2020 International Conference for Emerging Technology (INCET)
Belgaum, India. Jun 5-7, 2020

Machine learning Implementation in IoT based Intelligent System for Agriculture

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***Abstract*— Innovation in Internet of Things (IoT) has acquired changes in everyday life. Agriculture plays a major role in most of the countries and the need for this sector is to become "Smart". A primary inference is the absence of knowledge with respect to soil. There are many types of soil present and each kind of soil has various qualities. A thorough knowledge about soil conditions give rise to various information of soil that can be handled to obtain better yields of crop. Machine learning is a trending technology and it helps in the agricultural area to build the exactness and gives solutions for the crop yield problem. Machine learning (ML) is combined with enormous informational advancements and superior figuring to make new chances to unwind, measure, and understand the data intensive prediction in agricultural environments. This paper conducts a thorough study of various concepts of machine learning for IoT based Smart Agriculture system.**

Keywords*— *Internet of Things (IoT), Cloud computing, Wireless sensors network (WSN), Smart Agriculture, Machine Learning (ML).

I. INTRODUCTION

Internet of Things (IoT) refers to millions of physical devices connected over the globe to collect and share information. Internet of Things is an application area which combines various technologies (software) and devices (hardware) described in [1]. “Internet” is connectivity which helps in communication and by the term “Things” it means a combination of sensors, computing devices, smart-phones, Radio frequency identification (RFID) etc. In [2], the author discusses the technological advancement and cost effectiveness that has made it possible for any kind of user to use it with flexibility by making living very simple and progressively agreeable.

The wireless sensor network (WSN) is a collection of distributed sensors and it is designed to control, monitor environmental and physical conditions. Sensors can communicate through radio signals. In [25], author explains needs and importance of different wireless sensor in the fields of agriculture. Wireless sensors are used in many fields such as the health care sector, industries, agriculture, military, factories, traffic control, etc. Agriculture is also one of the main domains where sensors and networks are used to get benefits. Wireless Sensor Networks (WSNs) contain small nodes with capacities for sensing, processing and communication as explained in [3]. The work in [4], explains sensors are designed with wireless protocols that they can communicate with another network. WSN includes modest sensor nodes that can detect, compute, and communicate the sensed data to monitor environmental conditions such as sound, temperature, pollutants, vibration and pressure. Wireless sensors sense live data so it can help to know the day to day weather condition and soil condition in particular area is discussed in [26]. The use of wireless multimedia sensors networks (WMSN) to monitor farming for context aware monitoring of agriculture field using multi-agent based information gathering techniques has been proposed in [5]. In [8], the author suggests energy-efficient data aggregation, describing two specific network algorithms: one network can be clustered and other associated with the sensor node. In [20], the study of various quality of service (QoS) parameters for important and promising wireless technology such as WiFi, WiMAX and LTE is described. Wireless sensors are used to measure soil pH, soil temperature, soil moisture and humidity, barometric pressure, carbon dioxide gases, enormous harvest zone inspection, vegetation monitoring, forest fires, biomass farming, animal husbandry, irrigation system, fertilizer dispersion, pesticide, sunlight.

Agriculture plays a vital role in the development of the country. In developing countries like India, the economy is mainly dependent on agriculture, although there is no improvement in crop yield and proper utilization of agricultural land. Problems related to agriculture have consistently reduced the economic growth of the nation, so the solution is to modernize farming technology. IoT plays an important role in water resource management for irrigation as discussed in [6]. Understanding crop variation, assessing fertilizer prerequisites and assessing crop outcomes helps for better decision by farmer. Large landowners and small farmers can consider the commercial potential in IoT for agriculture by developing smart technology to improve productivity, profitability and sustainability. Large and small-scale farmers with fast-growing populations can effectively meet food demand if agriculture is effectively implemented with IoT technologies [7]. Farmers can inspect the conditions on the field from anywhere to gain profit by implementing IoT in agriculture. The benefits are as follows: Reducing risk- if farmers gather up-to-date information, they can identify the future situation and any potential problems. Farmers can use data to improve production and change business processes. Data set- all the information such as temperature, livestock health, crops can be collected with the help of sensors deployed. The information stored in a single platform can be easily verified and analyzed to make the right decisions. Greenhouse automation- a combination of multiple sensors controls greenhouse conditions or parameters and automatically sets up equipment to ensure the best condition of each greenhouse. The information’s that are collected from sensors provides data on the various environmental factors for the framework. The factors such as insect and weed attacks can be managed by applying appropriate, weed killer and pesticides to the field. At a time of harvesting agriculture field can be targeted by wildlife, winged animals and insects. Significantly, after harvesting

978-1-7281-6221-8/20/$31.00 ©2020 IEEE

farmers have problems in collecting harvested crops. It is important to create an integrated system that addresses all the factors which affects the production at each stage of post-harvest planting, processing and storage it provides a solution to the problems mentioned above. Work in [9], as described various features such as remote controlled monitoring dependent on GPS, sensing of moisture and temperature, scaring of intruders, protection, wetness of the leaf and proper irrigation. It uses wireless sensor networks to constantly note the soil properties and environmental factors. Similar sensor nodes are deployed at various farm locations. In [10], the author explores three different genres. First one includes smart GPS-based remote-controlled robotics for weeding, spraying, moisture sensing. Second, better decision making based on accurate data from a real-time agricultural field. Third, smart warehouse management involves the detection of the temperature, humidity and theft. All such operations are carried out via the Internet or any remote device connected to the machine and this operation is carried out by using Raspberry Pi, Sensors, Wi-Fi or Zigbee devices, Camera and Micro-controller actuators. In [11], the authors proposed a way of combining the benefits of new technologies, such as web services and Internet of Things (IoT) to ensure that the big data involved in agricultural development is effectively managed. In [12], the authors proposed a low cost and effective network of wireless sensors method for obtaining soil moisture and temperature from different farms. It takes the decision to allow the irrigation system to be turned On-Off depending on the crop requirement. The technological development of wireless sensor networks has allowed the use of greenhouse parameter tracking and controlling in precision farming [13].

The paper is organized as follows: Machine learning concepts for agriculture is explained in section II. Section III discusses various IoT cloud platforms that can be considered for machine learning and section VI explains the proposed methodology. Results are discussed in section V and section VI concludes the paper.

II. MACHINE LEARNING CONCEPTS FOR AGRICULTURE

The emerging concept of smart agriculture makes agriculture more efficient with the help of more precise algorithms. The data obtained discretely from sensors at regular time intervals enable IoT based smart agriculture system to learn the soil parameters continuously. In [14], cellular communications can be used in the case of Machine-to-Machine (M2M) to transfer computer data to a base station. Wired networks have some strengths, costs, performance, usability and other weaknesses, so in agriculture, cellular M2M is a potential technology. However, the word machine learning has its origins in computer science and several vector quantification methods has been developed for the coding of signal processing, compression and telecommunications [27-28]. In [16], the author suggests a communication channel between two or more objects without direct human interference with the M2M interactions. Some wireless technologies [15] has been proposed, which operate on specific WiFi, Bluetooth, Wide Area Networks (WAN) and ZigBee mobile and cellular forms, which are commonly used in agriculture IoT applications. M2M connectivity is used in wireless technology and the improvement of IoT based smart agriculture will increase awareness and reduce waste. In [17], real-time micro-controller data are feed into a device that uses data mining techniques to evaluate target-trained data sets to provide effective crop selection. The sensor values are assigned to the KNN classifier and the Euclidean distance is measured. In [18], the author presented two types of Machine learning algorithms, supervised learning and unsupervised learning. In supervised learning- logistic regression, K-nearest neighbor (KNN), Support Vector Machine (SVM), Naive Bayes and linear regressions are explained. In unsupervised learning- clustering and vector quantization are discussed. The work reviewed in [19] includes three different classifications, such as (a) crop control, yield forecast testing, disease detection, weed identification and species identification (b) animal welfare and animal production (c) soil water management. Machine learning is applied to sensor data, artificial intelligence systems is developed by agronomic management systems which provides the best advice and overview for subsequent decisions and actions with the ultimate potential to improve performance.

III. IOT CLOUD PLATFORMS FOR MACHINE LEARNING

Cloud computing refers to the application which provides Internet in data centers for hardware and software. The data centers of hardware and software are called cloud. Arduino and Raspberry Pi are most popular micro-controller boards that can be used in IoT systems integrate with the cloud platform. In [21], the author explains cloud platform offers and various types of services which can support IoT: logic case, data storage in the cloud, integration of channels. The advantages of cloud computing are cost avoided, competitive gain, back-up recovery data, accuracy, instant cloud device deployment and the disadvantages are hardware or software failure, performance can vary, risk to cloud stability, downtime, lack of support, internet connectivity.

Below are the applications of IoT Cloud which can be useful for IoT projects:

a) ThingSpeak: This platform is an open source Internet of Things applications. HTTP and MQTT protocols are used to store and retrieve information through the Internet. ThingSpeak offers the possibility to develop sensor logging software, application fields and informal information collection.

b) Kaa: Kaa is a multi-functional middleware open-source platform for full end-to-end development of IoT and smart devices. This reduces the expense, risk of failure, developing time and market time. Kaa also offers a number of IoT tools which can be easily connected to IoT applications and it integrates millions of devices.

c) Microsoft Azure: - A cloud-based computer infrastructure designed to test, install, manage softwares and services through Microsoft's controlled data center. It provides multiple programming languages, methods and frameworks, third-party software as well as Platform as a services (Paas), Software as a services (Saas) and Infrastructure as a services (Iaas) [22].

d) Firebase: Google Company offers the Firebase platform. In Firebase, the Google Cloud Messaging (GCM) is used to reply Android, IoS and web based notifications and messages that can be used for free. The Google Cloud Messaging platform focuses on the new form of Firebase Cloud Messaging (FCM) described in [23].

e) AWS: Amazon Web Services (AWS) is a division of Amazon which offers customers, organization and governments with distributed computing services on request [24].

TABLE I. CLOUD PLATFORMS FOR IOT

Platforms	Services Integration	Data store	Data Visualization	SDK API	Free account
ThingSpeak	Yes (Email, SMS)	Yes	Yes	Yes	Yes
Firebase	Yes (Email, SMS)	Yes	Yes	Yes	Yes
AWS	No	Yes	No	Yes	No
Kaa	Yes	Yes	No	Yes	Yes
Microsoft Azure	Yes	Yes	Yes	Yes	No

The Table 1 provides information about various parameters related to cloud that can be used to integrate with IoT devices.

Services integration: Service integration is a system of tools and technology that helps to connect different applications and systems. Service integration gives you the option to send notifications.

Data Store: It describes whether storage is available in the cloud or not.

Data visualization: Information is represented in the form of graph, chart and images.

SDK and API: Software Development Kit (SDK) is a software tool that can be used to develop software applications. Application Programming Interface (API) helps software programs to communicate with each other.

Free Account: This describes whether cloud platforms are free or not.

IV. PROPOSED METHODOLOGY

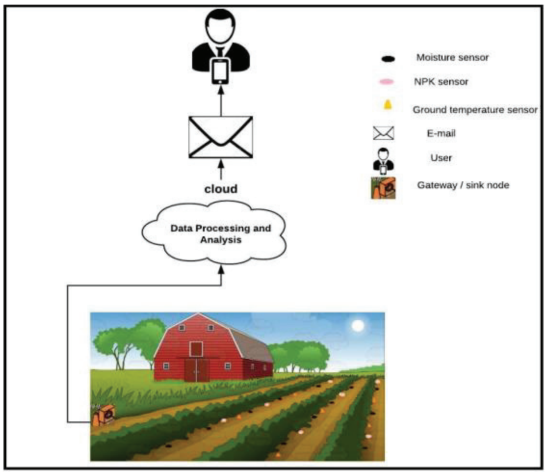

Fig. 1. IoT Architecture for Smart Agriculture

Fig. 1, depicts IoT architecture for smart agriculture consist of variety of sensor nodes that are deployed at various locations in the agricultural field, which comprehend the ecosystem status of the soil and update the live data to the cloud platform. Machine learning technique is applied to classify the sensed data based on threshold value. Users receive regular notification as Mail/SMS about soil parameters and environmental conditions of the agricultural field.

The proposed methodology involves following steps:

Step 1: Sensors sense the data and transmit it to sink node.

Step 2: Sink node which is connected to internet sends this data to the ThingSpeak cloud (an IoT Cloud platform).

Step 3: In ThingSpeak cloud the data is analysed using Machine learning.

Step 4: Data falling beyond threshold value is classified separately.

Step 5: Action to be performed for data falling beyond threshold value is send to users E-mail.

V. RESULTS AND DISCUSSIONS

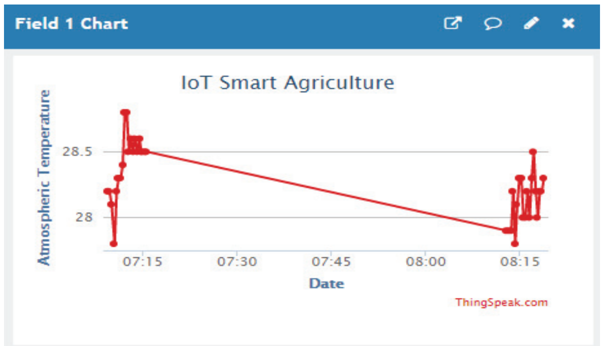

Fig. 2. Atmospheric Temperature Data

Fig. 2 represents Atmospheric temperature live data being received from the sensors to ThingSpeak cloud.

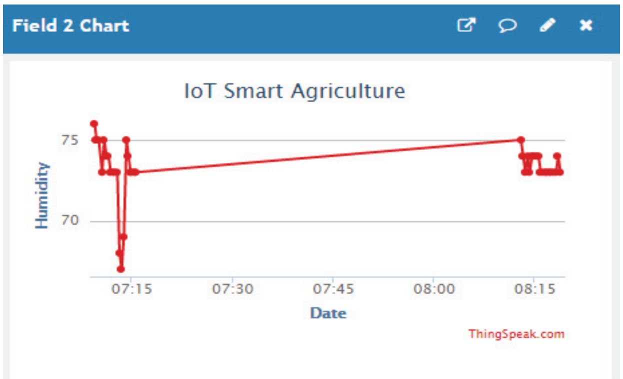

Fig. 3. Humidity Data from Sensor

Fig. 3 depicts Humidity live data being received live from the sensors to ThingSpeak cloud.

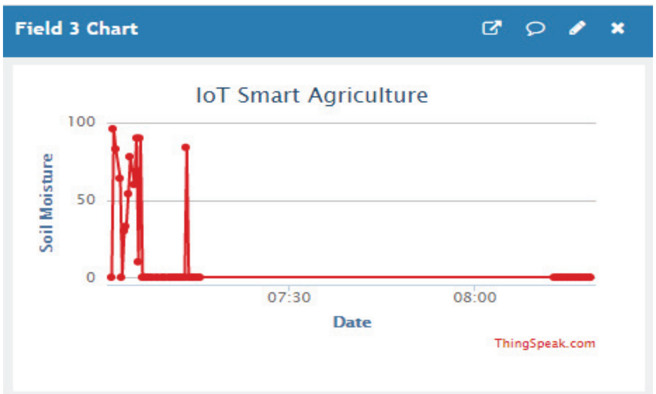

Fig. 4. Soil Moisture Data from Sensor

Fig. 4 represents Moisture data being received live from the sensors to ThingSpeak cloud.

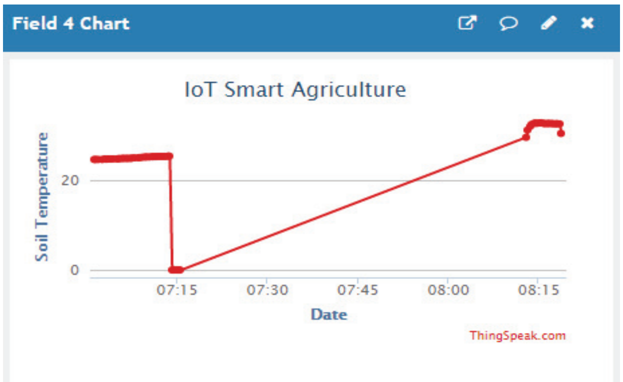

Fig. 5. Soil Temperature

Fig. 5 depicts Soil temperature data being received live from the sensors to ThingSpeak cloud.

Naive Bayes classification algorithm is used an accuracy of 76.47 were obtained.

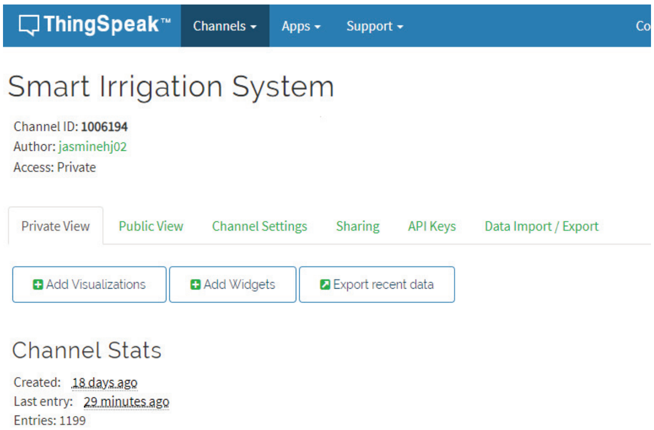

Fig. 6. Smart Irrigation System in ThingSpeak Cloud

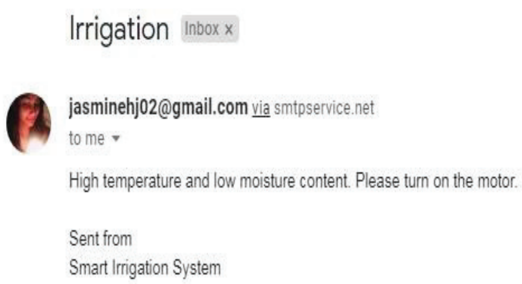

Fig. 7. e-mail from Smart Irrigation System

Fig. 6 shows the Smart Irrigation System in ThingSpeak cloud where the information for the action to be performed regarding the data beyond threshold value is being sent through e-mail and Fig. 7 shows the e-mail being received by the user.

VI. CONCLUSION

An IoT based intelligent system for agriculture has been proposed in this paper which discusses the implementation of machine learning in ThingSpeak cloud platform. The current state of IoT in agriculture is analysed through major literary works, developments in IoT, popular hardware, cloud platforms, agricultural applications, IoT-applications and recent challenges have been discussed in this work. Integrating IoT into agriculture improves crop quality and productivity. In the proposed work only irrigation is considered for productivity and fertility parameters can be considered for future scope of work.

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