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Smart, Connected IoT Applications for Maximizing Agricultural Business Performance

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ABSTRACT

Agriculture is essential in life and one of the diminishing fields also. Especially in the eastern countries the number of farmers is reduced. This happens due to lack of man power and the globalization. The farmers cannot stand in front of the huge markets. The cost of yield is increased while the ROI is less for the farmers. There are significant technologies have been developed to automate agriculture in order to decrease the production cost and to increase profits of the farmers. The Internet of Things (IoTs) in agriculture can support the production process and can scale from small to big farmers. In this paper we have studied various areas of agriculture and the implementation of IoT in those areas. The study reveals that the importance of drone and the necessity to do more R&D of drone in agriculture.

Keywords: Internet of Things, Agriculture, Green House, Future Agriculture, Drone.

1. INTRODUCTION

Six of Earth's seven continents are permanently inhabited on a large scale. Asia is the most populous continent, with its 4.3 billion inhabitants accounting for 60% of the world population. The world's two most populated countries alone, China and India, together constitute about 37% of the world's population. The population on 2050 will be around 9.7 billion [Table 1]. The food production must be increased by 70% by 2050 due to population [Figure 1]. The technology needs to be involved to improve agriculture. Smart, Connected Internet Applications Maximize Agricultural Business Performance [1]. In developing countries the agriculture business is driven by multiple intermediate hands that make the commodity to higher price and the farmer is getting lesser price for his work. Nowadays farming lands are sold as real estate plots because of no proper yields from farming / agriculture.

Table 1
Population projection by UN population department

	Population(Millions)			
	2015	*2030*	*2050*	*2100*
World	7349	8501	9725	11213
Africa	1186	1679	2478	4387
Asia	4393	4923	5267	4889
Europe	738	734	707	646
Latin America	634	721	784	721
Northern America	358	396	433	500
Oceania	39	47	57	71

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Figure 1: Shows the world population by 2050 and the required food supply

An unique opportunity is to create and deliver a transformational suite of Internet of Things-based agricultural management services. These services would be delivered as easy-to-use, smart, connected product applications that would provide customers with the ability to have a real-time big picture of the large and varying data points necessary for them to create optimal agricultural working and growing conditions. To do so in agriculture requires optimizing three key variables: production yield, cost, and risk avoidance, and having a real-time and holistic big picture for optimizing each variable for maximum profitability.

The overall solution is determined necessary was a set of “dashboard-driven connected services utilizing an IoT backend” that would accomplish several key things: (a) A framework of connected smart agriculture business that can fit to small farmers to large scale food production industry; (b) Collect data from incompatible sensors via wireless networks; (c) Integrate, analyze, and correlate different data sets of information into easily-understood and easy-to-customize reports leading to specific actionable outcomes; (d) The end user can control remote greenhouses using their mobile or desktop; (e) Manage end-user permissions, distribute reports and business intelligence through a customizable Web interface that would include dashboards, allowing custom organization of data applicable to the business employing the suite of services [2].

Agriculture can be broadly grouped into farming, crop and food plants. The growth of the plants and the quality of the products from plants include various components such as (i) Temperature of the grow room, (ii) Relative Humidity, (iii) Light Intensity received etc.. Light intensity plays a major role in yields of a plant, causing the stem length, leaf color and flowering. An agriculture control system can maintain an adequate and

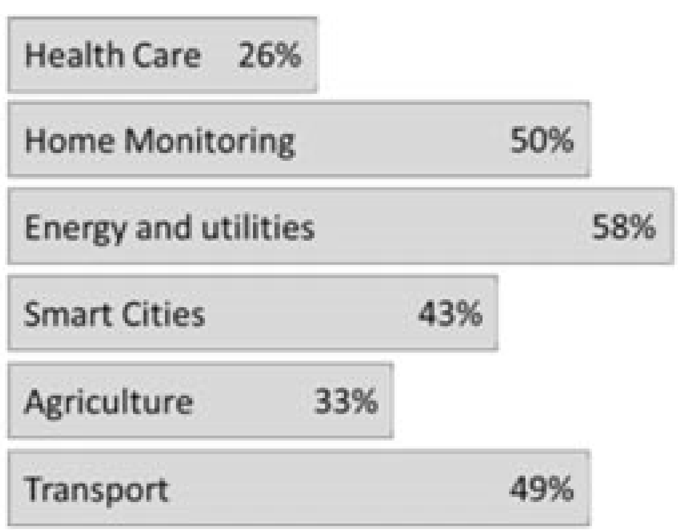

Figure 2: Increase of the IoT in different areas by 2014 to 2015

appropriate lighting intensity and temperature [3]. The IoT has been playing a vital role in many sectors. The implementation of IoT is increased every year. The IoT based agriculture products are increase by 33% by the last year [Figure 2].

Sensors can monitor critical parameters that focus on temperature, humidity, oxygen, carbon dioxide, ethylene and also an optical sensor for liquid phase and composition that will be linked to the database and analysis software for storing and analyzing the monitored data [4].

In section II we have discussed in detail about the impact of IoT in agriculture. In Section III Typical IoT Greenhouse Model is explained. Section IV describes the use of drone in agriculture. In section V, a view of Bigdata in Agriculture has been discussed. The paper is concluded in Section VI.

2. AGRICULTURE AND TECHNOLOGY

Using sensors, agriculture gains advantage of real-time traceability and diagnosis of crop, livestock and farm machine states. Genetic tailoring of food and producing meat directly in a lab. Using large-scale robotic and micro-robots to check and maintain crops at the plant level will help to automate agriculture. Engineering involves technologies that extend the reach of agriculture to new places and new areas of the economy.

2.1. Field Preparation

Crops can be monitored, measured and responded back using Precision Agriculture (PA) or satellite farming which is a farming management concept. GPS is a space-based global navigation satellite system that provides location and time information in all weather and at all times and anywhere in the earth [5]. WebGIS is a very important milestone of GIS that marks the GIS to shown in the web and which is used to store, process, analyze, display and apply spatial data [6]. This will be done using GPS and Machineries like drone or movable vehicles along with the sensors and central server and databases. The concept of Precision Agriculture has been designed and the system model has been tested [7]. Jiuyan Ye et.al., has studied the Precision Agriculture Management System based on WebGIS. They propose the function and workflow of the system [8].

2.2. Soil Testing

Environmental monitoring is a significant driver for wireless sensor network research, promising dynamic, real-time data about monitored variables of a landscape and so enabling scientists to measure properties that have not previously been observable. Soils are composed mix of solids, liquids and gases variable proportions. Soil has physical and electrical properties. Soil has Color, texture, grain soil etc. A microwave reflectometer-sensor system is developed to operate from 1.35 to 1.95 GHz and used to measure volumetric and gravimetric moisture content for various types of soils from 0% to 45% [9]. For larger area of soil testing we can use radiometers and microcomputer system for data preprocessing and recording on board an aircraft. There are software available for estimating and mapping the water content in the top one meter layer using both radiometer data and a priori information on hydro physical properties of soils [10]. Optimized field management regimes are available to solve the problems of irrigation water shortage, low soil fertility, and abuse of inorganic fertilizers, pesticides and herbicides [11].

2.3. Humidity and Temperature

The crops growth and product quality in greenhouse are dependents on temperature and humidity. The greenhouse humiture monitoring system based on ZigBee wireless sensor networks (ZWSN) is the best solution [12]. Adopting the technology of wireless sensor network based on Zigbee, GPRS and Web Services technology, we can get a set of low cost, low power consumption, flexible automatic networking temperature humidity monitoring system of soil [13].

2.4. Water flow

An optimized irrigation system has become a necessity due to the lack of the exhausting resources like water, oil etc.,. Automatic irrigation of wireless sensor network and Internet technology can be used to improve irrigation water and to reduce cost of irrigation water. Use of Smart phones or wireless PDA can easily monitor the soil moisture content and control the irrigation [14]. Irrigation using sprinklers is widely adopted in agriculture. When a rotating sprinkler malfunctions due to jamming, clogging or being worn out, may cause over watering in some small areas. To overcome the issue the camera based irrigation control system can monitor the sprinklers using standard security cameras and control the sprinklers [15]. The drip irrigation schedule system can saves the cost of water, price of yield, uniformity of the drip irrigation system, crop response to water [16].

2.5. Pesticide

Identification and monitoring of plant diseases, nutrient deficiency, controlled irrigation and controlled use of fertilizers and pesticides needs to be managed for crops from early stage to mature harvest stage. eAGROBOT (a prototype) is a ground based agricultural robot that overcomes the challenges existing in large and complex satellite based solutions and helpdesk form of solutions available as m-Services [17]. Variable rate spraying control system can automatically change with the variation of duty factor at the fix frequency. The characteristics of the flow control system provides development platform, fuzzy control, PID algorithm, PWM, temperature property, response speed for spraying [18]. An optimal pest management strategy of the chemical control needs to be maintained the level below the economic threshold, which makes pesticide residuals and the total dose of the spraying pesticides least, and reduced pest populations [19]. There are several ways for spraying pesticide together with their possible disadvantages such as crops may be crushed when using tractor, pesticide droplets may be perfused unevenly when it is applied by a person, or using aircrafts such as helicopter or plane for spraying may contaminate regions surrounding the target area. We can use Unmanned Aerial Vehicle (UAV) that is able to fly on and spray farmland autonomously [20].

2.6. Harvesting

At the harvest season, crops are harvested using various methods at different times. Mapping and monitoring of the patterns of croplands during the harvest provides information for farmers to help guide the harvest practices that are time critical and to support early warning of threats to food security [21]. Harvesting labor is a major cost factor in the production of specialty crops. Today accruing harvest labors is still done by hands, which is error-prone and costly. By integrating cloud-based web application with purposely designed Labor Monitoring Devices (LMDs), we can attain the monitoring and accruing harvest labors [22]. Automatic detection of harvesting using multi-source information fuzzy inference with the overall accuracy of 93% will lead to effect decides the harvesting time [23].

2.7. Drying, Monitoring and control

The grain moisture sensors are already in yield monitoring processes on harvesters employing precision farming. High-quality products can be yield with better grain handling and storage operation management. This can be achieved through the ability to more closely monitor the grain moisture content, which will provide important information of grain status on time [24]. The trend is towards simplified methods of drying in which the advantage is of the drying properties of unheated air and towards techniques which gives to a favorable and economic use of electric heating of the air [25]. An intelligent control method for the cold-storage of fruits and vegetables, humidity will make a direct impact on the quality of the food storage of high-precision monitoring environmental parameters which can effectively improve the quality of food storage, energy conservation significantly, the cost [26].

3. TYPICAL IOT GREENHOUSE MODEL

The typical greenhouse model has been shown in the Figure 3. The main entities in this model are Greenhouse, sensors, actuators, embedded systems, internet cloud, customers, corporate software and support team. The

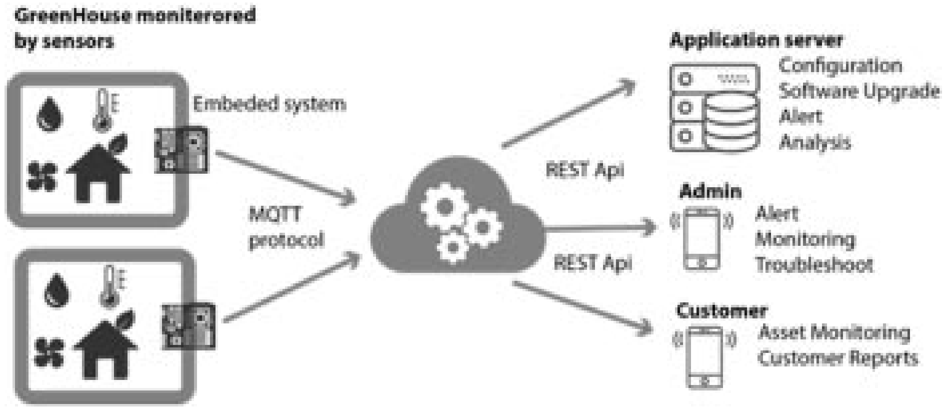

Figure 3: IoT Greenhouse

corporate software can run based on the SAS model to enable pay as what you have used. So that one or more greenhouse can be attached with the central software via internet cloud. The sensor data will be collected and stored for analysis and live feedback. The actuators controls the various parameters of the greenhouse like soil moisture, humidity, pest and temperature. The controlling of actuators and collecting sensor data will be done using the embedded system that mount on each greenhouse. Ardunio or Raspberry pi can be used for embedded devices. The user can use the stored or live data to monitor or control the green house. There will be a support team can help the remote farmers to explain or handle the alert situations.

The Greenhouse sensors has been connected to the embedded system. Inside the greenhouse they can use either wifi, wired, zigbee etc for connected to the embedded system. The embedded system (Rasberry pi) then collects the data and then sends the data to the central application server using the internet cloud. The embedded system will alalyse the threshold of the different parameters and then enables to actuators to maintain the self-sustained environment. For example the embed system can control water flow using drifting system as well as spray; the light intensity, humidity of the farm using fan and spray, fertilizers and pesticide etc., .The data will be logged to the application server. The application server is responsible to send the alert to the users if any critical values from the embedded system is detected; upgrading the embedded systems with the latest software or patch which is connected to the server; preparing the reports for the end user. The admin and the stack holders can send the signal to the embedded system to control the greenhouse remotely.

The MQTT protocol can be used to communicate from embedded to the cloud system. The REST API is for communicate with the client and support team. The REST API provides the flexible model to desktop, web and mobile communication and it's a platform independent too.

4. DRONE IN AGRICULTURE

New technological methods based on Unmanned Aerial Vehicles (UAV) leverage precision agriculture approach that includes crop monitoring which provide farmers real time data about the plant health and crop spraying chemicals over the field [27]. The application of pesticides and fertilizers in agricultural areas is of very importance for crop yields. The aircrafts are becoming increasingly common in carrying out this task mainly because of its speed and effectiveness in the spraying operation. However, some factors may reduce the yield, or even cause damage (e.g. agriculture areas not covered in the spraying process, overlapping spraying of crop areas, applying pesticides on the outer edge of the crop) [28]. Particle Swarm Optimization (PSO) is used to reduce the amount of pesticide used and improve the quality of agricultural products as well as mitigate the risk of environmental damage [29].

Recent technologies such as Cloud computing, wireless sensors, communication, networking technologies, embedded systems, Data Mining and Data Warehousing, NANO, Radio Frequency Identification using the standardized Internet routing protocol, IPv6 provide the farmers with new opportunities to use these technologies for holistic innovative approaches.

5. BIG-DATA IN AGRICULTURE

Agriculture produces good amount of data in both public and private domains. National soil databases provide information about carbon balance across different climate zones and vegetative land covers, digital elevation models, regional and national inventories, remote sensing data, geophysical data, socio-economic and many other data sets. This agriculture - related records are interesting in agriculture sector, Ecology, environment, business, policy, various sciences, etc. Investigation and impact of land-management approaches, such as fertilization, grazing, irrigation, and more can be done with the historical data. Agriculture data analysis can help to understand the problems and lead policy makers to implementing risk mitigation and restoration strategies [30]. Optimized data and service analysis based on Map-Reduce algorithm along with Bigdata analytics techniques will yield better use of Bigdata [31].

6. CONCLUSION

In agriculture, there is a quite research and development has been done. The economy of eastern countries is still depends on the agriculture. And those agriculture is depends on the small formers. These small formers cannot use big vehicles for agriculture due to small land constraints. But we can use drone in this case. So there is a need to utilize the drone in most of the agriculture area. The implementation of drone will reduce the time and efficiency of the production which leads the higher production. At the same time the cost of the IoT implementation needs to be reduced. This will enable the small farmers to utilize the smart agriculture. The farmer needs to be educated or the agriculture studies could have separate subjects about the current development of IoT and the connected smart world. The fully customizable modular approach needs to be enabled in the agriculture software for adopt the vast area of the agriculture segments. Most of the IoT products running on the electricity; but the new technologies need to be inventing like sensors running on the bio gas for implementing the IoT on the rural area. Now a days the mobile networks are focusing on urban areas compared to the rural area. So we need to find the new technology that can enable ad-hoc joining of the rural area in the existing mobile networks with the small device. The investment on the agriculture needs to be increased and the farmer to customer model needs to be motivated.

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