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IoT-based pesticide distribution control system with photometric sensor framework

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ABSTRACT

The use of pesticides is often given under extreme conditions. The excess use of these pesticides can harm both the farmers directly and the affected environment; this is the impact of the uncontrolled use of pesticides. There is a need for a control system to control the distribution of pesticides on agricultural land. This article seeks to provide a control system design for controlling the distribution of pesticides by utilizing photometric technology integrated with the internet of things (IoT). The control system is designed automatically with a sensing system or an operating record. It is expected to be able to disseminate the correct use of pesticides to achieve production efficiency. This study provides a design of an automatic control system for pesticide distribution IoT-based. We use a photometric sensor to control the pesticide distribution. Future work can be implemented for prototype work due to smart farming to control pesticide distribution automatically.

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1. INTRODUCTION

Pesticides are now an integral element of the agricultural system. Using pesticides to control pests in agricultural land tends to be uncontrollable. Farmers use pesticides to overcome the attack of plant pests [1], [2]. The pesticides used by farmers tend to be slightly adjusted to crop damage caused by problems and the level of pest toxicity to the environment [1], [3]. However, if the distribution of pesticides cannot be controlled, it can poison farmers and damage the environment [4]–[7]. One of the technology-based agricultural applications is the smart farm. Smart-farm can be in the form of technology integration with agriculture and technology-based agricultural management [8]. For example, an IoT-based agricultural control system is an internet of things (IoT). With IoT, human work is easier and more automatic because of the sensors that detect specific parameters [9], [10].

The application of the internet of things (IoT) is very diverse. Several references that apply IoT for various purposes make it easier for humans, such as the research of [11] in developing an IoT-based disinfectant fogging drone. Another study by [10], [12] developed an intelligent helmet with various sensors applied to IoT. In addition, *Smart-iMbulance* app is based on IoT for efficiency of road emergency priorities [13]. IoT-based monitoring tool for baby while sleeping [14]. Besides, research by [15] created an intelligent irrigation control system based on IoT. Based on IoT, Reas et al. [16] created a wireless sensor network to detect active radiation in the coconut-cacao intercrop model. Research by [17], [18], [19] developed an intelligent irrigation control and monitoring system based on IoT. Besides, the study by [20] developed mobile innovative irrigation

management and monitoring system integrated with IoT. Another research by [21] designed clothes dryers and sterilizers with IoT-based bimetallic and UV rays.

One of the helpful control systems in agricultural science is the management of pests on agricultural land. Because a control system that can monitor the distribution of these pesticides can control the distribution of pesticides and the level of pest disturbances found in agricultural land, this research tries to assist farmers in monitoring their agricultural land from the uncontrolled distribution of pesticides. The distribution of pesticides can be monitored by a photometric sensor connected to the internet of things (IoT) automatic control system. The control system is designed automatically with a sensing system or an operating record. It is expected to be able to disseminate the correct use of pesticides to achieve production efficiency.

2. METHOD

The control system design in this study refers to [8], [22]–[26] with the SDLC (system development life cycle) with the waterfall method. Figure 1 depicts the following study flowchart.

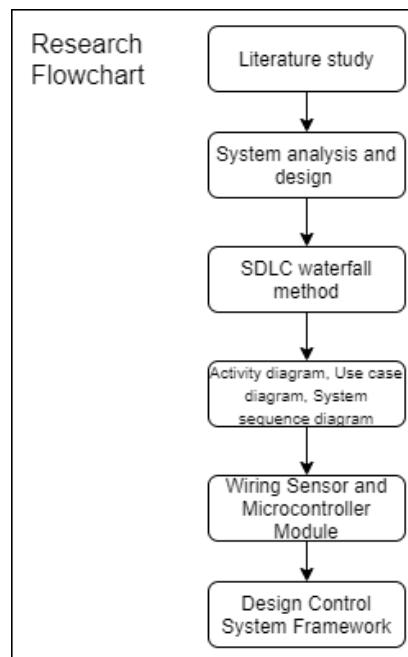


Figure 1. Flowchart of research includes study literature, system analysis and design, SDLC method, UML design, wiring sensor and module, and framework design.

2.1. System Analysis and Design

System analysis and design consist of system requirements analysis and system design. Analysis of system requirements is system requirements, problems found, and how the system can run to meet the solution to each situation. System requirements include an operating system based on Android version 6.0 Marshmallow or higher with active internet connectivity and GPS to make it easier for the system to run well when activated. The problems found include not much research on the prevention and control of pesticide distribution on agricultural land with automatic remote systems, the need to use technology to support smart farms, and smartphone devices that can be used to monitor the distribution of pesticides from any location and whenever.

The system must first be designed with an activity diagram, use case diagram, and system sequence diagram (all are unified modeling language/UML designs) to run correctly; this is useful for knowing how the system and users interact. The system can be affected by user actions when activated, and this can be seen from the flow diagram in UML diagrams. Figure 2 depicts the system flowchart initially.

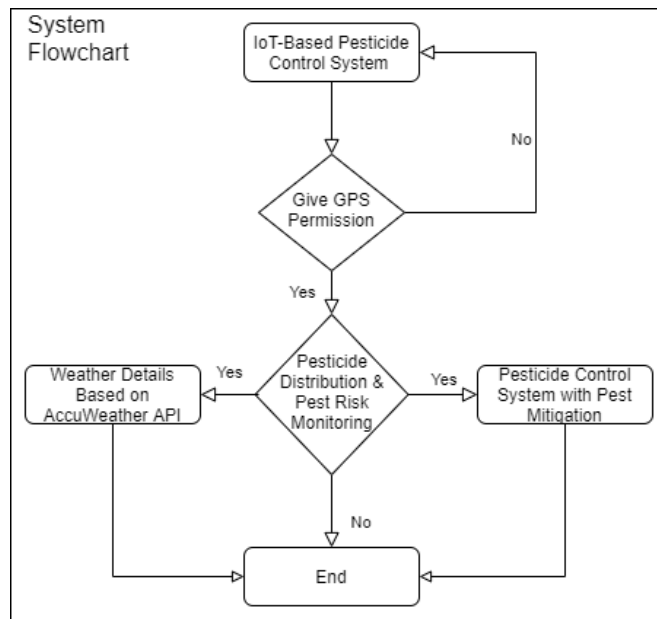


Figure 2. System flowchart for an Internet of Things-based pesticide distribution control system.

Based on Figure 2, the system starts with GPS access first. If this is not given the key, then the system stops. The system continues once GPS access on the device is allowed. The system continues to take the current location of both the user and the area of the designated agricultural land (if not, it is required to enter data on the extent of agricultural land, which is monitored in the future). During GPS-based location data collection, the system calls a photometric sensor to monitor the condition of the pesticide distribution. It is based on the principle of a photometric sensor measuring illuminance (lux), which is defined as the ratio between the luminous flux (lumen) across a surface and the surface area (m²) of a compound. The system’s work ends with user actions to control the distribution of pesticides and pest mitigation obtained from the detection of photometric sensors. It was built by the SDLC waterfall method due to a control system framework design for the end.

2.2. SDLC Waterfall Method

The SDLC waterfall method was designed with UML diagrams. A detailed activity diagram of the running system connects the user to the system. The system tries to understand requests from users. The user seeks to engage with the system’s features. Figure 3 depicts the running system’s activity diagram.

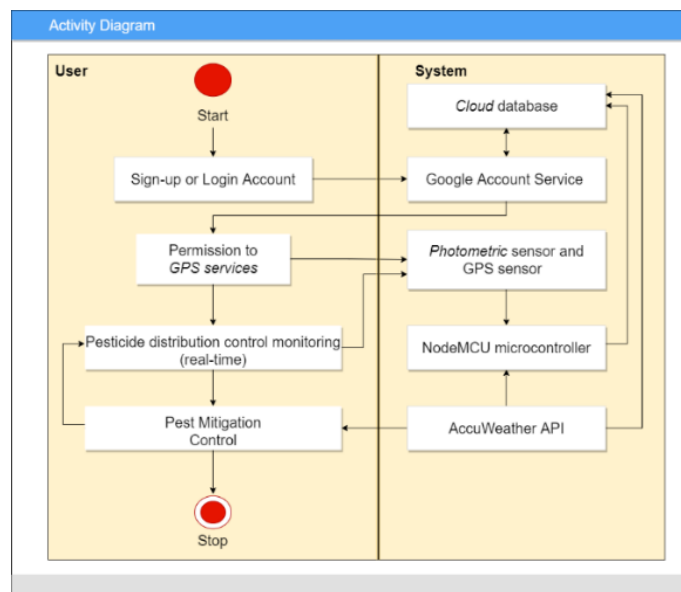


Figure 3. System activity diagram when running.

Based on Figure 3, the system runs when the user activates the control system application program. Users are asked to log in or sign-up if they do not have an account, and the user account is integrated into the cloud with the Google account service. Users are asked to access the GPS feature on the mobile device. The GPS sensor connected to the NodeMCU microcontroller module detects the user's current location and its distance from agricultural land that be or has been predetermined. The user can update the current weather from the AccuWeather API call planted in the system. Then the user can see how the pesticide is distributed on his farm by utilizing photometric sensor detection in the field. After obtaining the latest pesticide distribution, users can carry out pest control on agricultural land.

After designing the activity diagram, the next step is to develop the use case diagram. The use case diagram depicts the interaction between users and the system. The system tries to understand the features the user requests. The user attempts to run the features provided by the system. The use case diagram illustrates a user experience that serves as the foundation for creating a graphical user interface (GUI) and user experience (UX) based on how the user interacts with the system while it is operating. The flow of how the control system process runs can be seen from the use case diagram illustration at each stage of the process; this makes the framework design more computationally accurate. Use case diagrams can be seen in Figure 4.

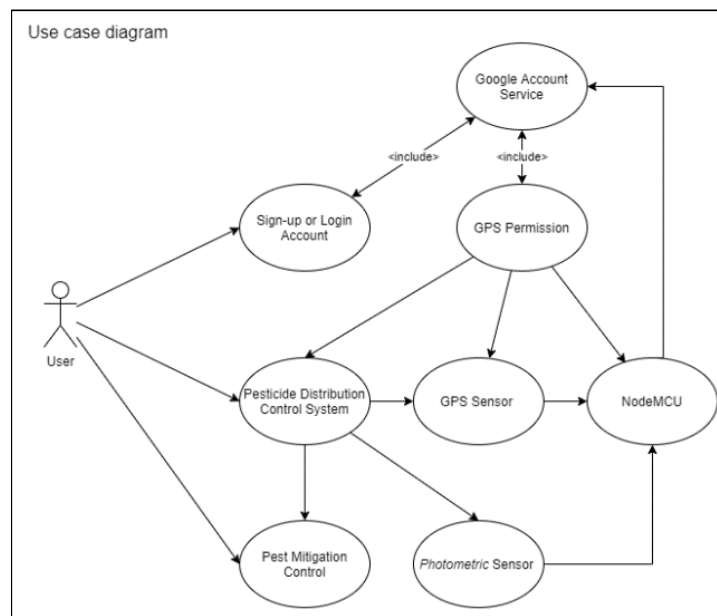


Figure 4. System use case diagram.

Next, the system was also designed with a system sequence diagram. The system sequence diagram provides details on using an IoT-based control system from start to finish. The system process is depicted in the system sequence diagram. It can be seen in Figure 5.

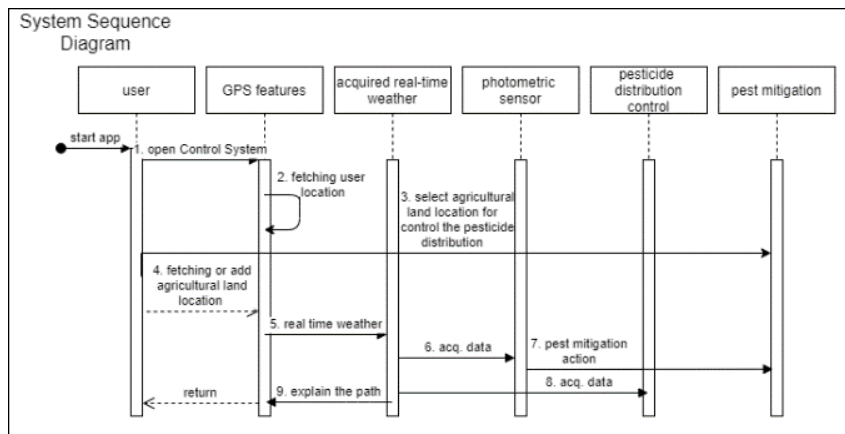


Figure 5. Design of system sequence diagram.

Figure 5 explains how the system flows after the procedure is started. It required a total of 9 sequences. Each sequence needs some features to support the flow to be a success. We designed some API for some lines, including acquired real-time weather support and GPS features (maybe it can increase the powerful thing of the GPS feature with Google Maps API or something like that).

2.3. Wiring Sensor and Microcontroller Module

A simulation is necessary by illustration (wiring) to connect each existing sensor to the microcontroller module. A simulation is critical by definition (wiring). The simulation tries to explain how the sensors are connected. The microcontroller module used in this study is a type of NodeMCU microcontroller. The primary sensors used are photometric and GPS sensors to build an IoT-based control system to determine the conditions of pesticide distribution. The photometric sensor generates a curve picture in response to the photometric probe's spectrum, which is comparable to the human eye; this is known as the standard photopic curve $V(\lambda)$. The difference in spectral response between the sensor and the standard photopic curve $V(\lambda)$ is estimated with an inaccuracy of $f'1$. Photometric sensors are designed for outdoor conditions over a long period. Photometric measurements in open spaces are usually carried out during the day in meteorology and climatology. The photometric sensor is based on the concept of a solid-state sensor by responding to the filter corrected spectral. The photometric sensor has a glass dome with a diameter of 50 mm that protects it from atmospheric harm. A PTFE diffuser and a specified shape set the cosine correction response. The cosine response on the photometric sensor is outstanding in supporting conditions when the sun is low (Figure 6) [27].

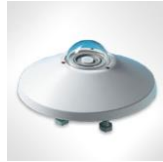


Figure 6. Photometric sensor. Source: [27].

2.4. Design Control System Framework

After all the stages are carried out, the next stage is the design stage of the control system framework that uses a photometric sensor based on the internet of things (IoT). The design framework is made with *draw.io* software. The design framework can be implemented in a mobile app and installed on an Android smartphone device with an adequate minimum specification.

3. RESULTS AND DISCUSSION

Each sensor connected to the microcontroller module is different from the wiring sensors connected to the port. In more detail, the wiring of the pesticide distribution control system can be seen in Figure 7.

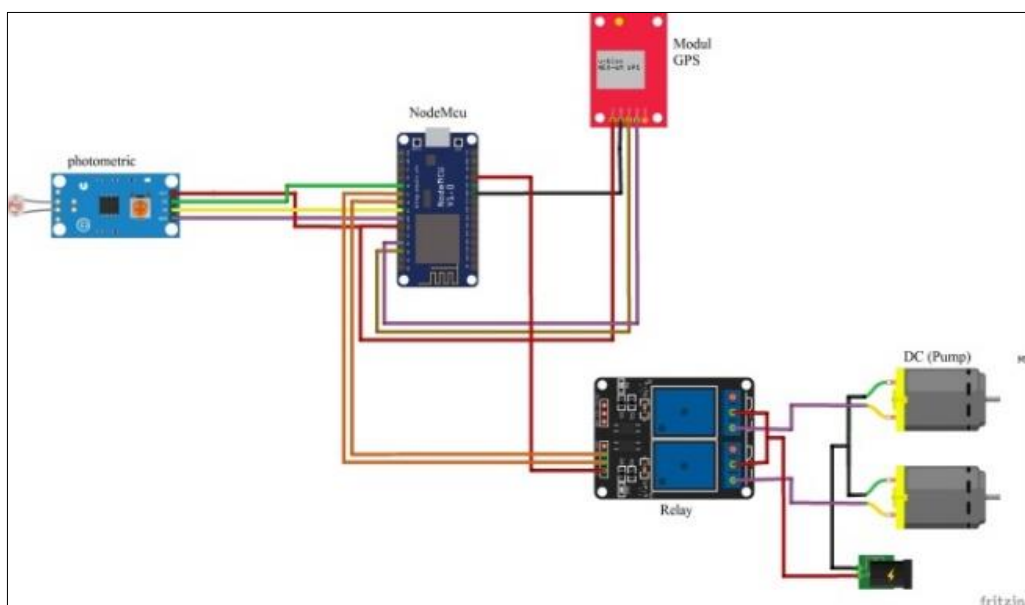


Figure 7. System control wiring schematic.

The control system framework is designed to describe system requirements and user requests. The framework is based on system requirements analysis and system design (activity diagrams, use case diagrams, and system sequence diagrams). Figure 8 depicts the control system structure in further detail.

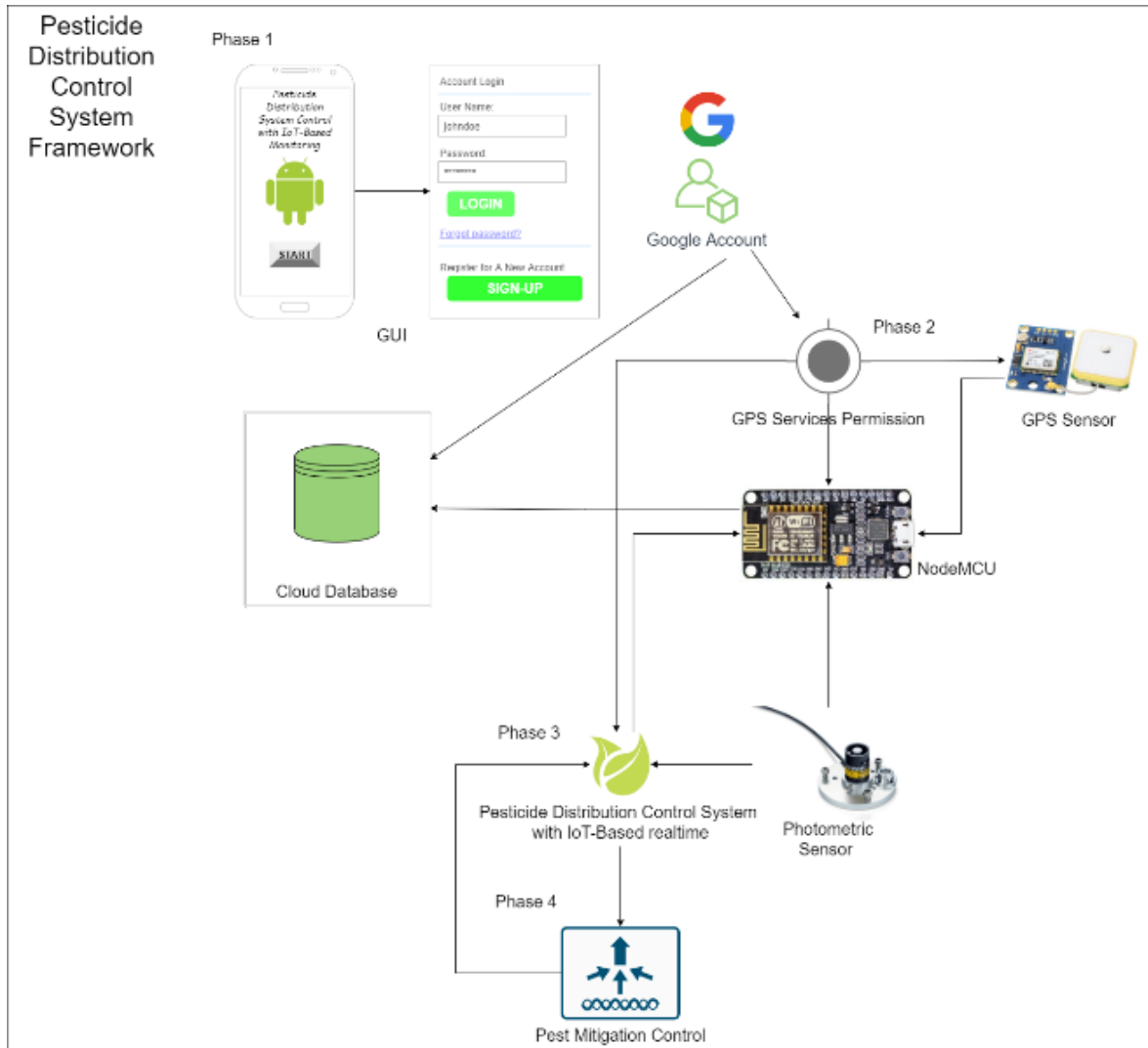


Figure 8. Framework for an IoT-based pesticide distribution control system.

Based on Figure 8, the system is designed in 4 phases. First, we planned the graphical user interface (GUI) for the system's app based on the Android OS. This design required login features. If a user is not registered, it must be signed up, and it can become synchronous with a google account. After the user logs in to the system, it passes to the 2nd phase. In this phase, the GPS feature is confirmed due to acquiring the accurate location based on the user point. Also, it is needed to access GPS sensors in the field. The microcontroller module (in this case, we used the NodeMCU module) wired the sensors to the module. This module also connects to the photometric sensor that can control the distribution of pesticides in the field later. For this step, a user enters the 3rd phase. In this phase, the user can monitor and control the pesticide distribution based on detection with the photometric sensor. After the user takes control of pesticide distribution, it enters the 4th phase; this is the final phase for the system to control IoT-based pesticide distribution.

4. CONCLUSION

Based on the findings and description provided above, it is possible to infer that the design of the pesticide distribution control system based on the internet of things (IoT) is applied to Android-based mobile apps. Further research is intended to enable the framework to be implemented into an application program.

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