Smart Agriculture Using Internet of Things

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Abstract- **Recent researches hypothetically shown the potential of Internet of Things (IoT) to change major industries for a better world, which includes its impact towards the agriculture industry. Farming industry must grasp IoT to feed 9.6 billion of global population by 2050. Challenges such as extreme weather conditions and rising climate change shall be overcome to fulfil the demand for food. Smart farming based on IoT technologies will enable growers and farmers to reduce waste and enhance productivity ranging from the quantity of fertilizer utilized to the number of journeys the farm vehicles have made. So, what is smart farming? Smart farming is a capital-intensive and hi-tech system of growing food cleanly and sustainable for the masses. It is the application of modern ICT (Information and Communication Technologies) into agriculture. In this paper, the hardware and software of the IoT for smart farming will be presented besides sharing the successful results.**

Keywords **– IoT, smart farming, agriculture, ICT and sensor technology.**

I. INTRODUCTION

Malaysia has witnessed rapid economic growth of post-independence, especially after the introduction to heavy industries in the 1980s and 1990s. The country, originally based on agriculture and fisheries, today is led by services that account for about 55 percent of Malaysia's Gross Domestic Product (GDP) value. Over the last decades, the contribution by Malaysian agricultural sector has been declining due to the development of the local industry and the services sector. In 1970, almost 30 percent of GDP was contributed by agriculture. However, this percentage has dropped sharply to 8.2 percent in 2017 [1]. The dominance of commodity cultivation in local agriculture due to its higher commercial value has resulted in crop yields such as the paddy, vegetables and fruits, which remained weak in terms of crop size and contribution to the economy. It is therefore desirable to be given new breath to the local agriculture sector, especially the source of food crops. To achieve this, the Malaysian agricultural sector needs structural changes in a massive scale driven through the Smart Farm Revolution or smart farming to nurture this area. The Smart Farm Revolution refers to the latest use and integration of the latest technology in agriculture, with the aim of increasing the quantity and quality of domestic crop harvest. For example, drones can be used to spray insects, analyse soil cultivation and monitor crop yields quickly and without the use of a bunch of labour. In addition, an Internet of Things (IoT) based sensor can be used to transmit real-time plants data to farmers for their appropriate actions.

In addition, to encourage farmers to improve their agricultural technology, the government may also introduce a new system. In this system, the government will give subsidy to farmers according to the rate of their technology adoption [2]. However, it is imperative for farmers to be given comprehensive assistance and advice on the use of smart farming techniques before the proposed system is widely introduced. It is time for Malaysia to tackle its efforts to empower local agriculture through a technological revolution, especially through smart agriculture.

In order to provide skilled and semi-skilled manpower for the purpose of preserving the technology revolution, there is a need to emphasize the study about the Technical and Vocational Education and Training (TVET) on agricultural industry. This emphasis will create employment opportunities for young people and future generations to be more open and competitive. This will reduce the dependency on foreign workers.

Agriculture will continue to be an important element for Malaysia and the concept of smart farming will change the country's agricultural landscape in the long run. IoT technology will enable farmers to view their farms remotely. At the same time big scale agriculture could easily be implemented and monitored precisely.

Section 2 will discuss about the revolution in agriculture industry. The next section will elaborate the architecture of IoT system for smart farming. Section 4 will share some data captured by IoT system in smart farming. The positive results also will be explained in 4th section. Section 5 is the conclusion.

II. RESEARCH BACKGROUND

As a reference we can see the development of a longer agricultural revolution in Europe. It starts with a land ownership system. Private land ownership systems and public land selection systems have been established. The following lands belong to the rich and the individual. The following land is used for small-scale farming, livestock rearing, animal hunting, fishing and day-to-day living. The Government leveraged public land for the purpose of massive agricultural production. The landlord fenced the public land. Land Enforcement Act is enforced. Larger areas are available for planting. This has caused ordinary people to lose the source of livelihoods and smallholder farmers into farm labourers. Some of them migrated to the city and became factory labourers.

The plant rotation system created by Lord Townshend was established for land optimum usage [2]. It is used continuously throughout the year. This system tells to plant different crops according to season, using different soil nutrients. This strategy to make sure plants able to grow fertile. New plants are also introduced. Among them, clover, clover, turnip and potato. New tools such as seed drill are also created by Jethro. Seed drilling is used for digging and retailing. It's done fast.

Commercial farming serves as the source of the country's economy and is in commercial trading. When it comes to commercial production, agricultural overhaul products can be exported and farmers will become international traders. Commercial farming also allows for sufficient food to be provided by a large labour force. The landlord became a farmer [3]. The Agricultural Revolution also sparked an increase in international trade as agricultural products could not be marketed all over the country. Profit from agricultural activity has been maximized. The revolution also advances the field of transport. For example, there are steam engine designs and railway designs. The emergence of labourers and employers has created a large-scale economic system. However, the working class did not get any good service.

Malaysia has become the world's leading commodity producer by exporting results such as cocoa, rubber and oil palm. Bio-technology has been used in the agricultural sector. In addition, the Malaysian agricultural sector has become an increasingly developed industry. Malaysia is also a centre of herbal production. Another success is that Malaysia has created various research agencies such as RISDA and MARDI that contribute to the development of the agricultural sector. Farming management such as FAMA, FELDA, FELCRA is a success because of growing Malaysian agricultural produce. Agricultural technologies such as hydrophonic, hanging fertigation and fertilizer have been used in agricultural activities. Malaysian agricultural products have a wide international market [4]. Malaysia has become the pioneer of halal hubs.

The challenges facing Malaysia in the 21st century to ensure the well-being of the nation's economy is from the financial, investment, technology, globalization, market and labour aspects. This paper will focus on the use of IoT technology in smart agriculture. One of the example revolution for agriculture is in robot revolution for agriculture. This is shown in Figure 1.

Agriculture with robotic revolution started with working as half or fully autonomous machine systems at scalable productivity. Technology available, first applications as master slave systems in research. Second revolution is working at plants from seed to harvest. Singular solutions exist. Handling of large masses in short time limited. Third revolution is working at the plant to improve health and growth. First ideas and applications known. Future is working within the plant to improve health.

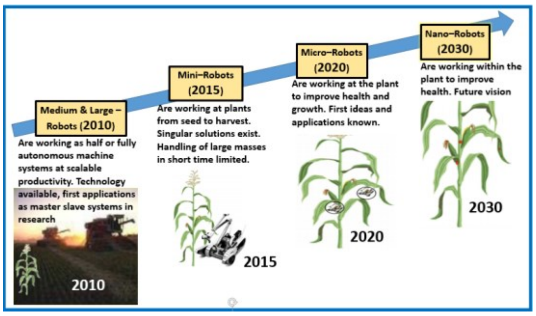

Fig.1. IoT Agriculture Revolution in Robotic [2]

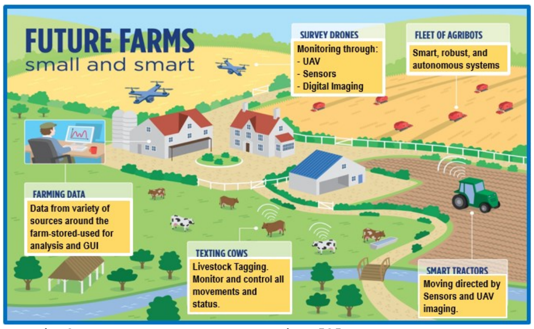

Fig.2. IoT Future Smart Farming [2].

Figure 2 shows how the future farming will be. The farming data reside in cloud. The farm generates vast quantities of rich and varied data. This is stored in the cloud. Data can be used as digital evidence reducing time spent completing grant applications or carrying out farm inspections. In smart tractors, Smart Tractors GPS controlled steering and optimized route planning reduces soil erosion and saving fuel costs [5]. An agricultural drone is an unmanned aerial vehicle applied to farming in order to help increase crop production and monitor crop growth. Through the use of advanced sensors and digital imaging capabilities, farmers are able to use these drones to help them gather a richer picture of their fields. Sensors attached to livestock allowing monitoring of animal health and wellbeing. They can send texts to alert farmers when a cow goes into labour and developers infection increasing milk yields.

In Fleet of agro robots, robots capable to reduce fertilizer cost by 99.9% [6]. Aerial drones survey the fields, mapping weeds, yields and soil variation enable precise application of inputs and mapping to increase yields by 5% [7].

III. IoT SYSTEM ARCHITECTURE

Generally IoT sensor node system for smart agriculture has several components, these components are Processor units, memory, power supply units, interface parts, and sensors. Figure 3 shows the basic configuration of IoT sensor node for smart agriculture.

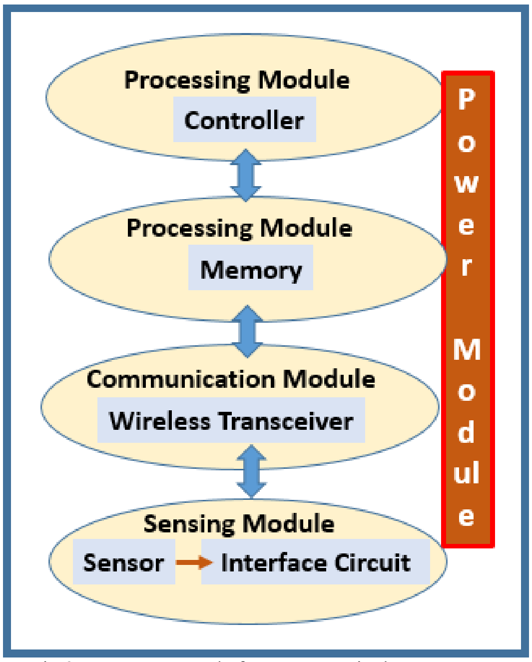

Fig.3. IoT Sensor Node for Smart Agriculture

The Central Processing Unit (CPU) is a unit that contains microcontroller that interpret input signals and execute control measures, in accordance with the programs stored in memory, and communicate the decisions they take as control signals to the output interface. The power supply unit is required to convert the source AC voltage to the DC voltage (5 V) needed by the processor and circuit series in the input-output interface modules [8 - 9]. The memory unit is the place where the program used to perform the control measures is stored. Programming tools is used to insert the required programs into memory. The program is made using this device then transferred into IoT sensor node. Input and output units are the interfaces where the processor receives information from and communicates information control to external devices.

The term IoT system for smart agriculture usually refers to a centralized system that can monitor and control all parts of a widespread system [10 - 11]. Most of the controls are performed by remote node units or named as sensor node in this paper. Host Control function is usually limited to parameter settings. Figure 4 shows an example IoT centralized system.

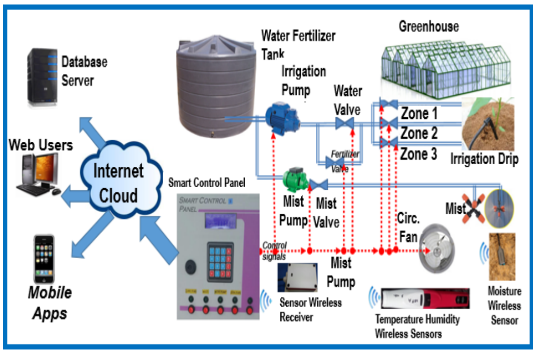

Fig.4. Overall IoT Architecture

From Figure 4 it can be seen that actuator controls the valve instead of control centre. Control centre only set the parameters to be sent to remote nodes. Remote note will compare the parameters and the actual parameters to reach the set point will activate the related devices accordingly. All of these processes can be monitored on control centre GUI (Graphical User Interface). GUI can be seen from normal PC, tab or mobile phone as illustrated in Figure 4.

The IoT big system typically implements a distributed database or commonly called a database tag, which contains several data elements called tags or points. A point represents one input or output monitored or controlled by the system. Point can be either "hard" or "soft". Hard point represents the actual input / output in the equipment that is monitored or controlled. The soft point is the logic or arithmetic operation of the system. Distributed database means the reference parameters reside in remote node or sensor node.

GUI is a device that provides processed data onto the machine to the farmer and farmers can control the equipment through GUI at control centre. GUI at control centre is usually connected directly to the database and software system. GUI is the part that manages data exchange, data acquisition, data management such as scheduling processes, to help control certain equipment, etc. The GUI system usually presents data onto the form of graphs or images, this facilitates the farmer to control the equipment and monitor it.

In Figure 4 there are several valves to drain the water. In addition, humidity, temperature and other parameter sensors can be viewed as well. This of course facilitates the farmer in monitoring the situation of the existing system. The farmer can also control the valves and pumps by selecting the set devices and also change the colour according to the desired condition. GUI packages are usually included with the program. With the program farmer can change existing GUI layout or create own layout of system which will be monitored or controlled. The most important part of GUI is an alarm feature. Alarm is a digital state of NORMAL or ALARM. IoT system alarms can be set according to our needs such as type of alarm and level of alarm set point. Figure 5 shows the sample of GUI screen.

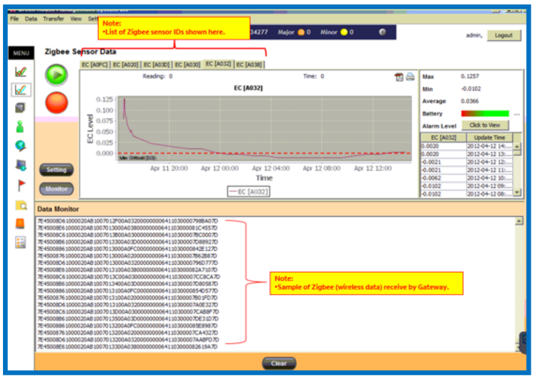

Fig.5. IoT System GUI

Figure 6 shows the low cost smart dosing system. Smart dosing function is to automatically run the mixing process to add water and fertilizer according to the EC level set by the GUI.

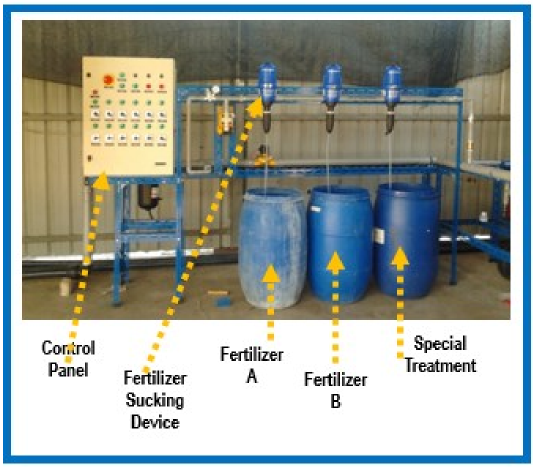

Fig.6. IoT System GUI

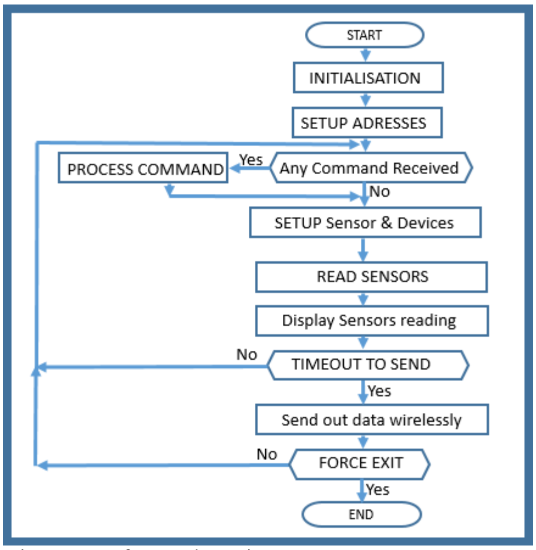

Fig.7. IoT Software Flow Diagram

Before placing on the IoT system, what needs to be done is to set the interface correctly. System can be controlled by three methods. The control methods are manual, schedule and automatic. Manual means farmer need to ON and OFF the hardware button manually. Schedule or semi-automatic means that farmer need to set the time to ON and OFF the individual devices. Automatic means farmer need to setup the threshold value that will be a close loop to the devices such as circulation fan, exhaust fan, sprinkler, misting, pump, valve, thermal screen, ventilation screen, roof and irrigation drip valve.

Figure 7 shows the flow of the software for the smart wireless sensor node.

IV. DATA COLLECTION

In this section, few data samples collected from the IoT system will be displayed. Figure 8 and Figure 9 shows the data for temperature and humidity captured by IoT system. Figure 9 shows the data collected by IoT system for Carbon Dioxide (CO2). Two positive results will be shared in this paper. The first result is about the IoT system for mushroom cultivation. Second result is about the irrigation management done by IoT irrigation system.

Table I shows the size comparison between two mushroom house, the conventional mushroom house and IoT mushroom house. IoT mushroom house produced bigger and thicker mushroom compared to conventional mushroom house within the same period of time.

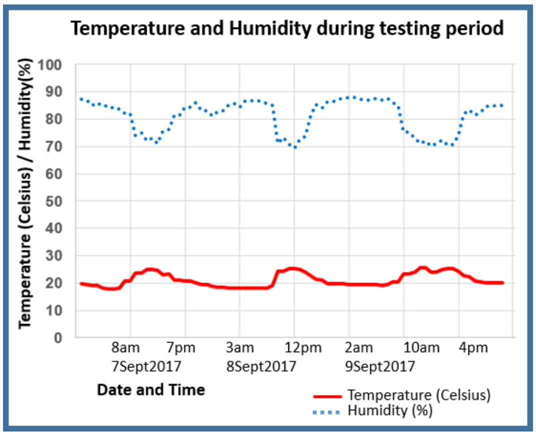

Fig.8. Temperature and Humidity Data from IoT system.

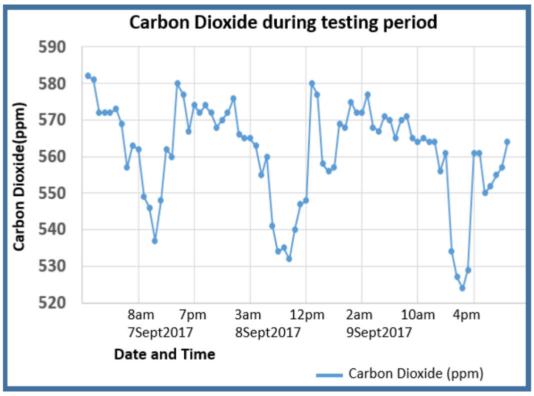

Fig. 9 Carbon Dioxide (CO2) Data from IoT System

Table I: Yield Comparison between conventional mushroom house and IoT mushroom house

Average Per Mushroom	Smart Mushroom	Conventional mushroom House
Thickness	2.6cm	2.3cm
Weight	40gram	35gram

Table II shows the amount of water and the amount of fertilizer used in a day for scheduled and automatic irrigation mode. Based on the data in Table II, in scheduled mode irrigation, 2,500ml of water fertilizer consumed in a day while in automatic irrigation mode, the total amount of water fertilizer in a day is 1000ml only. Average saving for each chili crop in a day is 1,500ml. 1,000 chili trees saved 1,500 litres of water fertilizer.

Table II: Usage of Fertilizer with Water (WF) Consumption Scheduled vs. Automatic Irrigation.

Type of Irrigation (Irr.) of Water Fertilizer (WF)	Total Irr. per day	WF per Irr. (ml)	Total WF (ml)
Scheduled	5	500	2,500
Automatic	2	500	1,000

V. CONCLUSION

In IoT-based smart farming, a system is built for monitoring the crop field with the help of sensors (light, humidity, temperature, soil moisture, etc.) and automating the irrigation system. The farmers can monitor the field conditions remotely. IoT-based smart farming is highly efficient when compared with the conventional approach. The applications of IoT-based smart farming not only target conventional and large farming operations, but could also be new ways to uplift other growing or common trends in agricultural like organic farming, family farming (complex or small spaces, particular cattle and/or cultures, preservation of particular or high quality varieties etc.), and enhance highly transparent farming.

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