DESIGN AND IMPLEMENTATION OF AN IOT BASED MONITORING AND MANAGEMENT SYSTEMS FOR AGRICULTURE INDUSTRIES

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DESIGN AND IMPLEMENTATION OF AN IOT BASED MONITORING AND MANAGEMENT SYSTEMS FOR AGRICULTURE INDUSTRIES

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in partial fulfillment of the requirements for the degree of
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DECLARATION

I declare that this thesis entitled “DESIGN AND IMPLEMENTATION OF AN IOT BASED MONITORING AND MANAGEMENT SYSTEMS FOR AGRICULTURE INDUSTRIES is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

I hereby declare that I have checked this report entitled "DESIGN AND IMPLEMENTATION OF AN IOT BASED MONITORING AND MANAGEMENT SYSTEMS FOR AGRICULTURE INDUSTRIES" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Mechatronics Engineering with Honours

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DEDICATIONS

To my beloved mother and father

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ABSTRACT

This project focuses on design and implementation of an Internet of Things (IoT) based system for agriculture industries especially chili plantation. Every year chili farmer experience huge losses due to the pest infestation and lack of technology precise manage chili farm. To solve several problems, the IoT system was designed can continuously monitor pest detection status, temperature, humidity index and soil moisture level simultaneously. Beside these, the IoT system also designed for long distance remote water, pesticide and fertilizer pump. An IoT platform was applied in this project to provide a monitoring dashboard and switches to empower long distance remote several pumps with the LoRa communication systems in wide cover range of chili farm. There are three experiments was designed to determine the cover range of LoRa network. All experiments and data collection was done in the campus Universiti Teknikal Malaysia Melaka (UTeM) and Melaka area. All experiments was analysed based on the result collected such as Received Signal Strength Indicator (RSSI), Signal-to-noise ratio (SNR) and Packet Reception Rate (PRR). Based on the experiment result and conclusion, LoRa communication system suitable apply to chili farm in order to monitor all the elements such as soil moisture and pest detection status. The experiment also concludes this LoRa network can be work effectively up to cover range 260m with elevation of gateway.

ABSTRAK

Projek ini akan focus dalam reka bentuk dan implikasi sistem berasaskan IoT bagi kegunaan industry pertanian terutamanya tanaman cili. Petani cili menghadap kerugian yang besar disebabkan jangkitan perosak dan kurang teknologi yang canggih untuk mengurus tanah pertanian. Untuk menyelesaikan masalah dihadapi, sistem berasaskan IoT ini telah dirancang supaya boleh mengesan perosak, mengukur suhu, kelembapan persekitaran dan tahap kelembapan tanah. Bukan itu sahaja, sistem IoT ini dirancang untuk dapat mengawal suis pam air, racun dan baja dari jarak jauh. Terdapat satu platform IoT diaplikasikan dalam sistem ini untuk menyediakan papan pemuka pemantauan dan butang suis untuk menyedari kawalan suis pam dari jarak jauh dengan menggunakan sistem komunikasi LoRa di dalam ladang cili yang luas. Terdapat tiga ujikaji dilaksanakan untuk menganggar keluasan sistem komunikasi LoRa. Setiap ujikaji telah dikenalpasti dengan beberapa parameter seperti RSSI, SNR dan PRR. Segala ujikaji dan aktiviti pengumpulan data dilaksanakan dalam kampus Universiti Teknikal Malaysia Melaka (UTeM) dan daerah Melaka. Berdasarkan pada keputusan ujikaji, sistem komunikasi LoRa sesuai untuk diguna dalam ladang cili dan memuktamadkan meninggikan kedudukan gateway boleh memperbaiki julat penutup sistem komunikasi LoRa dengan jarak 260m.

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CHAPTER 1

INTRODUCTION

1.1 Motivation

The Gross Domestic Product (GDP) of developing nations are highly dependent on agriculture sector [1]. Agricultural practice ranges from crop cultivation (farming), forestry and livestock farming for domestic use or commercial purposes as raw materials and other operations. This was the main precursor of human evolution. The ever-increasing population has put enormous pressure on the agriculture sector to satisfy the demands of the rising population and technology. The global population is predicted to hit 8.5 billion by 2030 and 9.7 billion by 2050 [2]. China and India are the two most population countries in the world with more than 1 billion inhabitants, 19% and 18% of the world's population. The population of India is projected to over perform China by 2022 [2]. Both countries are highly dependent on agriculture in order to sustain the supply of livelihoods for their increasing population.

Internet of Things (IoT) is a system of interrelated computing systems, mechanical and digital computers, objects, animals or individuals with unique identifiers (UIDs) and the ability to transmit data over a network without the need for human-to-human or human -to-computer interaction [3]. As the field is spread over a wide area of farmland for agriculture or animal gazing, the use of Wireless Sensor Nodes (WSN) is the best choice [4]. The low power consumption allows it to run on a stationary node battery or solar node. The actuator nodes are linked to the Personal Area Network (PAN) since it required high power and the quantity are not as high as the sensor nodes. This overall framework can be built into an IoT-based system utilizing the current Local Area Network (LAN) and the Internet [5]. This hardware framework is supported by cloud-based tools for data analytics, which allows to track and manage field nodes remotely. In this way, IoT will play a crucial role in improving the role and work of any part of agriculture and farming. From the condition of field, IoT will integrate the system into cloud-based system. Each crop can be a node in IoT system and their status can be registered in the system with performance parameters. It is important to use this information for real time monitoring and control of various production factors such as soil moisture, nutrients, humidity and temperature of farm. In developing nations, the main benefits of the IoT in agriculture is the economic technology for the development of agriculture sector.

Agriculture would become water-saving agriculture, mechanical and intelligent agriculture, high-quality, high-yield and pollution-free agriculture in the 21^{st} century. For both reasons, informatization of agriculture is an essential and successful solution and is the central technology of modern agriculture. The nature of agricultural knowledge is to use information technology to digitalize each method in any aspect of agriculture such as crop processing and pest detection. The Agriculture Management Information System (AMIS) is needed to unite all aspects of Digital Agriculture during this digitalize process and manages different data formats. Both standardized and proprietary are share data with providers that provide automated agriculture with computing. At present, AMIS has gradually expanded the degree of complexity due to the emerging technology of online access, Internet connectivity have generally been implemented, and application of IoT.

In all developing countries around the world, agricultural digitalize has been rapidly developing. In Japan, computers have been commonly used in crop breeding, insect utilization, crop management and prepare weather report. In United States, farmers are connected to big data, a farmer at home has access to the database of government, research institute and libraries. Each user connected to the database able to get the latest data of price fluctuations, sed melioration and emerging skills and technology in agriculture sector. Computer can help farmers to evaluate the suitable crop and seasons should be planted and most suitable of farming mode then farms should have highest yields and benefits. There are a few major commercial supplier of FMIS such as Wisu and Agrineuvos have plug-in or similar applications available for various farm management specialties. [6]

Instructing agricultural production by recognize the related and available information is highly necessary. Agricultural data is the basis of AMIS, the quality of the acquisition and processing of agricultural data would have a significant effect on the management of agricultural information. Due to the farmland ecosystem is a rather complex ecological framework and involves several types of variables, from environment to individual, from ecology to economic, and from geography to culture, the collection of data typically incurs the substantial costs and technologies. [7]

1.2 Problem Statements

The number of harvestable cops that are decreased by pest and disease attacks will be negatively impacted by those crops that survive to be harvested from all species thus afflicted can be adversely affected. In most crops, harmless fungal mycelium is present, but fungal traces are more dangerous in some cases and even can be poisonous. Pests that cause a decrease in the ability of photosynthesis to the plant lead to a reduction in the supply of nutrients to the fruits, then reducing the synthesis of the endosperm starch portion. As a result, crops are less well filled and become shrunken, and thin when mature.

In view of the normal farming practices, farmers also need to visit agricultural sites frequently to get a better understanding of the conditions of their crops such as soil moisture level. Farmers using a lot of resources such as manpower and time consuming to monitoring and understanding the condition of crops and farm. Farmer did not have a standard and precise technology to help them monitor and manage the farm.

Since the chili farm have a large size of land, a effectively wireless communication system is a challenge to monitor and manage the condition of chili farm.

1.3 Objectives

1) To design and develop an IoT systems for crop management based on three aspects: monitoring condition of chili farm, control several pumps in the chili farm and able monitor and manage farm from dashboard

2) To analyse the cover range of wireless communication system in chili farm

1.4 Scope of the Project

The scope of the project is to design an IoT platform that able to real time monitoring the condition of farm such as temperature, humidity, pests, and soil moisture. To make this IoT platform convenience and humanize, this must have a control interface that can view and make decision on smartphone and tablet. To make sure farmer can receive the emergency condition of farm immediately, this IoT platform must be able to send important notification to farmer by email and able to long distance make decision immediately on smartphone such as switch on water pump and pesticide pump. By conducting experiment and test to determine the cover range of wireless communication system in chili farm and conclude a solution to maximize the limitation of cover range.

CHAPTER 2

LITERATURE REVIEW

2.1 Monitoring and Management System for Agriculture

Khajol, Akshay et al. [8] designed a smart monitoring system using the current technologies such as Internet of Things (IoT), cloud computing and image processing. The system was designed not only for monitoring the farm but also provide suggestion to farmers about the moisture of soil, detecting pest and the type of crop suitable for the soil. To analyses to moisture of soil, a line follower robot was developed by using Raspberry pi, which able to monitors the moisture level of soil at every 100m distance. A camera was directly connected to the system for detect the pests. After done the survey from farm, the system retrieves all stored data from cloud and SQLite database to analyses the moisture content and pest information for provide suggestion to farmer with the required pesticide. The energy sources of system were batteries or solar panel.

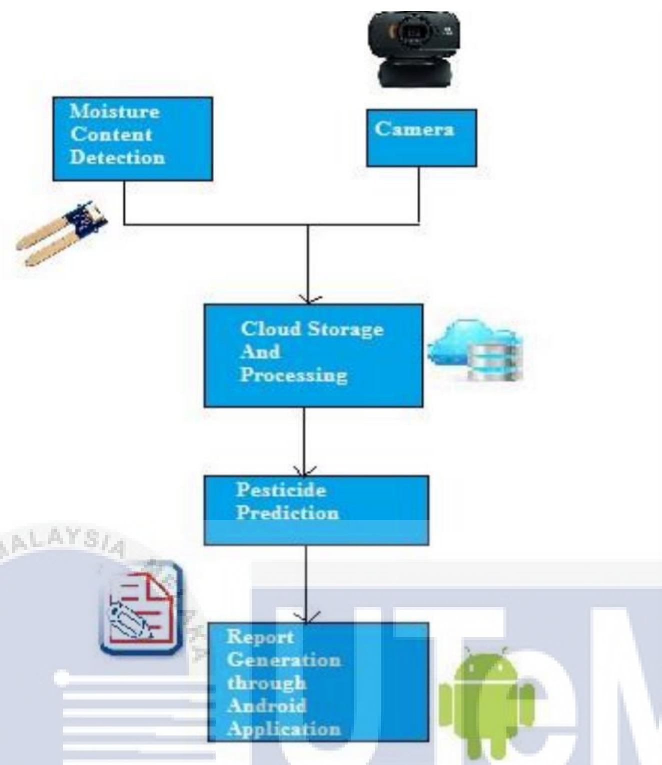

Figure 2.1: Flowchart of the system

2.2 Wireless Sensor Networks for Monitoring in Agriculture

Abel, Riccardo et al. [9] was proposed an ad-hoc ergonomic, low cost, miniaturized platform, characterized by low environmental impact, low power consumption and high performance of multi-function wireless sensor. Each set of sensors called Sensor Node (SN) was the relevant component of the system. The SN was equipped with environmental sensors and a camera. The Base Station (BS) was developed by using a Raspberry pi to receive the data from multiple SN. The communication between SN and BS was using radio wave technology. The power sources of SN and BS was supplied by using solar panel and batteries.

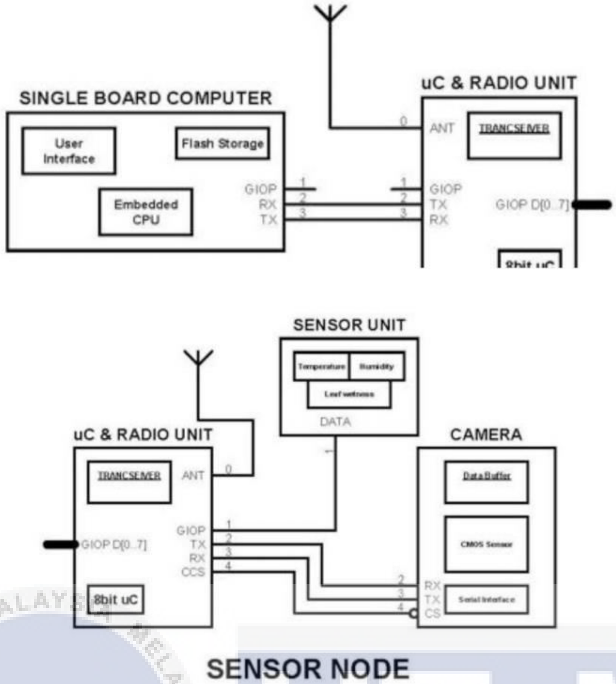

Figure 2.2: BS Scheme (Top) and SN scheme (Bottom)

Figure 2.3: Top left (The BS), Top right (The SN),
Bottom left (The SN inside the case), Bottom right (The SN installed in farm)

2.3 Count Pest by using Image Processing Technology

Dan, Lin et al. [10] was developed the image processing algorithm to analyses the number of pests. The insect pest count obtained is filtered and processed based on the previous image references from the same hour. During the aforementioned instances, the algorithm is repeated with adjusted contrast and brightness to reduce error of counting. Then, the pest detection result will summarise and post into IoT dashboard. This project has been prove that the pest detection system able improve to IoT system, so user can more convenience to understand the pest condition in the farm.

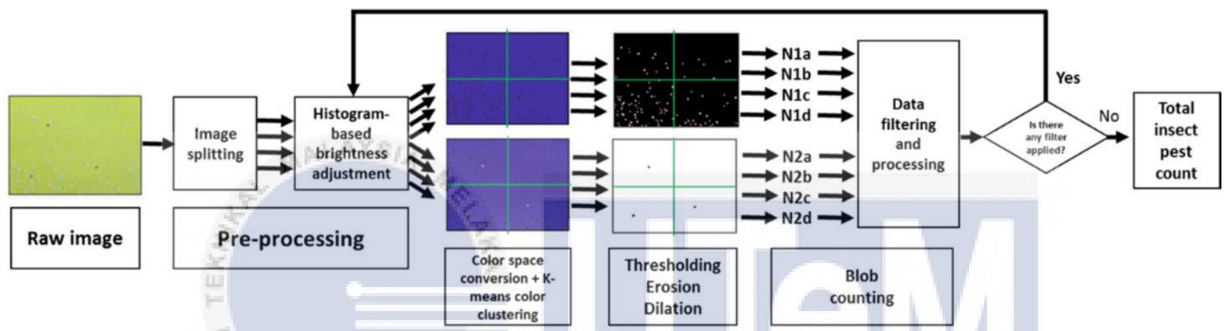

Figure 2.4: Insect pest counting image and data processing algorithm flowchart

2.4 Soil Sampling and Mapping

Soil sampling was the first stage of analysis to survey field-specific data, which is then further used at make important decision at various stages. The major purpose of soil analysis is to study the nutrient in the soil so that the data can be collected accordingly when nutrient deficiencies are found. Comprehensive soil mapping are advised on an annual basis and usually in spring. However, it may be conducted in fall or winter is depending on soil conditions and weather consents [11]. The consideration factors for the study of soil nutrient levels are important such as soil composition, cropping history, fertilizer use and irrigation level. These reasons provide information based on the data collection such as chemical and biological information of a field to determine the limitation factors such that the crops can be dealt accordingly. In a particular field, soil mapping provides to sowing various crop varieties to best balance soil properties accordingly such as seed suitability, suitable time to sow and even the depth of planting, as some are deep rooted and others are less.

Manufacturers are currently offering a board variety of sensors and toolkits that able help farmers monitor the condition of the soil make decisions to prevent its degradation. These systems allow soil contents such as soil humidity and absorption rate to be controlled effectively helping to minimise degradation, densification, salinization, acidification and pollution by prevent excess application of fertilizer. Lab-in-a-Box is a soil testing tool kit produced by AgroCares, based on its services provided is considered a full laboratory service [12]. Through using this, farmer can examine over 100 samples a day and over 22,000 nutrient samples collected a year without having any laboratory experience.

Drought is a serious issue that reduces the production of crop yield. This challenge is faced by most areas across the world with different intensities. Remote sensing is used to deal with this problem especially in very crucial areas by obtain frequent data on soil moisture that could helps to analyse agriculture droughts in different regions. The Soil Moisture and Ocean Salinity (SMOS) satellite was launched for remote sensing in 2009, which offer global soil moisture mapping services for every one or two days. Martinez, Gonzalez et al. [13] used SMOS L2 to measure the soil water deficit index (SWDI) in Spain, 2014. They followed various methods in this attempt to obtain the parameters of soil water in order to compare the SWDI collected from in situ data. Vagen et al. [14] used the moderate resolution imaging spectroradiometer (MODIS) sensor to monitor different soil functional properties to evaluate the risk of land degradation in sub-Saharan Africa. The forecast models were established by using soil maps and soil collected information, which covered all important areas on the continent.

Sensors and vision technology are beneficial in accurately decide the length and depth for seed sowing. Santhi, Kapileswar et al. [15] proposed a sensor and autonomous robot with vision technology named Agribot for efficiently seed sowing. The robot will operate on any agriculture land by the self-awareness of the location of the robot is determined by the global and local maps provided by the Global Positioning System (GPS) while a personal computer equipped with the on-board vision system. Furthermore, Karimi, Navid et al. [16] proposed the various wireless sensing techniques to evaluate the rate of seed flow while the sensors are fitted with LEDs built from infrared, visible light and laser-LED especially the radiation receiver. The output voltage varies depending on the movement of seeds through the sensor and dropping of the shades on the receiver components. The signal information is connected to the moving seeds for determine the seed flow rate.

2.5 Agriculture Irrigation

About 97% of the Earth's water is salt water formed by seas and oceans, where fresh water is only consists 3%, over than two-third of which is freeze into form of glaciers and polar ice caps [17]. Then, only 0.5% of unfreeze fresh water was in the air or ground and others was store in underground [18]. In summary, human using this 0.5% to satisfy all its needs to survive and protect the environment as sufficient fresh water needs to be maintained in rivers, lakes and other related reservoirs to support it. It is worth recalling that roughly 70% of this available fresh water is primary used by the agricultural industry [19, 20]. The condition is rising to 75% in many nations such as Brazil, also in some underdeveloped nations up to 80% [21]. The major factor for this high volume of water used in the monitoring process as visual inspection of crops for irrigation decision making was very popular in 2013, it was observed by almost 80% of farms in the United States [22]. According to reports from the UN Convention to Combat Desertification (UNCCD), 168 nations have been affected by desertification in 2013 and almost half of the world's population will live in zones with high potential of water shortages by 2030 [23]. Considering the statistics of water shortages across the globe, and at the same time the demands on agriculture and other industries, it should be supplied only where it is essential, and most importantly in quantity available. For this purpose, strengthen awareness of the protection of current under-stress water supplies has been introduced using more effective irrigation systems.

Various regulated irrigation skills such as drip irrigation and sprinkler irrigation are being promoted to solve water wastage problems which have already been found in conventional techniques such as flood irrigation and furrow irrigation. Both crop quality and quantity are significantly impaired by water scarcity, as intermittent irrigation, even abundance, leads to reduced nutrient in the soil and induces numerous microbial infections. It is not an easy process to correctly measure water consumption for crops where factors such as crop type, irrigation system, type of soil, precipitation, content of crop needed and soil moisture retention are included. In view of this, an accurate soil and air humidity management device using non-contacted sensors not only ensures efficient use of water, but also increases health of crop.

Nowadays, the irrigation techniques are likely for improve with the introduction of new IoT based systems. A major improvement in crop production was predicted with the use of IoT-based technology such as crop water stress index (CWSI) irrigation management [22]. For this reason, the achievement of crop canopy at different times and temperature of air is important for the measurement of CWSI. A wireless monitoring system, where all field sensors are linked to acquire the measurements stated above and further transmitted to the production center where suitable software and application that are intelligently used for analyse farm information. Not only this, but also data from other resources, including information of weather and satellite imaging was applied to CWSI models for evaluation of water needs, and a particular irrigation index value is finally generated for each area.

2.6 Fertilizer

Fertilizer was a natural or artificial material that able supply essential nutrients for fertility and growth of plant. Plants primarily require three primary major nutrients which are nitrogen (N) for growth of leaf; phosphorus (P) for the health of root, flower and fruit growth; potassium (K) for growth of stem and movement of water [24]. Every kind of nutrient shortage or excessive application can be extremely damaging to plant health. More specifically, the excess applied of fertilizer not only will reflect in financial costs, produces bad impacts on land and the atmosphere by depleting soil fertility, poisoning soil water and adding to global climate change. Overall, crops consume less than half of the nitrogen used as fertilizer while the remaining will be either released to the atmosphere or wasted as runoff. Uncontrolled application of fertilizers contributes to unbalance of both soil nitrogen ratios and global environment, as currently about 80% of the world's deforestation has arisen primarily as a result of farming practices [25].

Smart agricultural fertilization assists to accurately predict the necessary dosage of nutrients, effectively minimizing their harmful effects to the environment. Fertilization includes site-specific measurements of nutrients in the soil levels based on different reasons such as type of crop and soil, absorption potential of soil, product yield, fertility and consumption rate, weather conditions, etc.