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Implementation Of New Energy In Monitoring The Design And Construction Of Plant Watering Systems

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ABSTRACT

Watering plants, especially orchids, requires special attention as these plants have an air humidity limit between 60-80% RH and an ambient temperature between 18–34°C. Improper watering can cause orchid plants to become too moist or dry. In Baru Village, East Jakarta, the one million orchids program faces challenges because watering is still done manually without humidity and temperature control. With about 200 pots of orchids to be watered daily, this process relies heavily on human labor. This service activity aims to implement a microcontroller-based automatic watering system for orchid plants in Baru Village. The system uses a DHT22 sensor to detect the humidity and ambient temperature of the plant. With a microcontroller, a humidity parameter of 60% RH and a maximum temperature of 33°C can trigger the activation of the pump relay. A battery-powered 12 Volt DC pump is used for watering, with hoses and nozzle sprayers that spray water in a mist to reach the entire plant. The device operates on its own energy from a solar panel with a capacity of 30 Wp. The results of the activity show that the device works automatically at a temperature of 33°C and a minimum humidity of 60% RH, with a watering frequency of about 2-3 times within 6 hours. Charging the battery from the solar panel works well, reaching a maximum voltage of 14.6 Volts.

Keywords: watering, automatic, orchid, DHT22, solar power.

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1. INTRODUCTION

Watering plants manually is often constrained by time constraints, especially in the midst of an increasingly busy lifestyle and an increasingly high cost of living. The need to work harder often makes humans not have enough time to take care of plants, including in terms of watering. Watering plants is an important activity in plant maintenance, so a system is needed that can make this work easier.

The authors propose to create an automatic plant watering system that can monitor soil conditions and save time. The system uses a soil moisture sensor and an Arduino Mega 2560 as the main control, as well as a copper plate as an electrode to measure soil resistance. According to Gunawan and Sari (2018), this copper plate will measure the resistance of the ground which is then converted into analog voltage, and then converted into digital data so that it can be processed by an Arduino microcontroller. The soil moisture level that has been set according to the needs of the plant will be displayed on the Liquid Crystal Display (LCD) screen, indicating whether the soil is in a moist or dry condition. The system is also equipped with a water pump for watering. According to Kalsum (2020), when the soil moisture sensor detects dry soil conditions, the motor will move to water the plants. Once the soil gets enough water intake, the motor and faucet will automatically stop working. This system is expected to make it easier to maintain plants, especially for those who have limited time.

With an automatic watering system, plant owners don't have to worry about missed watering schedules or plants that don't get enough water, especially when they're busy or not at home. This is especially important because irregular watering can result in stress on the plant, which in turn can affect its growth and health. In addition to saving time, these automated systems also help optimize the use of water, which is an increasingly valuable resource. By utilizing the soil moisture sensor, the system will only activate the water pump when needed, thus avoiding the water wastage that often occurs with manual watering methods. It can also contribute to environmental sustainability by reducing excessive water use.

The use of technology such as the Arduino Mega 2560 also allows the addition of other features such as a connection to the internet for remote monitoring or watering settings based on weather predictions. This innovation not only makes plant maintenance easier for individuals, but can also be adopted by the small to medium-scale agricultural sector to improve efficiency and productivity. Overall, the development of this automatic plant watering system aims to provide a practical solution to the problem of time and resource limitations in plant care. In addition, the system also offers additional benefits such as water savings and the potential for integration with other technologies for more effective monitoring and management. Therefore, this system has the potential to have a significant positive impact in various aspects of life, both at the individual and community levels.

2. LETERATURE REVIEW

Solar Panels

A solar panel is a device made up of solar cells that convert light energy into electrical energy in the form of direct current (DC). Solar panels consist of an assembly of photovoltaic cells that convert sunlight into electricity. Generally, solar panels have a lifespan of more than 20 years and during that period, significant drops in efficiency are rare. These panels are also known to be easy in terms of maintenance as they have no moving parts. The thing to consider is to make sure there are no obstructions that block sunlight from entering the panel.

Working Principle of Solar Panels

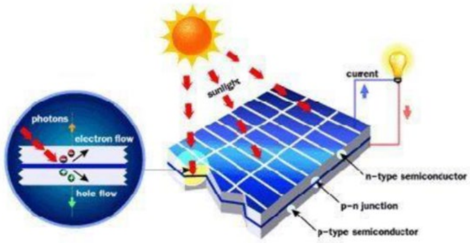

Figure 2.2 Working Principle of Solar Panels

Solar cells work on the principle of p-n junction. The semiconductor commonly used in solar cells is silicon. However, pure silicon does not have enough free electrons, so its conductivity is poor. To improve the electrical properties of silicon, silicon is doped with an impurity element (dopant).
P-type silicon: P-type silicon is obtained by doping pure silicon using atoms with an electrovalence of 3, such as boron. Boron atoms have three valence electrons, resulting in a lack of electrons in silicon and creating a "hole" that acts as an acceptor.
N-type silicon: To obtain n-type silicon, silicon is doped with atoms that have an electrovalence of 5, such as phosphorus. The phosphorus atom has five valence electrons, which leads to an excess of electrons acting as donors.

NodeMCU ESP8266

NodeMCU is a development board for Internet of Things (IoT) products based on eLua Firmware and the ESP8266-12E System on a Chip (SoC). ESP8266 is a WiFi chip with a complete TCP/IP protocol stack.

NodeMCU can be thought of as ESP8266's "Arduino board". While programming ESP8266 can be a bit of a hassle as it requires additional wiring techniques and a USB to serial module to download programs, NodeMCU has integrated ESP8266 into a compact board that comes with a variety of microcontroller-like features. With these features, NodeMCU allows for simpler programming using only a USB data cable, just like the one used to charge a smartphone.

The author's reasons for choosing NodeMCU ESP8266 are its ease of programming, the availability of adequate I/O pins, and the ability to access the Internet network via a WiFi connection, which allows for effective data transmission or retrieval. Here are the specifications of the NodeMCU ESP8266:

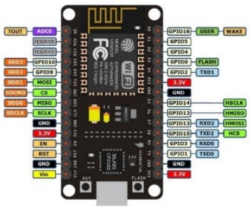

Figure 1. NodeMCU ESP8266

- 10 GPIO pin ports: Used for digital input and output.
- PWM Functionality: Supports Pulse Width Modulation for analog signal control.
- I2C and SPI interfaces: Allows communication with a variety of external sensors and devices.
- 1-Wire Interface: Supports communication with devices that use the 1-Wire protocol.
- ADC (Analog-to-Digital Converter): Allows reading analog signals from sensors.

Relay

A relay is an electrically operated switch and is an electromechanical component consisting of two main parts: electromagnet (coil) and mechanical (a set of switch contacts). Relays work on the principle of electromagnetism, which allows small electric currents (low power) to control larger electric currents.

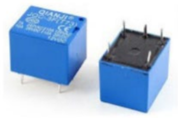

Figure 2. Relay

In general, relays function to control circuits with low currents, so that they can control higher voltage electrical currents without being directly connected. For example, a relay with electromagnets operating at 5V and 50 mA can drive an armature relay (the mechanical part that acts as a switch) to carry 220V of electricity at 2A. In this way, the relay allows the control of a high-voltage circuit with a signal that is low-voltage.

Sensor DHT11

The DHT-11 sensor is a single chip that measures relative humidity and temperature, with a pre-calibrated digital output. The sensor provides temperature data with a resolution of 14-bit and humidity data with a resolution of 12-bit. The output of the DHT-11 is a digital signal, so there is no need for additional signal conditioners or Analog-to-Digital Converters (ADCs) for data processing.

The DHT-11 sensor was chosen compared to the DHT-22 because it has a wide measurement range: 0% to 100% for humidity and -40°C to 125°C for temperature. The sensor also offers high accuracy with a single-bus-based digital output.

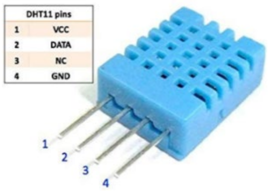

Figure 3. Sensor DHT22

In reaction to the data read by the sensor, I used a DC fan that would operate when the humidity reached 60% or the temperature exceeded 40°C. These values can be changed as needed in the schema used.

Water Pump

A water pump is a device that is often used in aquariums and has waterproof properties, allowing its use in water. This pump has a considerable flow capacity, reaching 1000 liters per hour (L/h), so it is very suitable for plant watering applications.

This water pump is designed with high pressure and is strong, so it can drain water to several plants at once. Its ability to generate large pressures and flows makes it effective for watering systems, especially for areas with a lot of plants or high watering needs.

Figure 4. Water pump

Sensor Soil Moisture

Soil Moisture Sensor is a module designed to detect soil moisture levels and determine the presence of water content in or around the sensor. Its use is quite simple: the sensor is inserted into the ground and the potentiometer is adjusted to regulate the sensitivity of the sensor.

The output from the sensor will be a digital value of 1 or 0, which indicates the soil moisture conditions—1 if the humidity is high and 0 if the humidity is low. This value can be adjusted using a potentiometer to set a threshold.

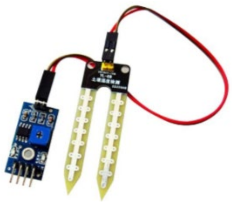

Figure 5. Sensor Soil Moisture

The specifications of this sensor are:

- Comparator using LM393: Allows the sensor to compare the input signal with a reference value to produce a digital output.
- Using 2 small plates as sensors: These plates serve as soil moisture measurement elements.
- Supply Voltage 3.3-5 VDC: The sensor can be operated with input voltage within this range.

- Digital Output (D0): A digital output that can be directly connected to a microcontroller (MCU) easily.

3. RESEARCH METHOD

In this research method, several stages are carried out to realize the application of an automatic watering system on plants. These stages include:

1) Problem Identification
   It was found that the watering process was still done manually and relied on labor. Watering is carried out based on the habits of the workers, which is usually done when they have free time. In addition, inefficient use of water is a problem, especially with a fairly large number of plants, around 200 pots, which must be watered at least twice a day. Based on these problems, a plan was made to implement automatic sprinklers on plants that are expected to work automatically with independent energy sources, not relying on conventional electricity.
2) Problem Formulation
   The problem formulated is how the application of automatic sprinklers on this plant can work automatically by using an independent energy source in the form of solar panels. The system is designed to work by using temperature and air humidity sensors, which will detect the minimum humidity level or maximum temperature that has been set according to the characteristics of the plant. In addition, the watering mechanism must be designed to be effective. This tool uses a 12V DC pump, with a flexible hose at the output to reach the position of the plant pot, as well as a nozzle sprayer at the end of the hose to produce water mist.
3) Tool Planning
   This stage involves a literature study on the application of automatic watering systems and tool design, from component purchase, assembly, to tool design and construction trials. Components used include solar panels, temperature and humidity sensors, DC pumps, flexible hoses, and nozzle sprayers.
4) Tool Testing
   Initial testing was carried out at the Unkris Engineering Laboratory and continued at the cultivation site until the tool was declared fit to operate. At this stage, temperature and humidity measurements are carried out by reading sensors and testing the watering function. Temperature and humidity change data are recorded and analyzed to ensure that they match the specified parameters.
5) Evaluation
   After the automatic sprinkler was installed and completed the test and evaluation, the author also prepared a final report on the results of this activity, as well as monitoring the equipment for one week.

4. Results and discussion

Application of Automatic Sprinklers on Plants Using Solar Energy

The automatic watering system for this plant is designed based on the diagram block shown in Figure 3. The system uses a DHT22 sensor to detect changes in temperature and humidity around the plant. This DHT22 sensor will send data to a ESP8266 microcontroller that has been programmed to process certain parameters. If the air temperature around the plant exceeds 33°C or the humidity drops below 60%, the microcontroller will issue instructions to activate the pump relay, which will then carry out the watering process.

The energy source for this system comes from a battery charged by a 30 Wp solar panel, via a solar charge controller. These solar panels become the main source of energy, ensuring that the appliance can operate independently without depending on the conventional power grid. This is essential to optimize the use of renewable energy and reduce operational costs.

Sensor and Device Placement

The DHT22 sensor is placed on a shelf between plant pots to accurately detect changes in temperature and humidity. This placement allows the sensor to obtain representative environmental data around the plant. The entire device and components, including the microcontroller and power source, are housed in a special panel to protect against the weather and ensure the safety of its use.

In addition, the use of soil moisture sensors can also be integrated in this system to provide additional data that can be directly processed by the microcontroller, as suggested by Effendi (2022). This allows the system to detect soil conditions in real time and adjust watering more appropriately.

Watering Process

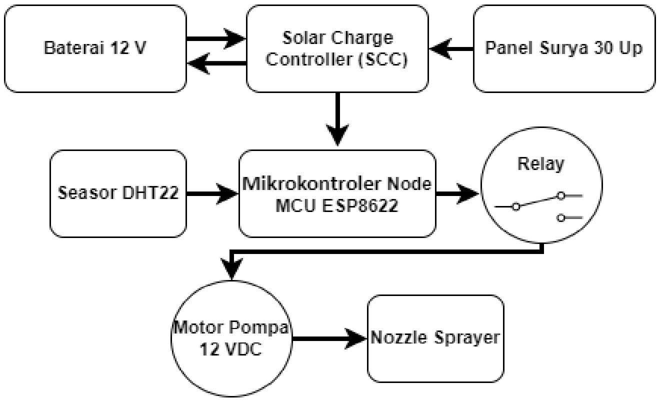

Figure 3. Diprogramming Solar Energy Sprinkler

The water is stored in jerry cans placed near the system and sucked up by the water pump. A flexible hose is used to distribute water from the pump to a sprayer nozzle placed along the plant rack. These hoses are designed to be branched to ensure the water pressure is evenly distributed to all pots, so that each plant receives a sufficient amount of water, and the positioning of sensors, tool devices, and water pumps, and the installation of solar panels, the placement of nozzle sprayers, and the visualization of the watering process through water fogging.

Figure 4. Sensors, microconrolers, scc, and water pumps

By placing each device close to the plant rack, monitoring and maintaining the system becomes easier. This is important to ensure that the system runs smoothly and quickly in case of problems. Consistent monitoring also helps ensure efficient water and energy use, as well as maintain plant health.

Testing and Evaluation

Testing of automatic sprinklers is carried out in two stages: first in the faculty laboratory environment and second at the research site. The functional test of the tool is focused on this initial test. After the installation and application of automatic sprinklers on orchid plants, tests were carried out on all functions of the equipment, such as temperature and humidity measurements, as well as automation of the watering process using a DC pump. Table 1 shows the data collected after the automatic sprinkler is installed on site. Data is taken for one day or within a period of 6 hours.

Table 1.Temperature and humidity reading test results using DHT22 sensor

Testing Time	Temperature°C	DHT22 Humidity %RH Sensor	Pump Condition
10:00 -10:30	30,5	72	OFF
10:30 - 11:00	31.2	68	OFF
11:00 - 11:30	31,7	67	OFF
11:30 - 12:00	32,4	63	OFF
12:00 - 12:30	33,2	62	OFF
12:30 - 13:00	32,5	63	OFF
13:00 - 13:30	33,2	68	ON
13:30 - 14:00	32,5	64	OFF
14:00 - 14:30	33,1	67	ON
14:30 - 15:00	32,2	65	OFF

From the data in Table 1, it can be seen that the temperature reaches more than 33°C during the day between 13:00 – 14:30. This is detected by the DHT22 sensor, which then triggers the process of watering the plants, characterized by the ON pump condition. This means that during this period, there were two automatic waterings on orchid plants. Before automatic watering occurs, the air humidity tends to decrease closer to 63-64%. After the watering process, the humidity increases by about 67-68%.

These results show that the application of automatic sprinklers in orchid cultivation is able to work well, maintaining the temperature and humidity around orchid plants. In addition, tests are also carried out on the solar energy source used, because it is hoped that this automatic sprinkler can continue to operate without relying on conventional power sources, so that it is not disturbed by power outages. The test is carried out by monitoring the battery voltage when the pump is ON, to evaluate the battery capability and charging efficiency by the solar panel both in standby conditions and when the pump is operating.

Table 2. Performance of the sprinkler pump against battery voltage

No.	Battery Voltage (V)	Standby Pump	Pump ON	Solar Panels
1	14,5	14,5	13,8	v
2	14,6	14,6	13,8	v
3	14,6	14,6	13,8	v

Information:

- Battery Voltage (V): The voltage measured on the battery.
- Pump Standby: The voltage of the battery when the pump is in standby condition.
- Pump ON: Battery voltage when the pump is on.
- Solar Panel: checklist marked with "v".

From Table 2, it can be explained that the pump works well when the condition is ON, with the battery voltage at 13.8 Volts. This shows that the solar panel is able to provide sufficient power supply, both to the battery and directly to the pump. Thus, this automatic sprinkler works well, including charging from solar panels that runs effectively.

In the future, the application of this tool can be developed into a more integrated system, as mentioned by Purnomo (2021). For example, by building an integrated orchid farm that includes regular irrigation, fertilization, and pest control processes, all of which can be monitored through smartphones.

After a series of tests, the tool was carried out at the site of research activities and this automatic sprinkler was declared suitable for operation. It is hoped that with the application of this automatic sprinkler, orchid plant cultivation, especially in the aspect of maintenance, will become easier and more efficient. In addition, further development of this automatic watering system could include various innovations to improve efficiency and sustainability in orchid cultivation. For example, the integration of IoT (Internet of Things) technology can enable real-time monitoring and remote control through smartphone applications. This will allow farmers to monitor plant conditions, such as humidity and temperature levels, and automatically control watering and fertilization according to plant needs.

The use of additional sensors, such as light sensors to measure the intensity of light the plant receives, can also be a consideration. With more comprehensive data, the system can be set to adjust watering and fertilization based on specific weather conditions or times. This not only improves the efficiency of water and fertilizer use but also ensures that plants get optimal care.

Additionally, with the integration of security systems such as surveillance cameras or motion sensors, farmers can monitor their gardens to prevent theft or damage by wild animals. This provides an additional layer of protection for investment in crop cultivation.

With the successful implementation of this automatic watering system, the team hopes to inspire other farmers and agricultural communities to adopt similar technologies. The use of technology in agriculture not only increases productivity but also allows for more sustainable and efficient agricultural practices.

5. Conclusion

The application of automatic sprinklers on orchid plants shows satisfactory results. The DHT22 sensor successfully detects temperatures above 33°C, triggering the pump to water the plant automatically. The watering process occurs twice a day, which helps to maintain the temperature and humidity around the orchid plant. The lowest detected humidity is 63%, which is still within the limits of the allowable humidity parameters for orchid plants.

This tool works by using an independent energy source from a battery that is recharged by solar panels. When the pump is active, the battery voltage is measured at 13.8 Volts, while when on standby it is in the range of 14.4 - 14.6 Volts.

In the future, the development of this tool can involve integration with Internet of Things (IoT) or artificial intelligence-based technology to enable remote monitoring and control through smart devices. The availability of water in jerry cans must also be maintained properly to ensure that the watering process runs as planned and the needs of the plants are met. Thus, this tool can continue to support the care of orchid plants efficiently and sustainably.

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