	Result	
	Expected Result	Testing Result
Temperature monitoring graph	Display average temperatures	Successes [√] It didn't work [ ]
Air humidity monitoring graph	Display air humidity graph	Successes [√] It didn't work [ ]
Soil moisture monitoring graph	Display soil moisture graph	Successes [√] It didn't work [ ]
Water discharge data monitoring to android	Displays information in the form of water discharge text	Successes [√] It didn't work [ ]

4. CONCLUSION

In the research of automatic sprinkler systems on verticultural plant cultivation based on the Internet of Things with the prototype method, a prototype of the skeleton architecture of verticultural plants and automatic sprinklers was successfully made. In addition, the monitoring system has been tested on the android application through the blynk app application. The tests that have been carried out resulted in 98.6% for water discharge monitoring measurements and a delay of 1.55 seconds for real time testing.

6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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p- ISSN 2829-4157 e- ISSN 2829-4149

7. REFERENCES

[1] Kusumo, R. A. B., Sukayat, Y., Heryanto, M. A., dan Wiyono, S. N. (2020). Budidaya sayuran dengan teknik vertikultur untuk meningkatkan ketahanan pangan rumah tangga di perkotaan. *Dharmakarya: Jurnal Aplikasi Ipteks untuk Masyarakat*, *9*(2), 89-92.

[2] Hendri, M., Rozirwan, R., Apri, R., and Handayani, Y. (2018). Intensification of seaweed cultivation euchema cottonii with verticulture method in the water of Kelagian Island, Lampung bay. *International Journal of Marine Science*, *8*(14), 114-126

[3] Ariati, P. E. P. (2017). Produksi beberapa tanaman sayuran dengan sistem vertikultur di lahan pekarangan. *Jurnal Agrimeta*, *7*(13). 76-86

[4] Wigmore, O., Mark, B., McKenzie, J., Baraer, M., and Lautz, L. (2019). Sub-metre mapping of surface soil moisture in proglacial valleys of the tropical Andes using a multispectral unmanned aerial vehicle. *Remote Sensing of Environment*, *222*(1), 104-118.

[5] Sudarmaji, A., Supriyo, H., and Widodo, A. (2020). Simple parallel probe as soil moisture sensor for sandy land in tropical-coastal areas. *Pertanika Journal of Science and Technology*, *28*(3), 829-838.

[6] Fuadi, S., dan Candra, O. (2020). Prototype alat penyiram tanaman otomatis dengan sensor kelembaban dan suhu berbasis arduino. *JTEIN: Jurnal Teknik Elektro Indonesia*, *1*(1), 21-25.

[7] Rajakumar, G., Sankari, M. S., Shunmugapriya, D., and Maheswari, S. U. (2018). IoT based smart agricultural monitoring system. *Asian Journal of Applied Science and Technology (AJAST)*, *2*(2), 474-480.

[8] Goap, A., Sharma, D., Shukla, A. K., and Krishna, C. R. (2018). An IoT based smart irrigation management system using machine learning and open source technologies. *Computers and Electronics in Agriculture*, *155*(1), 41-49.

[9] Abdullah, A., Cholish, C., dan Haq, M. Z. (2021). Pemanfaatan IoT (internet of things) dalam monitoring kadar kepekatan asap dan kendali camera tracking. *CIRCUIT: Jurnal Ilmiah Pendidikan Teknik Elektro*, *5*(1), 86-92.

[10] Arini, D., dan Kumara, P. W. (2019). Robot line follower berbasis mikrokontroller arduino uno atmega328. *INFORMANIKA*, *5*(1). 18-25

[11] Dalimunte, B., dan Sitorus, P. (2021). Pengembangan prototype traffic light mikrokontroler berbasis rduino mega pada mata pelajaran teknik pemrograman mikroprosesor dan mikrokontroler di SMK negeri 1 Percut Sei Tuan. *JEVTE: Journal of Electrical Vocational Teacher Education*, *1*(1), 10-17.

[12] Raut, M., Shete, G., Shinde, V., and Suryawanshi, A. (2019). Automatic mini CNC machine for pcb drawing using arduino. *International Research Journal of Engineering and Technology (IRJET)*, *6*(6), 310-314.

[13] Maroli, A., Narwane, V. S., and Gardas, B. B. (2021). Applications of IoT for achieving sustainability in agricultural sector: a comprehensive review. *Journal of Environmental Management, 298*(1), 1-8.

[14] Purwanti, S., Febriani, A., Mardeni, M., and Irawan, Y. (2021). Temperature monitoring system for egg incubators using raspberry pi3 based on internet of things (IoT). *Journal of Robotics and Control (JRC)*, *2*(5), 349-352.

DOI: https://doi.org/10.17509/coelite.v2i1.57108
p- ISSN 2829-4157 e- ISSN 2829-4149

[15] Bhatnagar, V., Chandra, R., and Prasad, J. (2019). Soil moisture sensors for sustainable irrigation: comparison and calibration. *International Journal of Sustainable Agricultural Management and Informatics*, *5*(1), 25-36.

[16] Mardika, A. G., dan Kartadie, R. (2019). Mengatur kelembaban tanah menggunakan sensor kelembaban tanah YL-69 berbasis arduino pada media tanam pohon gaharu. *JoEICT (Journal of Education and ICT)*, *3*(2), 130-14.

[17] Srivastava, D., Kesarwani, A., and Dubey, S. (2018). Measurement of temperature and humidity by using arduino tool and DHT11. *International Research Journal of Engineering and Technology (IRJET)*, *5*(12), 876-878.

[18] Shrestha, R. (2019). Study and control of DHT11 using atmega328P microcontroller. *International Journal of Scientific and Engineering Research*, *10*(4),518-521.

[19] Rangan, A. Y., Yusnita, A., dan Awaludin, M. (2020). Sistem monitoring berbasis internet of things pada suhu dan kelembaban udara di laboratorium kimia XYZ. *Jurnal E-Komtek*, *4*(2), 168-183.

[20] Harija, H., George, B., and Tangirala, A. K. (2021). A cantilever-based flow sensor for domestic and agricultural water supply system. *IEEE Sensors Journal*, *21*(23), 27147-27156.

DOI: https://doi.org/10.17509/coelite.v2i1.57108
p- ISSN 2829-4157 e- ISSN 2829-4149