Caisim Growth Model Using Smart Farm IoT-Based Machine Learning

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Abstract*— Indonesia is a developing country where the majority of people still work as farmers. The caisim plant is one of the most extensively farmed plants. Caisim production increases year after year. Farmers, on the other hand, have been unable to satisfy the demands of a very high market demand because they frequently encounter crop failure due to caisim plants harmed by pests and diseases. The difficulties encountered are due to the scenario for remote plant monitoring and a lack of understanding about growth parameters in caisim plants. Based on these issues, the development of a website and growth prediction model will provide a solution for producing caisim plants with optimal growth. When measuring QoS (Quality of Service) for data transmission from the tool to the website, the average latency was 371,57 ms. During the QoS test, the average throughput for reading data from the device to the database was 3469,14 bit/s. Meanwhile, data for the plant growth prediction model was retrieved from the website and converted to a CSV file dataset. In this prediction model, the KNN approach was used. This algorithm will generate classification results in the form of optimal and non-optimal values for each characteristic used.

***Keywords* — smart farm, caisim, MySQL, machine learning, IoT.**

I. INTRODUCTION

Caisim (Brassica juncea L.) is a vegetable plant with a sub-tropical climate, but is able to adapt well to a tropical climate. Caisim is generally planted in the lowlands, but can also be planted in the highlands. Caisim is a plant that is tolerant of high temperatures (heat). At present, the need for caisim is increasingly increasing along with the increase in the human population and the benefits of consuming it for health. Caisim itself has a high economic value after crop cabbage, flower cabbage and broccoli[1].

Ongoing advancements in ICT offer tremendous possibilities for farm-level data management. Farmers can monitor their farms with unprecedented levels of precision, in a variety of dimensions, and in near real-time, thanks to sensing technologies, at least in theory. This opens up the intriguing possibility of developing farmspecific models that individual farmers can use to plan their activities in response to changing circumstances, allowing them to explore the various trade-offs inherent in any decision-making process while also addressing the problem of information overload. For the rest of this paper, we'll look at how modeling has progressed, as well as the technology required to build farm-specificmodels[2].

II. THEORITICAL REVIEW

A. Internet of Things

Internet of Things is the concept of connecting any device to the Internet and to other connected devices. The IoT is a giant network of connected things and people all of which collect and share data about the way they are used and about the environment around them [3].

That includes an extraordinary number of objects of all shapes and sizes from smart microwaves, which automatically cook your food for the right length of time, to self driving cars, whose complex sensors detect objects in their path, to wearable fitness devices that measure your heart rate and the number of steps you've taken that day, then use that information to suggest exercise plans tailored to you. There are even connected footballs that can track how far and fast they are thrown and record those statistics via an app for future training purposes[4].

Devices and objects with built in sensors are connected to an Internet of Things platform, which integrates data from the different devices and applies analytics to share the most valuable information with applications built to address specific needs. With the insight provided by advanced analytics comes the power to make processes more efficient. Smart objects and systems mean you can automate certain tasks, particularly when these are repetitive, mundane, time-consuming or even dangerous.

B. Smart Farm

Smart farming is a management concept focused on providing the agricultural industry with the infrastructure to leverage advanced technology including big data, the cloud and the internet of things for tracking, monitoring, automating and analyzing operations. Smart farming is growing in importance due to the combination of the expanding global population, the increasing demand for higher crop yield, the need to use natural resources efficiently, the rising use and sophistication of information and communication technology and the increasing need for climate-smart agriculture [5].

C. Hardware

Hardware is best described as any physical component of a computer system containing a circuit board, ICs, or other electronics like machine learning. A perfect example of hardware is the screen on which you are viewing this page. Whether it be a monitor, tablet, or smartphone, it is hardware[6].

A small computer board working on the Linux operating system, which connects to a computer monitor, keyboard, and mouse. Raspberry Pi can be applied to an electronic structure and programming network work. It can also be served as a personal computer and Apache Webserver, MySQL could be installed on the board [7].

Figure 1 Raspberry Pi 3B+

The YL-69 hygrometer sensor is an electrical resistance sensor that consists of two electrodes. It works by passing a current across the two electrodes through the soil and returns the resistance measurement for soil moisture content determination [8].

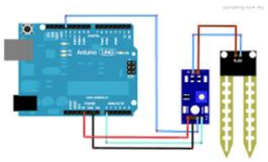


Figure 2 YL-69

The water pump is a mechanical device that can move fluids by sucking or by applying pressure. If we pay attention to the water pump, there are two primary components that we will find. First, the motor is the pump's driving force, and a pump is a tool that transports or moves water [9].

Figure 3 Water Pump

Relay is an electronic component in the form of an electric switch or switch that is operated electrically and consists of 2 main parts, namely electromagnets and mechanics. This electronic component uses the electromagnetic principle to move the switch so that a small electric current can deliver higher voltage electricity. The following is a symbol of the relay component [10].

Figure 4 Relay

A type of ADC that has a resolution of 16 bits. In this ADC, four channels can convert the value of 4 sensors at once with bipolar and single differentials. This ADC feature is an onboard reference and oscillator. The data received will be transferred or sent via I2C communication consisting of SCL and SDA [11].

Figure 5 ADS1115

A light sensor module based on the BH1750 IC. BH1750 is a light sensor IC with IC interface. This module provides digital output values via the IC bus, so you don't need to add an ADC converter anymore [12].

Figure 6 GY-302 BH1750

DHT22 is a digital sensor consisting of a thermistor and a capacitive sensor for determining the humidity. The DHT22 sensor measures both temperature and humidity in the room. The working temperature is 40°C - 80°C, and the humidity 11 range is from 0-100%. The temperature has an accuracy of 0.5° C and the humidity [13].

Figure 7 DHT22

D. Caisim

Green mustard is one of the popular leaf vegetables in Indonesia. Another name is mustard meatballs or caisim. When entering the reproductive stage, the stem will grow elongated and the leaves getting smaller and smaller and end with flower infloresens. caisim contains calcium, potassium, iron, vitamin B2, magnesium, as well as phosphorus. Cooked caisim has higher vitamin A levels reaching 96% AKG. Levels of vitamin K and copper in it also increased [14].

Figure 8 Celery Plant

It is important for room temperature for growth caisim, each plant has a different room temperature to get good growth results. The ideal room temperature for growing this vegetable caisim is between 15C-32C [15].

In growth caisim, soil, water, and humidity have a very important role in its growth. required 80%-90% humidity and 80 soil moisture, this plant needs water all the time but does not overwhelm the plants as well as the soil[16].

This vegetable growth caisim requires room humidity around 80-90, caisim is required to be wet but not to be flooded by water, if this vegetable caisim is not suitable with humidity, then the results will not be produced. good, this caisim requires 80-90 soil moisture, caisim is required to be wet but not flooded by water, if this vegetable caisim is not suitable for moisture, the results will not be good [17].

Mustard greens need 4-5 hours of sunlight with a light intensity of 1000-1720 lux, the light intensity itself can vary depending on the situation and also the conditions around it [18].

E. Database

A database or database is a collection of information stored on a computer systematically so that it can be checked using a computer program to obtain information from the database. The main use of the database system is so that the user is able to compile a view of data abstraction [19].

A relational database management system (RDBMS) is a program that allows you to create, update, and administer a relational databaseIt uses a structure that allows us to identify and access data in relation to another piece of data in the database. Often, data in a relational database is organized into tables [20].

Mysql here is used to run the codingan database that has been made, here it is used to find out the temperature and humidity of the plants in the green house [21].

F. Machine Learning

Machine learning is a branch of artificial intelligence focused on building applications that learn from data and improve their accuracy over time without being programmed to do so. The better the algorithm, the more accurate the decisions and predictions will become as it processes more data [22].

Supervised learning is a method used to enable machines to classify objects, problems or situations based on related data fed into the machines. Supervised learning is used to provide product recommendations, segment customers based on customer data, diagnose disease based on previous symptoms and perform many other tasks [23].

A data set is a collection of related, discrete items of related data that may be accessed individually or in combination or managed as a whole entity. A data set is organized into some type of data structure [24].

The working principle of K-Nearest Neighbor (KNN) is to find the shortest distance between the data to be evaluated and the K closest neighbors in the training data[25]. This technique belongs to the nonparametric classification group. This technique is very simple and easy to implement. Similar to the clustering technique, we group a new data based on the distance of the new data to some data/nearest neighbors [26].

G. Python

Python an interpreted, object oriented, high-level programming language with dynamic semantics. Its high level built in data structures, combined with dynamic typing and dynamic binding, make it very attractive for Rapid Application Development, as well as for use as a scripting or glue language to connect existing components together [27].

H. Wireshark

Wireshark is a free and open-source packet analyzer. It is used for network troubleshooting, analysis, software and communications protocol development, and education. It runs on all popular computing platforms, including Unix, Linux, and Windows [28].

I. Quality of Service

Quality of Service is a measure of how well the network is and attempts to determine the characteristics, nature of services and attempt to define a service’s characteristics. QoS is designed to help end-users be more productive by ensuring that end-users get reliable performance from network-based applications [29].

Delay is the time it takes for a packet to be sent from a device to the destination device. To find the delay in the transmitted packet by dividing the length of the packet divided by the link bandwidth [30].

Throughput is the actual bandwidth measured at a certain measure of time in transmitting files. Different from bandwidth even though the unit is the same bits per second, but throughput better describes bandwidth at a time and in certain conditions and networks used to download a file of a certain size [31].

J. Confusion Matrix

The Confusion Matrix is a machine-learning-powered visual assessment tool. The columns of the Confusion Matrix represent projected class results, whereas the rows represent actual class results. It lists the possible causes of a classification difficulty. Additionally, the Confusion Matrix is a well-known decision-making technique in supervised machine learning. It is independent of the categorization method used and demonstrates the extent to which algorithms misunderstand certain classes[32].

K. Classification Report

A summary of the performance characteristics of a classifier computed using a fixed-size test set with both positive and negative occurrences. Any classifier is infinitely useful. Numerous performance metrics are utilized to analyze the observed classifier, which is defined by the existence of correct positive and false positive rates and is the source of all other performance metrics[33].

III. METHOD

A. The Workflow of Internet of Things

This phase is used to generate the model's input technique. Calibration of all new components and sensors isthe initial stage. The following components and sensors are DHT22 sensor measures the humidity and temperature in the greenhouse, BH-1750 sensor measures the greenhouse light intensity, YL-69 sensor measures each pot's soil moisture value, Relay as an automated electrical switch for irrigation automation, ADC ADS1115 is used as a converter to transform the sensor's analog to digital value, Water pump is used to transfer water from a tank to a plant.

Three distinct types of sensors are employed in this thesis to collect data from each observation pot and greenhouse. The components will be on standby 24 hours a day, during the times of greatest plant water irrigation demand. On the other hand, the sensor will collect data for nine days at a rate of one pixel per second. The ADC ADS1115 transforms analog to digital data immediately.

The characteristics of sensor-equipped components vary according to their intended function. The ADS1115 is a three-in-one integrated circuit that includes a relay, a water pump, and an ADC. Due to the fact that it serves as the foundation for the automated watering system. If the sensor detects insufficient water supply, it activates the relay and sends a signal to the water pump. Following that, the water pump is used to irrigate the celery plant until the water level returns to normal. When the sensor detects an adequate amount of water demand, the accompanying tools become obsolete.

The following figure 9 illustrates the operation of the automation system ona smart farm. As a result of this technology, the community will be able to control plant development and receive ideal yields.

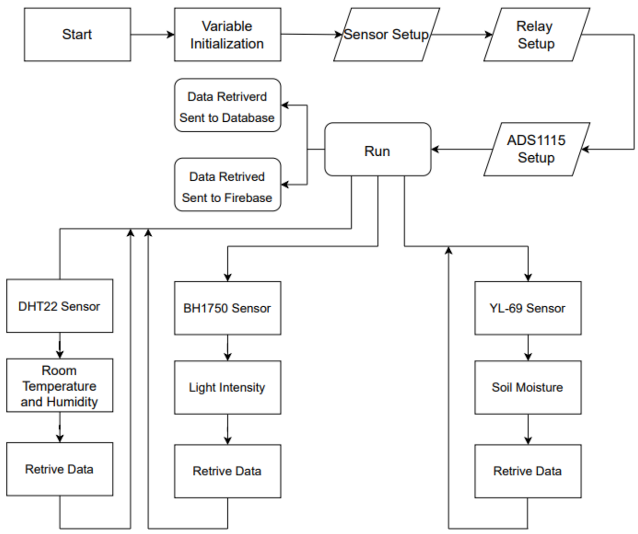


Figure 9 The internet of things hardware workflow

B. The Workflow of MySQL Database

Every minute, the Raspberry Pi sends the acquired data to the database. To keep the database's maximum storage size to a minimum, the projected schedule recommends obtaining extra data for model creation. MySQL is a relational database management system (RDBMS) comprised of three distinct components:

1. Caisim 1'sgroup takes into the date, time, and soil moisture from the first caisim plant seen.
2. Caisim 2's group takes into the date, time, and soil moisture from the second caisim plant seen
3. Caisim 3's group takes into the date, time, and soil moisture from thethird caisim plant seen.
4. Caisim 4's group takes into the date, time, and soil moisture from the fourth caisim plant seen
5. Caisim 5'sgroup takes into the date, time, and soil moisture from the fifth caisim plant seen.
6. The set of room conditions includes date-time, greenhouse humidity, temperature, and light intensity.

C. The Workflow of Prediction Model

Machine learning is anticipated to make predictions based on previously unseen data. To obtain the optimal outcome from the model projection, a large amount of data must be used to create the prediction. The architecture of the prediction model is separated into seven stages of machine learning, as illustrated in Figure 10: Problem formulation, data mining, data preparation, data visualization, data modeling, hyper parameter tuning, and model deployment.

The stages begin with the formulation of the problem. The problem solution formulation takes into account the type of data used as input. This thesis makes use of both categorical and continuous data. The anticipated output is the string representing the type of plant condition label. This system will focus on categorical attributes in order to produce a forecast based on the problem analysis. The second stage is data collection. The technique entails mining datasets from scratch in the 21 database and adding the values of manual observation attributes to complete the dataset.

Following that comes the stage of data preparation. This stage involves theprocess of separating the dataset from various sources of interference. The dataset is then suitable for model construction. The fourth dataset is a data visualization tool for quickly comprehending and comparing attribute information that may be used to create models. As the fifth step of model development, data modelling is critical because the prediction result is dependent on the learning and testing operations conducted using the machine learning algorithm of the classification approach created from the features of the chosen dataset to get insights. Additionally, the ratio of train to test is deemed decisive.

The sixth stage is known as hyper parameter tuning or model evaluation. To evaluate the model, a prediction based on the percentage of test data to train data must be generated. To make model evaluation more intuitive, the system makes advantage of the accuracy and precision parameters of performance indicators. The final stage is deployment of the model. Unseen examples are used as the input for the model's prediction function.

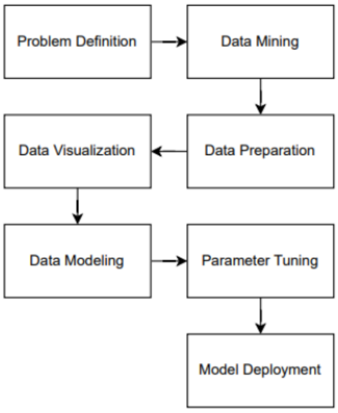


Figure 10 the prediction model workflow

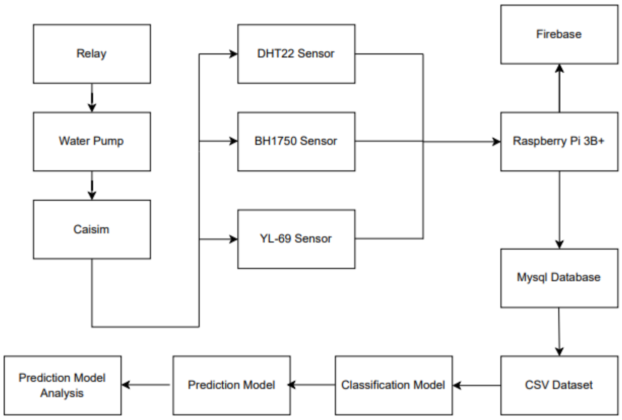
D. The Diagram Block

The diagram block in this thesis progresses from component calibration and sensor calibration to an analysis of the global system as a whole. The workflow design is organized into three stages of technical utilization to provide a comprehensive system explanation: IoT, MySQL database, and machine learning. Figure 3.3 illustrates the entire model building system.

The Internet of Things begins with the operation of the components and sensors needed to collect practical plant data. There is one gadget and three extra units, each of which contains a sensor. The database used to store the data obtained during the observation is one of the widely used RDBMS solutions. Finally, to leverage the information in the future, machine learning algorithms are employed to forecast previously unseen situations based on the input data.

The associated section of this chapter discusses the application of relevant parameters as one of the system's phases. It began with the application and device requirements system for executing the selected system architecture in addition to the IoT device, which is the laptop. The gathering of sensor data, which will be stored in a single file with the extension CSV, will also be described, as well as the utilization of available attributes based on sensor data and manual observation. The strategy for separating the datasets used to create the model and the sort of learning algorithm used will also be discussed. In terms of performance, this parameter analysis will be evaluated against the technology, the quality of service (QoS) for data transmission from the Raspberry Pi to the localhost, and classification metrics for the model's output. The overall analysis is conducted using the data acquired throughout each phase. This stage will be written in order to completely compile the thesis book.

Figure 13 The diagram block



IV. RESULT AND ANALYSIS

A. Device Functionality Check

This check seeks to identify the state of each component that has been attached on the raspberry pi is working properly. A system check will be performed on the raspberry pi at this time to see if the functionalities on the raspberry pi is working properly.

Table 1 The hardware test

No.	Device Function	Result
1	Raspberry Pi is connected and can transfer data to the website	Valid
2	Device integration on the Raspberry Pi 3B+ like DHT 22 sensor, YL-69 sen-sor, and BH-1750 sensor	Valid
3	The relay automatically switched on when the plant status is not optimal	Valid
4	The water pump automatically switched on if the relay is on and offif the relay status is off	Valid

B. Website Functionality Check

This check seeks to identify the state of each feature that has been built and is working properly. A system check will be performed on the website at this time to see if the functionalities on the website can display information gathered from sensors.

Table 2 The database page test

No.	Test Stage	Description	Result
1	The page shows website dashboard page	Dashboard page dis- played	Valid
2	The dashboard page displays room con- dition information	The dashboard page has successfully dis- played information on the room humidity and temperature and the light intensity in the room	Valid
3	The dashboard page displays information on the condition of the caisim plant	The dashboard page successfully displayed information on the soil moisture status	Valid

Based on the information of test the results, the website can display all of the information required.

C. The Quality of Service Test

A check will be carried out at this step to determine the network's quality from the database to the website that has been constructed using Quality of Service characteristics such as delay and throughput.

According to wireshark software test results, the average delay is 371.57 ms, with the highest value of 381 ms on day 1 and the lowest value of 358 ms on day 6. The delay is categorized as average based on the results of this test, with a valueof 300 - 450 ms

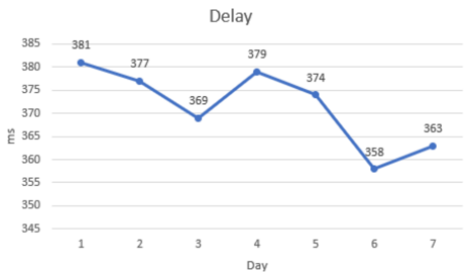


Figure 14 The delay check

According to wireshark software test results, the average throughput is 3469,14 bits/s, with the highest value of 3803 bit/s on day 6 and the lowest value of 3195 bit/s on day 1. The delay is categorized as very good based on the results of this test, with a value of > 2100bit/s.

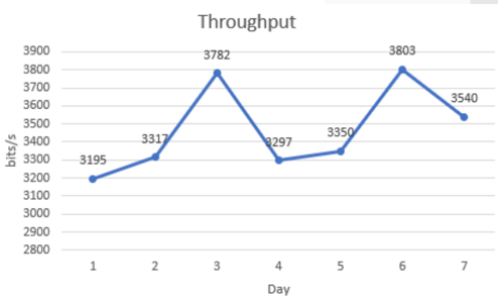


Figure 15 The throughput check

D. Accuracy Score

The analysis of this metric is to inform the accuracy score of the prediction model. Figure 4.13 showsthat the accuracy score of this prediction model is 98.61% in the form of float type data and the score shows that the main purpose is achieved.

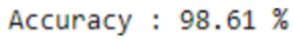


Figure 16 accuracy score

E. Confusion Matrix

Confusion Matrix is needed in order to be able to calculate performance parameters in the classification table, such as accuracy, precision and recall. Figure 4.12 shows the number of predictions made for the classification.

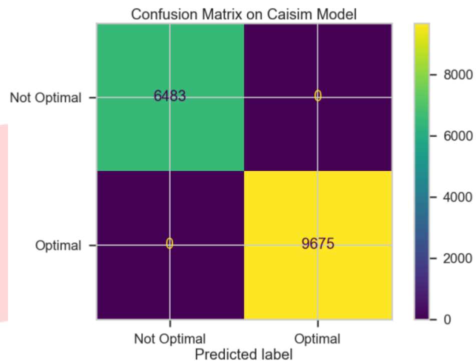
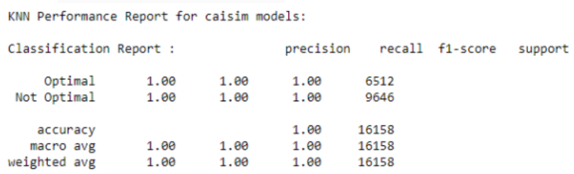


Figure 17 The confusion matrix

F. Classification Report

At this stage isthe final analysis derived from the Confusion Matrix. Figure 4.14 shows the value of the performance parameters that are considered in determining 40 the prediction model. There are 2 classification labels that are read according to the initial dataset used, namely optimal and not optimal.



KNN Performance Report for caisim models:

Classification Report :

	precision	recall	f1-score	support
Optimal	1.00	1.00	1.00	6512
Not Optimal	1.00	1.00	1.00	9646
accuracy			1.00	16158
macro avg	1.00	1.00	1.00	16158
weighted avg	1.00	1.00	1.00	16158

Figure 18 The classification report

V. CONCLUSION

These are the conclusions drawn from this thesis prior chapter. Following are the author conclusions:

1. The monitoring system at the caisim plant is functioning properly, and the raspberry pi data can be stored in the database and monitored viawebsite.
2. In analyzing the monitoring results, it was discovered that the greenhouse's room temperature, room humidity, and light intensity were affected by uncertain weather conditions. However, the weather did not harm the plants because they were contained in a greenhouse.
3. In QoS testing for sending tool data to the website the average value of delay obtained is 371.57 ms meanwhile the average throughput is 3469,14bit/s.
4. The processed data is derived from the conditions of five caisim plants. The monitored website has been thoroughly tested, and all of its features are

operable. The accuracy of the prediction model classification report has a 98,61% score.

5. The model anticipated that only the Not Optimal label data would be met, given that the Less Optimal label data in the test data had much more data than the Optimal label data (9646 by 6512 instances). This prediction turned out to be accurate.

Several flaws in the system that has emerged can be used as research material in the future, including:

1. Add pH sensor to measure acidity of the soil
2. Install camera to monitor the plant growth.
3. Add Ultrasonic sensor to measure the plant height.

REFERENCE

[1] R. Rukmana, “Bertanam petsai dan sawi,” Yogyakarta: Kanisius, 1994.

[2] E. Margiyanto, “Budidaya tanaman sawi,” Bantul: Cahaya Tani, 2008.

[3] M. J. O’Grady and G. M. O’Hare, “Modelling the smart farm,” Information processing in agriculture, vol. 4, no. 3, pp. 179–187, 2017.

[4] “Ieee draft standard for framework of blockchain-based internet of things (iot) data management,” IEEE P2144.1/D3, August 2020, pp. 1–20,2020.

[5] J. Gubbi, R. Buyya, S. Marusic, and M. Palaniswami, “Internet of things (iot): A vision, architectural elements, and future directions,” Future generation computer systems, vol. 29, no. 7, pp. 1645–1660, 2013.

[6] N. Islam, B. Ray, and F. Pasandideh, “Iot based smart farming: Are the lp- wan technologies suitable for remote communication?” in 2020 IEEE Inter- national Conference on Smart Internet of Things (SmartIoT), 2020, pp. 270– 276.

[7] B. Sarma, R. Baruah, and A. Borah, “Internet of things based smart farming,” in 2020 Fourth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), 2020, pp. 30–34.

[8] D. Negi, A. Kumar, P. Kadam, and B. N. Savant, “Smart harvest analysis using raspberry pi based on internet of things,” in 2018 Fourth International Con- ference on Computing Communication Control and Automation (ICCUBEA), 2018, pp. 1–5.

[9] L. Kamelia, Y. S. Nugraha, M. R. Effendi, and T. Priatna, “The iot-based monitoring systems for humidity and soil acidity using wireless communica- tion,” in 2019 IEEE 5th International Conference on Wireless and Telematics (ICWT), 2019, pp. 1–4.

[10] M. Suresh, S. Ashok, S. Kumar, and P. Sairam, “Smart monitoring of agri- cultural field and controlling of water pump using internet of things,”in 2019 IEEE International Conference on System, Computation, Automation and Net- working (ICSCAN), 2019, pp. 1–5.

[11] U. Uyoata, J. Mwangama, and R. Adeogun, “Relaying in the internet of things (iot): A survey,” IEEE Access, pp. 1–1, 2021.

[12] S. Truitt, T. D. Gage, B. E. Vincent, and S. Chun, “Low-cost remote monitor- ing system for small-scale ups installations in developing countries,” in 2019 IEEE Global Humanitarian Technology Conference (GHTC), 2019, pp. 1–6.

[13] I. G. E. W. Putra, I. K. P. Suniantara, and I. N. S. Kumara, “Sunlight intensity measurement system with solar tracking system,” in 2018 2nd International Conference on Applied Electromagnetic Technology (AEMT), 2018, pp. 12– 15.

[14] Y. A. Ahmad, T. Surya Gunawan, H. Mansor, B. A. Hamida, A. Fikri Hishamudin, and F. Arifin, “On the evaluation of dht22 temperature sensor for iot application,” in 2021 8th International Conference on Computer and Communication Engineering (ICCCE), 2021, pp. 131–134.

[15] E. P. D. Winarsih and E. Saptiningsih, “Kadar serat dan kadar air serta penam- pakan fisik produk pascapanen daun caisim (brassica juncea l.),” in (IEEE): D. Winarsih, E. Prihastanti, and E. Saptiningsih, ”Kadar Serat dan Kadar Air serta Penampakan Fisik Produk Pascapanen Daun Caisim (Brassica juncea L.) yang Ditanam pada Media dengan Penambahan Pupuk Organik Hayati Cair dan Pupuk Anorganik,”, vol. 14, no. 1, 2012, pp. 25–32.

[16] N. Istiqosari, ““net income analysis and risk of caisim (brassica rapa) produc- tion farming in liang anggang district, banjarbaru city,” in IOSR Journal of Agriculture and Veterinary Science), 2020, pp. 42–50.

[17] W. . F. B. N. . N. D. Hindersah, R. ; Rachman, “Populasi mikrob di rizosfer dan pertumbuhan caisim (brassica juncea) di tanah dikontaminasi insektisida organoklorin setelah aplikasi konsorsia mikrob dan kompos.” Jurnal Natur Indonesia 2013, vol. 15, pp. 115–120, 2013.

[18] H. Xianzhe, “Room temperature and humidity monitoring and energy-saving system,” in 2011 6th International Conference on Computer Science Educa- tion (ICCSE), 2011, pp. 537–540.

[19] S. B. Khot and M. S. Gaikwad, “Development of cloud-based light inten- sity monitoring system for green house using raspberry pi,” in 2016 Inter- national Conference on Computing Communication Control and automation (ICCUBEA), 2016, pp. 1–4.

[20] N. Putjaika, S. Phusae, A. Chen-Im, P. Phunchongharn, and K. Akkarajitsakul, “A control system in an intelligent farming by using arduino technology,” in 2016 Fifth ICT International Student Project Conference (ICT-ISPC), 2016, pp. 53–56.

[21] J. Wei, Y. Zhao, K. Jiang, R. Xie, and Y. Jin, “Analysis farm: A cloud-based scalable aggregation and query platform for network log analysis,” in 2011 International Conference on Cloud and Service Computing, 2011, pp. 354– 359.

[22] P. Dedeepya, U. Srinija, M. Gowtham Krishna, G. Sindhusha, and T. Gnanesh, “Smart greenhouse farming based on iot,” in 2018 Second International Conference on Electronics, Communication and Aerospace Technology (ICECA), 2018, pp. 1890–1893.

[23] R. Varghese and S. Sharma, “Affordable smart farming using iot and machine learning,” in 2018 Second International Conference on Intelligent Computing and Control Systems (ICICCS), 2018, pp. 645–650.

[24] M. T. Shakoor, K. Rahman, S. N. Rayta, and A. Chakrabarty, “Agricultural production output prediction using supervised machine learning techniques,” in 2017 1st International Conference on Next Generation Computing Applica- tions (NextComp), 2017, pp. 182–187.

[25] B. Lotfi, M. Mourad, M. B. Najiba, and E. Mohamed, “Treatment methodol- ogy of erroneous and missing data in wind farm dataset,” in Eighth Interna- tional Multi-Conference on Systems, Signals Devices, 2011, pp. 1–6.

[26] T. Rismawan, A. W. Irawan, W. Prabowo, and S. Kusumadewi, “Sistem pen- dukung keputusan berbasis pocket pc sebagai penentu status gizi menggu- nakan metode knn (k-nearest neighbor),” Teknoin, vol. 13, no. 2, 2008.

[27] B. Santosa, “Data mining teknik pemanfaatan data untuk keperluan bisnis,”Yogyakarta: Graha Ilmu, vol. 978, no. 979, p. 756, 2007.

[28] F. R. J. L o´pez and A. J. Lo´pez, “Field variables monitoring in real time (gps, soil moisture, temperature) with precision farming applications,” in 2012 6th Euro American Conference on Telematics and Information Systems (EATIS), 2012, pp. 1–5.

[29] S. Wang, D. Xu, and S. Yan, “Analysis and application of wireshark in tcp/ip protocol teaching,” in 2010 International Conference on E-Health Networking Digital Ecosystems and Technologies (EDT), vol. 2, 2010, pp. 269–272.

[30] A. Montazerolghaem and M. H. Yaghmaee, “Load-balanced and qos-aware software-defined internet of things,” IEEE Internet of Things Journal, vol. 7, no. 4, pp. 3323–3337, 2020.

[31] X. Li and S. Song, “Stabilization of delay systems: Delay-dependent impul- sive control,” IEEE Transactions on Automatic Control, vol. 62, no. 1, pp. 406–411, 2017.

[32] S. Kompella and A. Ephremides, 2014.

[33] D. J. Hand, “Principles of data mining,” Drug safety, vol. 30, no. 7, pp. 621– 622, 2007.