Data analysis and digitalisation in the agricultural industry

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Abstract. As we know the growing population give birth to many serious problems in the whole world but, the major one is the increase in hunger and unavailability of food. Due to the reduction in natural sources, limited arable land, unpredictable weather conditions crops growth is at risk today. The IoT allows agriculture to become data-driven, leads to more timely and cost-effective production and management, and limiting uncertainties and inefficiencies of environmental impact. This review is about an analytical survey of the application of IoT in arable farming to overcome challenges, suggesting possible solutions, and implementation and present some future directions in contrast with other agricultural systems. Current issues like the latest technologies, smartphones, intelligent management of WSN, middleware platforms etc. protrude because they have the power to transform arable farming into smart arable farming. For implementation, various challenges are encountered and interoperability is major hurdle throughout the architecture of the IoT system, which can be discussed by shared standards and protocols. Challenges like affordability, device power consumption, network latency etc. can be reviewed and solutions of these challenges are suggested.

1. Introduction

Since the domestication first started from the beginning, there have been some significant changes in the agricultural industry. Even in the last century, farming was used to be one of the most common works around the world, and people used to produce their own food. This scenario has changed with the gradual decrease of available farming land [1]. With the rapid growth of the worldwide population, the demand for food has become one of the biggest global issues. To solve this issue, researchers are trying to come up with new solutions. Their effort has resulted in the emergence of the Internet of Things (IoT), which has a huge potential to solve the food issue. Most of the current agricultural inventions are heavily relying on IoT, machine learning, data analytics, and other state-of-the-art technologies. With the help of this technology, it has been possible to increase agricultural production than before. Over the years, IoT, and data analysis have been used in many technologies. Some of these technologies have made it possible to monitor agricultural farm from home with the help of microcontroller and IoT. Agricultural surveillance devices mostly use different types of sensors, and camera to conduct real-time monitoring and as these devices are
connected to the internet, the farm owner can check any time and also receives alarm in the case of any sort of inconveniences [2].

In this paper, a detailed review of current applications of IoT and data analysis has been provided. Different current agricultural solutions have been thoroughly investigated to find out the recent trends in the agriculture industry. In addition to that, the possible future of IoT and data analysis has been also analyzed.

2. IoT implementation
To cover a range of technologies, standards, protocols etc. there are three layers present in this report.

2.1. Device/perception layer
This layer contains different objects or things that can be automatically identified, sensed and connected to the internet. Sensor devices analyze and collect parameters automatically and transmit data to the internet. When these devices become actuators they receive all the information from the internet. Devices have a transceiver, microcontroller, interfacing circuit and sensors. Sensors measures physicals data and translated into analogue signals which are afterwards converted into digital signals by interfacing circuit. Then, microcontroller collects digital data via ADC and transfers them to the transceiver which communicates data into gateway number of IoT device installations in agriculture is expected to increase around 30 million from 2015 to 75 million in 2020 [3].

2.2. Network layer
This layer communicates the data to the proxy server to the internet via communication protocols. The use of 3G or 4G having smartphones and other systems like that are increasing day by day among agricultural applications. They also obey the rules of communication standards and protocols. They also include Bluetooth, GPS, GNSS and RGB camera sensors, can easily programmed and display GUI applications. A range of technologies, standards and frequency bands are used to depict relevant interoperability and application challenges found in the IoT. Communication standards for digital farming can be classified into two ranges according to communication distance: short-range and long-range. These ranges decide definite usability in various needs. This is particularly the case for small farms where use is adequate but large farms limit the use of wireless technologies [4]. A WSN consists of devices called motes or sensor nodes which integrate sensors that correspond wirelessly forming a network.

Base stations act as gateways sending data to the internet. Different technologies correspond to different network nodes. RFID technologies are used in agricultural research and industry [5]. Lastly, the latest 5G can open new possibilities and may overcome some of the challenges, allows new options for miniaturization and better communication.

2.3. Application layer
It stores and provides access for the end-user to the processed information. It is the most important layer as it adds value to the directly controlled data through devices. Many important services like processing, analysis, access and storage occurred through API occurred. This layer also includes middleware platforms that help to handle the heterogeneous cloud data enhancing interoperability. Data storage can be cloud-based, relational databases or non-relational databases. They are gaining attention, especially while dealing with large data.

3. Data analysis
It can be gained by cloud computing, where computer resources are managed to analyze data. Cloud computing has the advantage to provide high-quality services, allows the self-governing implementation of multiple applications even if they are on the same platform. The use of IoT middleware platforms is
achieving interest in solving different challenges found in applications and simplify complex communications by using enablers like standardized API and protocols. Even if many more solutions can be found in IoT’s marketplace, an intelligent middleware solution that can solve many observed problems in digital farming can be successfully implemented [6]. To correspond to data across various devices, API’s are essential. The services may include tracing, monitoring, management and forecasting etc. for agriculture.

3.1. Steps in data flow

There are also 6 stages involved in data flow:

1. Perception
2. Transfer
3. Storage
4. Processing
5. Analytics
6. Display

Order can be different because of different IoT setup and computer techniques involved [7]. But, usually, perception is the first step where all data is collected from different sensors and then go to other steps. It is not important that data can flow through all stages mentioned above.

4. Applications

Various applications can become resultant from implementations. These are always conceptualized from all three layers that are discussed above. By elaborating we can see that these applications are described as:

- **Monitoring**
  It refers to timely sensing of different parameters and it is usually the primary point of entry of other applications. It is the obvious initial step. Sensors placed systematically can automatically sense and transmits data to the internet for further steps. These are used to monitor crops parameters like leaf area, colour, size, shape and height. Also for soil parameters like moisture, soil chemistry, irrigation water parameters like salinity and hp, weather parameters like air temperature, rainfall, aero pressure etc. Moreover, remote sensing can also be utilized. These parameters usually need some form of processing and don’t directly dependent on targeted parameters. Agricultural machinery, environmental impacts, storage of crops and use of thermal sensing can also be remotely monitored. This is extremely relevant to robots and automatic vehicles in agriculture [8].

- **Documentation**
  It covers the storage of samples. It is mostly the natural application of data and other samples also. This data is stored as raw data at different intervals. it is important in decision making, analyzing and an important component in FMIS. Mapmaking is also a form of documentation in which different objects are projected on maps. Installed sensors on vehicles can also form automatic mapping. Also, remote sensing can be used for crop development mapping. This is proved as feasible for all its applications and becoming more popular. Documentation data is referred to as traceability when extended to trace hole supply chain and it is an important notion in the agri-food supply chain management [9].

- **Forecasting**
  It utilizes precisely analytical methods to gain various resources for data. Access to current time data and historical data is used for forecasting events that need successfully management of crops. It is employed as preventive measures that need actions due to prediction using four various machine predicting algorithms (decision tree, boosted tree, random forest, and regression). The summary of all this is that IoT allows sampling of large data which can be engaged as training data by the machine learning algorithms to make
predictive models. Scientific modelling is also engaged for forecasting like IoT. These modelling tools are really important as they are verified from scientific communities [10].

- Controlling
  It is the result of monitoring to control actuators in a predefined manner. In this monitoring, variables are automatically adjusted to gain what we need. It is important in small farming as it allows automation of systems. In this, all the implementations are implemented to reduce undesired consequences.

  Mostly systems that are IoT based to contain a minimum of two such applications and isolated applications are rarely seen [11]. Also, FMIS and associated decision support gain special attention to enhance operations and production.

5. Discussion
The agriculture industry has been facing a huge challenge to meet worldwide food demand. In order to face this challenge, the industry needs to adapt to the latest technologies. IoT has been used in almost every application in today’s world. The use of IoT can boost up the current agriculture technologies and ensure better performance of different devices. IoT-based devices use different sensors, microcontrollers, and connectivity tools to ensure better performance and control on the farm. This results in better crop yield and hence the farmers make more profit than before. With the help of the latest technologies, farm owners can also check their farms on a regular basis while not visiting them in person. This saves valuable time, which they can use to grow a better connection with the consumers. In addition to that, the use of data analysis can be also beneficial in many areas of agriculture. Various data analysis techniques such as Big Data analysis, Machine Learning, Deep Learning can be used to thoroughly investigate different issues of this domain. However, the cost of implementing these technologies is still pretty high, which forces many farm owners to stick to classic farming. In the future, there is a chance that this scenario might change.

6. Conclusion and future directions
A writing audit of current and predictable IoT innovations furthermore, frameworks in arable cultivating was completed. This has incorporated a diagram of the cutting edge of IoT advances, a framework of the current and likely applications, and an exhaustive depiction of the difficulties and arrangements. IoT technologies and different systems are discussed in this report. Data analysis and challenges and their solutions are also discussed and importance of IoT in agriculture is described and future actions are also described in detail. In future solutions of these problems, FMIS, big data analysis and DSS are kept in mind for enhancing systems.

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