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Android-Based Agricultural Insect Trap Monitoring System Using Solar Panel and Arduino Technology

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Abstract: This paper presents an Android-based agricultural insect trap monitoring system that utilizes solar panel and Arduino technology. The system aims to provide an efficient and cost-effective way of monitoring insect populations in agricultural fields. The proposed system consists of a solar panel, an Arduino microcontroller, sensors, and an Android application. The solar panel provides power to the system, making it energy-efficient and self-sustaining. The Arduino microcontroller processes data from the sensors, which monitor insect populations in real-time. Random selection of respondents was conducted, totaling twenty (20) respondents, with ten (10) representatives from Information Technology Students, five (5) representatives from farmers, and five (5) randomly selected representatives from the Faculty and Staff of SPAMAST-Digos Campus as respondents. The project achieved a combined mean favorability score of 4.4, indicating agreement on its functionality and reliability.

Keywords: Agriculture, Android-Based, Monitoring, Arduino

Introduction

One of the constraints that impede rice production in Asia, including the Philippines, is pest infestation (Savary et al., 2000), to mention a few, Rice plant hoppers, Black Bugs, Rice Bugs, and the list goes on. In a study conducted by Phil Rice in Negros Occidental, as much as 2.4-8.4 million in damage was recorded in 2017 and 2018, respectively. This is due to pest infestation, particularly rice grain bugs. Despite the big figure of income loss of farmers' productivity each year due to pest infestation (Snelder et al., 2018), it still remains a question of what the best practices are that can effectively mitigate such problems. With this, PhilRice Crop Protection Division recommends natural ways of mitigating the damage that the insects may cause in the field/crop without using too much insecticides or pesticides (Sornito, 2019) as these can impose serious health risks in the future to farmers and consumers when expose to foods that are too much exposed to those chemicals (Snelder, 2008; Brown, 2020) one of their recommendation is through Light Trappings.

This paved way for the researchers in conducting a study that can automate the trapping of insects by applying a mechanical method to gather data in real-time. Trap-ping mechanism was applied through a highly electric charged screen; the input charge from the solar panel was stored in the battery which was measured via voltage sensor and displays the voltage level in the system server. The automation of switch mechanism in LED and electric screen was applied and automatically managed with the help of a sensor called Relay; this sensor will turn ON during night-time and automatically switch OFF during day-time. The data of the monitored weight of the trapped in-sect was sent from the load cell data to the systems server, then that processed data using graphical representation for ease of understanding will be sent to the farmer's android phone.

Android-based Agricultural Insect Trap Monitoring System Using Solar Panel and Arduino Technology aimed in solving the following problems; first objective is to develop a system server with the following modules: a module that displays the real time voltage level that stored in the battery, a module that can display the volume of the trapped insect using load cell sensor, second objective is to automate the switch mechanism of the LED and electric screen trap, and lastly, is identify the level of effectiveness of the Android-based Agricultural Insect Trap Monitoring System Using Solar Panel and Arduino Technology in terms of Functionality, Reliability and Usability of the study. Figure 1 shows the general architecture framework of AI powered IoT ecosystem for agriculture discussed in the study [8], where improvement in agriculture through IoT-based smart systems, data visualization, early detection and treatment recommendations through AI, and among other were discussed.

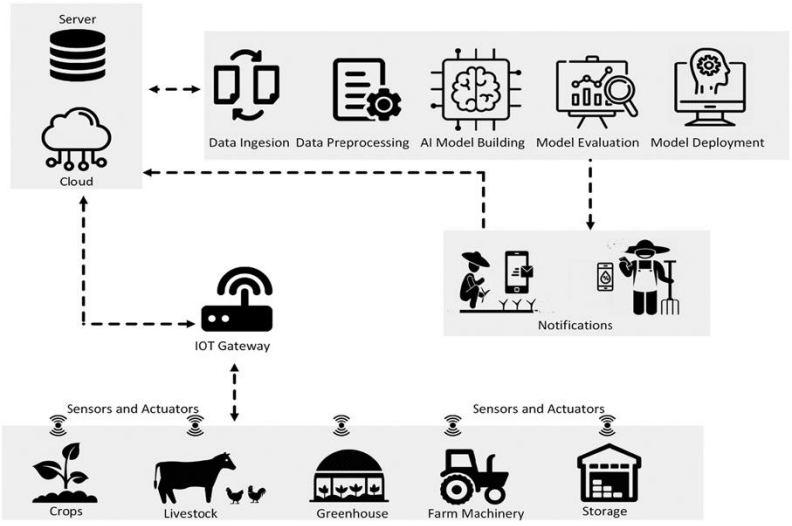

Figure 1. Generalized architecture of AI powered IoT Ecosystem for Agriculture.

Methods and Technologies Used

To ensure that the study's prototype is a self-contained system, the research team employed solar panel technology to power it (Haq et al., 2014; Sermsri et al., 2015). This allows the study's prototype to be deployed in remote areas where farms do not have access to energy. With the help of a relay sensor coupled to an Arduino board, the research study also automates electrical switch mechanisms at night and during the day.

To prevent overcharging or overheating, a battery charger controller was employed to regulate the discharge of energy in the LED and stored electricity in the battery. To keep an eye on the battery's voltage energy level and the volume of the trapped insect, an Android-based monitoring system was utilized. The birds-eye-view of how the project will be implemented is shown in detail in Figure 2, illustrates how the data from each sensor in the prototype sends its data to the system, the system automatically sorts the data to be store in the database which serves as the basis for generating Graph-based Information accessible to the farmer's android smartphones

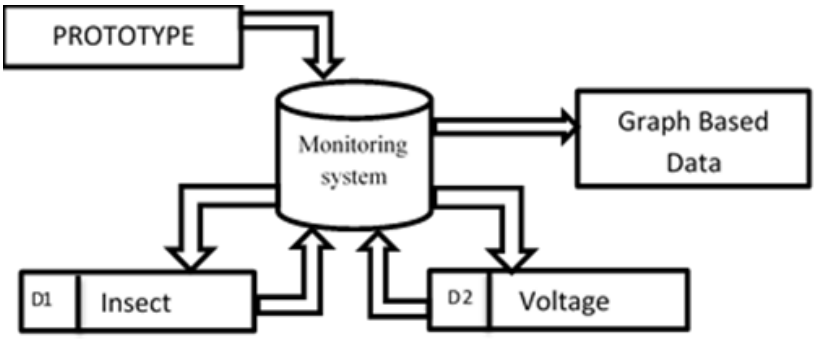

Figure 2. Data Flow Diagram of the Project.

Project Architecture

Figure 3 shows the prototype's overview, with wireless data transmission to the server and Android app using WiFi technology (Meshram et al., 2018). An internet connection is necessary for data transmission, but as long as the laptop and smartphone are on the same network, the smartphone can receive data such as insect trap voltage and volume.

Figure 4 shows the Front View, while Figure 5 Back View of the prototype, this will provide a structural over-view of the projects prototype, which utilizes solar panel and Arduino technology. These figures showcase various aspects of the prototype, including its physical structure and internal components, offering a detailed view of the system's design and functionality.

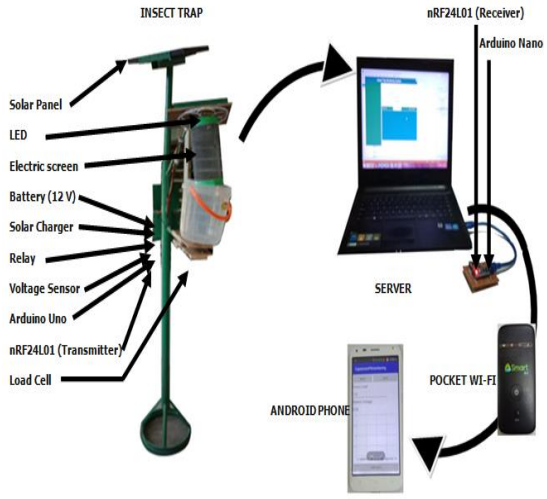

Figure 3. Project Prototype.

It also shows the detailed connections and arrangement of the hardware used to attract and trap the insects. With the use of an LED wrapped in the highly charge electric screen, insects that get attracted by the light gets electrocuted and collected using the container placed underneath it. The weight is then measured by the load cell, from which data is then sent to the systems server.

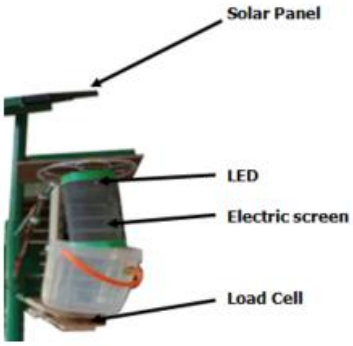

Figure 4. Front View of the Prototype

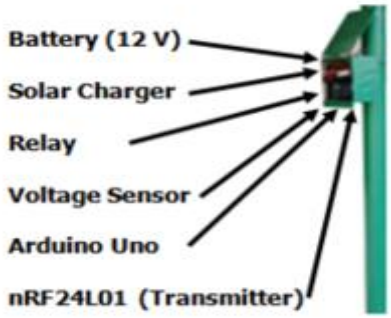

Figure 5. Back View of the Prototype

Circuit Diagram of the Project

Figures 6 and 7 demonstrate the process of transmitting data from the insect trap prototype to the server. Figure 6 shows the circuit diagram for acquiring and transmitting data, while Figure 7 displays the circuit diagram for receiving data using Arduino Nano and NRF24LO1. The desktop application retrieves and stores the data into a database for further analysis.

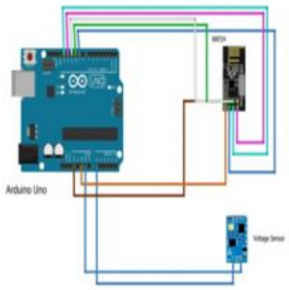

Figure 6. Transmitting Data.

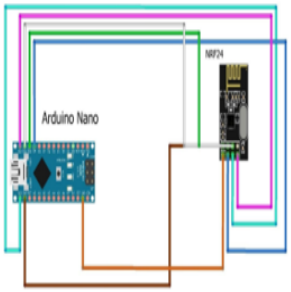

Figure 7. Receiving Data.

System Server and Android App Module

The research team employed Wamp Server as their local server to process the recorded data transmitted by the prototype's various sensors. This approach helped ensure that the farmer's phone receives visualized data instead of raw data. The team utilized GraphLib, an open-source An-droid library, to convert the raw data into graphical representations, making it easier to interpret. The system's main form is presented in Figure 7, which displays a user-friendly graphical interface that can retrieve three types of data: Voltage Level, Insect Load, and Reports. The Voltage Level represents the energy stored in the battery from the Solar Panel (Hoeller and Frohlich, 2011), while Insect Load refers to the weight of the trapped insects in the prototype, measured using a Load Cell. The Reports module allows farmers to retrieve specific data from the system. On the other hand, Figure 8 presents the processed data from the server, where the Android application can only display the Insect Load and Voltage Level in the battery. This approach in data processing allows the project team to present the data in a more accessible and user-friendly to the farmers (Wijaya et al., 2018).

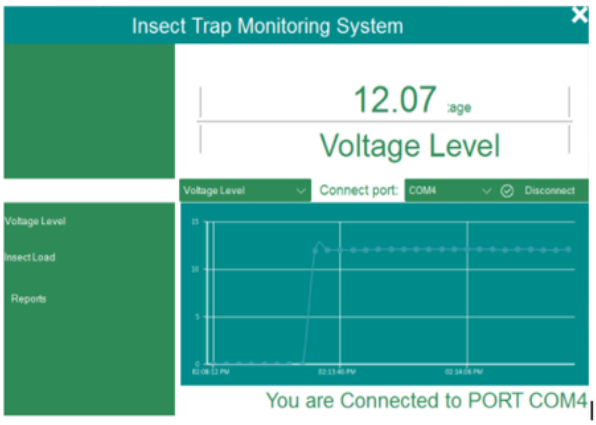

Figure 7. System Server Interface.

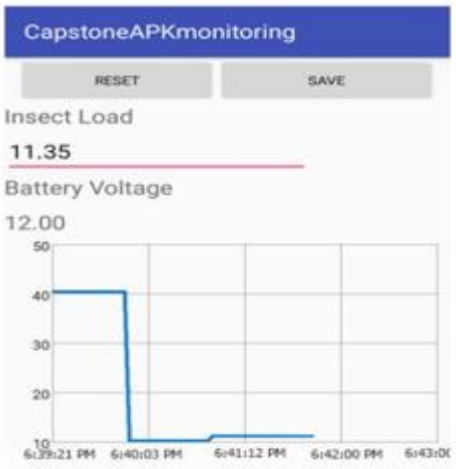

Figure 8. Android Application Interface.

Testing and Evaluation

A Random Sampling was used to evaluate the pro-jects Usability and Functionality. The distribution evaluators consisted of fifteen (Liu, 2014). Table 3 shows the distribution of respondents involve in the study. The respondents were given the opportunity to express how much they agree or disagree with a given statement using a five point Likert scale system to measure the software quality, namely; Excellent, Good, Fair, Poor, Very Poor. Table 4 shows the point range verbal interpretation for the Likert scale. The statements for the questionnaire used by the researchers were modified statements taken from ISO/IEC 9126-1:2001 or the Software Product Quality Standards (Meshram et al., 2018).

Table 1. Distribution of Respondents.

Evaluators	**Sample Size**
IT Students	5
Farmers	5
Advisory Committee (except Adviser)	5

Results and Discussion

To assess the Functionality, Usefulness, and Reliability of the project, a thorough testing process was conducted that involved administering a questionnaire to respondents to gauge their experience of using the application in line with its intended functionalities. Prior to the testing, the researcher provided an orientation and presentation of the project to the respondents to ensure that they understood its objectives and functions. The researchers randomly selected 15 respondents from a diverse pool were classified based on relevant criteria (See table 3 for distribution). The testing process was designed to ensure that the project was rigorously evaluated and could be relied upon to per-form optimally in its intended context.

Table 2. Descriptive Rating of the Functionality.

Particulars	**Mean**	**Verbal Interpretation**
Required task are performed by the system satisfactorily	4.4	Good
The project resumes working after failures resolved	4.2	Good
The system helps the user overcome any problem	4.4	Good
Consolidated Mean	**4.3**	**Good**

Functionality refers to the essential features and capabilities of software, which enable it to perform specific tasks. For example, in a prototype designed to trap insects, the software's functionality may include generating data on the voltage and volume of the trapped insects. In the survey, respondents gave a mean score of 4.3, indicating that a high level of agreement that the project is able to deliver its intended functionality

Table 3. Descriptive Rating of the Reliability.

Particulars	Mean	Verbal Interpretation
Reports presented in the app/system is data stored in DB	4.4	Good
The project is capable of maintaining its performance despite the presence of errors when used.	4.25	Good
xMost errors have been corrected overtime	4.4	Good
Consolidated Mean	**4.4**	**Good**

Reliability refers to the ability of a system to consistently deliver its intended services and functions over a specified period of time, even under challenging conditions or stress. This includes maintaining a high level of performance, avoiding errors or crashes, and minimizing down-time or disruptions to service. In the survey of project, the respondents gave a mean score of 4.4 on reliability, indicating a high level of agreement that the project is able to deliver its intended services consistently and reliably.

Table 4. Descriptive Rating of the Usefulness.

Particulars	Mean	Verbal Interpretation
The user interface is intuitive and receptive to learning.	4.54	Excellent
The documentation is very informative.	4.35	Good
The Prototype is self-powered	5	Excellent
Consolidated Mean	**4.5**	**Excellent**

Usability is a critical aspect of this project, this refers to the ease of use and effectiveness of the software for its intended users. Specifically, usability is defined as the ease of use for a given function with which users can complete tasks or achieve goals using the software (Djouab and Bari, 2016). In the sur-vey of respondents, the project received an excellent mean score of 4.55 for usability, indicating a high level of satisfaction with the software's usability.

Table 5. Overall descriptive rating from the respondents in terms of Functionality, Reliability and Usefulness.

Particulars	Mean	Verbal Interpretation
Functionality	4.3	Good
Reliability	4.4	Good
Usefulness	4.5	Good
Consolidated Mean	**4.4**	Good

Generally, results show that application’s Functionality, Reliability, and Usefulness was determined to be GOOD, which indicated that majority respondents agreed that the android

application can fetch data from the web system designed to store data sent from the sensors attached to the prototype. Prototype on the other hand can send data to the though WiFi particularly data on Voltage Level, and weight of trapped insects with the use of Load Cell sensor. These sensors make the prototype effective and can be used to determining appropriate measures for farm management (Liu, 2014).

Conclusions

The project achieved an overall performance rating of 4.4 from the evaluators, which was interpreted as "Good." This evaluation focused on various aspects of the project, including its usefulness, functionality, and reliability. The majority of respondents agreed on the functionality and reliability of the project, indicating that it met their expectations in delivering its intended results and functions. This positive feedback underscores the project's success in achieving its primary goals.

However, digging deeper on the data of total weight of the insect trapped and the voltage level collected in the android application from the sensors used can provide better reflection as to what these data represents. Data particularly on the total weight of the insect trapped, can use computer vision and artificial intelligence in order to determine the type of insect it trapped. This is in support to the study on the potential of ICT technologies over traditional farming practices discussed in (Ahmed et al., 2016). Additionally, in a study conducted by (Lopez, 2012) emphasis on the importance and benefits of using robotic technologies as an effective and efficient way of farm management in pest and disease.

Moreover, some evaluators noted areas for improvement, such as enhancing the user interface design, providing better user documentation and training materials, and increasing the efficiency of certain workflows. These insights are invaluable and will be taken into account in future iterations of the project to enhance its usability and user satisfaction. The evaluators represented a diverse range of backgrounds and experiences, ensuring that their feedback is reflective of the needs and perspectives of the project's user base. This diversity in feedback highlights the project's broad applicability and relevance.

Overall, the high rating received by the project reflects the team's dedication to delivering a quality product that meets the needs of its users. The project successfully achieved its goals of providing a useful, functional, and reliable solution, while also identifying key areas for future improvement to further enhance its value and effectiveness.

Recommendations

The Android-based Monitoring System for Agricultural Insect Trap for Rice Crop Using Solar Panel and Arduino Technology underwent a rigorous evaluation process to ensure its effectiveness and usability. As a result of the evaluation, three major recommendations were identified to enhance the system's functionality and usability. These recommendations included:

1. Optimizing the system's power management to improve its efficiency,

2. Improving the web system and android applications' user interface to enhance its ease of use for farmers and other stakeholders;
3. Use of Computer Vision and Artificial Intelligence Model trained to recognize insects to quantify the type of insects trapped in the prototype;
4. Conduct stress testing on the android applications software compatibility.

The recommendations were derived from a combination of user feedback, technical analysis. The project team is currently working to integrate the recommendations into the system to ensure that it delivers a high level of performance and usability for its intended users. By taking these recommendations into account, the Android-based Monitoring System for Agricultural Insect Trap for Rice Crop Using Solar Panel and Arduino Technology will be better equipped to address the needs of farmers and improve the overall sustainability and productivity of rice crop agriculture.

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