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Artificial Intelligence Enabled Smart Monitoring and Controlling of IoT-Green House

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Abstract

Green houses are being built and expanded at a breakneck pace. The green house climate directly affects plant's development, and its continuous indoor environment monitoring is critical. Most green house systems rely on manual temperature and humidity monitoring which can be inconvenient for personnel required to visit the green house daily and manually control it. This research uses a modern approach by implementing automated environmental control technology to improve green house control technology effectively. The integration of the Internet of Things (IoT) and artificial intelligence (AI) can develop a capacity for independently predicting and controlling IoT devices. The microcontroller controls the system, which serves as the central processing unit for sensors and actuators. The sensor data utilizes input parameters for the microcontroller, which processes it using the long short-term memory (LSTM) approach to anticipate output parameters for controlling actuators, such as fan exhaust, misting, and motor control. Intelligent control is not placed directly on the embedded system but on a framework known as *Laravel* through the results of knowledge trained by the LSTM method. Using the traditional embedded system, no data can be learned using only simple conditioning. The test findings from the LSTM training data obtained that the learning rate was less than 0.002 with a total of 250 steps, where the results were processed from the accumulation of data every minute for one month, are near to a good value. Consequently, the proposal can accurately forecast the actuator control in three minutes based on data collected from the accumulated data in the preceding three minutes. The system will collect data for future use to anticipate and optimise the melon product. The primary purpose of using AI, IoT and LSTM is that the system can see the wide range of agricultural applications by taking into account several other complex parameters, each owned by LSTM to be applied using IoT devices, so that they can be will be applied directly using publish and subscribe method.

Keywords Actuator · IoT · LSTM · Monitoring · Smart green house

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1 Introduction

Due to its high water, vitamin, and mineral content, watermelon is one of the most popular fruit groups in the market. Melon is a fruit that is difficult to produce if the environmental conditions, including soil and air do not match the plant's requirements [1]. Jember Regency is located between 0 and 3300 ms above sea level (MASL) and 37.75% of the territory is between 100 and 500 ms above sea level. Jember Regency has a tropical climate. The range of temperatures is between 23 and 31°C, with the dry season from May to August and the wet season from September to January [2]. There are numerous strategies to produce melons by lowering the number of failure factors, one of which is to utilize hydroponic media and place them in a green house to reduce reactivity with the air and surrounding environment, thereby decreasing the failure factor 'x'. When hydroponic medium and green houses are utilized, failure reasons have seen to be reduced. Regular monitoring and inspection are required to ensure that the parameters for growing melons are adequately met. According to the authors [3], currently the need for assistive technology is growing rapidly, especially for people with special needs. In addition IoT devices with AI help in the further use of machine-learning model implementations. This leads to a rise in the implementation of AI in smart green house. Moreover, it will open further opportunities for general users and people with special needs to help maintain production at an optimum level.

Green house systems are meant to monitor and adjust micro-climatic factors such as temperature, relative humidity, gas level, and lighting ratio to create optimal growing conditions for plants within green houses [4]. Conventionally, farmers had to visit the green house daily and physically regulate it. However, with the advancement of green house technology, farmers can now use current technologies to control and monitor automatically, lowering the cost of electrical components. The development of the IoT in agriculture, particularly green house technology, is accelerating and its use is expected to serve as a solid bridge between agriculture and technology. The IoT is a concept in which devices in our environment can be connected over an internet network, allowing people to communicate with those devices easily. By far, IoT is most closely associated with machine-to-machine (M2M) connections in manufacturing, power, and petroleum, among other industries [5]. The IoT devices utilized in this study are the product of engineering designs tailored to the present smart green house environmental circumstances. Arduino is used as a micro-controller to receive data from the attached sensors. For example, consider using the AM2305 sensor, which measures temperature and humidity. Additionally, Arduino may function as a controller for many motors in the green house. For instance, actuators on the exhaust, water pumps, internal circulation fans, misting, and even motors on the green house cover [6, 7].

AI is utilised to automate green house actuators using sensor data. It plays a significant role in developing the existing systems. Not only are existing sensors recorded through IoT, but with intelligence they are projected to be able to make environmental decisions autonomously from the green house [8]. Putting AI on the IoT begins with training on pre-existing data to create a model capable of comprehending the state of data from sensors with a range of values [9]. The system's judgments are effective and have a low error value. Additionally, the application of AI will aid in developing more sophisticated methods. Due to the complicated patterns, this study's predictive modelling requires more than conventional modelling approaches to achieve high accuracy. In order to address this issue, many deep learning models based on recurrent neural network (RNN) and convolutional neural network (CNN) techniques have been presented. LSTM is a class of RNN. It comprises short-term and long-term memory blocks made up of memory units. These memory cell unit enable the LSTM to retain state values for an extended period. Each LSTM block has three distinct gate units that learn to guard, exploit, or destroy a state as needed. LSTM neural networks have been effectively used in applications involving sequential data, including stock forecasting, natural language processing, and the study of social behaviour [10–12].

1.1 Contributions and Organization of the Article

This study will begin with the problems discussed above and end with a solution expected to accurately predict the actuator control in the next 5 min based on the data collected from the accumulated data a few minutes earlier. The application is developed through IoT technology by applying AI, using the LSTM method to an intelligent green house system so that it can be monitored and managed remotely in real-time. The sensor record data for future use in anticipating and optimizing the melon produced. Our research makes two contributions to this paper:

(1) We are using a combination of AI and IoT to control the smart green house's existing agricultural system.

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(2) We propose a unique sensor design on IoT devices to support the IoT system of smart green houses.

The structure of this paper is organized as follows: (1) Introduction; (2) Related Works; (3) The proposed method; (4) Experimental test and performance analysis; (5) Conclusions.

2 Related Works

This section discusses the previous related works relevant to our proposed scheme.

2.1 Smart Green House

The smart green house is an agricultural invention that combines technology with agriculture [13]. According to a prior study [14], the IoT system is meant to operate electrical items using internet technology, which can take the form of online or mobile applications. Additionally, IoT devices are often tiny and straightforward, but the advantages consumers gain might exceed the size of the IoT device itself. While most research utilises home-based IoT technology, researchers still research agricultural-based IoT. According to a study [15], IoT aims to increase the number and quality of agricultural goods, benefiting farmers. The application of IoT in hydroponic agriculture is also conceivable, as demonstrated by a study done by [16], where the hydroponic system is also a popular agricultural media outlet. The planting medium is water rather than soil, and special treatment must ensure that plants grow correctly in a hydroponic system. If hydroponic handling is not done correctly, it is very likely that the plants will not develop or may even rot. Therefore, an IoT device is required to regulate the pH, humidity, temperature, and irradiation levels and monitor the growth and development of the hydroponic plant itself. Along with assisting hydroponic farmers in creating precision farms, they also assist plants in obtaining the necessary nutrients.

2.2 Internet of Things (IoT)

The IoT is a futuristic technology widely used in numerous parts of life [17]. However, according to IoT [18], some things to consider. (1) Sensing components, including sensors, actuators, and devices. (2) Protocols for communication; examples include CoAP and MQTT [19], QUIC [20], and MP-QUIC for IoT [21]. (3) Cloud computing and computation (4) Applications and service components. Nonetheless, significant issues remain [22], including security, privacy, and network challenges. It is still a considerable risk, but our advanced solution is utilized on a secure local network. To address these security concerns, according to the OLHE study [23], numerous frameworks may be employed, including the Industrial Internet of Things (IIoT) security framework, which has been evaluated and is secure for industrial usage without regard for existing security concerns. Additionally, there are steps designed to avert security issues, such as: Risk analysis Security requirements The model development Formal specification and verification Prototype study phase Thus, the IoT system will become more secure by implementing these strategies. This research will expand the system's coverage area and incorporate more sensors and supporting equipment in its growth.

2.3 IoT-Smart Green House

An IoT-smart green house is an excellent combination of sustainable agriculture; not only can it boost output, but it can also save expenses [24]. The study shows that the IoT can supply information to farmers and compare the precision with which they gather data on their crops. In other research [25], IoT-smart green house is a combination of monitoring, controlling, tracking, and predicting; sensor devices and communication protocols are used to transmit data to obtain the data.

2.4 Artificial Intelligence (AI)

According to [26], AI is used to support decision-making to generate predictions against more accurate data. AI in an IoT system intends to forecast the environment in intelligent green houses and control the temperature via the components involved. As a result, it is projected that the smart green house system's electricity consumption will be more efficient. Additionally, according to a report published by [27], precision farming will be a trend in the following years, among numerous other disciplines, such as drone analytic, agricultural robotics, and animal monitoring. As a wrap-up, implementing precision farming in smart green houses is a prudent course of action.

2.5 Long Short-Term Memory (LSTM)

According to the research [28], LSTM comprises distinctive units, namely memory blocks inside the recurrent hidden layer. Each memory block has memory cells with self-connections that store the network's secular state. In Fig. 1, an LSTM architecture uses a forget, input, and output gate. According to a study by [29], long short-term memory, or LSTM, provides benefits over back propagation in forecasting data utilized in the innovative green house.

The LSTM contains an input and an output gate. Each input gate regulates the flow of activation from the input to memory cells. Using time as the primary foundation for training models, LSTM is commonly used to forecast sequential

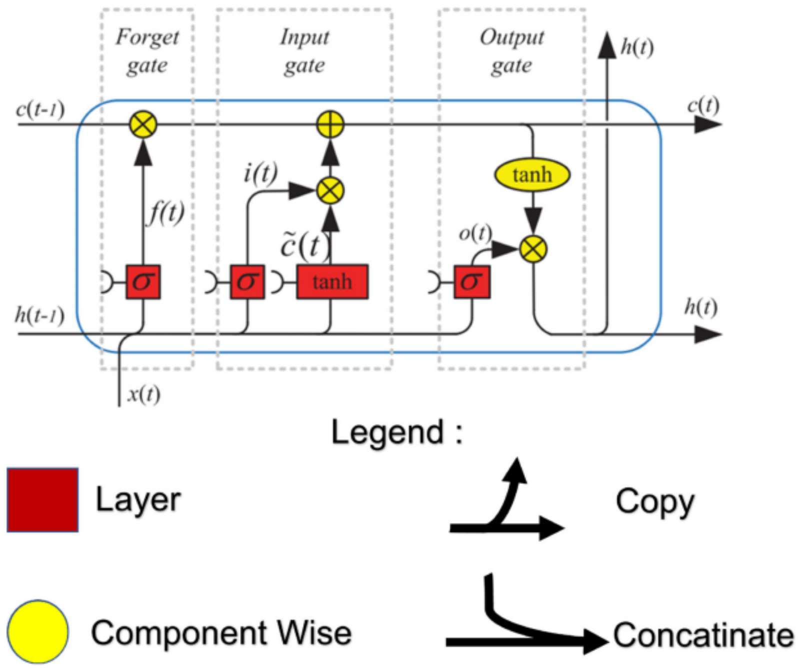


Fig. 1 LSTM design

or time series. Additionally, the LSTM configuration can be paired with LSTM itself, resulting in a more complicated network. The article [30] describes several types of LSTM. This research only utilized a forget gate, which contains a function that determines whether or not the information owned should be discarded in the cell section. The following is the mathematical representation of LSTM with Forget Gate (Eq. 1).

$$
\begin{aligned}
f_t &= \sigma\left(W_{fh}h_{t-1} + W_{fx}x_t + b_f\right)\\
i_t &= \sigma\left(W_{ih}h_{t-1} + W_{ix}x_t + b_i\right)\\
\widetilde{c}_t &= \tanh\left(W_{\tilde{c}h}h_{t-1} + W_{\tilde{c}x}x_t + b_{\tilde{c}}\right)\\
c_t &= f_t \cdot c_{t-1} + i_t \cdot \widetilde{c}_t\\
o_t &= \sigma\left(W_{oh}h_{t-1} + W_{ox}x_t + b_o\right)\\
h_t &= o_t \cdot \tanh\left(c_t\right)
\end{aligned}
\quad (1)
$$

where the Equation has a value of 1 and keeps the information, and if it has a value of 0, it will delete the existing information.

2.6 Rectified Linear Unit (ReLU)

The activation function is critical in an artificial neural network because the information contained in the network cannot be processed without it. According to the paper [31], each neuron has an activation function that determines the firing rate of the neurons to be activated. A paper entitled "A Review of Activation Function for Artificial Neural Networks" [32] explains that activation functions are classified into two: (1) Piecewise Linear Activation Function, and (2) Locally Quadratic tasks in this study. We only use an activation function of the type piecewise linear activation function, namely ReLU. The usage of ReLU in LSTM is done to prevent gradient vanishing as in [33] study; in addition to the vast amount of data, ReLU is an activation function that is suited for use in the suggested scheme.

A piecewise linear function is a function that consists of a limited number of linear segments defined by several interval numbers. The mathematical equation for ReLU (Eq. 2) for this section, namely:

$$\mathrm{ReLU}(x) = \max(0, x) \quad (2)$$

ReLU is a linear identity for all positive values, while for all negative values, it is 0. Although ReLU is a simple activation function compared to others, it is pretty popular and used to train other models such as logistic sigmoid and hyperbolic tangent. Consequently, we picked ReLU as the activation unit for our training model. While training model's findings will be discussed in the next section.

2.7 Adam Optimizer

According to the [34], which explains the significance of this method, this algorithm is used to perform gradient-based first-order optimization of stochastic objective functions. The

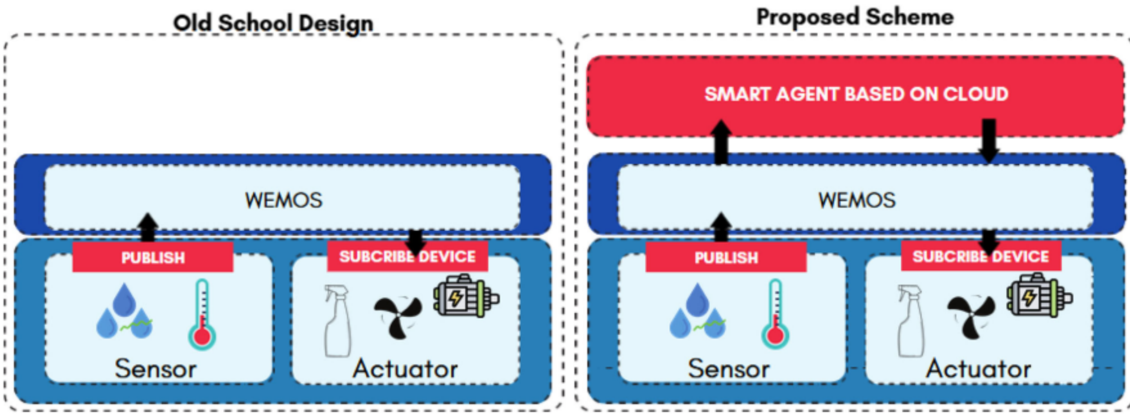


Fig. 2 Fundamental schematic difference between old school design and proposed scheme based on smart-agent

author demonstrates that the usage of the Adam optimizer offers several benefits, including a low memory footprint and suitability for a wide variety of data, as well as difficulties with high noise or sparse gradients. Additionally, there is research on using Adam as an optimizer for LSTM [35]. In this work, the authors successfully anticipate power price forecasts by employing LSTM to handle time-series data. Therefore, we apply the Adam optimizer to the LSTM so that intelligent agents may make decisions on the state of our smart green house.

2.8 Laravel

Laravel is a PHP framework based on [36] that will develop an integrated system. The Laravel system will aid in visualizing data from sensors and serve as a command center for farmers to handle smart green houses. Smart green house's Laravel-based online system obtains data from a database system, discussed in Sect. 3. According to a study [37], the Laravel system is a framework that utilizes the MVC or view and controller model. Additionally, usage simulations were conducted in this publication, such as monitoring memory and CPU usage while the Laravel system was running. Excellent results were obtained, demonstrating that Laravel could handle high traffic while consuming little CPU, making it possible well-suited for use in complex systems. And this research used the Laravel framework for this system of green houses.

2.9 Smart Agent

Smart agent is a service that included AI [38]. With AI in each service implementation, it can reduce the cost of operation. Smart agents can do important work without any limited time and can serve human needs. Another important aspect of the smart agents [39] is it can give an impact on business and society for human needs. This smart agent is related to the existing scheme, where the smart agent is a service with AI to aid human decision-making in achieving ideal results or goals.

Table 1 Optimal growing conditions for melon plants

No.	Type of condition	Optimum value
1	Temperature	30–35°C
2	Humidity	60–80%
3	Sunshine	70–80%

3 Proposed Scheme

This part updates the current system, which leverages the Laravel website framework to bridge the old school and the LSTM method's understanding. In this section, the publish and subscribe units are utilized. This section explains the difference between the old school system and the proposed scheme. The old-school system means that the existing system only publishes and subscribes to pre-set rules using Wemos. For example, the fan will turn on if the temperature reaches a specific maximum value. However, the system will be highly complex and challenging to develop if it has multiple parameters that determine its decision-making. With this suggested method, a system based on an intelligent agent may assist farmers in using additional plant condition determinants, such as fan activation, misting, nutrition, and other supporting parameters, in obtaining optimal decision values. In this suggested method, a modified LSTM is used to determine the accurate weight of the existing parameters. The proposed system may regulate smart green houses by gen-

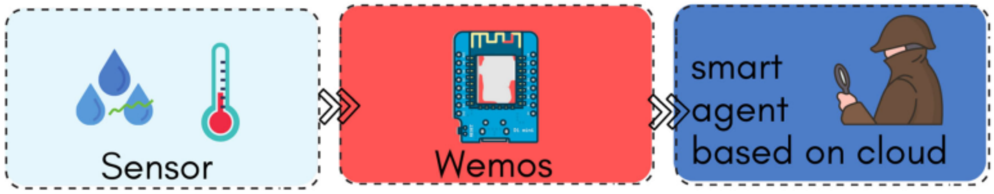


Fig. 3 Publish design that will send data to the cloud for data processing by smart agents

erating huge and tasty fruit, particularly for melon farming. Even if the weather is now unpredictable, growers can produce good melons throughout the year if the proposed scheme is implemented (Fig. 2).

As stated in Table 1, specific parameters must be satisfied for melons to grow well in green houses.

Table 1 displays the optimal growing conditions for melon plants. In the old system, the inability to predict plant conditions, such as temperature, humidity, and nutrient requirements, was a common obstacle in the plant management process; the system only accepted input based on the data provided. Farmers can monitor the system by predicting the environmental conditions of the smart green house or the state of the melon plant itself and a sensor obtained simultaneously. Currently, no system provides a warning prediction of the smart green house's environmental conditions or the melon plant itself. The suggested scheme system will modify the settings of the intelligent green house to maximize watermelon production. To carry out the control process, we employ the publish and subscribe mechanism, where publish provides information from sensors to smart agents for data processing and subscribes to control mechanical devices in existing smart green houses; the publish and subscribe system will be explained in the following section.

3.1 Publish

Figure 3 depicts the data retrieval procedure that occurs in the publish portion. The sensor data will be transmitted via Wemos to the cloud system containing the Laravel system, where it will be processed using the LSTM sandwich described in the following section. We proposed five importance role that can affect the publish process.

3.1.1 LSTM Sandwich Architecture

This section describes developing machine learning to forecast and control the previously discussed components. This study obtained the training model, used sequential Sandwich LSTM time series training with the following architecture in Table 2. Stack the LSTM in this study to obtain more accurate time-series data. The activation function in this study is the ReLU activation unit, and the optimizer in this training model is the adam optimizer, as described in the previous work. The number of units utilized in each LSTM determines parameter values. With 32 batch configurations, a learning rate of 0.01 is employed, which will decrease dynamically as a result adapts and use the Adam optimizer i. Climate forecasts will be accepted on the smart green house by analyzing data from sensors three times. Farmers will utilize the forecasts produced to determine the weather conditions.

Table 2 LSTM architecture

Layer (type)	Output shape	Parameters
LSTM1	(None, 3, 1000)	4,060,000
LSTM2	(None,500)	3,002,000
Dense	(None,14)	7014

Table 3 Type of the data collected by the sensors

No.	Data	Type of data
1	Temperature sensor [1,2,3,4]	Integer
2	Humidity sensor [1,2,3,4]	Integer
3	Temperature sensor average	Integer
4	Humidity sensor average	Integer
5	Exhaust fan	Binary
6	Misting fan	Binary
7	Roller motor	Binary
8	Cooling pad	Binary

Additionally, predictions will inform the system about how the smart green house's electrical systems impact climate conditions. AI design influences decision-making when using variables collected from smart green house sensors. The sensors process each piece of gathered data into training. The type of data processed consists of numerous components, as illustrated in Table 3.

Multiple sensors will be installed differently in Table 3, necessitating multiple sensors. The data taken with serial numbers 11–14 shows that the data is in the form of binary which is taken as material for considering the training model on hardware conditions by considering other variables so that the resulting training model is able to predict the temperature and humidity of the smart green house and also able to pro-

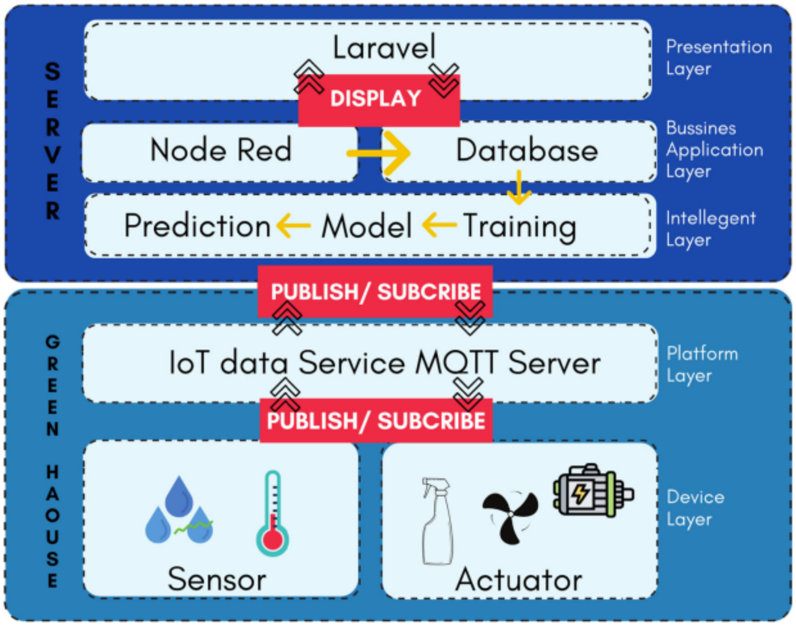


Fig. 4 System Design, a mix of the cloud environment and smart agent

vide predictive considerations for the four types of hardware. For example, when the gadget should switch on and off to maximize the system's energy efficiency.

3.1.2 Sensor and IoT Design

This section describes the design of sensors and other IoT devices that serve as the system's backbone. The following figure summarizes the sensors and components utilized in this system. Figure 4 shows the device's architecture, sensors, and data transmission procedure.

The data transmission and information processing processes are separated into three distinct phases, namely:

3.1.3 Sensors and Components

In this section, several sensors and components are used to influence the climate of a smart green house. Sensors used to obtain existing environmental data are AM2305, used to obtain temperature and humidity. AM2305 is one series of DHT sensors, a composite temperature and humidity sensor, a humidity capacitive Digital Temperature and Humidity Module, and a calibrated digital signal output. Here is the design of the AM2305 sensor, and several components are needed to make the sensor reader, namely:

1. PCB FR04 8 × 12cm
2. 2pcs 4k7 ohm resistors (as a communication buffer resistor i2c temperature sensor Am2315)
3. D1 mini Pro (micro controller which also connects the device to the internet network)
4. Am 2315 temperature sensor
5. Hi-link (Module power supply 220VAC to 5VDC)
6. Two-pin connector terminal
7. Four pin connector terminal
8. Box fuse 3 cm
9. Fuse 1 A
10. Plastic box for a series of 10x16 cm
11. Cable gland pg-6

The AM2315 sensor design utilized in our smart green house system is depicted in Fig. 5. The system can be operated appropriately even when environmental circumstances vary, and the sensor value is monitored precisely. The relay system is designed as a support for the AM2315 sensor and includes the following components:

1. PCB FR04 10 × 14 cm
2. Resistor 1k
3. Diode 1n4148
4. Buzzer 5Vdc
5. Terminal connector 2 pin
6. Box fuse 3 cm
7. Fuse 1 A
8. Transistor BD139
9. Optocoupler
10. Relay 5vdc
11. D1 mini Pro

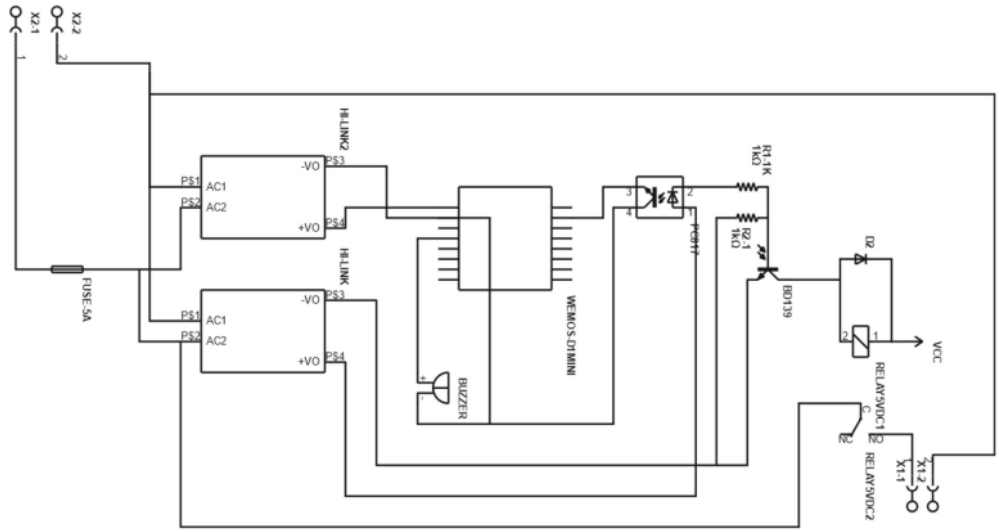


Fig. 5 Linking of the AM2315 sensor and Wemos to the previously constructed network

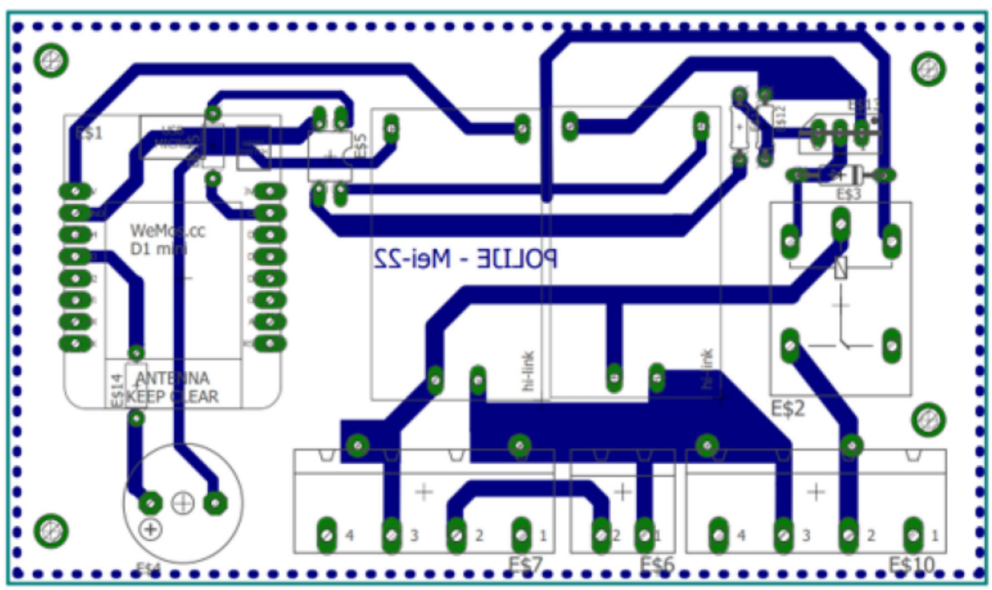


Fig. 6 Design of the Driver Relay Actuator

12. Hi-link (Modul power supply 220VAC to 5VDC)

Figure 6 shows the design of the relay actuator driver used, taking into account the condition of the existing electrical system at the smart green house. This research modified the relay system to operate appropriately and resist more than the existing system. Additionally, JSN Sensors are employed to determine the reservoir's water level. As a result, the system can accurately determine the reservoir's water level. The sensor maintained water level in reservoir at a perfect quantity for work. Additionally, it relieves farmers of the need to physically fill pools tank and may be operated via the system's applications and websites. As a result, water in the reservoir is constantly accessible.

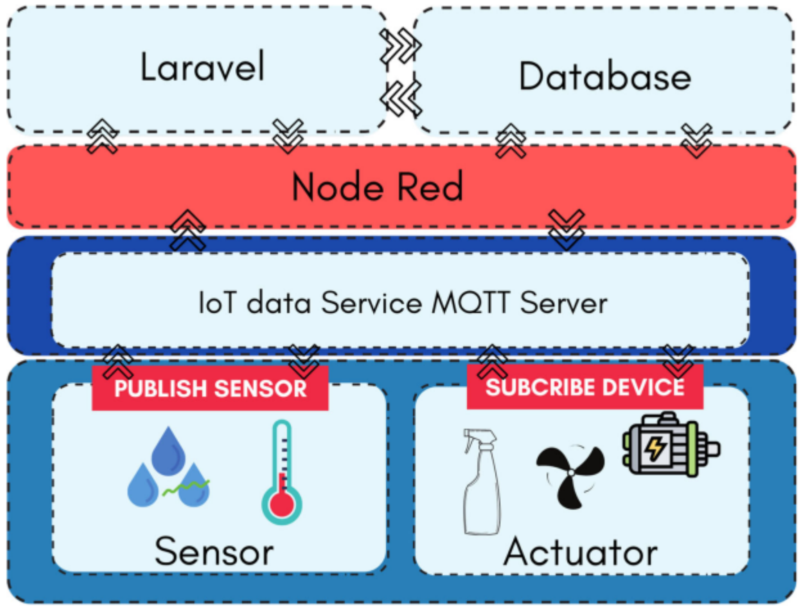


Fig. 7 Green house server and cloud architecture

3.1.4 Smart Agent Based on Cloud

This portion contains the logic for processing sensor data, and it utilizes Node-Red to control the sensor system and other supporting devices. This part has three major components: the MQTT server gets data from sensors, node-red receives data from the MQTT server, and the MQTT server and node-red store data in the database system. The server is separated into three major components in this research to ensure that the system's performance is maintained effectively. The cloud-based system is configured as follows: (1) 4 GB RAM, (2) 4 CPU cores, (3) 30 GB SSD storage, and (4) Debian OS. These characteristics can support the smart green house's performance for a total of 24 h. The system uses a private IP, which ensures the safety of the intelligent green house system. Users must install VPN to access the intelligent green house system. The VPN installation process is relatively simple. Due to the complexity of the system we install, this research includes a VPN as one of the defences in utilizing this intelligent green house. Additionally, this research deploys the system, as seen in Fig. 7.

This research employs two red nodes and an MQTT broker; the MQTT broker is located in the green house; data from the MQTT broker is provided to the green house's red node, and the red node's function is to communicate with the green house's red node. The green house is designed to anticipate when the network connection to the cloud is broken; farmers may receive system information via the local node-red network. The specs used to develop MQTT Broker, and node-red on the green house system are a regular intel-nuc pc running Windows. The database is still stored on the cloud infrastructure that Laravel-based websites use. The MQTT broker utilized is mosquitto; mosquitto was chosen as the MQTT broker because it is simple to install and highly stable under the conditions of the system being used. MQTT-Broker gets up-to-millisecond publications from smart green house sensors and also publishes devices needed to perform weather engineering on built smart green houses. Support for the global community is likewise excellent for the Mosquitto and includes comprehensive documentation; the broker's security is also perfect. Where system authentication is offered to ensure data security. As a result, public or subscribed data will be more secure. Additionally, the MQTT broker provides data to cloud-based red nodes, saving all data from sensors to the database and controlling operations initiated by Laravel-based websites. The usage of the current server system architecture yields excellent results, and farmers will also have access to data via the cloud server or the local network of smart green houses.

3.1.5 Users

Users can access the intelligent green house system through a website or a mobile device application, allowing users to observe and operate the current system. On user-facing systems, retrieved data straight from the cloud. As a result, data gathering is real-time and accessible from any location-a website system built on the Laravel framework. Thus, the user's primary duty is to monitor and operate the control systems manually. Even after the system has been successfully

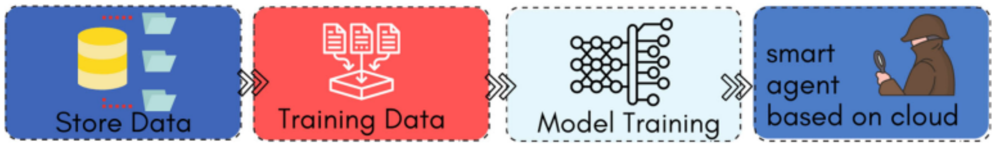


Fig. 8 Process of knowledge management in Laravel

Table 4 Software requirements on Laravel system

Type	Predict
Framework	Laravel 8+
PHP	7.4.0+
Mysql	8+
Webserver	Nginx/Apache
Protocol	MQTT

run, the user continues to oversee, and the system users are farmers in smart green houses.

3.1.6 Laravel System Knowledge Process

This section is a component of the Laravel system that does LSTM-based processing. Using the LSTM that we develop in the manner depicted in 3.1.2, we transform the received data into knowledge using the knowledge processing procedure depicted in Fig. 8.

In the Laravel design image, any data obtained by the sensor will be processed in Laravel using the MQTT protocol, then the data will be stored in the database system using mysql that has been previously prepared, and then to carry out the training process the data will be processed through a trigger between python and Laravel, and after the training process has been carried out, the training model will be deployed on the Laravel system.The requirements for the Laravel system are shown in Table 4.

3.2 Subscribe

After Laravel evaluates the knowledge model and takes judgments, the subscription process will be executed in order to provide information and other necessary commands. Figure 9 depicts the flow from the decision-making process to the actuator responsible for implementing the decision. The subscription process employs the MQTT protocol to convey the information necessary by the actuator, allowing the user to view the data transmission decisions. For automation control of actuator components as follows:

1. Misting is an intelligent green house component that adjusts humidity levels by spraying water. The water storage facility and water pump back up the misting system, controlled centrally. The user application and the training model suggestions will determine how long the misting system runs.
2. Exhaust fans and cooling decks, components that regulate the temperature in the smart green house to maintain it below regulatory limits. It utilizes two exhaust fans to suck air from within the smart green house and push it to travel through the cooling decks as necessary. The following section will discuss the exhaust fan's specs in further depth.
3. Internal circulation fan, is responsible for channeling air circulation within the smart green house for the airflow to circulate swiftly. The relay, temperature, and humidity sensor modules are the internal circulation fan's supporting components. Additionally, the technology created for this research can regulate the internal circulation fan.
4. The motor used to create the smart green house cover will open when the outside temperature drops below 29°C and the inside temperature rises. This motor system will strive to improve the energy efficiency of exhaust fans, circulating fans, and cooling decks.

4 Performance Analysis and Implementation

1. AI training for data sensor prediction

To monitor the training model in this study, we used a training machine setup with a GPU P100, 4GB of memory, 16GB of RAM, and a CPU Core i7-10xx. This research employs an online graphic-generating tool, wandb.ai, to create features capable of monitoring the system's performance, including GPU, CPU, Memory, and internet network utilization. Additionally, this study may be used to monitor current models, including their learning rate, loss rate, and epoch. For the training model's settings, namely: (1) Optimizer = Adam, (2) Learning Rate = 0.01 (may decrease dynamically), (3) Batch Size = 32. Then the loss rate will be close to zero, which is 0.1, and the acquired results will match the predicted value.

Figure 10 illustrates the resultant loss rate during the training procedure, close to zero. A dynamic learning rate that produces better outcomes and a loss rate that approaches a value of 9, where the learning rate is less than 0.002 with a total of 250 steps.

The training outcomes are shown in Fig. 11. The model provides information on temperature, humidity, and the use of Fan, Motor, and Misting by utilizing input data from three minutes earlier. In the illustration, this research performs an example of manually entering data into the system to observe

Fig. 9 A subscription design to execute commands

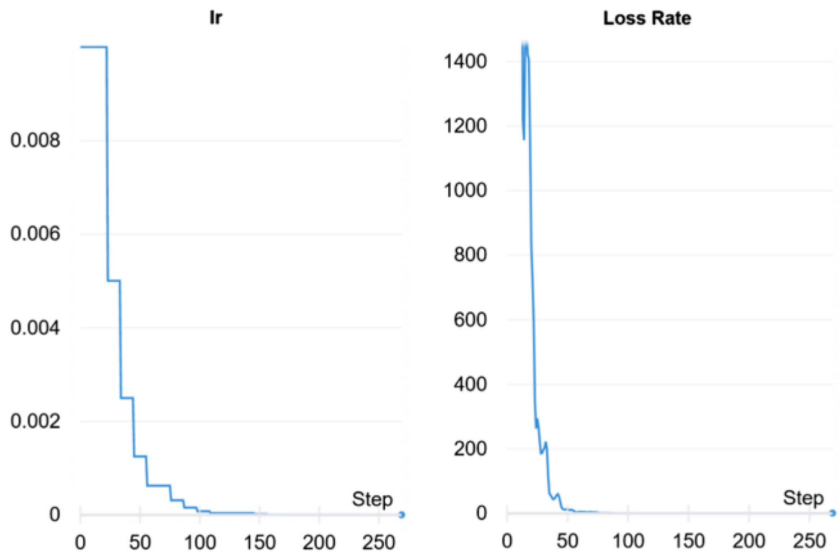
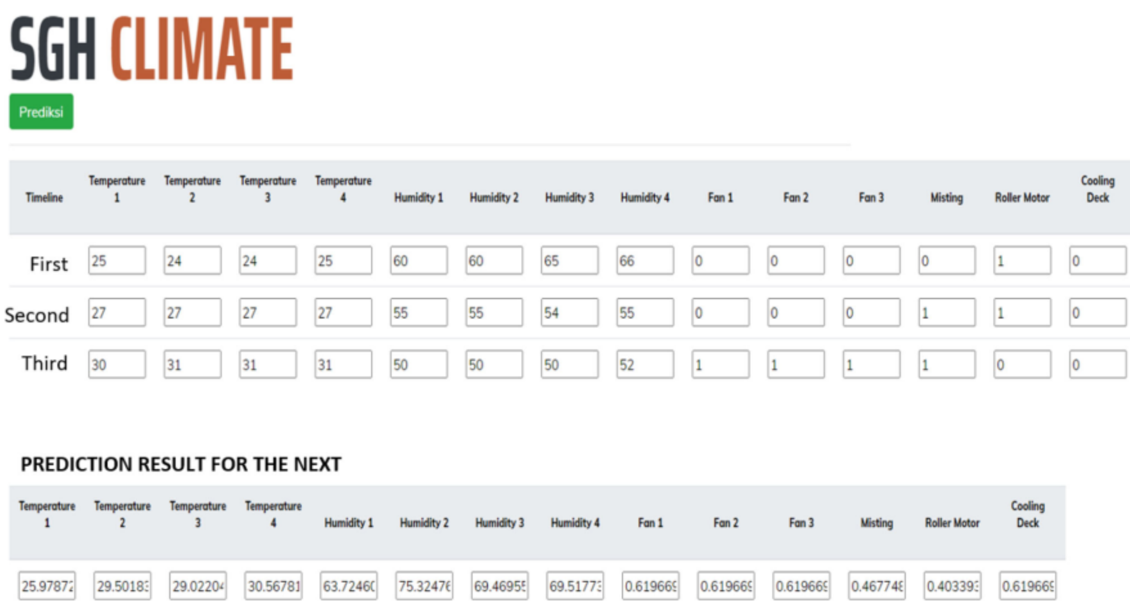


Fig. 10 Learning rate and Loss rate



Timeline	Temperature 1	Temperature 2	Temperature 3	Temperature 4	Humidity 1	Humidity 2	Humidity 3	Humidity 4	Fan 1	Fan 2	Fan 3	Misting	Roller Motor	Cooling Deck
First	25	24	24	25	60	60	65	66	0	0	0	0	1	0
Second	27	27	27	27	55	55	54	55	0	0	0	1	1	0
Third	30	31	31	31	50	50	50	52	1	1	1	1	0	0

PREDICTION RESULT FOR THE NEXT

Temperature 1	Temperature 2	Temperature 3	Temperature 4	Humidity 1	Humidity 2	Humidity 3	Humidity 4	Fan 1	Fan 2	Fan 3	Misting	Roller Motor	Cooling Deck
25.9787	29.5018	29.0220	30.56781	63.7246	75.3247	69.4695	69.5177	0.61966	0.61966	0.61966	0.46774	0.40339	0.61966

Fig. 11 Training results and test

Table 5 Data collected by the sensors

Type	Minute 1	Minute 2	Minute 3
Temp. 1	25	27	30
Temp. 2	24	27	31
Temp. 3	24	27	31
Temp. 4	25	27	31
Humidity 1	60	55	50
Humidity 2	60	55	50
Humidity 3	65	54	50
Humidity 4	66	55	52
Fan 1	0	0	1
Fan 2	0	0	1
Fan 3	0	0	1
Misting	0	1	1
Roller	1	1	0
Cooling deck	0	0	0

Table 6 Result prediction

Type	Predict
Temp. 1	25.97
Temp. 2	29.50
Temp. 3	29.02
Temp. 4	30.56
Humidity 1	63.72
Humidity 2	75.32
Humidity 3	69.46
Humidity 4	69.51
Fan 1	0.61
Fan 2	0.61
Fan 3	0.61
Misting	0.47
Roller	0.40
Cooling deck	0.61

the training outcomes created by the system. The system's reasoning is as follows: (1) If the temperature within the smart green house exceeds 29°C, the 1,2,3 fans and cooling deck will activate. (2) If the ambient temperature is less than 29°C, the motor roller starts, and all other components are turned off. (3) If the internal humidity value is less than 60, the misting system is activated; if the value is more than 60, the misting system is turned off.

Table 5 contains data from the previous three minutes, and projections will be made for the following one minute. The fan values 1–3, fog, rollers, and cooling deck will operate normally if the value is near one, i.e., 0.5–1, and will operate improperly if the value is less than 0.5–0.

And the resulting value prediction are shown in Table 6. The table consists of anticipated values. However, this research is particularly interested in the expected values for fan 1, fan 2, fan 3, misting, roller, and cooling deck. The value of one (1) indicates that the component must be activated, whereas a value of 0 indicates that it does not have to be started. Because fan value between 1 and 3 is near to 1, or 0.6, it is advised, fan should remain due to expected humidity value of 0.4, which is often less than 0.5 and near 0. For the cooling deck, the predicted value is 0.6, which is close to a value of 1, indicating that the cooling deck is on. The forecast system generates a value consistent with the logic used to activate the components of the intelligent green house climate system. All training operations utilizing time-series data types in succession.

Fig. 12 Water flow sensor to calculate the plant's water discharge

2. Pump control

This system manages misting, nutrition, and irrigation pumps, as well as the sorts of cooling decks. All misting, irrigation, and nutrition pump control systems have a water flow sensor to determine the amount of water that has entered the pump control system, as seen in Fig. 12.

Figure 13 shows a control integrated misting nutrition and irrigation pumps from a single location. Each pump has its control system, which means that if one of the control devices fails, the other control systems remain unaffected. The following description is a more detailed overview of the pump system's misting, nutrition, and irrigation control.

3. Misting

The misting system is implemented in the smart green house system by installing a black pipe and a spray system at a distance of 0.5 m from each spray, as shown in Fig. 14. When the misting pump control system receives a trigger indicating that misting must be run, water is pumped through the pump control system, and the water will flow through the spray. The

Fig. 13 Misting pump control, nutrition and irrigation, cooling deck

Fig. 14 A misting system installed on the ceiling of a smart green house

Fig. 15 Nutrition and irrigation systems in polybags

Fig. 16 Installation of nutrition and irrigation systems

misting system will continue to operate until the humidity requirement is satisfied or the current value is reached.

4. Nutrition and irrigation

Only monitoring is carried out in this nutrition and irrigation system; the LSTM sandwich system produces no predictions; all nutrition and irrigation data is given to the database for monitoring. Figure 15 is a polybag-based nourishment and watering system shown in the illustration. Each polybag will have its pipe.

It is also applicable to ground soil, as seen in Fig. 16, with the only variation being the kind of planting media. No value forecast was provided for nutrition and irrigation because it was not within the scope of the research, as we were only conditioning on the climate.

5. Cooling deck

This research used a wet cooling deck system to support cooling from the smart green house. This system consists of a wet lattice fed with water and equipped with a mechanism that draws air from the outside and directs it through the cooling deck's gaps. The cooling deck system operates when the air inside the smart green house becomes too hot, and cooling is required. The cooling deck will communicate actively with the exhaust and circulating fan systems. The wet cooling deck's cooling system can cool the environment in the smart green home. This cooling system has an Agrofan deck of 1000 cm × 30 cm × 200 cm (length × thickness × height) and can bring the air temperature in the smart green house environment to the desired level. This cooling deck system performs well in extremely hot/humid conditions, keeping the air inside the smart green house cold and adequate for chilling.

Fig. 17 Installation of a cooling deck system

Fig. 18 Strategic placing of humidity and temperature sensors

Fig. 19 Humidity and outdoor sensors determine the temperature difference inside and outside the smart green house

Fig. 20 Exhaust fan for effective circulation of the air in the smart green house

Figure 17 depicts the installation of a cooling deck on a smart green house. This cooling deck technology uses a specialized pump to circulate water across the cooling deck, and the water from the cooling deck is reprocessed to conserve existing water. After going through the cooling deck system, the predicted air temperature is 27–29°C. c. Sensor design and implementation This section describes the sensor design and system implementation in a smart green house; the sections following illustrate numerous points.

6. Humidity and temperature sensor

This result used AM2315 to obtain humidity and temperature sensor data as seen in Fig. 18.

This sensor system consumes just around 10 watts of electricity, and the sensor is suited for usage on an industrial scale or in an industrial product. As a result, the resistance of these sensors is exceptionally high, making them suitable for usage in a wide variety of existing situations. Two temperature and humidity sensors are positioned in the region farthest from the exhaust fan, one outside and one in the exhaust fan area. By arranging these various devices, values will be produced that will serve as references and datasets for developing a more accurate training model. As a result, the efficiency of using power will also improve. Figure 19 depicts the sensor's placement outside the smart green home, the sensor is placed outdoors to obtain the sensor's actual value in the environment outside the smart green house.

7. Exhaust fan

Figure 20 illustrates the exhaust fan placed in the smart green house system, which utilizes a twin exhaust fan on the exterior of the smart green house that this research is constructing. The fan will be activated if the smart green house's temperature has to be lowered. The exhaust fan's parameters are shown in Table 7.

These specs can drain air and draw air into the intelligent green house system's cooling deck. Each green house has two exhaust fans. Additionally, the exhaust fan is responsible for

Table 7 Exhaust specifications

Type	Exhaust Axial Spectek 44" 3P
Diameter	44 inch (1000 mm)
Speed	450 RPM
Air Flow	37,000 CMH
Power	750 W
Voltage	3 Phase 380v

Fig. 21 Controlling of the exhaust fan system using the actuator relay driver

drawing air from the outside that will flow through the smart green house's cooling deck. Thus, the exhaust fan takes the hot air from the smart green house outside, forcing it to travel through the cooling deck'.

Each exhaust fan is equipped with a control system that enables individual control and prevents the system from being started manually in the case of a failure shown in Fig. 21.

8. Circulating Fan

It is helped in drawing air to circulate by an internal exhaust fan. This internal exhaust fan will activate when the system suggests starting the fan based on the temperature parameters and training model. The system will improve recommendations from the training model. The circulating fan that was employed has the following specs.

The parameters for the circulating fan system are shown in Table 8, with a total of two for each smart green house constructed. Both the design and the user may control this system. Although the procedure may adapt to existing circumstances, this does not exclude its use in all locations or regions of internet-based contemporary agriculture or popularly referred to as a smart green house. It not only can be circulating fans move air, but they can also accelerate temperature changes caused by the exhaust fan and cooling deck.

Table 8 Circulating fan specifications

Type	MPCF 500
Dimensions	−/+565 mm × 320 mm
Fan diameter	500 mm
Power	120w
Voltage	220 v/50 Hz
Motor rotation	1400 rpm
Airflow	6300 m^3/h

Fig. 22 A fan to circulate the air within the smart green house

So the exhaust fan does not have to work excessively hard to suck air from the newly constructed smart green house.

The placement of the circulating fan in the smart green house is shown in Fig. 22. Because the circulating fan is situated above the plants, it does not interfere with their growth. Two circulating fans are paired side by side; each circulating fan will operate when triggered by a centralized control system or manually by a user system.

9. Roll cover motor green house

This system is composed of plastic rolled up using an electric motor. This technology will operate as long as the temperature outside the smart green house is colder than the temperature within. As a result, all exhaust fans, circulating fans, and cooling decks will enter a dormant state to maximize efficiency. As a result, the temperature and humidity within the smart green house are controlled by a single system.

The motor system seen in Fig. 23 is utilized to roll plastic to allow appropriate air flow from the outside. Additionally, the plastic motor system is beneficial for the climate-controlling smart green house system. Thus, the plant will experience

Fig. 23 Motor system in a smart green house

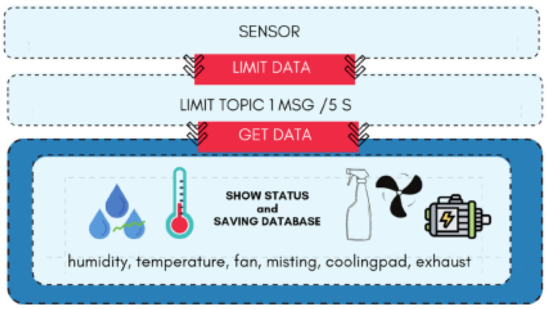


Fig. 24 Node-red implementation

cool weather in a variety of settings. Whether it's raining or it's scorching.

10. Node-red Implementation

In this research, the logic system handles the sensors on the intelligent green house using Node-red. Node-red is the operating system for the current system due to its strong community support. Additionally, this technology simplifies obtaining data from the smart green house system. This research can segment the current system and save time by reusing existing functions and modules. Additionally, node-red is compatible with hardware devices like the raspberry pi as a small local server. Alternatively, they may be employed on cloud-based platforms, as this research has done previously.

As seen in Fig. 24, the data acquired will be saved in the database and used for additional user requirements, either application-side or through the usage of training model data. The green house system transmitted will be separated into three sections: (1) Chart, which will display data from the smart green house. (2) Managing the system's supporting components that affect the climatic conditions in the smart green house. (3) Data storage in the database. This section's role is to store data in the database system; the database storage function is to receive data records and climate conditions from the smart green house to train the model system to improve its accuracy and performance. Along with the integrated intelligent system, this research uses the website as a manual control center in this study. This is important to determine whether the developed system has malfunctioned or failed to operate and allow the user to switch the system's operations into manual mode. This system displays temperature and humidity data for the last 24 h on a real-time webpage, although historical data may also be examined.

Figure 25 displays the website for user controls and the website created for further functionality. With this website system in place, consumers will have an easier time controlling the intelligent green house as a whole. The website system will retrieve data from the database, and it is channelled via the node-red system according to the appropriate rules for manual activities. Because the website system is hosted in the cloud, the link to the green house system established using the previously established internet network. Figure 2 illustrates the presentation of predictions made by the previously constructed training model system; the data feed is collected from the system's database system. In addition to being shown, the data will be utilized to generate predictions. After the sensor data is contained in the database system, it is retrieved and processed by the training model.

Additionally, farmers may manually make forecasts using the supplied buttons to obtain the most up-to-date data because the forecast data will be updated only at specific intervals. Figure 26 shows the design of the training model and Laravel-based website. The model training system will always get input from the database, and users can make predictions through the existing web system. So it will be easier to get the latest prediction values. Additionally, the training model makes recommendations to the system on whether the system should be switched off permanently or not. The pump or fan system's initial electric draw may be appropriately adjusted. For example, if the training model predicts that the temperature will be over 35 degrees Celsius for a few hours or minutes in the future, the pump and fan will be instructed to remain alive. The system can place the fan and pump in a dormant state or at a low rpm in a transitional state. Thus, if the sensor reads the same number at the projected minute, the fan system and pump may work at full speed to modify the climate system in the innovative green house. However, the sensor value generated in the next minutes is below 29 degrees Celsius or categorized as cool air. In that case, the fan and pump will be turned off. Information will be sent as a note that the training system has made a wrong prediction, so the values obtained will be The new training data will be used as training data for the new model

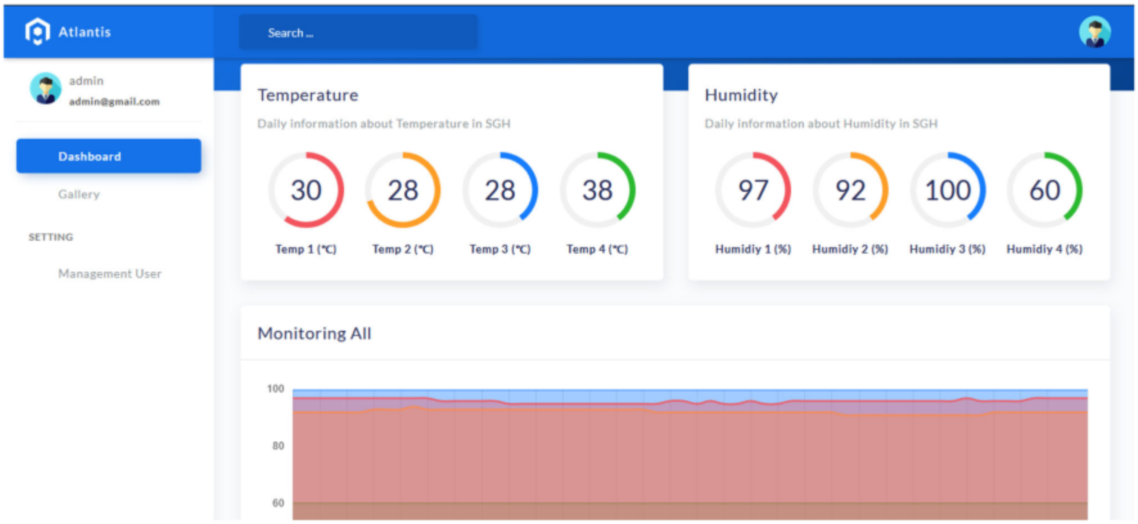


Fig. 25 Center command using Laravel

Fig. 26 Design training model on the web system

so that the training system will be more accurate and better. A training data model will be selected with predictions close to the actual value by comparing the previous training data models. So that farmers do not need to worry about the training model created because this system already has a design failure system. If the training data or training model fails to make predictions, the value of the sensor remains the primary benchmark. And the advantage of using the training model is the system can be done or set to be dormant and does not need to be completely shut down.

5 Conclusion

Smart agent has an important role in smart green house management starting with gathering data using sensors that were implemented in the green house. The sensor data is not only for sensor indicators, but it will be used for learning models to produce good quality products based on the environmental situation. The sensor data will be stored in a database system using a publish mechanism. There is a learning process in the cloud which uses sensor data on the database with exceptional LSTM architecture, which we call sandwich LSTM. In this article, sandwich LSTM was tested to achieve the predicted results. We combined the learning model with Laravel to create an intelligent agent that can produce a decision based on new sensor data with high accuracy. The difference between this system and the old decision system is that the smart agent can adapt the prediction to the new environment without new learning and the old system parameter's configuration. Moreover, intelligent agents can predict clever green house situations a few minutes and hours later based on the current sensor data. This feature can help the farmers provide decision assistance and increase product quality. After the intelligent agent gets the optimal value based on sensor input data, Laravel sends the value using subscribe method on the actuator, like the exhaust fan, misting, and cooling deck. Based on the results of our proposed scheme analysis and implementation of an intelligent agent in an IoT-based green house, our contribution to the innovative green house for melon plants is system integration with fairly complex parameters. The use of several drives aids the control process. We have designed it to adapt to the environmental conditions of the innovative green house. In addition to the decision-making and control processes carried out by a cloud-based intelligent agent, it will help farmers to manage and provide predictions for the environmental conditions of the innovative green house. This is a process of giving nutrients based on values that farmers have determined, so we focus only on the climate area of the intelligent green house to create ideal conditions for melon plants to grow well. In addition to that, in subsequent studies, it is the integration of smart-agent weather management and the dynamic delivery of nutrients according to the needs of each melon plant itself so that it will be able to create new variations of the current type of melons.

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