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Internet of Things and its Applications in Agriculture

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ABSTRACT: Connecting various devices through the internet in coordination with each other to perform one or more tasks is conceptualized as the Internet of things (IoT). The term 'Things' in IoT refers to the multiple devices such as electronic devices, sensors, network peripherals, signal flow switches, and actuators. These devices work inter-operate with each other within the network infrastructure and collectively performs a set of tasks by leveraging data from each device. These devices can be treated as end-points, which operate in synchrony to perform the desired task. Every device (thing) is an individual entity within the network, performing a separate or collaborative task by aggregating data from different sources or by collecting it individually.

KEYWORDS: IOT, Sensors, Actuators, Signal flow switches

I. INTRODUCTION

An IoT eco-system, a network surveillance system aggregates data from multiple cameras, proximity sensors, and security gateways, and performs data analytics on a legacy or cloud infrastructure to complete a set of operations dependant on the data obtained from these sources. If an authorized person passes through a security terminal, access to entry or access to information is automatically provided by matching the identity of the individual with the databases of authorized individuals. In the opposite case, when an unauthorized individual walks through the same security terminal, access to resources is restricted as the identity of that individual does not co-relate with the database.

II. RELATED WORK

The definition of the Internet of things has evolved due to convergence of multiple technologies, real-time analytics, machine learning, commodity sensors, and embedded systems. Traditional fields of embedded systems, wireless sensor networks, control systems, automation (including home and building automation), and others all contribute to enabling the Internet of things.

The concept of a network of smart devices was discussed as early as 1982, with a modified Coke vending machine at Carnegie Mellon University becoming the first Internet-connected appliance, able to report its inventory and whether newly loaded drinks were cold or not. Mark Weiser's 1991 paper on ubiquitous computing, "The Computer of the 21st Century", as well as academic venues such as UbiComp and PerCom produced the contemporary vision of the IoT. In 1994, Reza Raji described the concept in *IEEE Spectrum* as "[moving] small packets of data to a large set of nodes, so as to integrate and automate everything from home appliances to entire factories". Between 1993 and 1997, several companies proposed solutions like Microsoft's at Work or Novell's NEST. The field gained momentum when Bill Joy envisioned Device to Device (D2D) communication as a part of his "Six Webs" framework, presented at the World Economic Forum at Davos in 1999.

The term "Internet of things" was likely coined by Kevin Ashton of Procter & Gamble, later MIT's Auto-ID Centre, in 1999, though he prefers the phrase "Internet *for* things". At that point, he viewed Radio-frequency identification (RFID) as essential to the Internet of things, which would allow computers to manage all individual things.



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A research article mentioning the Internet of Things was submitted to the conference for Nordic Researchers in Norway, in June 2002, which was preceded by an article published in Finnish in January 2002. The implementation described there was developed by Kary Främling and his team at Helsinki University of Technology and more closely matches the modern one, i.e. an information system infrastructure for implementing smart, connected objects.

III. THE IMPORTANCE OF IOT

The idea of the IoT is being adopted widely in almost all the sectors, since it revolutionizes relationships with people as well as surroundings. The networking is helping to create myriad of innovative instruments since the market for IoT devices and services are expected to grow into a multi-trillion dollar industry in the near future. It has emerged as an important field, attracting prospective high-end investors and value of the market in future will rise on both the consumer's end as well as on the investor's end.

The IoT will make our lives easier, and hassle-free; also the interconnectivity between people can increase and times spent on doing things manually will be saved. Resources and infrastructures can be used to their maximum potential while diverting the manual attention towards the important matter. It helps to create smarter cities, homes, devices; improves healthcare systems; and develops other important sectors and industries. Data generated from the IoT facilitates services, based on the needs of a specific individual.

IV. THE CURRENT IOT TRENDS

- The relationship between IoT, *Containers* and Artificial Intelligence: IoT is creating an inter-network between devices and people. It is generating mass data that are becoming part of the cloud and is being analysed by various applications to create a report. Thus, the demand for such applications is on the rise and more of these applications are being created through containers, which provide suitable deployment environment. Machine learning clouds and artificial intelligence is being used to mine bigdata accumulations.
- Business prospect: IoT has gained a considerable momentum on the path of innovation. Due to the new digital revolution, new innovative ideas are constantly being created and implemented. Thus at the moment, it is a field being heavily invested on, with more businesses are coming up with new solutions that are attracting investors as well as talents. New prospects in the smart marketers are about to follow where the cost of devices will be shared with the consumer and one way to achieve it is to bundle services with products.

V. UNCERTAINTIES OF IOT

- **Security:** It's the major concerns regarding IoT, since more devices are added to the internet.
- **Data Privacy:** it is concerned regarding the fact as to who owns, views, and uses the data generated by us. It has emerged as a major concern among different nations as multitudes of people are demanding transparency of regulations from the cloud providers and big data accumulating companies.
- **Fragmentation:** There is no specific and unified standard to maintain and conduct the internet of things. There are various solutions and each company, configuration or network use a different set of standards, thus, there is no unity across the networking.
- 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 sustainably for the masses. It is the application of modern ICT (Information and Communication Technologies) into agriculture.



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- 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 from anywhere. IoT-based smart farming is highly efficient when compared with the conventional approach.
- The applications of IoT-based smart farming not only target conventional, large farming operations, but could also be new levers 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.
- In terms of environmental issues, IoT-based smart farming can provide great benefits including more efficient water usage, or optimization of inputs and treatments. Now, let's discuss the major applications of IoT-based smart farming that are revolutionizing agriculture.

VI. APPLICATIONS OF IOT IN AGRICULTURE

1. Precision Farming

- Precision Farming known as precision agriculture, precision farming can be thought of as anything that makes the farming practice more controlled and accurate when it comes to raising livestock and growing of crops. In this approach of farm management, a key component is the use of IT and various items like sensors, control systems, robotics, autonomous vehicles, automated hardware, variable rate technology, and so on.
- The adoption of access to high-speed internet, mobile devices, and reliable, low-cost satellites (for imagery and positioning) by the manufacturer are few key technologies characterizing the precision agriculture trend.
- Precision agriculture is one of the most famous applications of IoT in the agricultural sector and numerous organizations are leveraging this technique around the world. Crop Metrics is a precision agriculture organization focused on ultra-modern agronomic solutions while specializing in the management of precision irrigation.
- The products and services of Crop Metrics include VRI optimization, soil moisture probes, and virtual optimizer PRO, and so on. VRI (Variable Rate Irrigation) optimization maximizes profitability on irrigated crop fields with topography or soil variability, improve yields, and increases water use efficiency.
- The soil moisture probe technology provides complete in-season local agronomy support, and recommendations to optimize water use efficiency. The virtual optimizer PRO combines various technologies for water management into one central, cloud based, and powerful location designed for consultants and growers to take advantage of the benefits in precision irrigation via a simplified interface.

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Fig 1. Precision farming

Precision agriculture (PA), satellite farming or site specific crop management (SSCM) is a farming management concept based on observing, measuring and responding to inter and intra-field variability in crops. The goal of precision agriculture research is to define a **decision support system** (DSS) for whole farm management with the goal of optimizing returns on inputs while preserving resources.

2. Agricultural Drones

- Technology has changed over time and agricultural drones are a very good example of this. Today, agriculture is one of the major industries to incorporate drones. Drones are being used in agriculture in order to enhance various agricultural practices. The ways ground-based and aerial based drones are being used in agriculture are crop health assessment, irrigation, crop monitoring, crop spraying, planting, and soil and field analysis.
- The major benefits of using drones include crop health imaging, integrated GIS mapping, ease of use, saves time, and the potential to increase yields. With strategy and planning based on real-time data collection and processing, the drone technology will give a high-tech makeover to the agriculture industry.
- PrecisionHawk is an organization that uses drones for gathering valuable data via a series of sensors that are used for imaging, mapping, and surveying of agricultural land. These drones perform in-flight monitoring and observations. The farmers enter the details of what field to survey, and select an altitude or ground resolution.
- From the drone data, we can draw insights regarding plant health indices, plant counting and yield prediction, plant height measurement, canopy cover mapping, field water ponding mapping, scouting reports, stockpile measuring, chlorophyll measurement, nitrogen content in wheat, drainage mapping, weed pressure mapping, and so on.
- The drone collects multispectral, thermal, and visual imagery during the flight and then lands in the same location it took off.

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Fig. 2 Agriculture Drone

- An agricultural drone is an unmanned aerial vehicle applied to farming in order to help increase crop production and monitor crop growth. Sensors and digital imaging capabilities can give farmers a richer picture of their fields. This information may prove useful in improving crop yields and farm efficiency.

3. Livestock Monitoring

- Large farm owners can utilize wireless IoT applications to collect data regarding the location, well-being, and health of their cattle. This information helps them in identifying animals that are sick so they can be separated from the herd, thereby preventing the spread of disease. It also lowers labour costs as ranchers can locate their cattle with the help of IoT based sensors.

4. Smart Greenhouses

- Greenhouse farming is a methodology that helps in enhancing the yield of vegetables, fruits, crops etc. Greenhouses control the environmental parameters through manual intervention or a proportional control mechanism. As manual intervention results in production loss, energy loss, and labour cost, these methods are less effective. A smart greenhouse can be designed with the help of IoT; this design intelligently monitors as well as controls the climate, eliminating the need for manual intervention.
- For controlling the environment in a smart greenhouse, different sensors that measure the environmental parameters according to the plant requirement are used. We can create a cloud server for remotely accessing the system when it is connected using IoT.
- This eliminates the need for constant manual monitoring. Inside the greenhouse, the cloud server also enables data processing and applies a control action. This design provides cost-effective and optimal solutions to the farmers with minimal manual intervention.
- Illuminum Greenhouses is a drip installation and Agri-Tech greenhouse organization and uses new modern technologies for providing services. It builds modern and affordable greenhouses by using solar powered IoT sensors. With these sensors, the greenhouse state and water consumption can be monitored via SMS alerts to the farmer with an online portal. Automatic Irrigation is carried out in these greenhouses.

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- The IoT sensors in the greenhouse provide information on the light levels, pressure, humidity, and temperature. These sensors can control the actuators automatically to open a window, turn on lights, control a heater, turn on a mister or turn on a fan, all controlled through a Wi-Fi signal.



Fig. 3 Smart Greenhouse

Smart Greenhouse is a self-regulating, micro-climate controlled environment for optimal plant growth. Climatic conditions inside the greenhouse, such as, temperature, humidity, luminosity, soil moisture are continuously monitored.

VII. CONCLUSION

4. The IoT agricultural applications are making it possible for farmers to collect meaningful data. Large landowners and small farmers must understand the potential of IoT market for agriculture by installing smart technologies to increase competitiveness and sustainability in their productions. The demand for growing population can be successfully met if the ranchers as well as small farmers implement agricultural IoT solutions in a successful manner.

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