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A Review of IoT based Smart Farm Monitoring

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Abstract—It is an application combined with hardware in which a farmer can monitor and control certain parameters of field and do real time monitoring. This paper confers a study of weather station and mobile data logging type monitoring. A short deliberation on Smart IoT based farm monitoring and their interrelationship is presented. In the 1800s, they had grain elevators, mechanized plougher, chemical fertilizers, and primitive gas-powered tractor. Then in the 1900s end, farmers began the use of satellites to plan various tasks in farmland. IoT is about to drive into the future generation of farming to become a successful benchmark. Smart farming in todays time is becoming more promising among the farmers, and technology based farming is swiftly flattering the standard thanks to technological advances in farming in field of automation, ICT (information and communication technology) and robotics. Several applications of IoT are present for use in agriculture and farming purposes. Uses of "Internet of Things farming" will assist the agriculture sector in future to develop and do the production much more efficiently. This paper gives information regarding multimedia devices, communication protocol, sensors and systems, which are largely used to monitor smart farming and specific algorithms used for such purpose. This paper will also help future researchers and provide them guidelines to follow in growing automated Smart IoT based monitoring. To meet the needs of large growing population by year 2050, the productivity needs to be increased by 25%. This goal can be achieved by the efficient use of advancements in robotics and automation.

I. Introduction

Smart farm based on IoT incorporates ubiquitous computing and communications via internet for remote monitoring and control which brings smartness in monitoring, safety, control, security, and service and energy conservation along with sav-ing enormous time. It uses communication technology and web technology to furnish remote monitoring and remote control various parameters from computer/Smart phone device. Smart farming offers better control and monitoring than manual control. This provides comfort to the farmer by providing him remote access and control of farm environment and provides him continuous context awareness. It enables farmer to execute tasks sitting at home. Ambient intelligence systems which continuously monitors field parameters and optimizes the predefined parameters to execute tasks. Smart Farming utilizes traditional sensors and actuators by using intelligent monitoring and access control.

Efficient communication and user friendly accessibility of data for monitoring is important precondition to create a perceptive environment in Smart farming. Cancar & Antonio Barrientos used fewer sensors for precision humidity and temperature measuring in Farming. However their work is ground based Mobile Robots which just loss the data and cant be retrieved remotely. [2] Sonal sharma and Rushikesh Borse used image processing for specific task of pest control. However it doesnt provide various parameters to anticipate environmental conditions to favor pesticide and it does limited task. [3]. James Cruz and Scott Herrington used a complete monitoring station. However it can monitor and control the parameters in limited area. [4] Pablo Gonzalez-de Santos used heavy machinery and quiet costly hardware for onsite control and monitoring of past. However in countries like India, farmers cant afford such a huge machinery to do the task as its not user friendly nor economical. [5]

II. Smart Farming

Smart farming is application of contemporary (ICT) Information and Communication Technology in agriculture, directing to 3rd Green Revolution.

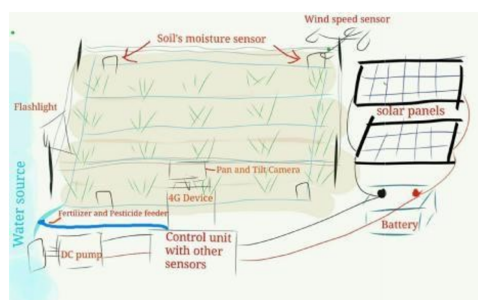

Fig. 1: Smart Farming

Based on genetics revolutions and plant breeding, this 3rd Green Revolution controlling the agricultural sector based on the application of ICT and IOT (Internet of things) solutions such as precision equipment, sensors and actuators, geo-positioning system, UAVs, drones, Big data, robotics, etc. [5] Smart farming has a caliber to give a more sustainable and productive agriculture production, based on more precise and resource efficient approach from the farmers point of view, Smart farming helps farmer in making better decisions and more efficient management and operation. In country like

India its just a start of Smart farming technology (SFT) which comprises to ¡ 1% considering the largest profession of people of India is farming. However, while in USA probably 80% farmers use SFT, in Europe it is less than 24%. [5]

Smart farming is associated with 3 interconnected technology fields:-

1) Management Information System: Functions and oper-ation are carried out by planned systems to process, control, store and disseminate data in the form required.
2) Precision Agriculture: Use of input methods and reduce impact on environment follows the increased economic returns by management of spatial and temporal variabil-ity.
3) Agriculture automation and robotics: Farmbots and far-mdrones are applications of robotics, automation and AI methods at different levels of agriculture production.

Smart farming applications dont target only large, conventional farming exploits, but could also be new levels to boost other common or growing trends in agricultural exploitations, such as family farming, organic farming, and enhances a very respected and transparent farming. Environmental benefits are like more efficient use of water and optimization of inputs and treatment. [4]

III. Review Of The Project

Advancement in farming automation has been supervision over last several decades, conveying various functions, utili-ties and ideas. Smart farming is expanding and focusing on the present day technology to be implemented in automated farming. This is drawing the attentiveness of researchers & farmers requirement. In this part, it confers the study of smart automated farming according to scrutiny objectives & covet services. Smart farming provides easy accessibility, comfort, remote monitoring, required updates, security and services to the farmer. Security measures not only furnish alert to any trespassing but also saves crop from birds and animals. Table 1 represents the classification of smart automated farming.

A. Comfort

Main objective of smart automated farming is to ease routine life of farmers by increasing productivity and comfort. This way a single farmer becomes capable of handling many fields and completely rely on the technology. The following projects aim to automate some aspects of farming.

1) Monitoring parameters: Monitoring is an important concept before controlling. Various parameters are controlled in farming e.g. moisture, water level, temperature, wind, humidity, intruder, pest, etc. the projects discussed in this category use various sensors and arrangements. Temperature and precision humidity measurement in farming using mobile robot was introduced by L. Cancar. These mobile robots use a combination of multidisciplinary technologies: artificial intelligence, complicated manuverity and mobile robots. Its hardware is divided into 3 layers Microcontroller LPC1769, servomotors and communication hardware Xbee and GPS taking data from temperature and humidity sensor. ROBO-SPHERE includes Wi-Fi, Bluetooth and Xbee modules are used to communicate to base station and external sensors [2]. However Xbee utilizes RF communication which has limited range and such costly mobile robot equipment has no security of its own and in constant danger of theft.

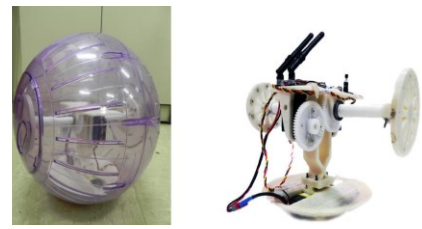

Fig. 2: ROSPHERE design and mechanism [2]

2) Controlling parameters in addition with monitoring: Automatic agriculture spraying robot with smart decision making designed by Sonal Sharma for pest control. They used ARM7 based microcontroller comprising of various sensors in addition with water, pesticide and fertilizer fodder all fit over a mobile robot. Its also equipped with webcam for image processing via MATLAB and does communication using Zigbee. It uses GSM module for message alert. In this two types of communication is used which has their own limitations and the whole setup cant service a large farmland with dependent and limited power source. It also doesnt have security of own and in constant threat of theft in practical farming application [3].

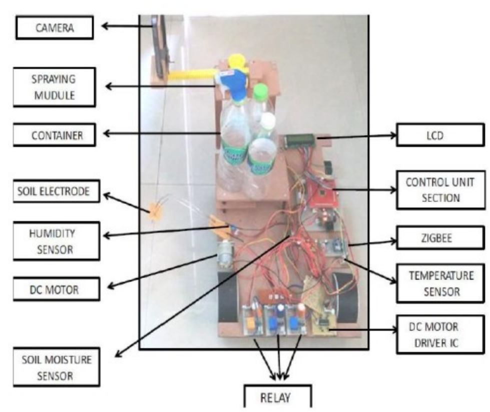

Fig. 3: Agriculture robot hardware assembly [3]

Farmbot designed by James Cruz presented at California polytechnic state university is an excellent model of preci-sion farming which comprises of raspberry pi with advance 3D printed mechanical structure having various sensors and actuators to sense and control each and every parameter of farming. The control and monitoring of every parameter can be done through an user friendly application and internet based communication makes it much more reliable and distance in-dependent communication. However, the mechanical structure has limitation that it cant be spreaded over a huge farm land

and hence it limits the farmbots capabilities to gardening and small scale farming only [4].

Fig. 4: Farmbot [4]

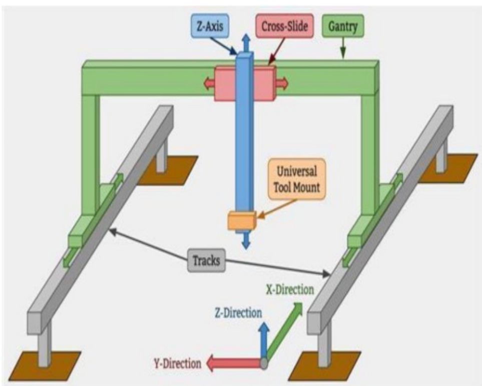

Fig. 5: Farmbot structure

3) Only controlling: Fleets of robots for environmentally safe pest control in agriculture presented by Pable Gonzalez-de-santos comprises of UAVs and an agriculture tractor along with other pneumatic actuators to drive in the land and spread fertilizer and/or pesticide in the farmland. Decisions are made by stationary equipment at base station which considers all the parameters to accomplish the mission. However this system is quite complicated and high chances of frequent failures. It has not much remote monitoring capabilities but it can be further modified for cultivation as well as harvesting purposes. The operation requires high technical skills and not economical.

Fig. 6: The RHEA fleet: UGVs and UAVs [5]

The workspace decomposed through an approximate cel-lular decomposition, following the taxonomy proposed by [Choset, 2000], which means that workspace is sampled like

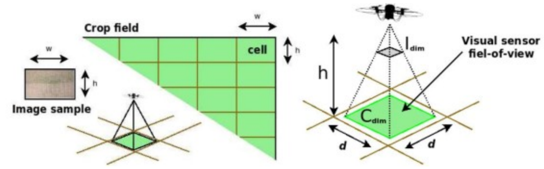

Fig. 7: Data acquisition in a grid-based decomposed environ-ment [9]

a regular grid. This grid-based representation with optimal dispersion is reached by dividing the space into cubes, and placing a point in the center of each cube, therefore can be defined has a kind of Sukharev grid [LaValle, 2006]. In this type of decomposition is normally assumed that once the robot enters a cell it has covered a cell, even by it footprint or end-effectors (see Figure 7).[10]

IV. Discussion

The design of Smart automated farm depends on field size, field type and rainfall conditions in the area. Generally, Smart automated farm offers comfort, safety, security, remote monitoring, remote control, resource conservation and energy conservation. This farms out to be a boon for elderly and disabled farmers. Anyhow its useful for every farmer it saves their time and energy. They need not go in farm in afternoons or sleep in farm in night for crop security. Smart automated farming can offer electrified fences which can be activated in night to prevent trespassing and intrudes.

Smart farming method can also be efficiently utilized in the floor by floor farming as its advancement in agricultural field. Smart farming provides services and utilizes to optimize user requirements. A network of farming parameters sensor creates a real-time data connectivity by utilizing ICT and IoT. Algorithms and data processing is used for making decisions and it supports facilities to introduce and expand services. The following section discuss smart farm components that are responsible for the functionality control and monitoring.

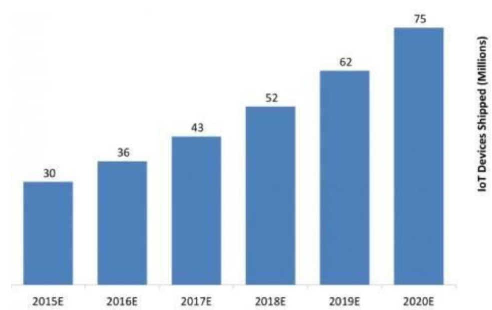

Fig. 8: Estimated Agriculture IoT Device shipments (Global) [7]

Farming industry will become credibly more significant than before in next decagons. 70% food is subsumed to be produced by the world in year 2050, more than it did in 2006, so as to manage the increasing population. This is assumed by the agriculture organization and UN food. [7]

A. Devices And Equipments

Smart farm relies on data acquisition from various sensors to access and devices to operate.
Monitoring devices classified into 2 categories:

1) Sensors
2) Multimedia devices

Sensors are used to measure environmental and farmland parameters.

Multimedia devices capture audiovisual information and provide a user-friendly interface between system and user. Table 1 describes the classification of farm monitoring equipment and devices.

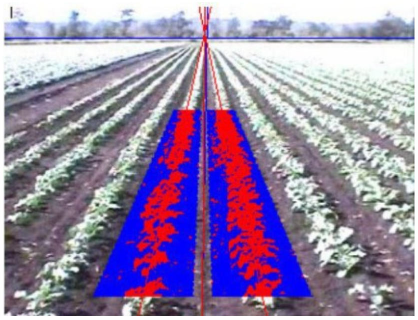

Fig. 9: Camera view with rows identified [10]

The central algorithm was based on a regression fit of lines to plants seen in keyholes that moved to track the rows. Discrimination of plant/not plant employed a variable level that tracked a farmer-entered estimate of percentage ground cover. Steering was implemented by a sub-module with an embedded microprocessor that switched valves in the hydraulic steering system, the loop being closed by a Hall-effect steering sensor. Figure 9 shows the row-fitting algorithm in action. [9]

A sensor network is responsible for farm land data acquisi-tion in smart farming. The use of moistures and temperature sensors is very common because of their simplicity. Light sensors are also used to detect inhabitant intensity. Pressure sensors are used to detect inhabitant location. Power sensors are used to identify the devices that are currently in use and active. [2] Sensors use very low data bandwidth for communication. Smart farm use a grid of fine pipes evenly distributed over the field which facilitates feeding of water, fertilizer mixed with water and pesticide mixed with water to the crops. Multimedia devices have been introduced to create reliable communication and audio visual accessibility. A 4G smartphone is used for high speed internet communication which communicates with microcontroller via Wi-Fi shield. Data can be easily accessed by internet from any corner of the world. A pan and tilt setup of smartphone enables its camera to transfer audio-visual information to the user [6].

To make the whole setup in the farm self-sustained, its powered through solar panels and battery storage. There are circuitry to save power when the system is not in use. As the whole setup requires DC power for operation, hence no electrical energy conversion is needed. However its required when electric fences are installed for security purpose. The electric fence is triggered when a considerable motion is detected in the area via camera or other sensor in a way to save power. The fence is powered by an inverter which converts the stored DC power into AC power.

TABLE I: Categorization and purpose of smart farm monitoring devices [6]

Category	Name	Purpose
Sensors	Light	Measure intesity of light
	PIR	Identify user location
	Temperature	Measure room temperature and body temperature
	Pressure	Identify inhabitant location
	Switch sensor	Door open or close status detection
	RFID	Object and people identification
	Ultrasonic	Location tracking
	Current	Measure current usage
	Power	Calculate power usage
	Water	Measure volume of water usage
Physiological device	ECG	Pulse rate and variability
	PPG	Pulse rate and blood velocity
	Galvanic skin response	Sweating.
	Pulse oximeter	Measure oxygen saturation of blood
	Sphygmomanometer	Blood-pressure measurement
	Weight	Measure patient weight
	Pulse meter	Monitor heart rate
Multimedia device	Camera	Monitoring and tracking
	Microphone	Voice command
	Speaker of headset	Announce alert and information

B. Communication Media

Smart farming utilizes communication network either solely or in addition. Internet has become more reliable and distance independent making the system functionally greater.

Table II represents the classification ICTs used in smart farming. It can be classified into 3 categories: wired, wireless and hybrid. Zigbee is quite popular protocol for wireless form communication [6]. Zigbee makes a low speed wireless ad-Hoc network of nodes, it is a involute protocol with tight power and bandwidth constraints.

The internet is most efficient and easily available solution for remote communication with advancement of technology and cheapness of data uses makes it fit for the purpose. It provides data access facilities for smart farms. Mobile internet and now availability of 4G high speed internet makes the whole system wireless based communication and hassle free. However Ethernet can also be used to connect smart automated farms. Wi-Fi zone provided by government estimates the need of 4G on system internet and makes the system more economical.

C. Algorithms And Methods

The algorithm provides an intelligence to the farm automa-tion system. Various parameters are required for an algorithm to make decisions. Prediction, motion detection, categorization & brief algorithms have added to make the farming smart. Table III lists commonly used algorithms. Artificial Neural Networks (ANNs) can forecast the doom state of farm automa-tion by analyzing daily designs of farming. [6]. Huge amount of data is required to train ANN systems, which require a long time to work efficiently.

Fuzzy logic is systematic for sub system sway such as pump, electric fence, specific sensor, trigger, night flash light etc. It uses multivalued logic for logical reasoning. They are quite useful and efficient in control of smart farm.

Image-processing allow to get specific detail, for motion detection which can be used to trigger required sub-system. [3] For example, an intrusion makes the camera to detect motion and this alerts the farmer/user along with activating certain sub-system to tackle the situation like activating electric fence or switching ON the flashlight.

Algorithms are used to process information of various parameters and execute a specific function. Total farm au-tomation is practical sense is long time to achieve. Although different methods are being used to semi-automate, monitor and control farming remotely.

TABLE II: Classification of ICT protocols their medium and significance [6]

Media Type	Media	Name	Significance	Disadvantage
Wired	AC Power line	X10	Lower cost; easy to install; bit rate 20bit/s	Prone to noise
		KNX (PL110)	Higher data rate compared to X10 (1200bit/s)	Interference from AC signal
	Phone line	Traditional Tele-phone	Voice communi-cation	Human operator required
		DSL	Remote access via home gateway	Only works in IP network
	ISDN line	ISDN	Higher dedicated bandthwidth	Expansive com-pared to other in-ternet services
	Twisted pair	Ethernet	Builds IP network; provides remote access	Applicable only for IP network
		KNX	For TP-1 bit rate 9600bit/s for fast Ethernet	Ethernet has not been implemented
Wireless	RF	Zigbee	Low-power wire-less protocol	Tight power and bandwidth constraint
	ISM	Wi-Fi	High bandthwidth	High power re-quirement
Hybrid	Ethernet; IF; RF	UPnP	Zero configuration	Lack of default authentication

D. Services And Utilities

Smart framing technology has reached remarkable suc-cess in easy and accessible farming efforts, such as remote monitoring, security and automatic decision making. Smart

TABLE III: Various algorithms and procedures used in Smart Farming [6]

Category	Algorithms and methods	Purposes
Artificial Neural Network	Artificial Neural Network	Prediction of the future of the en-vironment Create and evaluate behavioraal model Detect and recognise activities of daily life
Multiagent Sys-tem	Distributed intel-ligent system	Health monitoring from remote lo-cation
Statistical meth-ods	Multiagent system	Simulation of agent interactions and task interactions
	Hidden Markov model	To create and evaluate behavioral model
	Bayesian statistics	ADL recognition To determine location of the inhab-itants Location aware activity detection
	Summarization algorithm	To track any changes in the system To model circadian activity rhythms (CARs)
	Statistical predic-tive algorithm	To predict activities of daily life(ADL)
C4.5	C4.5	Build spatiotemporal context
Data compression	Active LeZi	Next activity prediction
CBR	CBR	Context awareness
Fuzzy logic	Fuzzy logic	Recognise routines and also devia-tions from routines Control lighting system
SVM	SVM	Activity recognition

farming tracks the data from cultivation to harvesting. The data so acquired can be used for future research, rain pat-terns, sunlight patterns, and temperature and humidity pattern. Growth monitoring logs the useful data for different crops. Smart farms can be utilized by the farmer who owns huge farmland, old and disabled farmers. Although it can benefit any farmer or any type of cultivator of farm or garden. Smart farming system assists the farmer in viewing remotely his farm, take snaps, send voice output, activate pump for irrigation and to remove excess water in heavy rain. Voice output or pre stored voice commands facilitates farmer to scare crows, other birds. For the safety of farmland electric fences and flashlights are used which can be turned automatically by motion detection / ultrasound sensor. Motion activation prevents unwanted wastage of energy.

V. Future Challenges

Future smart farms will be able to offer all sort of services, e.g. full automation, complete communication, crop quality, efficient energy use, easy accessibility, and safety and com-plete security. People saving significant time and energy can invest it making life more productive. Main objective is to facilitate old and disabled farmers. Remote farm monitoring will grow among group of farmers requiring lesser human efforts. Other services such as comfort, control & security will improve slowly with advancement of constituting sub-systems and components.

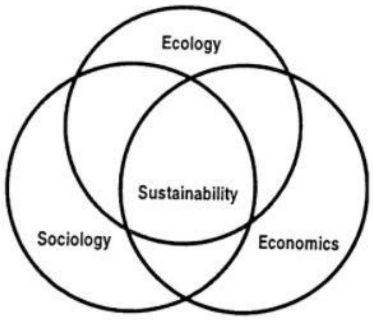

Fig. 10: Sustainability as described by the intersection of three disciplines: ecology, economics and sociology [8]

Applying the concept to agriculture, the American Society of Agronomy (1989) defines Sustainable Agriculture as the one that, over the long term, enhances environmental quality and the resource base in which agriculture depends; provides for basic human food and fiber needs; is economically viable; and enhances the quality of life for farmers and the society as a whole. [8]

The U.S. currently produces 7,340 kgs of cereal (e.g. wheat, rice, maize, barley, etc.) per hectare (2.5 acres) of farmland, compared to the global average of 3,851 kgs of cereal per hectare, heading the world in IoT smart agriculture.

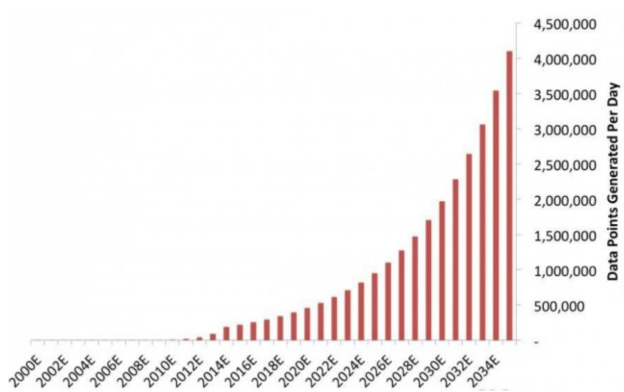

Fig. 11: Average data points generated per day by farms [7]

A smart farming grid concept is under research in which all the farmland in the state and country can be interconnected to each other and considering the weather forecast, early steps can be taken to save the crops. It will become a boon for the farmers in a country like India where agriculture is major profession. From the support of government crop security could to provide to the farmers which will prevent the increasing suicides of farmers in India.

VI. Conclusion

To meet this demand, farmers and agricultural companies are turning to the Internet of Things for analytics and greater production capabilities. Smart automated farms is a significant area of research and it is highly potential considering the result of various technological advances in agriculture. The research confers the common survey of smart farm projects and various specifications of it. It explains the pros & cons of smart farm realizing blocks. The classification of devices, communication methods, media, algorithms, services and security presents an informative and effective comparison between associated tech-nologies. A number of different future ways are recognized by this paper & concerns about smart farm analysis. With advances in technology in agriculture standardization of smart farm equipment will take place which will help facilitation to integrate heterogeneous devices and add-ons. This system will also useful for other fields. Such as the parameters and data collected will be very useful for agriculture research scholars, soil researchers and food technology research scholars. In future, Smart farms will be facilitated by several service providers to automate and optimize farm and receive services. The smart farming/agriculture grid is potential area of service integration which would facilitate government agencies to heed the concerns of farmers and provide them crop security. Smart farms will give huge popularity in the future because of facility and services they are providing for the welfare of farmers and advances in agriculture.

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