AN INTEGRATIVE DECISION SUPPORT MODEL FOR SMART AGRICULTURE BASED ON INTERNET OF THINGS AND MACHINE LEARNING

A Thesis

Submitted

In Partial Fulfilment of the Requirements

for the Degree of

MASTER OF TECHNOLOGY

In

COMPUTER SCIENCE & ENGINEERING

Submitted by

Sadaf Saqib

(1901621007)

Under the Supervision of

Dr. Faiyaz Ahmad

(Assistant Professor)

Department of Computer Science & Engineering

INTEGRAL UNIVERSITY, LUCKNOW, INDIA

August, 2021

CERTIFICATE

This is to certify that **Ms. Sadaf Saqib** (Roll. No. 1901621007) has carried out the research work presented in the thesis titled "**An Integrative Decision Support Model for Smart Agriculture Based on Internet of Things and Machine Learning**" submitted for partial fulfilment for the award of the Degree of **Master of Technology in Computer Science & Engineering** from Integral University, Lucknow under my supervision.

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Department of CSE,
Integral University, Lucknow
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Dept. of Computer Science & Engineering	Dept. of Computer Science & Engineering
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ABBREVIATIONS

AI: Artificial Intelligence

G.D.P: Gross domestic product

G.P.S.: Global Positioning System

IoT: Internet of Things

ID: Identity

IPv6: Internet Protocol version 6

MAC: Media Access Control Address

MEMS: microelectromechanical system

ML: Machine Learning

R&D: Research and development

RF: Random Forest Regression

SVM: Support Vector Machine

SVR: Support Vector Regression

U.V.: Ultraviolet

Wi-Fi: Wireless Fidelity

ABSTRACT

The Internet of Things (IoT) has achieved an upset in a considerable lot of the circles of our current lives, like automobile, medical services offices, home automation, retail, education, manufacturing, and many more. The Agriculture and Farming ventures significantly affect the acquaintance of the IoT with the world. Machine learning (ML) is a part of artificial intelligence (AI) that permits software applications to turn out to be more precise at foreseeing results without being expressly customized to do as such. It uses historical data as input to predict new result values.

In the event that a specific industry has sufficient recorded information to help the machine "learn", AI or ML can create outstanding outcomes. Farming is likewise one such important industry profiting and advancing from machine learning at large. ML can possibly add to the total lifecycle of farming, at all phases. This incorporates computer vision, automated irrigation, and harvesting, predicting the soil, weather, temperature, moisture values, and robots for picking off the crude harvest. In this paper, I'll work on a smart agricultural information monitoring framework that gathers the necessary information from the IoT sensors set in the field, measures it, and drives it, from where it streams to store in the cloud space. The information is then shipped off the prediction module where the necessary analysis is done using ML algorithms and afterward sent to the UI for its corresponding application.

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Agriculture forms the major part of our Indian economy. In the current world, agriculture and irrigation are the essential and foremost sectors. It is a mandatory need to apply information and communication technology in our agricultural industries to aid agriculturalists and farmers to improve vice all stages of crop cultivation and post-harvest. It helps to enhance the country's G.D.P. Agriculture needs to be assisted by modern automation to produce the maximum yield. The recent development in technology has a significant impact on agriculture. The evolutions of Machine Learning (ML) and the Internet of Things (IoT) have supported researchers to implement this automation in agriculture to support farmers. ML allows farmers to improve yield make use of effective land utilisation, the fruitfulness of the soil, level of water, mineral insufficiencies control pest, trim development and horticulture. Application of remote sensors like temperature, humidity, soil moisture, water level sensors and pH value will provide an idea to on active farming, which will show accuracy as well as practical agriculture to deal with challenges in the field. This advancement could empower agricultural management systems to handle farm data in an orchestrated manner and increase the agribusiness by formulating effective strategies. This paper highlights contribute to an overview of the modern technologies deployed to agriculture and suggests an outline of the current and potential applications, and discusses the challenges and possible solutions and implementations. Besides, it elucidates the problems, specific potential solutions, and future directions for the agriculture sector using Machine Learning and the Internet of things.

Machine learning is an approach to data evaluation that automates analytical system development. It is a department of artificial intelligence-based totally on the concept that systems can study from data, perceive patterns and make choices/decisions/predictions with minimal human intervention. Food Security is one of the most necessary for the developing food needs of an ever-increasing population. Due to the increasing populace, we can't produce meals to meet the requirement of 1.38 billion, and nonetheless increasing the populace will put a large burden on the Indian economy. Around the globe, India is having a massive agricultural hub and the mainstream of the Indian populace is established on the agricultural area for meeting their requirement. Agriculture accounts for a fundamental component of GDP (Gross Domestic Product) now not solely of developing countries. However additionally for many developed nations. Thus, improvising and optimizing the current farming technologies is the want of the hour. It will no longer solely assist in flourishing sustainable improvement of mankind, plant life, and fauna but will additionally assist in dealing with the global crisis such as local weather alternate and epidemics such as draught. Internet of things has upgraded due to convergence of greater than one technologies like machine learning, wireless sensors, and embedded systems, real-time analytics. Conventional fields of networking of wireless sensors, embedded systems, automation (including domestic and constructing automation), and many more make contributions to enable the Internet of Things. In the consumer market, IoT technological know-how is most synonymous with product pertaining to the thought of the smart home, gadgets and home equipment (such as lights fixtures, thermostats, domestic protections systems, and cameras, and different domestic appliances) that help one or greater frequent ecosystems, such as smartphones. The home automation systems are being drastically lookup and developed however, this essential area of Agriculture and especially Smart Agriculture tends to lag at the back of different domains, and require pretty a lot of R&D to gain sustainable goals now not solely at the industrial stage, however, at the root degree of this agriculture industry. Automation of traditional irrigation methods can lead to many folds make bigger in crop yield. To form agriculture based on IoT, there are some needs that are to be fulfilled necessarily. In the first place, the particular sensors (e.g., temperature sensors, moisture sensors, pressure sensors, etc.) required for the IoT utility are to be decided smartly. Secondly, the algorithms must be developed maintaining in thinking all the feasible possibilities required for the quality prediction and machine learning to have to be utilized effectively. Seeing next, the sensors are extra likely to get damage in the fields, so pursuits monitoring of these is required timely. Considering that, the framework of the wireless data transmission has to be as per the needs of the devices to join over a precise land region in the field. Lastly and majorly, the safety, security, and privacy of the device must be ascertained through authenticating the setup system, assuring its concealment, candor, and managed admittance. The model proposed here in this paper is about how the Internet of things and machine learning used in the agricultural system. The proposed system may want to be such there will be no compromise between efficiency, security, performance, and safety of the system, and the favored effect has to produce exquisite precision and accuracy.

Précised agriculture depends on the utilisation of selective resources like water, fertilisers, seeds, and other necessary things. Sensor technology in the agriculture domain provides excellent support and offers the farmers to map their fields easily. Around the globe, the researchers of the agriculture domain strongly depending on the sensor technologies for both plant phenotyping and soil quality by using the latest technologies, including multispectral cameras, satellite imagery and drones, with the aid of internet of things (IoT) and cloud computing The achievement of increment in the production level of agriculture outcome by introducing sensor technologies which offer the improvement in crop and soil quality, safety of food, sustainability, and profitability It helps farmers to understand the crops on the microscale. Sensors-based techniques used to provide appropriate tools to achieve the goals mentioned above.

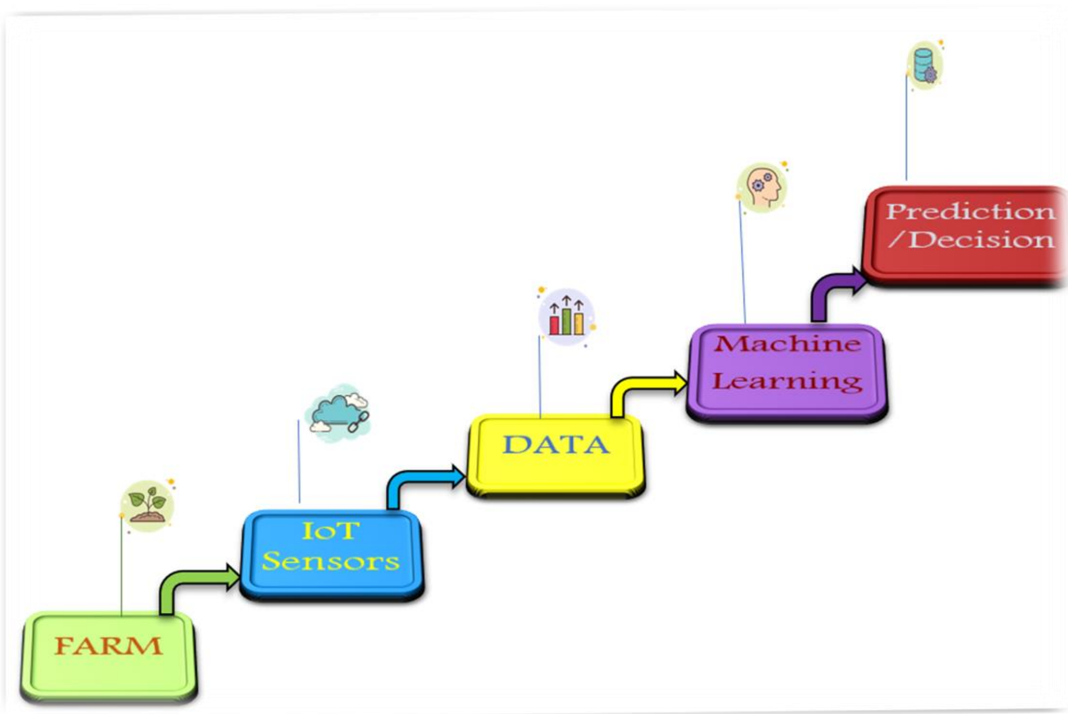

Figure 1. Flow Diagram of proposed work

1.2. Introduction to Internet of Things

The IOT refers to a wireless network between objects usually the network will be wireless such as household appliances. The term "Internet of Things" has come to elaborate a large quantity of technologies and study disciplines that allows the Internet to reach out into the actual world of physical objects. Prolonging the current Internet and keeping connection, communication, and inter-networking between physical objects and devices is a growing trend that is often referred to as the Internet of Things. The IoT, also indicated to as the Internet of Objects, will change everything including ourselves. IoT signifies the upcoming evolution of the Internet, taking a vast leap in its ability to gather, scrutinize, and distribute data that we can convert into information data, knowledge and ultimately, wisdom and understanding. The Internet of Things (IoTs) can be defined as relating daily objects like smart-handphones, Internet(web) TVs, sensors and actuators to the Internet where the devices are logically linked together allowing new forms of interaction between objects and people, and between things themselves. Nowadays anyone, from anytime and everyplace can have connectivity for everything and it is expected that these connections will prolong and create an entirely advanced dynamic network. IoTs technology can also be related to create a new concept and wide improvement space for smart households to run intelligence, luxury and to improve the quality of life. Modern progresses in electronics and communications Technologies have lead to the miniaturization and upgrading of the functioning of computers, networking and sensors. These changes have given rise to the expansion of numerous home mechanization technologies and systems. According to, home automation can be beneficial to those who need to Access home appliances while away from their home and can amazingly improves the lives of the disabled.

The Internet of things (IoT) is the extension of *Internet* connectivity into physical devices and everyday objects. Embedded with *electronics*, *Internet connectivity*, and other forms of hardware (such as *sensors*), these devices can communicate and interact with others over the Internet, and they can be remotely monitored and controlled.

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. In the consumer market, IoT technology is most synonymous with products pertaining to the concept of the "smart home", covering devices and appliances (such as lighting fixtures, thermostats, home security systems and cameras, and other home appliances) that support one or more common ecosystems, and can be controlled via devices associated with that ecosystem, such as *smartphones*.

1.2.1. Agriculture sensors

The technological advances and development facilities to attain the implementations on the agriculture domain by breaking the barriers to the basic needs of the farmers. Many sensing technologies that were already identified for precision agriculture by monitoring and optimising the crops [2]. Few of the sensors are listed below, which can offer the best solution for this precise farming.

- **G.P.S. based position or location sensors**

  This technology supports the proper application of agrochemicals and can safeguard water quality. Around 82 per cent of the implementation of the fertiliser can be uniform and appropriate by using a human resource controlled or lightbar guidance system [3]. Determination of longitude, altitude, and latitude by using the signals received from signals; these sensors can monitor the accurate position or location of the crop.

Figure1.2 : GPS based position or location sensor

The G.P.S. systems used to measure the distances to the precisely located G.P.S. satellites to find positions on earth. Radio signals broadcasted from the G.P.S. satellites monitored by receivers. A GPS position is usually determined by simultaneously measuring the distance to at least three satellites. The time taken for a radio signal which travels from the satellite to the G.P.S. receiver determines the length. For the calculation of positions, the information collected from the radio signals, which includes broadcasting time and satellite information, has to be processed.

This technology relatively inexpensive and also helps with parallel tracking devices, which assists the operators for the visualisation of the position concerning previous passes and to recognise the need for steering adjustments. Commonly, these aids are coming with different configurations. G.P.S. technology was used for monitoring yield or mapping the field and also soil sampling. The G.P.S. navigation system can increase the efficiency of the farm and improve the aspects of agribusiness by reducing environmental impacts. This system can also reduce the operator's fatigue and anxiety regarding fertiliser and pesticide application. The use of this technology can demonstrate to the non-agricultural community that advanced technology used for farming efficiently and safely sampling.

- **IoT sensors**
  - In the last decades, farming implemented by several technological transformations and becoming more industrialised and driven by the latest technology. Introduction of smart agriculture gadgets which helps farmers for gaining best control on the process of crops growth and maintaining livestock as well with excellent efficiency. Internet of Things (IoT), based devices started to occupy every part of our life, from health care, automation,

Figure 1.3: IoT System

automotive and logistics, to smart cities and industrialisation. The Internet of Things creates up an era of precision agriculture sampling.

Precision agriculture is a basic term for all the services based on digital systems and inventions on technical things for the fulfilment of the modern farmer's needs for the yield optimisation, reduction of wastage, and maintaining the quality of environment. IoT sensors installed in the crop can support the farmers for allotting the pesticides and fertilisers in the right way along with the following support:

i. Harvesting time optimisation

ii. The health of the crop

iii. Temperature, light and humidity level monitoring in greenhouses

iv. Soil quality and moisture level measurement

Many smartphone applications identified to incorporate with the Internet of Things (IoT) ideals, aggregation of data, and speed of the process, which may bring the data up to date, information can be provided to the small farmers like watering, seeding, fertilising and weeding. These applications are collecting the data from these sensors, especially from remote sensors and weather stations. It helps in an in-depth analysis of data and provides valuable recommendations too.

Seeding is not guesswork after the innovation and application of IoT technologies. The programmed smart device can find the exact place for a seed to be planted and grown in a possible way. The collection of crops by the smart tractors with more exceptional efficiency and care when the harvest is ripe. Presently, the percentage of energy needed for the cultivation of crop by repairing the tractor damage itself goes around 80 to 90. By using the G.P.S. controlled steering system and route planning based on the input data, we can:

I. Minimising erosion by tracking vehicle path

II. Fuel cost reduction

III. Improvement in accuracy on the operations

The applications developed for small-scaled farmers may support them in multiple ways. The diagnosis of the diseases on plants identified and forwarded to the experts to rectify. The number of nutrients needed by the fertilisers by the determination of leaf colour and soil quality. Also, the pH value of the soil and other conditions can be measured. From the observations on leaves, the water needs of the plants determined. The readiness on the crop harvesting with the aid of U.V. and white light-based photos can aid in the prevention of ripeness.

- **Optical sensors**

The optical sensors are used to collect and record the data about crop field and soil quality by the collection of light reflected from the growing plants. The application of nitrogen to the plants indicated to the users according to the health of the plants. As this technology is not depending on the atmospheric light, the optical sensors used day and night. It uses external light to analyse the properties of soil. Measurement of light reflectance frequencies is carried out by the sensors in near and mid-infrared and polarised light spectrums. Optical sensors can be easily placed or integrated on vehicles or drones or even satellites too. The aggregation of data, collected from optical sensors, can be processed further. Determination of the organic matter, clay, and soil moisture level content can also be analysed by optical sensors.

Figure 1.4: Optical System

According to the data collected using various platforms, like satellites, aerial (aeroplanes, UAVs and drones) and ground-based, the reflectance recorded. The collection of images from satellites, aircraft, and UAV's using cameras where the optical sensors installed in the ground are able to collect the reflectance data as a text file. According to the operation, these ground sensors classified either active or passive. The passive sensors are in need of an external source of light, like the sun. However, the active sensors are operated by their source of view of different wavelengths or a specific wavelength. The relationship between the visible light and the chlorophyll content provides plant details. From this analysis, we could identify healthy plants as green. The mesophyll cells are reflecting the near-infrared light, which is invisible to the human eye, found that more than chlorophyll content, the quantity in a plant, results in the highest reflectance than the visible lights. Biomass production and evaluation of colour classified by analysing both wavelengths. Sensor position may affect the field measurements, like the crop distance, light source dependency, leaves may cover by snow dews, and also because of other factors that may cause the plant stress. The moderated distance between the target and the sensor kept avoiding noise in the captured signal. It will lead to overcoming the limitations of the sensor output. It is essential to monitor the leaves, which should not be covered by water molecules or dews, which may change the reflectance.

- Electrochemical sensors and mechanical sensors

- Among different domains and their development like the Internet of Things (IoT) supported farming, the electrochemical sensor system is playing a vital role by detecting single or multiple soil components effectively, selectivity, and efficiently for soil quality measurements. It can be

Figure 1.5: Amperometry Sensor

done either remotely by sharing the data and in-situ like the direct point of care on soil health. This perspective is aimed for the description of the state of art sensor technology based on the electrochemical mechanism for the measurement of soil quality by considering present scenarios. The electrochemical sensing mechanism explored its applications in many fields and even for a point of use. Mainly, lab-based methods like an ion-selective membrane, impedance spectroscopy, and amperometry sensors are in use to detect the nutrients of the soil and other parameters of agriculture.

One of the attractive methods is to combine the electrochemical sensing technique by using ion-selective membrane transducers, which can easily monitor the parameters of soil like phosphate, nitrate, potassium, and others. Electrochemical sensing techniques are not so complicated like spectroscopy or any optical complexity and deployed directly to measure soil nutrients. These sensors are consisting of two electrodes of a working electrode, which can detect the target and another one of a reference electrode, which supplies a constant potential. The difference in potential between these two electrodes is either proportional or inversely proportional to the target according to its nature, either anions or cations. The working principle of this sensor governed by the Nernst equation. By relating the change in working electrode potential, which is compared with the potential of a reference electrode, based on the linearity of the activity of the sensed ion. The electrochemical sensors to deploy for in-situ measurements are expecting the electronic circuits embedded with the sensor.

Figure 1.6: Electrochemical Sensor

The microelectromechanical system (MEMS) based sensors embedded with electrochemical sensing units, which gains excellent potential for the analysis of soil quality because of their portability, rapidity, real-time measurement, and in-field deploy ability. The ability of electrochemical soil sensors to sense different soil parameters, needed to be present in those systems as a basic and essential part for smart farming. This micro-scaled sensing system with the high potential for soil analysis is the much need for next-generation agriculture. MEMS-based sensors can save the data easily due to their affordability & sharing, on-time analysis, and accuracy in the decision.

- **Mechanical sensors**

These sensors used to estimate the mechanical resistance of the soil. The penetration or cutting through the land to measure the force using individual devices like strain gauges or load cells is the basic phenomenon of these sensors.

The developed prototypes by the researchers can map the soil resistance continuously in a feasible way. Unfortunately, these prototypes are not available commercially. A new technique called the "traction control" system on tractors based on drift sensors is using a similar method to control the three-point hitch on the way.

- **Dielectric sensors**

Dielectric sensors are used for measuring the soil moisture levels by the utilisation of the dielectric constant of the material. It defined as the electrical property, which is getting changed according to the content of soil moisture.

Figure1.7: Dielectric Sensor

These sensors embedded with rain gauge stations and arranged around the farm. While the vegetation level goes down, the observation on soil moisture conditions can be performed by them. Also, the soil moisture sensors used the soil's dielectric constant to justify the content of the volume of water and the transmission of electricity based on the soil's capability depending on its dielectric constant. The dielectric constant land's water is larger compare with air, so that, if the water content of the soil increases, the increment of the dielectric constant of the soil will also be recorded. So, the constant dielectric measurement provides a fair observation of water content.

- **Airflow sensors**

Airflow sensors used to measure the permeability of air of the soil. The amount of pressure needed to pressurise a certain volume of air to some depth on the land, which is used to compare the multiple properties of soil.

Figure 1.8: Airflow Sensor

From multiple experiments, it is possible to distinguish between various soil types and soil structure, moisture levels and compaction. These measurements can be made not only at a single location, while in motion too dynamically. The expected outcome is the need for pressure to allow a particular amount of air to the ground in the wanted level of depth. By using such unique sensors, we can study various types of soil properties, including soil type, compaction, moisture level and structure, which produces unique identified signatures.

1.2.2. Application of IoT

- **Smart home:**

IoT devices are a part of the larger concept of home automation, which can include lighting, heating and air conditioning, media and security systems. Long term benefits could include energy savings by automatically ensuring lights and electronics are turned off.

A smart home or automated home could be based on a platform or hubs that control smart devices and appliances. For instance, using *Apple*'s *Home Kit*, manufacturers can have their home products and accessories controlled by an application in *iOS* devices such as the *iPhone* and the *Apple Watch*. This could be a dedicated app or iOS native applications such as *Siri*. This can be demonstrated in the case of Lenovo's Smart Home Essentials, which is a line of smart home devices that are controlled through Apple's Home app or Siri without the need for a Wi-Fi bridge. There are also dedicated smart home hubs that are offered as standalone platforms to connect different smart home products and these include the *Amazon Echo*, *Google Home*, Apple's *HomePod*, and Samsung's *Smart Things Hub*

- **Transportation:**

The IoT can assist in the integration of communications, control, and information processing across various *transportation systems*. Application of the IoT extends to all aspects of transportation systems (i.e. the vehicle, the infrastructure, and the driver or user). Dynamic interaction between these components of a transport system enables inter and intra vehicular communication, *smart traffic control*, smart parking, *electronic toll collection systems*, *logistic* and *fleet management*, *vehicle control*, safety and road assistance. In Logistics and Fleet Management for example, an IoT platform can continuously monitor the location and conditions of cargo and assets via wireless sensors and send specific alerts when management exceptions occur (delays, damages, thefts, etc.). This can only be possible with the IoT and its seamless connectivity among devices. Sensors such as GPS, Humidity, Temperature, send data to the IoT platform and then the data is analyzed and send further to the users. This way, users can track the real-time status of vehicles and can make appropriate decisions. If combined with *Machine Learning* then it also helps in reducing traffic accidents by introducing *drowsiness* alerts to drivers and providing self-driven cars too.

- **Agriculture:**

  There are numerous IoT applications in farming such as collecting data on temperature, rainfall, humidity, wind speed, pest infestation, and soil content. This data can be used to automate farming techniques, take informed decisions to improve quality and quantity, minimize risk and waste, and reduce effort required to manage crops. For example, farmers can now monitor soil temperature and moisture from afar, and even apply IoT-acquired data to precision fertilization programs.

In August 2018, *Toyota Tsusho* began a partnership with *Microsoft* to create *fish farming* tools using the *Microsoft Azure* application suite for IoT technologies related to water management. Developed in part by researchers from *Kindai University*, the water pump mechanisms use *artificial intelligence* to count the number of fish on a *conveyor belt*, analyze the number of fish, and deduce the effectiveness of water flow from the data the fish provide. The specific *computer programs* used in the process fall under the Azure Machine Learning and the Azure IoT Hub platforms.

Figure 1.9: Application of IoT in Agriculture

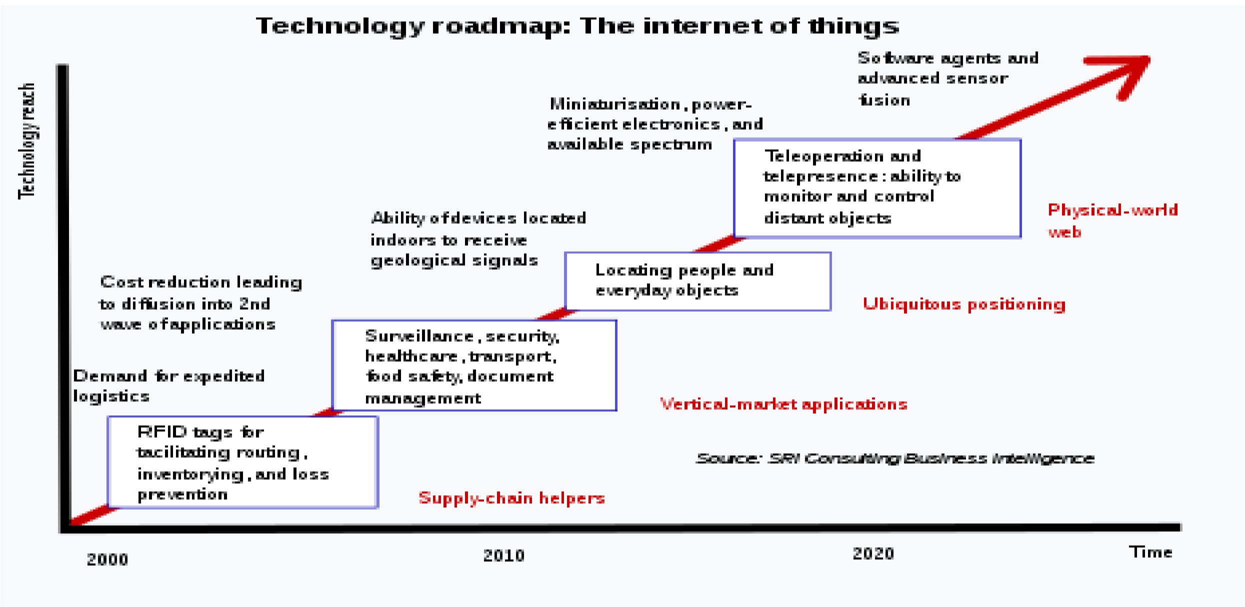

Figure 1.10: Technology Roadmap: The Internet of Things

The IoT's major significant trend in recent years is the explosive growth of devices connected and controlled by the Internet. The wide range of applications for IoT technology mean that the specifics can be very different from one device to the next but there are basic characteristics shared by most.

The IoT creates opportunities for more direct integration of the physical world into computer-based systems, resulting in efficiency improvements, economic benefits, and reduced human exertions.

The number of IoT devices increased 31% year-over-year to 8.4 billion in the year 2017 and it is estimated that there will be 30 billion devices by 2022. The global market value of IoT is projected to reach $7.1 trillion by 2022.

- **Intelligence:**

Ambient intelligence and autonomous control are not part of the original concept of the Internet of things. Ambient intelligence and autonomous control do not necessarily require Internet structures, either. However, there is a shift in research (by companies such as *Intel*) to integrate the concepts of the IoT and autonomous control, with initial outcomes towards this direction considering objects as the driving force for autonomous IoT. A promising approach in this context is *deep reinforcement learning* where most of IoT systems provide a dynamic and interactive environment. Training an agent (i.e., IoT device) to behave smartly in such an environment cannot be addressed by conventional machine learning algorithms such as *supervised learning*. By reinforcement learning approach, a learning agent can sense the environment’s state (e.g., sensing home temperature), perform actions (e.g., turn *HVAC* on or off) and learn through the maximizing accumulated rewards it receives in long term.

IoT intelligence can be offered at three levels: IoT devices, *Edge/Fog nodes,* and *Cloud computing*. The need for intelligent control and decision at each level depends on the time sensitiveness of the IoT application. For example, an autonomous vehicle's camera needs to make real-time obstacle detection to avoid an accident. This fast decision making would not be possible through transferring data from the vehicle to cloud instances and return the predictions back to the vehicle.

1.3.1. Introduction to Machine Learning

Machine learning is an application of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed. Machine learning focuses on the development of computer programs that can access data and use it to learn for themselves. The process of learning begins with observations or data, such as examples, direct experience, or instruction, in order to look for patterns in data and make better decisions in the future based on the examples that we provide. The primary aim is to allow the computers learn automatically without human intervention or assistance and adjust actions accordingly.

1.3.2. Types of Machine Learning

- **SUPERVISED LEARNING**

  Supervised learning is the process of ML when the system is initially provided data where the algorithm’s inputs (x) and their respective outputs (y) are correctly labeled. Because the input and output data are labeled accordingly, the system is trained to recognize patterns in the data with the algorithm. In future scenarios, this allows the system to receive inputs and produce correctly labeled outputs based on the pattern. Supervised learning is beneficial because it can be used to predict outcomes based on future input data without human interference, like when social media automatically recognizes someone's face after you've tagged them in a picture. When you tag your Aunt Sally in a picture (y), social media stores the facial features of Aunt Sally (x). When you upload pictures of Aunt Sally in the future, social media recognizes her facial features (x) and automatically tags Aunt Sally (y).

- **UNSUPERVISED LEARNING**

In unsupervised learning, data is fed to the system, but the outputs are not labeled accordingly like they are in supervised learning. Unsupervised learning allows the system to observe the data and determine patterns with the information it is given, rather than being trained to recognize the pattern. Once the system has stored the patterns it created, future inputs are assigned to a pattern (created by the system) to produce an output. Unsupervised learning is beneficial because it can show patterns in data that may have been overlooked when observed by humans. Unsupervised learning is used when social networks make recommendations of friends to follow; these recommendations are based on patterns created by demographic data individuals share online. If you went to University X and studied calculus, the algorithm is trained to recognize and recommend other individuals that went to University X and studied calculus as people you may know.

- **REINFORCEMENT LEARNING**

Though it is a separate classification, reinforcement learning is a type of unsupervised learning. Similar to unsupervised learning, the data provided to the system is not labeled, so the system is left to create its own patterns. Where reinforcement differs from unsupervised is that when a correct output is produced, the system is told that this output is correct. This type of learning allows the system to learn from its environment and its experiences to explore a full range of possibilities. It is quite literally, learning through reinforcement. When Spotify makes a recommendation for a song (based on a pattern it noticed in your music selection) you are given the option to "thumbs up" or "thumbs down" the recommendation. When you indicate "thumbs up" or "thumbs down," Spotify utilizes reinforcement learning because it's learning your music taste based on what you tell their system.

1.3.3. How Does Machine Learning Work?

To get the maximum value from big data, businesses must know exactly how to pair the right algorithm with a particular tool or process and build machine learning models based on iterative learning processes. Some of the key machine learning algorithms are

- Random forests
- Neural networks
- Discovery of sequence and associations
- Decision trees
- Mapping of nearest neighbour
- Supporting vector machines
- Boosting and bagging gradient
- Self organizing maps
- Multivariate adaptive regression
- SEO
- Analysis of principal components

As mentioned above, the secret to successfully harnessing the applications of ML lies in not just knowing the algorithms, but in pairing them accurately with the right tools and processes, which include -

- Data exploration followed by visualization of model results
- Overall data quality and management
- Easy model deployment to quickly get reliable and repeatable results
- Developing graphical user interface for creating process flows and building models
- Comparing various machine learning models and identifying the best

- Identify best performers through automated ensemble model evaluation
- Automated data-to-decision process

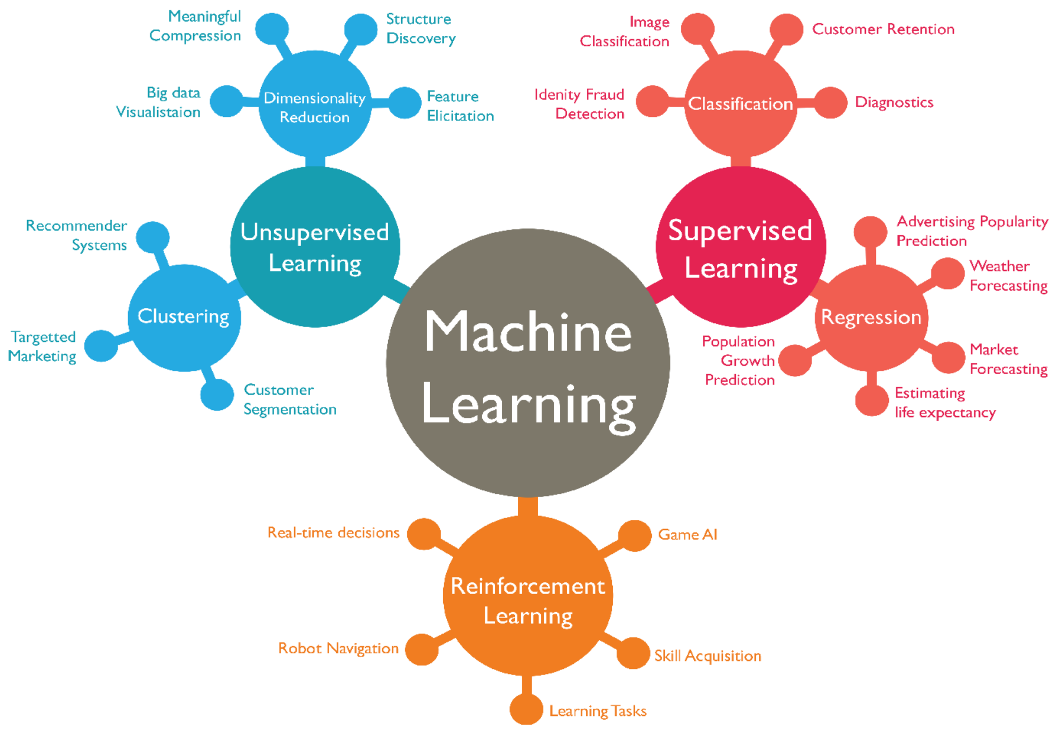

Figure11: Types of Machine Learning

1.3.4. Applications of Machine Learning

The value of machine learning technology has been recognized by companies across several industries that deal with huge volumes of data. By leveraging insights obtained from this data, companies are able work in an efficient manner to control costs as well as get an edge over their competitors. This is how some sectors / domains are implementing machine learning -

Financial Services

Companies in the financial sector are able to identify key insights in financial data as well as prevent any occurrences of financial fraud, with the help of machine learning technology. The technology is also used to identify opportunities for investments and trade.

Usage of cyber surveillance helps in identifying those individuals or institutions which are prone to financial risk, and take necessary actions in time to prevent fraud.

Marketing and Sales

Companies are using machine learning technology to analyze the purchase history of their customers and make personalized product recommendations for their next purchase. This ability to capture, analyze, and use customer data to provide a personalized shopping experience is the future of sales and marketing.

Government

Government agencies like utilities and public safety have a specific need FOR Ml, as they have multiple data sources, which can be mined for identifying useful patterns and insights. For example sensor data can be analyzed to identify ways to minimize costs and increase efficiency. Furthermore, ML can also be used to minimize identity thefts and detect fraud.

Healthcare

With the advent of wearable sensors and devices that use data to access health of a patient in real time, ML is becoming a fast-growing trend in healthcare. Sensors in wearable provide real-time patient information, such as overall health condition, heartbeat, blood pressure and other vital parameters. Doctors and medical experts can use this information to analyze the health condition of an individual, draw a pattern from the patient history, and predict the occurrence of any ailments in the future. The technology also empowers medical experts to analyze data to identify trends that facilitate better diagnoses and treatment.

Transportation

Based on the travel history and pattern of traveling across various routes, machine learning can help transportation companies predict potential problems that could arise on certain routes, and accordingly advise their customers to opt for a different route. Transportation firms and delivery organizations are increasingly using machine learning technology to carry out data analysis and data modeling to make informed decisions and help their customers make smart decisions when they travel.

Oil and Gas

This is perhaps the industry that needs the application of machine learning the most. Right from analyzing underground minerals and finding new energy sources to streaming oil distribution, ML applications for this industry are vast and are still expanding.

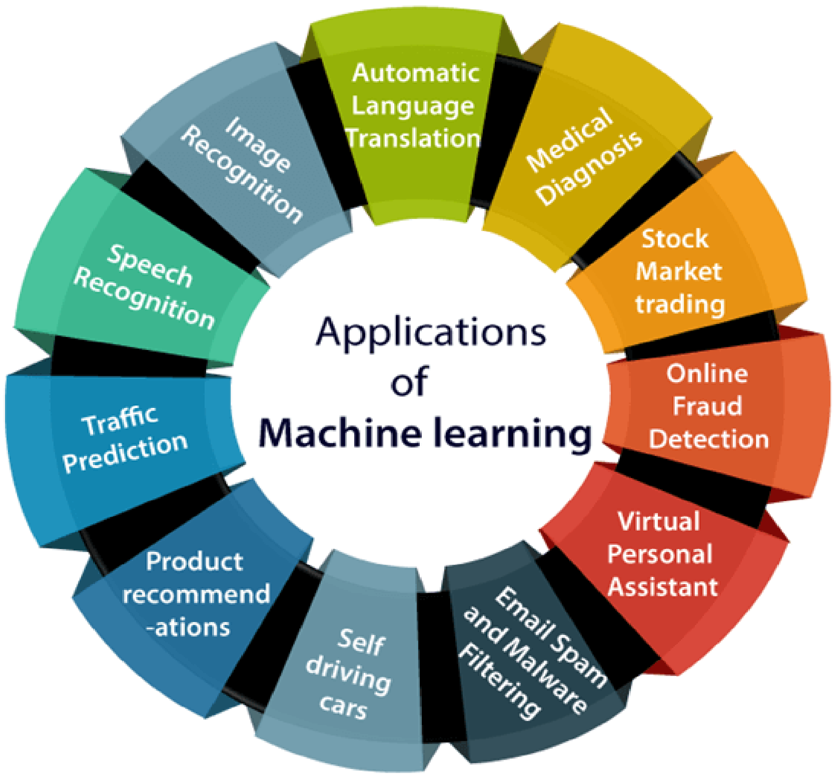

Figure 12: Application of ML

CHAPTER 2

LITERATURE REVIEW

2.1. LITERATURE REVIEW

A thorough literature review has been done and a fragment of the effective powerful technologies and algorithms based on literature survey and observations are put forward in this paper for the benefit of smart agriculture. In this current digital time, IoT assumes a huge part in each association just as nation advancement, and horticulture is one of the fields in which most of the things should be automated through IoT devices. This new idea unified on farming data has been known with several different names like Smart Farming, Smart Agriculture, Digital Farming, or Agriculture 4.0, and was born when telematics and information management were combined to the already familiar conception of preciseness Agriculture, up the accuracy of operations [13]. The utilization of new technologies to improve crop profitability are shown by [21]. The utilization of new technologies will be useful to measure and break down the information. To store data identified with soil, the authors are using the Blynk application. The data it will save will be its humidity, moisture, temperature, etc. Its uses are shown by [1]. While applying these new technologies, the test for retrieving information from crops is to come out with something intelligent and important, on the grounds that information themselves are not helpful, simply numbers or pictures. Homesteads that choose to be innovation-driven somehow or another, show significant valuable advantages, such as saving money and work, having an expanded creation or a decrease of expenses with insignificant effort, and delivering quality food with all the more environmentally friendly things. [13] Ç. Ersin, R. Gürbüz, A.K. Yakut, 2016 proposed the micro-controller based irrigation system which is very efficient and economical compared to different standard strategies, preciseness irrigation approaches are delineate by Liu[20]. [9] A farm vehicle and smart dispatching approach have been researched. [22] provided with associate interconnected approached towards smart agricultural. [J. Kwok, Y. Sun, 2018] work suggested plant detection using deep learning and so supported plant sort its applicable irrigation quantity required. Thus, once thorough study of presently out there literature, that deals with the current farming issues and their various answer, this paper highlights and provides a combined, precise view to the potential solution for smart farming.

Authors	**System Design**	**Findings**
[14] Veronica Saiz Rubio (February 2020)	From Smart Farming towards Agriculture 5.0: A Review on Crop Data Management	Optimized cost-effective decisions can be made by farmers while protecting the environment and transforming how food will be produced to match the coming up population growth using IoT and AI.
[7] G.Lavanya, S.Monika ,G.Sandra Karunya, A. Mathan Gopi4 , D. Rajini Girinath, (March2019)	IoT Enabled Assisting Device for Seizures Monitoring	Host Management System (HMS) which is fit for cloud service and checks that stores and controls the MEDIBOX usefulness.
Nikhilesh Wadhwa , Shikhar Tripathi , Chirag Agarwal , Rasika Yeolekar , Ashish Manwatkar (March, 2019)	Web based Intelligent Irrigation System	Methods to solve such problems like identifying crop suitable for which soil, level of water in soil, moisture etc. Mentioned Sensors and electronic devices.
[1] Hemlata Sahu, Prerana Modala , Anjali Jiwankar, Sonal Wagle, (March 2019)	Multidisciplinary Model for Smart Agriculture using IoT	Soil Monitoring for Precision Farming: Monitoring soil conditions is a simple use case but it can lead to a fantastic return on investment for farmers.
[17] Xiaohui Wang, Nannan Liu, (2017)	The Application of Internet of Things in Agricultural means	Smart agriculture based on IoT and Cloud Computing Use of cloud computing for agriculture

	of production supply chain management	utilizing for storing details of agriculture data.
[18] Sanjit Kumar Dash, Subasish Mohapatra, Prasant Kumar Pattnaik, (2017)	A Survey on Applications of Wireless Sensor Network Using Cloud Computing	IoT device can be interfaced to soil and environmental sensors to collect soil properties and current environmental conditions. Analysis of the gathered information for interacting between environment, work and result for high grade work model construction.
[19] S. S. Sarmila (IEEE 2017)	Smart farming: sensing technologies	Model includes smart GPS based remote controlled robot to perform. Controlling of all these operations will be through any remote smart device or computer connected to Internet and operations will be performed by interfacing sensors, Wi-Fi or ZigBee modules, camera, actuators with micro-controller and raspberry.
John R. Dela Cruz (IEEE 2016)	Design of a fuzzy-based automated organic irrigation system for smart farm	Automated organic irrigation system in controlling and properly allocating the available water resources for the irrigation system and pumping water for irrigation on right time and use.

[20] Akshay Atole, Apurva Asmar, Amar Biradar, Nikhil Kothawad (April, 2017)	IoT Based Smart Farming System	Smart Farming System that uses advantages of cutting-edge technologies such as IoT, Wireless Sensor Network and Cloud computing to help farmers enhance the way farming is done.

CHAPTER 3

SMART AGRICULTURE

3.1. What is Smart Farming

There are many ways to refer to modern agriculture. For example, AgriTech refers to the application of technology in agriculture in general.
Smart agriculture, on the other hand, is mostly used to denote the application of IoT solutions in agriculture. The same applies to the smart farming definition.

Although smart agriculture IoT, as well as industrial IoT in general, aren't as popular as consumer connected devices; yet the market is still very dynamic. The adoption of IoT solutions for agriculture is constantly growing. Namely, *BI Intelligence* predicts that the number of agriculture IoT device installations will hit 75 million by 2020, growing 20% annually.
At the same time, the global smart agriculture market size is *expected* to triple by 2025, reaching $15.3 billion (compared to being slightly over $5 billion back in 2016).
Because the market is still developing, there is still ample opportunity for businesses willing to join in. Building IoT products for agriculture within the coming years can set you apart as an early adopter, and as such, help you pave the way to success.

Smart Farming is an emerging concept that refers to managing farms using modern Information and Communication Technologies to increase the quantity and quality of products while optimizing the human labour required. Among the technologies available for present-day farmers are:

- Sensors: soil, water, light, humidity, temperature management
- Software: specialized software solutions that target specific farm types or use case agnostic *IoT platforms*
- Connectivity: *cellular*, *LoRa*.
- Location: GPS, Satellite, etc.
- Robotics: Autonomous tractors, processing facilities, etc.
- Data analytics: standalone analytics solutions, data pipelines for downstream solutions, etc.

- Armed with such tools, farmers can monitor field conditions without even going to the field and make strategic decisions for the whole farm or for a single plant.

- The driving force of smart farming is IoT—connecting smart machines and sensors integrated on farms to make farming processes data-driven and data-enabled.

3.1.2. Five Technology Use Cases for Smart Farming:

As we can see, the use cases for IoT in agriculture are endless. There are many ways smart devices can help you increase your farm's performance and revenue. However, agriculture IoT apps development is no easy task. There are certain challenges you need to be aware of if you are considering investing into smart farming.

- **The Hardware:** To build an IoT solution for agriculture, you need to choose the sensors for your device (or create a custom one). Your choice will depend on the types of information you want to collect and the purpose of your solution in general. In any case, the quality of your sensors is crucial to the success of your product: it will depend on the accuracy of the collected data and its reliability.
- **The Brain:** Data analytics should be at the core of every smart agriculture solution. The collected data itself will be of little help if you cannot make sense of it. Thus, you need to have powerful data analytics capabilities and apply predictive algorithms and machine learning in order to obtain actionable insights based on the collected data.
- **The Maintenance:** Maintenance of your hardware is a challenge that is of primary importance for IoT products in agriculture, as the sensors are typically used in the field and can be easily damaged. Thus, you need to make sure your hardware is durable and easy to maintain. Otherwise you will need to replace your sensors more often than you would like.
- **The Mobility:** Smart farming applications should be tailored for use in the field. A business owner or farm manager should be able to access the information on site or remotely via a smartphone or desktop computer. Plus, each connected device should be autonomous and have enough wireless range to communicate with the other devices and send data to the central server.
- **The Infrastructure:** To ensure that your smart farming application performs well (and to make sure it can handle the data load), you need a solid internal infrastructure.

- Internet of Things-consists of two words- Internet and Things.
  The term "Things" in IoT refers to various IoT
  Devices having unique identities and have capabilities to perform remote sensing, actuating and live monitoring of certain sorts of data. IoT devices are also enabled to have live exchange of data with other connected devices and applications either directly or indirectly, or collect data from other devices and process the data and send the data to various servers. The other term "Internet" is defined various servers. The other term "Internet" is defined as Global Communication network connecting trillions of computers across the planet enabling sharing of information.

- As forecasted by various researchers, 50 Billion devices based on IoT would be connected all across the planet by year 2020. The Internet of Things (IoT) has been defined as (Smith, 2012): A Dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual "Things" have identities, physical attributes, and virtual personalities and use intelligent interfaces and are seamlessly integrated into the information network, often communicate data associated with users and their environments". An ideal IoT device consist of various interfaces for making connectivity to other devices which can either be wired or wireless. Any IoT based device consists of following
  components:

- I/O interface for Sensors.
- Interface for connecting to Internet.
- Interface for Memory and Storage.
- Interface for Audio/Video.

IoT devices can be of various forms like wearable sensors, smart watches, IoT smart home monitoring, IoT intelligent transport systems, IoT smart health devices etc.

With the adoption of IoT in various areas like Industry, Homes and even Cities, huge potential is seen to make everything Intelligent and Smart. Even the Agricultural sector is also adopting IoT technology these days and this in turn has led to the development of "Agriculture Internet of Things."

Agriculture is considered as the basis of life for the human species as it is the main source of food grains and other raw materials. It plays vital role in the growth of country’s economy. It also provides large ample employment opportunities to the people. Growth in agricultural sector is necessary for the development of economic condition of the country. Unfortunately, many farmers still use the traditional methods of farming which results in low yielding of crops and fruits. But wherever automation had been implemented and human beings had been replaced by automatic machineries, the yield has been improved. Hence there is need to implement modern science and technology in the agriculture sector for increasing the yield. Most of the papers signifies the use of wireless sensor network which collects the data from different types of sensors and then send it to main server using wireless protocol. The collected data provides the information about different environmental factors which in turns helps to monitor the system. Monitoring environmental factors is not enough and complete solution to improve the yield of the crops. There are number of other factors that affect the productivity to great extent. These factors include attack of insects and pests which can be controlled by spraying the crop with proper insecticide and pesticides. Secondly, attack of wild animals and birds when the crop grows up. There is also possibility of thefts when crop is at the stage of harvesting. Even after harvesting, farmers also face problems in storage of harvested crop. So, in order to provide solutions to all such problems, it is necessary to develop integrated system which will take care of all factors affecting the productivity in every stages like; cultivation, harvesting and post harvesting storage. This paper therefore proposes a system which is useful in monitoring the field data as well as controlling the field operations which provides the flexibility. The paper aims at making agriculture smart using automation and IoT technologies. The highlighting features of this paper includes smart GPS based remote controlled robot to perform tasks like; weeding, spraying, moisture sensing, bird and animal scaring, keeping vigilance, etc. Secondly, it includes smart irrigation with smart control based on real time field data. Thirdly, smart warehouse management which includes; temperature maintenance, humidity maintenance and theft detection in the warehouse. Controlling of all these operations will be through any remote smart device or computer connected to Internet and the operations will be performed by interfacing sensors, Wi-Fi.

3.2. 1. **The Benefits of smart farming: How's IoT shaping agriculture**

Agriculture sensors can increase the food demand because of the utilisation of minimum resources like water, seeds, and fertilisers. These sensors fulfil the above basic requirements by resource conservation and field mapping.

Also, these sensors easily installed and used efficiently. They are cost-effective too. Along with the usage in agriculture, these sensors can also serve for the prevention of pollution and global warming. With the advantages of communication protocols, these sensors controlled remotely.

Technologies and IoT have the potential to transform agriculture in many aspects. Namely, there are 5 ways IoT can improve agriculture:

Figure 3.1 : IoT in Agriculture

- **Data, tons of data, collected by smart agriculture sensors,** e.g. weather conditions, soil quality, crop's growth progress or cattle's health. This data can be used to track the state of your business in general as well as staff performance, equipment efficiency, etc.

- **Better control over the internal processes and, as a result, lower production risks**. The ability to foresee the output of your production allows you to plan for better product distribution. If you know exactly how much crops you are going to harvest, you can make sure your product won't lie around unsold.
- **Cost management and waste reduction thanks to the increased control over the production**. Being able to see any anomalies in the crop growth or livestock health, you will be able to mitigate the risks of losing your yield.
- **Increased business efficiency through process automation**. By using smart devices, you can automate multiple processes across your production cycle, e.g. irrigation, fertilizing, or pest control.
- **Enhanced product quality and volumes**. Achieve better control over the production process and maintain higher standards of crop quality and growth capacity through automation.

3.2.2. Limitations of agriculture sensors

Precision agriculture and IoT technology are expecting flawless internet connectivity, which is a significant constraint and not available in many of the developing countries like I.N.D.I.A. there is a presumption among the customers that they may not be ready to utilise the present IoT devices integrated with agriculture sensors. Another significant impact on the infrastructure requirements like traffic systems, smart grids, and communication towers is not available everywhere, which also hinders the growth of the use of agriculture sensors.

3.2.3. Challenges and ideas to overcome limitations:

According to the expert's vision, precision agriculture has a standard potential to meet the increment in food demand around the globe. Even though the field has good growth and scope, still this has not robust as expected earlie31r. This domain has several challenges that we need to overcome.

The technology following the standards is not uniform and the same, which gets changed often. Precision agriculture expected, to a large extent. The challenge depends on converting smart devices like sensors and gateways to farmer-friendly platforms.

Setting up the architecture for IoT technology is needed to be implemented. Knowledge of precision farming must be reached the farmers and enrich them to operate the sensors/tools independently so that the loss of the workforce prevented.

Providing continuous internet connectivity is mandatory, and network performance like the speed of bandwidth closely monitored.

All the crops are not going to produce the same products. So the product functioning must be defined correctly. Dividing their land as small zones for proper management may also derive the right results.

To prevent the mechanical damage of the sensor/device, continuous monitoring of the operation of these devices is a must. So, food safety cant is compromised. Upgradation of the tools is also essential. E-waste of these devices should adequately evacuate.

3.3.1. **The Benefits of smart farming: How's Machine Learning shaping agriculture**

ML is a technology that aims to build an intelligent model that makes an accurate prediction without the intervention of human beings. The conventional machine learning approach depicted in. It constructs various algorithms to make effective decisions in the problem domain. The primary step is to select the data on the problem under investigation and to select the parameters for the examination. The model is trained by a sample set of data (termed as training data) to gain experience in the environment and make the model fit. Later, the model evaluated using a sample set of data (termed as test data). So this is the primary step involved in any machine learning model, i.e., Train-Test-Predict. Usually, the data set was divided into two viz., training (70%) and testing (30%). Testing data is kept separate and not used in the preparation. The conventional machine learning approach depicted in. The dataset with many alternatives is collected and pre-processed using any normalisation or standardisation methods. The pre-processed data set was divided as train and test data set. The machine algorithms take the train data as input to train the model or to learn for the historical information. The trained model is evaluated with test data. The data visualisation tools are used for visualising the prediction or classification results. Algorithms involved in machine learning are supervised and unsupervised learning. In supervised learning, the model is trained with input data and mapped it into the known results whereas, in unsupervised learning, the model is trained, validated with input data and finds all type of unknown patterns.

The most familiar learning models that fall under these two categories are clustering, regression, classification, and dimensionality reduction. Machine learning utilises a secondary dataset (termed as validation data) for training the model further to avoid the overfitting of the model by the trained data. If the model generates more error on validation data, that means the model overfitted with the prepared data so that training stopped. Now the data split can be done like 60, 10, and 30 per cent of training, validation, and testing, respectively. Machine learning employed in almost all scientific applications such as health care, home automation, smart city, robotics, aquaculture, digital marketing, financial solutions, enterprises, climatology, food safety, agriculture, and more.

As Agriculture forms the major economy for most of the countries, better assistance speeding up each stage of agricultural crop production is mandatory. ML and the Internet of Things (IoT) serve this platform more effectively. IoT devices such as sensors, actuators through wireless communication protocols continuously monitor the crop, soil, water and communicate their health to remote devices either by message or log data or buzzer to alert the agriculturalist to take necessary actions. The data from these devices will make meaningful predictions and recommendations to the user exclusively farmers through machine learning algorithms.

Machine learning models trained by the historical data of the agricultural field through which it gains experience and makes wise decisions for the data signals received from the IoT devices. The data collected from these IoT devices must be secured and ensure confidentiality for accurate prediction results. Precision Agriculture is a strategy adopted to integrate heterogeneous information (Spatio-temporal data) for making precise and effective managerial decisions for global sustainable agricultural practices. Most of the parts of our country are adopting this strategy to improvise agrarian production in a brief span. Application of machine learning in precision agriculture has reshaped the plan such as field-based crop suggestion, fertiliser recommendation, water supply prediction, harvest prediction, thereby controlling the water usage by assisting the agriculturalists or farmers for better yield in a smart way.

Digital agriculture (a term coined by use of Precision Agriculture and Remote sensing) evolved to increase agricultural productivity with a minimised impact on environmental factors. Digital agriculture uses the data (crop, soil, and weather) sensed from the IoT devices to make effective decisions on nutrient demand-based fertiliser recommendation, water supply through proper irrigation, soil nourishment, pest or weed control, and crop protection from intruders. Digital agriculture focuses on the best-of-breed optimisation algorithms fro crop production and its protection during growth. Multi-cropping is a technique adopted in Digital agriculture or smart farming, which allows the cultivation of more than one crop in a single cultivable land.

Digital agriculture has to take more precautionary steps while feeding these different crops with weeds and fertilisers as the mixed plant has a different nutritional requirement and water supply. So it takes into account inter-variability and intra-variability among the crops before feeding the fertilisers. It adopts the techniques like in-row treatment to spray fertiliser for each plant separately, sensor-equipped drones to track the weed, automated sensing of fertiliser details from the barcode label for a correct proportionate mix of pesticides, drift reduction techniques and integration of these applications with global positioning system and comprehensive information system for periodic relay to the agriculturalists.

The application of Machine learning in different stages of agricultural crop production are depicted.The necessary steps involved in crop cultivation are Land suitability analysis, appropriate crop selection, crop production, crop protection, nutrient supply, water supply, crop health monitoring (pest and weed control), human and animal attack detection, yield management, and post-harvesting.

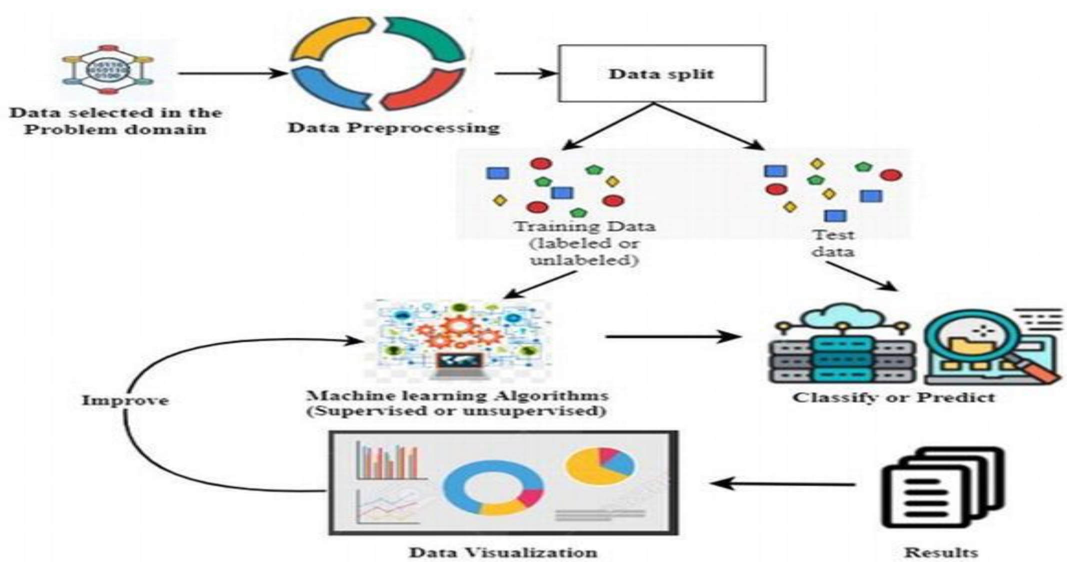

Figure 3.2: Machine learning approach

Although these steps are common for all types of crops, soil nourishment value and chemical composition determine the techniques adopted in each level. Also, this paves a significant consideration of fertiliser supply when multi-cropping is selected. This multi-cropping technique has been in evolution decades back and done explicitly in the hill areas with meagre farming areas yielding better productivity.

Machine learning in crop production

Crop Production and management include crop selection, soil preparation based on suitability analysis, sowing seeds, application of manure & fertiliser, water management through proper irrigation mechanisms, and harvesting. Machine learning in agriculture crop production links various participants in the food chain or agricultural chain. Machine learning helps the agriculturalists in making better decisions in crop quality determination, yield prediction, plant species determination, crop disease prediction, and harvesting techniques.

Animal intrusion detection is one of the threats to the agricultural crop. These intrusions identified and detected to avoid loss of crop production. IoT sensors provide periodic alerts on the detection of an animal object like rats, cow, sheep, elephant, and other wild animals. It can be detected effectively and prevented through wireless sensors alerts to farmers mobile and machine learning algorithms can be used for object classification. Also, Machine learning algorithms used to predict the animal or human object entry apriority by training the model with past data from IoT sensors.

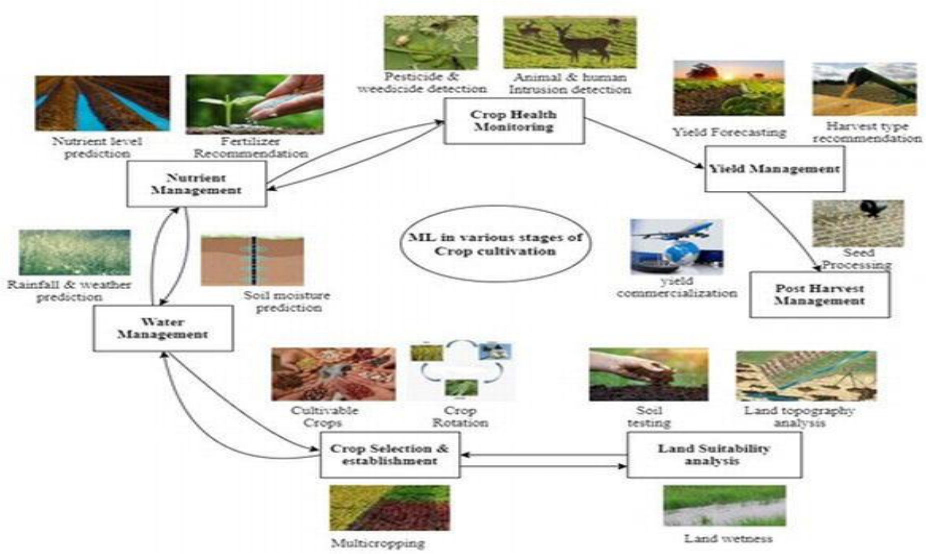

Figure 3.3: Machine learning in agricultural crop cultivation.

Species management

Species Breeding

Our favourite, this application is so logical and yet so unexpected, because mostly you read about harvest prediction or ambient conditions management at later stages.

Species selection is a tedious process of searching for specific genes that determine the effectiveness of water and nutrients use, adaptation to climate change, disease resistance, as well as nutrients content or a better taste. Machine learning, in particular, deep learning algorithms, take decades of field data to analyse crops performance in various climates and new characteristics developed in the process. Based on this data they can build a probability model that would predict which genes will most likely contribute a beneficial trait to a plant.

Species Recognition

While the traditional human approach for plant classification would be to compare color and shape of leaves, machine learning can provide more accurate and faster results analyzing the leaf vein morphology which carries more information about the leaf properties.

Field conditions management

Soil management

For specialists involved in agriculture, soil is a heterogeneous natural resource, with complex processes and vague mechanisms. Its temperature alone can give insights into the climate change effects on the regional yield. Machine learning algorithms study evaporation processes, soil moisture and temperature to understand the dynamics of ecosystems and the impingement in agriculture.

Water Management

Water management in agriculture impacts hydrological, climatological, and agronomical balance. So far, the most developed ML-based applications are connected with estimation of daily, weekly, or monthly evapotranspiration allowing for a more effective use of irrigation systems and prediction of daily dew point temperature, which helps identify expected weather phenomena and estimate evapotranspiration and evaporation.

Crop management

Yield Prediction

Yield prediction is one of the most important and popular topics in precision agriculture as it defines yield mapping and estimation, matching of crop supply with demand, and crop management. State-of the-art approaches have gone far beyond simple prediction based on the historical data, but incorporate computer vision technologies to provide data on the go and comprehensive multidimensional analysis of crops, weather, and economic conditions to make the most of the yield for farmers and population.

Crop Quality

The accurate detection and classification of crop quality characteristics can increase product price and reduce waste. In comparison with the human experts, machines can make use of seemingly meaningless data and interconnections to reveal new qualities playing role in the overall quality of the crops and to detect them.

Disease Detection

Both in open-air and greenhouse conditions, the most widely used practice in pest and disease control is to uniformly spray pesticides over the cropping area. To be effective, this approach requires significant amounts of pesticides which results in a high financial and significant environmental cost. ML is used as a part of the general precision agriculture management, where agro-chemicals input is targeted in terms of time, place and affected plants.

Weed Detection

Apart from diseases, weeds are the most important threats to crop production. The biggest problem in weeds fighting is that they are difficult to detect and discriminate from crops. Computer vision and ML algorithms can improve detection and discrimination of weeds at low cost and with no environmental issues and side effects. In future, these technologies will drive robots that will destroy weeds, minimizing the need for herbicides.

Livestock management

Livestock Production

Similar to crop management, machine learning provides accurate prediction and estimation of farming parameters to optimize the economic efficiency of livestock production systems, such as cattle and eggs production. For example, weight predicting systems can estimate the future weights 150 days prior to the slaughter day, allowing farmers to modify diets and conditions respectively.

Animal Welfare

In present-day setting, the livestock is increasingly treated not just as food containers, but as animals who can be unhappy and exhausted of their life at a farm. Animals behavior classifiers can connect their chewing signals to the need in diet changes and by their movement patterns, including standing, moving, feeding, and drinking, they can tell the amount of stress the animal is exposed to and predict its susceptibility to diseases, weight gain and production.

CHAPTER 4

PROPOSED WORK

4.1. Proposed Work (Framework and Algorithms)

The Internet of Things (IoT) has achieved an upset in a considerable lot of the circles of our current lives, like an automobile, medical services offices, home automation, retail, education, manufacturing, and many more. The Agriculture and Farming ventures significantly affect the acquaintance of the IoT with the world. Machine learning is an approach to data evaluation that automates analytical system development. It is a department of artificial intelligence-based totally In this proposed model IoT and machine learning is combined to create an efficient and effective smart faring model, which will increase the production save time, and resources as well. By the use of different types of sensors, various parameters being monitored for an interval of time best suit irrigation can be done on the farmland, crop management, field conditions management, appropriate use of fertilizers & pesticides all these can be done easily. The figure below gives a brief about the proposed work. It advances the significance and uses in dealing with the agricultural

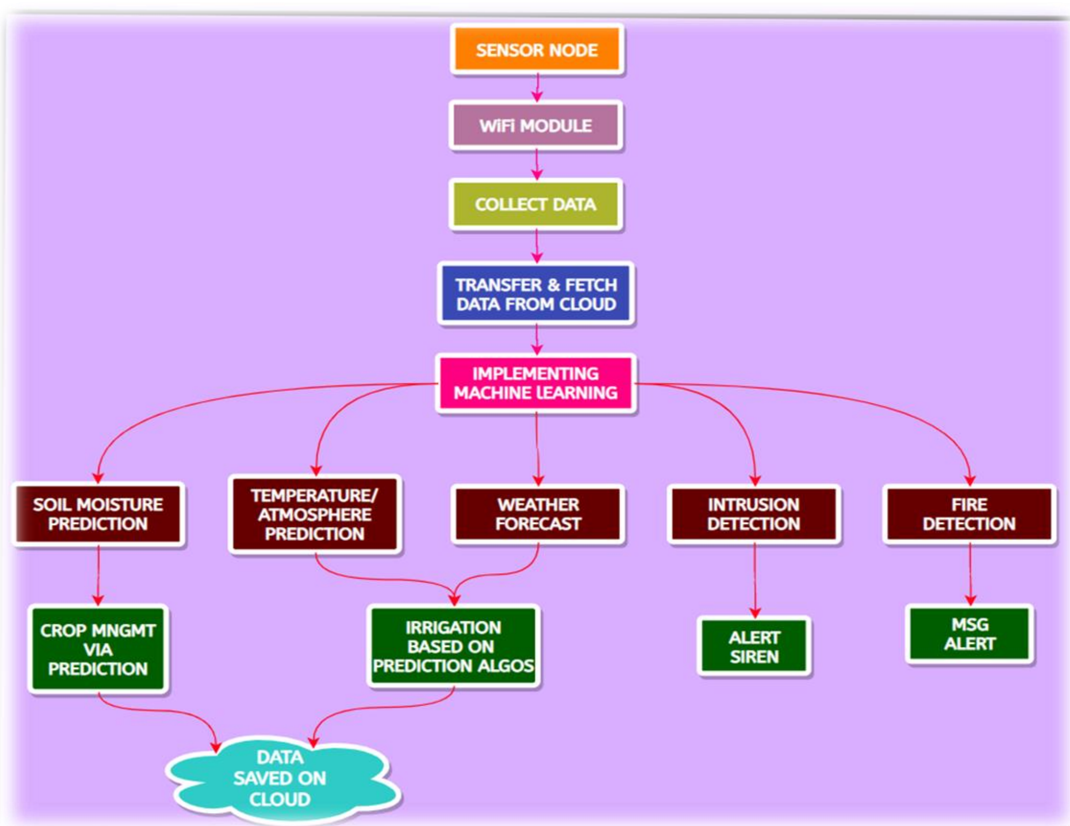

Figure 4.1. Flowchart for Proposed Work

environment for food security. And underlines low energy utilization alternatives for minimal effort or cost and natural maintainability.

4.2. Data Processing

As per Second Advance Estimates for 2019-20, complete food grain manufacturing in India is estimated at report 291.95 million tonnes which is greater with the aid of 6.74 million tonnes than the production of food grain of 285.21 million tonnes executed at some stage in 2018-19. However, the manufacturing throughout 2019-20 is greater by way of 26.20 million tonnes than the preceding 5 years (2013-14 to 2017-18) common manufacturing of food grain. To better understand the number of crops cultivated in India and their production volume a study on "Agriculture Production of Crop in India" the dataset is done obtained from the website "Kaggle". The dataset is training dataset. The data analyzation done is for training purpose.

The evaluation is done using python language and visualizations are outputs of code executed for the dataset on Google Colab Notebook. This evaluation forms the basis of the importance and needs for automation in the zone to limit cost and enlarge productivity. The bar graph shown is an outcome of the analyzed data.

```
plt.figure(figsize = (17, 5))
ax= plt.axes()
ax.set_facecolor("black")
crop_df['Production'].value_counts().head(8).plot(kind='bar'),crop_df['Crop'].value_counts().head(8).plot(kind='bar'
plt.xlabel('CROPS')
plt.ylabel('PRODUCTION')
plt.title("Crop PRODUCTION IN INDIA")
plt.show()
```

Figure 4.2. Code in python to plot bar graph

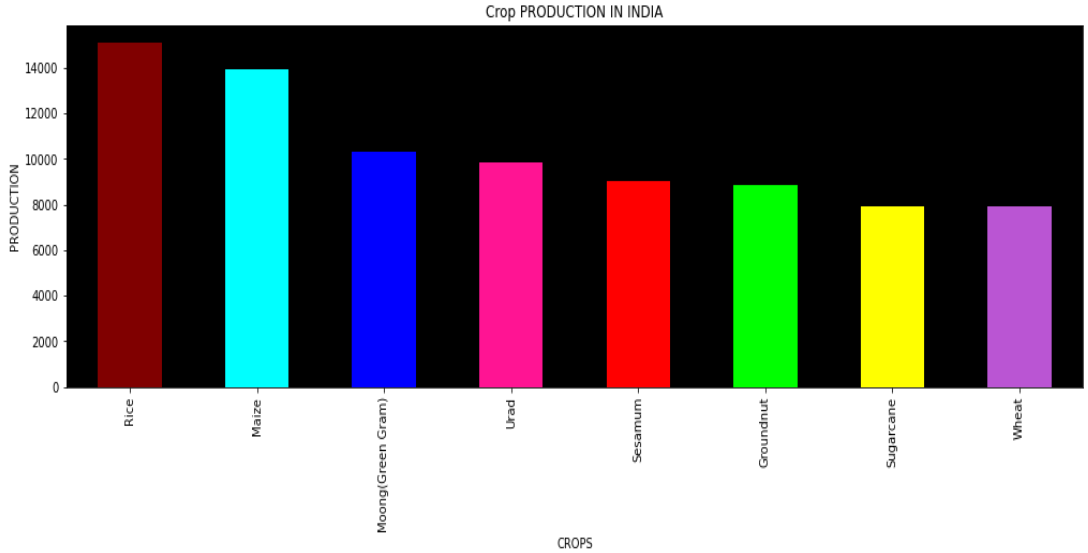

Figure 4.3. Production of different crops in India

Figure 3 represents the graphical analysis for few crops production. This shows the variety of crops with quantity of their production.

The development and usage of Smart Agriculture systems based on IoT and Machine Learning is changing the field of agriculture sector by not only improving the crop production but also making it cost effective. The agriculture sector has gone through a constructional transformation in recent years, demonstrated by hikes in prices and guided by population growth and urbanisation. There is no hesitation that the government needs to invest in the agriculture sector in order for it to bloom. The world seems to be making advancements in the field of technology and it is necessary to make reasonable advancements in the field of agriculture as well. According to the World Bank, the food consumption would increase by 50% by 2050 if the global population continues to rise at its current pace. As a matter of fact, the effects of drastic changes in climatic conditions have seen crops yield falling by more than a quarter. There needs to be a focus on the implementation of smart technologies in the field of agriculture to yield quality and bulk production of crops. The combination of IoT and Machine Learning can certainly help in lowering the cost and also help in increasing the scale of production through the collection of time series data from sensors. There are certain factors, which play a vital role in the production of crops. Nearly 51% of the crop yield is dependent on the influence of these factors. These factors include precipitation, temperature, humidity, and moisture and pH concentration.

```
[ ]
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
rice_df= pd.read_csv('/content/rice - Sheet1 (1).csv')
```

```
rice_df
```

	State_Name	Rice
0	Andhra Pradesh	165064
1	Assam	262347
2	Bihar	18112
3	Chhattisgarh	456491
4	Jammu and Kashmir	23727
5	Karnataka	176688
6	Telangana	418097
7	Uttar Pradesh	14515
8	West Bengal	780861

Figure 4.4. Rice Production dataframe

```
plt.figure(figsize = (17, 5))
ax= plt.axes()
ax.set_facecolor("black")
rice_df['Rice'].plot(kind='bar',color=['maroon', 'cyan', 'blue', 'deeppink', 'red','lime','yellow','grey','mediumorchid' ]),rice_df['State_Name'].value_counts().plot(kind='
plt.xlabel('STATES')
plt.ylabel('RICE PRODUCTION')
plt.title("RICE PRODUCTION IN INDIA")
plt.show()
```

Figure 4.5. Code for plotting bar graph Rice Production Vs States of India

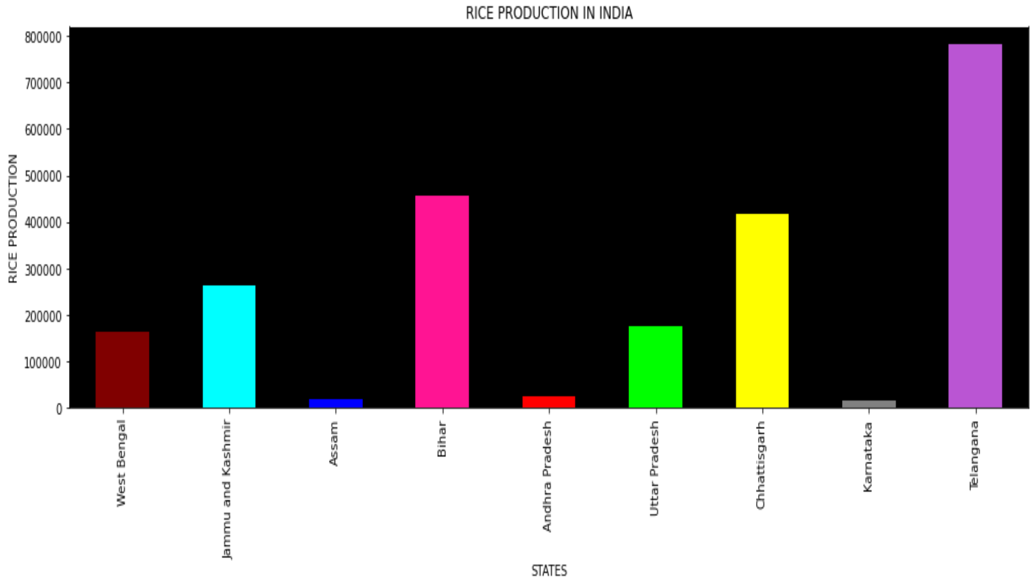

Figure 4.6. Bar graph for Rice Production in India

Precipitation

Precipitation refers to all the water that falls from the atmosphere in the form of rain, dew, and snow. Rain is one of the most important factors, which affects the vegetation of a location. Crops like rice, tea and coffee are grown in the areas, which have heavy and equally distributed rainfall whereas crops like millet, sorghum are grown in locations with less rainfall.

Temperature

The optimal range for temperature, which would yield maximum production for most of the crops range from 15 degree Celsius to 40 degree Celsius. The temperature of a location is highly dependent on the distance of the location from the equator. The growth production of the crops is highly related to the temperature.

Humidity

Humidity is also one of the most important factors affecting the crop production. Humidity refers to the water content present in the form of vapors. As a matter of fact, around 45-60% of relative humidity is preferred for production of most crops whereas only a few number of crops are able to perform well when the humidity is 75% and above. Humidity also increases the possibility of pests and diseases.

Soil quality identification for precision agriculture

One of the formidable global challenges is to feed the huge population soon. It predicted that the population could increases to 9.73 billion people by 2050 and estimated that it would require 70% additional food production in comparison to the present scenario. The conventional agriculture practices resulted in a decline in the total productivity, causing poor ecological diversity, reduce the pollination services, affects carbon sequestration, causes soil and water pollution, soil erosion and food security. It is in dare need to use newly emerged modern sensing and controlling digital technology for effective agriculture. The agricultural sector is not just about maximising productivity it has shifted to the spectrum of other activities like optimising landscape management, development of rural, protection of the environment and social justice outcomes.

Figure 4.7: Precision farming cycle.

Precision farming is one of the innovative methods practised, it incepted in the early 1980s, and with the past few years, it has become more common. It is a concept of “right practice at the right location at the right time at the right intensity”. Precision agriculture uses electronic information and other digital technologies to collect data and analyse spatial/temporal data to improve the efficiency, productivity, and sustainability of agricultural operations. Site-specific crop management practised from earlier decades like grid soil sampling and spot application of fertiliser and lime to optimise soil nutrient levels. Global positioning systems (G.P.S.) initiated for civilian use in 1983, and in 1990’s Global Navigation Satellite Systems (GNSS) enabled to develop equipment for variable rate fertiliser application for soil sampling and yield monitoring. Incorporating digital management and surveillance technologies in farming automates the farming with integrated crop management to maximise the effectiveness of crop and yield. The mechanical digitisation encompasses farm machinery for the sowing of seedling, fertilisers, cultivation, harvesting and the implication of satellites and tractors to drones, using Geographic Information Systems (G.I.S.), Global Positioning System includes yield mapping, remote sensing, variable rate irrigation, automatic tractor navigation, and robotics, proximal sensing of soils and crops, and profitability and adoption of precision farming. The details of the machinery discussed in the below sections. It is essential to understand the soil quality, functions and the role of indicators.

CHAPTER 5

IMPLEMENTATION

5.1. IMPLEMENTATION

The Internet of Things (IoT) portrays the network of physical connected smart devices that are embedded with sensors, other applied sciences technologies for the motive for interfacing and supplanting realities with various units and designs over the web.

This proposed model is based on a farming land, each region consists of different kinds of sensors which will explore it's close by climate by which farmers will be able to act accordingly and the necessities can be executed as soon as possible.

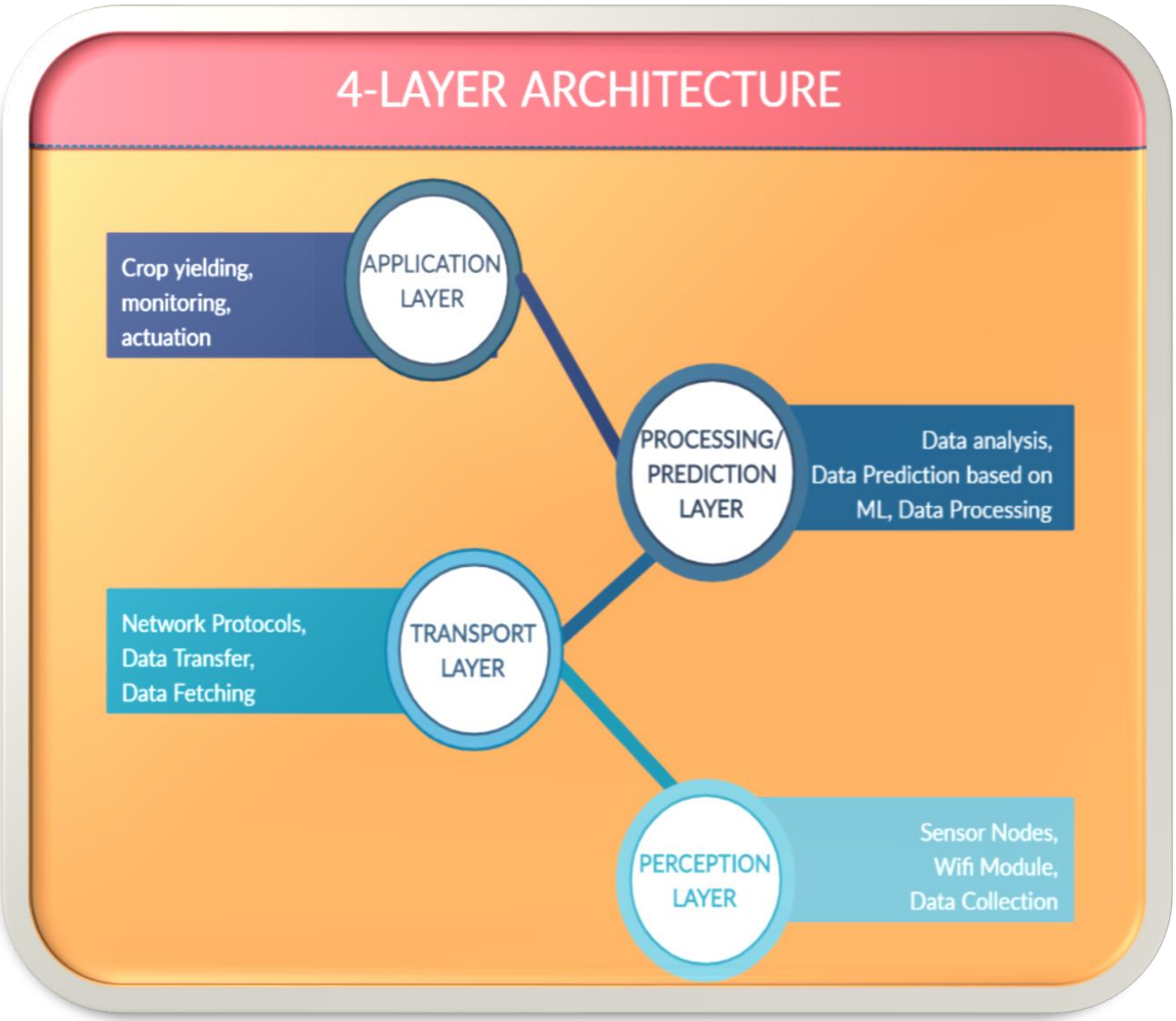

Figure 5.1. Four Layer Architecture of proposed model

5.1.2. Layer Architecture

The perception layer represents physical layer which has smart IoT devices. It identifies some physical parameters in the environment and how they communicate with one another and with the second layer transport layer. The IoT objects are responsible for gathering information/data, enabling the interaction between smart devices. This should be possible by utilizing sensor nodes or devices embedded with sensors, unmanned aerial vehicle and microcontrollers like Raspberry-Pi, Arduino to create sensor nodes and transmission gateways. Sensors are used to monitor soil moisture, atmospheric pressure, temperature, water level, fire detection, humidity, intrusion detection.

The transport layer relates to network layer which is responsible for interconnecting other smart IoT devices, network devices, and servers. It is also used for processing of sensor data and transmitting it.

The processing/prediction layer contains information storage, prediction, and visualizing assets. In this specific circumstance, big data helps store data in huge amounts and information handling, extraction of data in the briefest conceivable time. Such data are utilized as models by machine learning that is a data handling strategy through various algorithms to identify patterns and connections among perplexing and irrelevant information for the improvement of choices and decisions and automation of crop management, irrigation management, soil management, plant diseases monitoring.

The application layer consists of Internet of things and machine learning applications with help and provided data from other previous layers, it lets farmers do management of production process in a very effective and efficient manner.

5.2. Interacting IoT

a. Basic Components

In a typical social IoT setting, we treat the devices and services as bots where they can set up relationships between them and modify them over time. This will allow us to seamlessly let the devices cooperate among each other and achieve a complex task.

To make such a model work, we need to have many interoperating components. Let us look at Let us look at some of the major components in such a system.

- **ID**: we need a unique method of object identification method. An ID can be assigned to an object based on traditional parameters such as the MAC ID, IPv6 ID, a universal product code, or some other custom universal product code, or some other custom method.
- **Meta information**: along with an ID, we need some meta information about the device that describes its form and operation. This is required to establish appropriate relationships with the device and also appropriately place it in the universe of IoT devices.
- **Security controls**: this is similar to “friend list” settings on Facebook. An owner of a device might place restrictions on the kinds of devices that can connect to it. These are typically referred to as owner controls. These are typically referred to as owner controls.
- **Service discovery**: such kind of a system is like a service cloud, where we need to have dedicated directories of devices providing certain kinds devices providing certain kinds of services. It becomes very important to keep these directories up to date such that devices.
- **Relationship management**: this module manages relationships with other devices. It also stores the types of devices that a given device should try to connect with based on the type of services provided. For example, it makes sense for a light controller to make a for a light controller to make a relationship with a light sensor.

- **Service composition**: this module takes the social IoT model to a new level. The ultimate goal of having such a system is to provide better integrated service system to users. For example, if a person has a power sensor with her air conditioner and this device establishes a relationship with an analytics engine, then it is possible for the ensemble to yield a lot of data about the usage patterns of the air conditioner.

▪ **Privacy and security concerns:**

According to a recent study by Noura Aleisa and Karen Renaud at the University of Glasgow, the Internet of things potential for major privacy invasion is a concern with much of research disproportionally focused on the security concerns of IoT. Among the proposed solutions in terms of the techniques they deployed and the extent to which they satisfied core privacy principles", only very few turned out to be fully satisfactory. Louis Basenese, investment director at Wall Street Daily, has criticized the industry's lack of at Wall Street Daily, attention to security issues:

"Despite high-profile and alarming hacks, device manufacturers remain undeterred, focusing on profitability over security. Consumers need to have ultimate control over collected data, including the option to delete it if they choose without privacy assurances, wide-scale consumer adoption simply won't happen."

In a post-Snowden world of global surveillance disclosures, consumers take a more active interest in protecting their privacy and demand IoT devices to be screened for potential security vulnerabilities and privacy violations before purchasing them.

According to the 2016 Accenture Digital Consumer Survey, in which 28000 consumers in 28 countries were polled on their use of consumer technology, secure technology, security has moved from being a nagging problem to a top barrier as consumers are now choosing to abandon IoT devices and services over security concerns. The survey revealed that "out of the consumers aware of hacker attacks and owning or planning to own IoT devices in the next five years, 18 percent decided to terminate the use of the services and related services years until they get safety guarantees." This suggests that consumers increasingly perceive privacy risks and security concerns to outweigh the value propositions of IoT devices and to postpone planned purchases or service propositions of IoT.

Enabling technologies for IoT:

There are many technologies that enable IoT. Crucial to the field is the network used to communicate between devices of an IoT installation, a role that several, wireless or wired technologies may fulfill:

- **Short-range wireless:**

- **Bluetooth mesh networking** -Specification providing a mesh networking to Bluetooth low energy (BLE) with increased number of nodes and standardized application layer (Models).
- **Light-Fidelity (Li-Fi)**-Wireless communication technology similar to the Wi-Fi standard, but using visible light communication for increased bandwidth.

- **Near-field communication (NFC)-** Communication protocols enabling two electronic devices to communicate within a 4 cm range.
- **QR codes and barcodes-** Machine-readable optical tags that store information about the item to which they are attached.
- **Radio-frequency identification (RFID)** –Technology using electromagnetic fields to read data stored in tags embedded in other items.
- **Thread-**Network protocol based on the IEEE 802.15.4 standard, similar to ZigBee, providing IPv6 to ZigBee addressing.
- **Transport Layer Security**-Network security protocol.
- **WiFi-**Widely used technology for local area networking based on the IEEE 802.11 standard, where devices may communicate through a shared access point.
- **Wi-Fi Direct-**Variant of the Wi-Fi standard for peer-to-peer communication, eliminating the need an access point.
- **Z-Wave-** Communication protocol providing short-range, low-latency data transfer at rates and power consumption lower than Wi-Fi. Used primarily for home automation.
- **ZigBee-** Communication protocols for personal area networking based on the IEEE 802standard, providing low power consumption, low data rate, low cost, and high throughput.

  - **Medium-range wireless:**

- **HaLow** Variant of the Wi-Fi standard providing extended range for low-power communication at a lower data rate.
- **LTE-Advanced-** High-speed communication specification for mobile networks. Provides enhancements to the LTE standard with extended coverage, higher throughput, and lower latency.

- **Long-range wireless:**

- **Low-power wide-area networking (LPWAN)-** Wireless networks designed to allow long-range communication at a low data rate, reducing power and cost for power and cost for transmission. Available LPWAN technologies and protocols: LoRaWan, Sigfox, NB protocols: Weightless.

- **Very small aperture terminal (VSAT)-** Satellite communication technology using small disk antennas for narrowband and broadband data.

- **Wired:**

- **Ethernet-**General purpose networking standard using twisted pair and fiber optic links in pair conjunction with hubs or switches.

- **Multimedia over Coax Alliance (MoCA)-** Specification enabling whole home distribution of high definition video and content over existing coaxial cabling.

- **Power-line communication (PLC)-** Communication technology using electrical wiring to carry power and data. Specifications such as HomePlug or G.hn utilize as PLC for networking.

Some major components for model:

i. *Identification (ID)*: A unique technique for object identification strategy is needed. An ID can be allotted to an object dependent on examples like Internet Protocols (IPv6) id, machine address, a unique product code, or some other random technique.

ii. *MetaData*: Alongside a unique ID, we need some meta data about the object depicts its structure and activity. This is needed to build up proper associations with the object and furthermore suitably place it in together.

iii. *Security*: This is about controls on devices. A proprietor of a gadget may put limitations on the sorts of gadgets that can interface with it. He can decide settings and privacy of the device controlling.

iv. *Service*: such sort of a framework resembles cloud service. A dedicated space should be committed for devices giving particular sorts of administrations. It turns out to be vital to stay up with the latest to such an extent that gadgets.

v. *Interconnection*- It is like relationship management between various devices. It additionally stores the kinds of gadgets that a given gadget should attempt to associate with dependent on the sort of administrations gave.

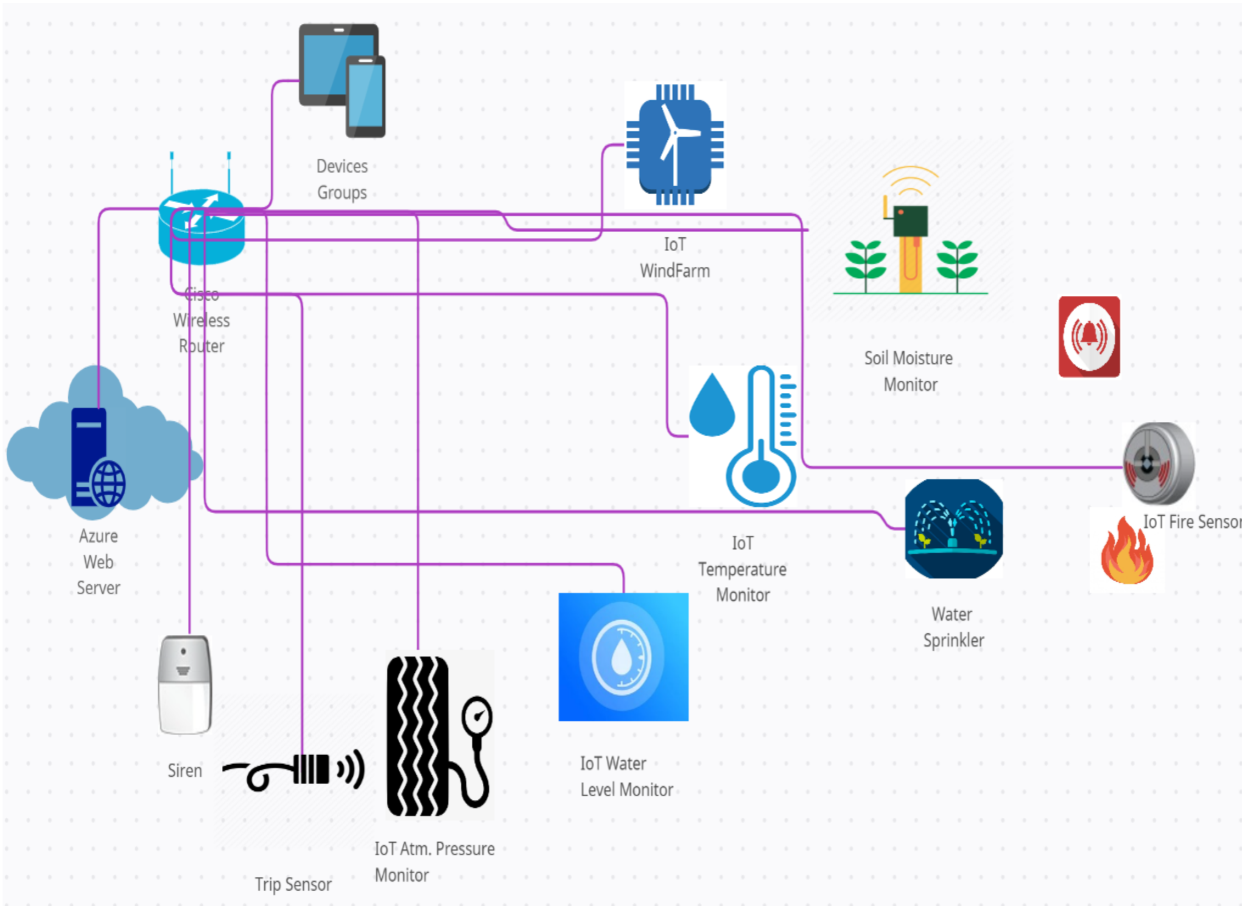

Figure 5.2. IoT framework in the farm field

b. IoT Structure:

i. Water Sprinkler supply water in the farm and water Level Monitor measures the level of the water if level of the water is high then Sprinkler turns OFF and Water Drain start working.

ii. Temperature Monitor and Humidity Monitor measures the temperature, humidity present in the environment.

iii. Atmospheric Pressure is placed which measured the pressure in the atmosphere.

iv. Fire Monitor detected the fire in the farm when it detects fire Alarm turns ON.

v. Trip Sensor senses when any animal or thief try to enter in the farm then Siren starts.

vi. Soil moisture sensor records the moisture of soil and it is sent on cloud and then fetched and applied machine learning algorithms for predictions.

5.3. Machine Learning Approach

Machine learning is an approach to data evaluation that automates analytical system development. It is a department of artificial intelligence-based totally on the concept that systems can study from data, perceive patterns and make choices/decisions/predictions with minimal human intervention. Successful farming comes down to recognizing the most powerful sections of land and harvests on a specific day. The present yield forecast advancements don't put together decisions exclusive with respect to chronicled information yet in addition use of computer software programming vision combined with shrewd climate investigation to meet the consistently developing farming interest. ML colossally affects the adequacy of yield arrangement and quality.

IoT can be combined with machine learning algorithms to give effective results. Machine Learning algorithms like SVM (Support Vector Machine) and SVR (Support Vector Regression) with Radial basis function kernel, Random Forest classifier and regression helps in predicting and classifying quantitative results for crop type, amount of water required for irrigation, soil type for variety of crops.

a. Support Vector Regression Algorithm:

Support Vector Regression is a supervised learning algorithm that is utilized to anticipate distinct values. Support Vector Regression utilizes a similar rule as the Support Vector Machines. The essential thought behind SVR is to locate the best fit line. In SVR, the befitting line is the hyperplane that has the most extreme number of points. Dissimilar to other Regression models that attempt to limit the blunder between the actual and predicted values, the SVR attempts to fit the most effective line inside a threshold value. The threshold value is the interval between the hyperplane and borderline. The analysis of Soil Moisture training dataset taken from kaggle is done and Support Vector Regression is applied on it to get the predicted values. The comparative study of various algorithms suggests that Support Vector Regression gives the accuracy approximately of 90.6%. Support Vector Regression is the correlation of SVM for regression problems. SVR recognizes the existence of non-linearity in the data and anticipates a effective prediction model. Smart farming with this machine learning algorithm will provide smooth flow of work for all kinds of different scales of farming. First soil moisture data will be collected from sensor then this algorithm will be applied on that provided data.

• Implementing Support Vector Regression

Support Vector Regression (SVR) is implemented in python using Google Colab Notebook.

```
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
```

Figure 5.3. Step 1: Importing the libraries

```
dataset = pd.read_csv('/content/soil_moisture - Sheet1.csv')
X = dataset.iloc[:, 4].values
y = dataset.iloc[:, 5].values
y = np.array(y).reshape(-1,1)
```

Figure 5.4. Step 2: Reading the dataset

```
from sklearn.preprocessing import StandardScaler
sc_X = StandardScaler()
sc_y = StandardScaler()
X = sc_X.fit_transform(X.reshape(-1,1))
y = sc_y.fit_transform(y.reshape(-1,1))
```

Figure 5.5. Step 3: Feature Scaling

```python
from sklearn.svm import SVR
regressor = SVR(kernel = 'rbf')
regressor.fit(X_train.reshape(-1,1), y_train.reshape(-1,1))

```

Figure 5.6. **Step 4: Fitting SVR to the dataset**

```python
y_pred = regressor.predict(X_test)
y_pred = sc_y.inverse_transform(y_pred)
y_pred

df = pd.DataFrame({'Real Values':sc_y.inverse_transform(y_test.reshape(-1)), 'Predicted Values':y_pred})
df
```

Figure 29. Step 5. Predicting a new result

```python

# Visualising the SVR results (for higher resolution and smoother curve)
X_grid = np.arange(min(X), max(X), 0.1)
X_grid = X_grid.reshape((len(X_grid), 1))
plt.scatter(sc_X.inverse_transform(X_test), sc_y.inverse_transform(y_test.reshape(-1)), color = 'cyan')
plt.scatter(sc_X.inverse_transform(X_test), y_pred, color = 'yellow')
ax= plt.axes()
ax.set_facecolor("black")
plt.title('SVR Regression For Soil Moisture')
plt.xlabel('MINUTES')
plt.ylabel('MOISTURE')
plt.show()

plt.plot(X_grid, regressor.predict(X_grid), color = 'deeppink')
ax= plt.axes()
ax.set_facecolor("black")
plt.title('SVR Regression For Soil Moisture')
plt.xlabel('MINUTES')
plt.ylabel('MOISTURE')
plt.show()
```

Figure 5.7. **Step 6. Visualizing the SVR results**

b. Random Forest Regression

Random Forest Regression is a supervised learning algorithm that utilizes an ensemble-based learning paradigm for the regression approach. Ensemble learning is a technique that combines multiple several ML algorithms predictions to get extra precise predictions compared to any other single model. Random forest regression in order to obtain the result uses multiple Decision Trees. The comparative study of various algorithms suggests that Support Vector Regression gives the accuracy of approximately 92.49%.

It follows the following steps :

Step 1. Picking random K data points from the training set.

Step 2. Put up a decision tree with respect to these K data points.

Step 3. Select the number of trees needed to be created and then repeat the above steps.

Step 4. For a new data point, make each of the selected number of trees to predict the values of the dependent variable for the provided inputs and assign that new point to the average value of the predicted values to the actual final result.

Smart agriculture with this machine learning algorithm will provide smooth progression of work to all sorts of various sizes of farming.

First temperature data will be gathered from sensor then this calculation will be applied on Random Forest Regression algorithm for accurate predictions.

• Implementing Random Forest Regression

Random Forest Regression is implemented in python using google colab notebook.

```
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
```

Figure 5.8. Step 1: Importing the libraries

```python
dataset = pd.read_csv('/content/temperature.csv')
X = dataset['Temperature'].values
y = dataset['Day'].values

dataset.head(8)
```

Figure 5.9. Step 2: Reading the dataset

```python
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.6)
```

Figure 33. Step 3: Split the dataset into the Training set and Test set

```python
# Fitting Random Forest Regression to the dataset
from sklearn.ensemble import RandomForestRegressor
regressor = RandomForestRegressor(n_estimators = 10, random_state = 0)
regressor.fit(X_train.reshape(-1,1), y_train.reshape(-1,1))
```

Figure 5.10. Step 4: Fitting the Random Forest Regression to the dataset

```python
y_pred = regressor.predict(X_test.reshape(-1,1))
y_pred

df = pd.DataFrame({'Real Values':y_test.reshape(-1), 'Predicted Values':y_pred.reshape(-1)})
df
```

Figure 5.11. Step 5: Predicting the Test set results

```python
# # Visualising the Random Forest Regression Results
X_grid = np.arange(min(X), max(X), 0.01)
X_grid = X_grid.reshape((len(X_grid), 1))
plt.scatter(X_test, y_test, color = 'yellow')
plt.scatter(X_test, y_pred, color = 'red')
ax= plt.axes()
ax.set_facecolor("black")
plt.title('Random Forest Regression')
plt.xlabel('Temperature')
plt.ylabel('Day')
plt.show()

plt.plot(X_grid, regressor.predict(X_grid))
ax= plt.axes()
ax.set_facecolor("black")
plt.title('Random Forest Regression')
plt.xlabel('Temperature')
plt.ylabel('Day')
plt.show()
```

Figure 5.12. Step 6. Visualizing the results

CHAPTER 6

RESULT

6.1. RESULT

An intelligence-based farm monitoring model is developed in this proposed work which will provide precise and sustaining solutions to various epidemics like food shortage, economic crisis, food security etc. Internet of Things and Machine Learning algorithms such as SVM (Support Vector Machine) and SVR (Support Vector Regression) with Radial basis function kernel, Random Forest Regression provides in predicting, classifying of water level, atmosphere pressure, soil moisture, weather forecast, irrigation system.

The analysis is done on training datasets obtained from "Kaggle" for Indian Agriculture production about farming information such as crop production in various states, particular crop rice production in Indian states, soil moisture, temperature.

The Support Vector Regression algorithm is applied on the soil moisture data as follows are the results:

	Real Values	Predicted Values
0	0.52	0.682535
1	0.56	0.598449
2	0.84	0.674151
3	0.83	0.743037
4	0.51	0.627465
5	0.51	0.749360
6	0.54	0.560640

Figure 6.1. Data Frame of real and predicted values of SVR

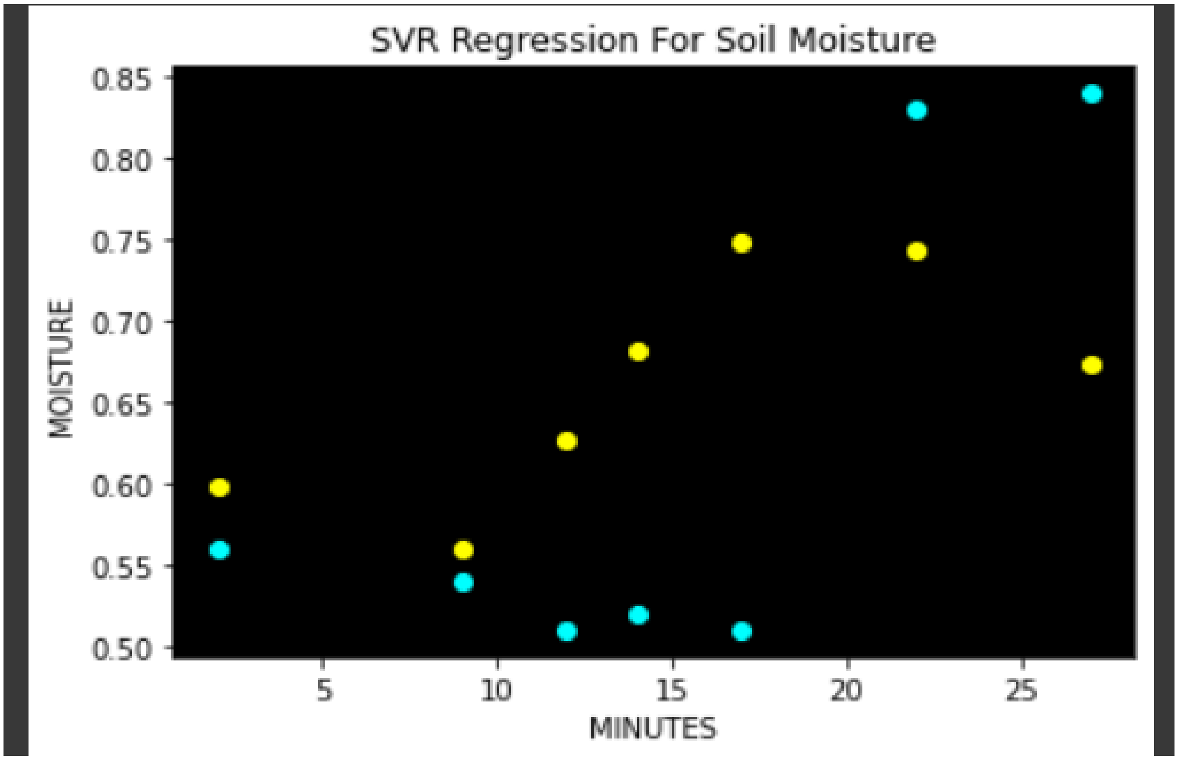

Figure 6.2. Cyan points are real values and yellow are predicted values

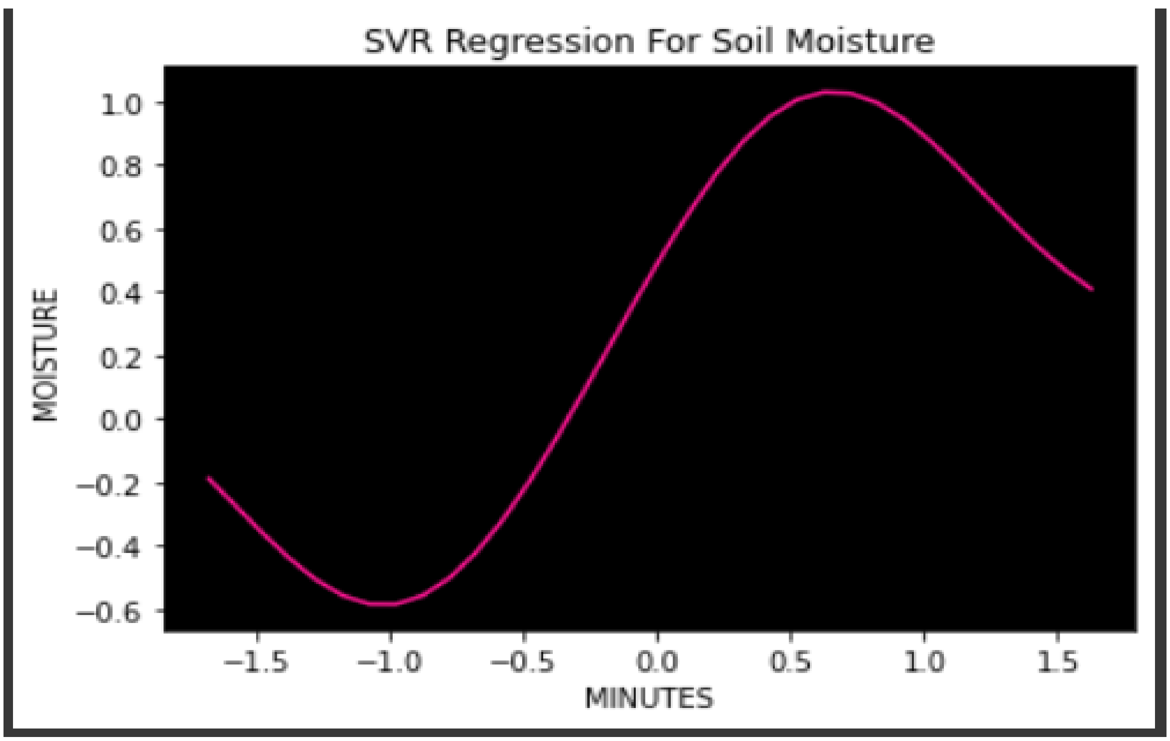

Figure 6.3. SVR curve

	Real Values	Predicted Values
0	23	25.9
1	20	22.4
2	21	22.4
3	18	22.4
4	25	25.9

Figure 6.4. Data Frame of real and predicted values of Random Forest Regression

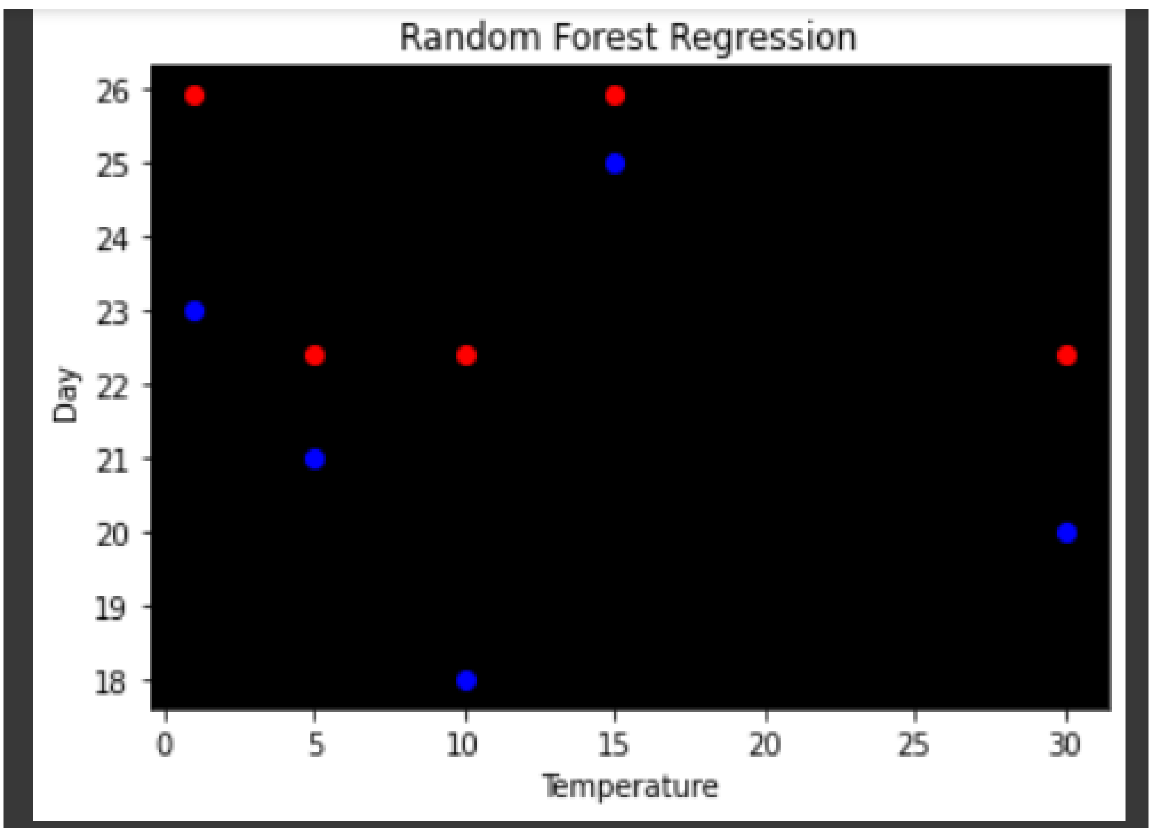

Figure 6.5. Blue points are real values and red are predicted values

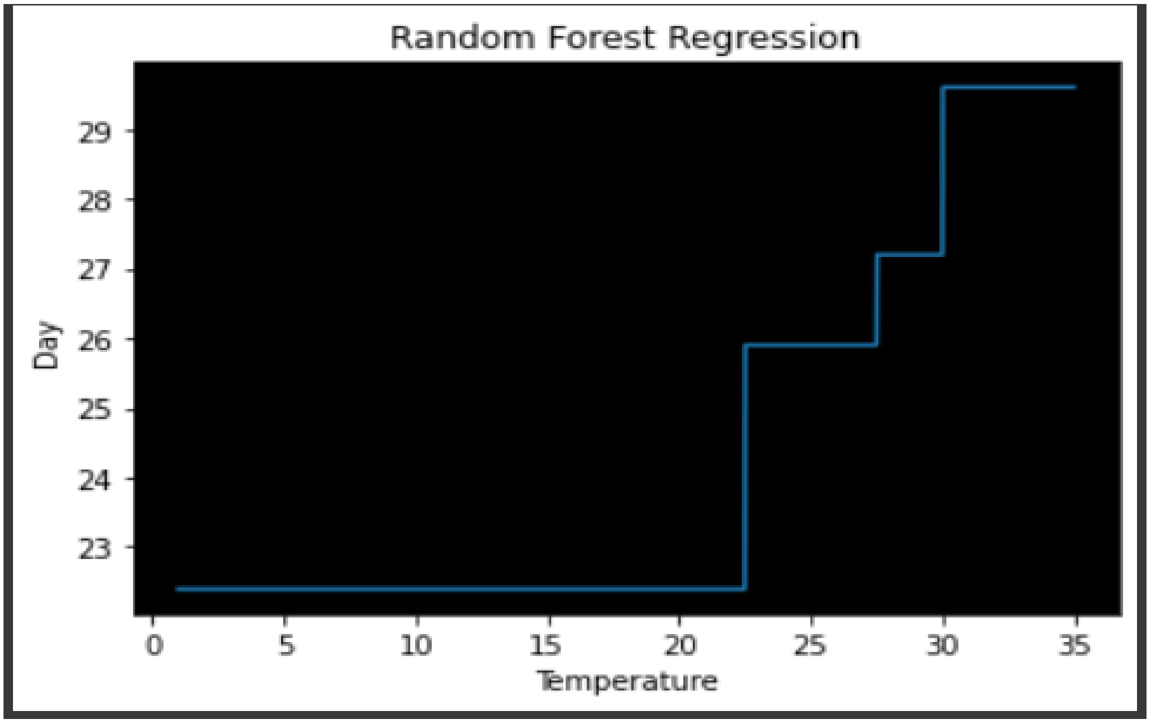

Figure 6.6. Random Forest Regression curve

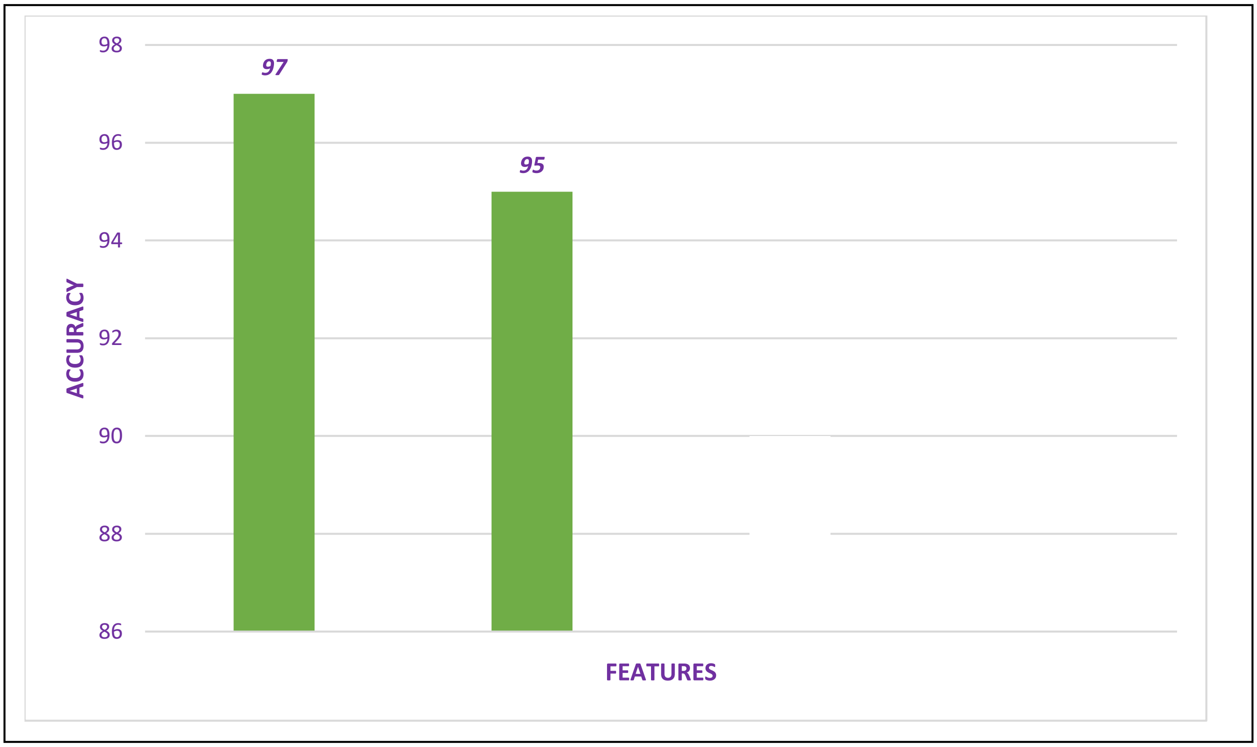

Figure 6.7. Accuracy bar plot

CHAPTER 7

CONCLUSION

7.1. CONCLUSION

As per UN Food and Agriculture Organization, people will have to produce 70% more food in 2050 rather than it did in 2006. In recent years IoT had been used to meet the challenge of different industrial and technical purposes. Now it is the time to meet the demand of future farming which can only be accomplished by smart Agro-IoT tool. There is a need to boost the productivity and minimize the pitfalls of traditional farming which is the main backbone of World's Economical growth. IoT will help in continuous monitoring of the field to give useful information to the farmers which will add a new era in future farming. IoT tool can be implemented for monitoring climate change, water management, land monitoring, increasing productivity, monitoring crops, controlling insecticides and pesticides, soil management, detecting plant diseases, increasing the rate of crop sale etc. In this book chapter we will focus on some case studies like monitoring of climate conditions, greenhouse automation, crop management, cattle monitoring and management for smart farming with IoT device which will provide a clear idea why to use the technique in agriculture rather than some pre existing agricultural tool developed earlier.

This paper represents an economically efficient approach towards successful and powerful automated agriculture or we can say agriculture 5.0, Smart Farming, Smart agriculture. It utilizes the Internet of Things and a Machine Learning-based approach to obtain the best effective outcomes of farming production. Sensor nodes are interconnected with each other to monitor the fields completely. Then the data is being collected and transferred to the cloud. From the cloud, the data is fetched, and then machine learning algorithms like SVM (Support Vector Machine) and SVR (Support Vector Regression) with Radial basis function kernel, Random Forest Regression are applied to predict and make accurate decisions for farm fields. Which results in very effective and efficient outcomes of farming. Therefore, smart agriculture is conceivable to convey a more profitable, sustainable, and manageable type of farming productions, based on ensemble learning giving more exact precise, and resource-efficient methodology.

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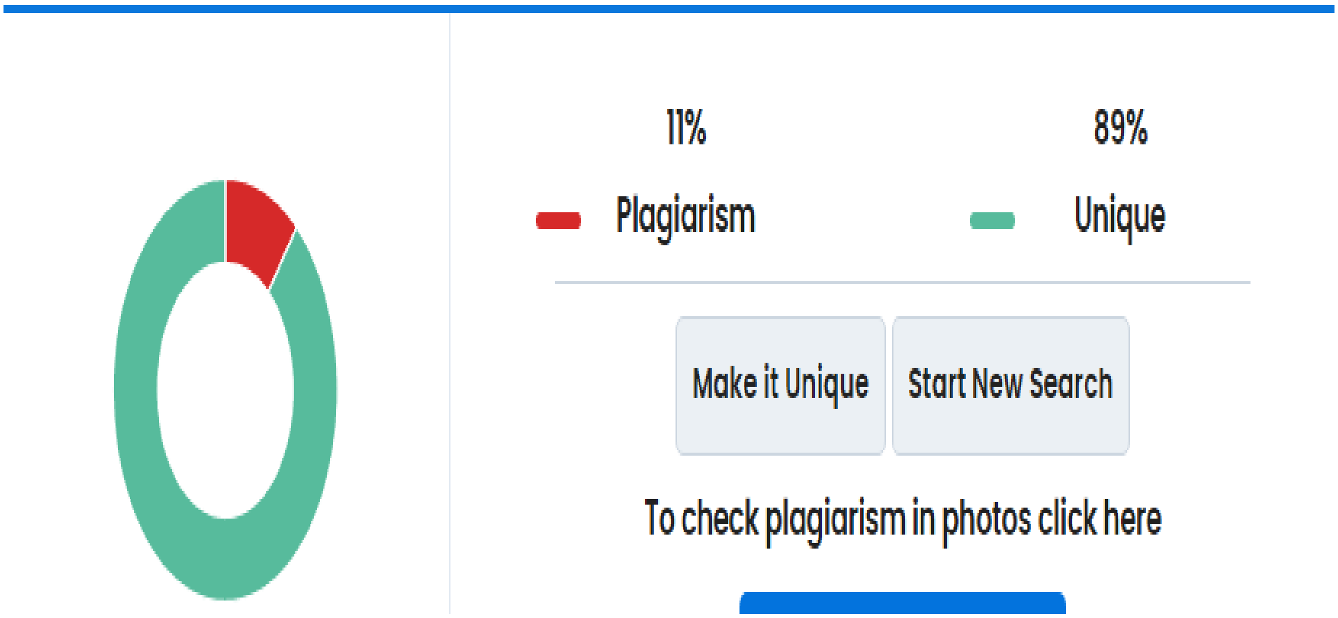
PLAGIARISM REPORT



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An Integrative Decision Support Model for Smart Agriculture Based on Internet of Things and Machine Learning

Sadaf Saqib, Faiyaz Ahmad

[1,2]Computer Science and Engineering Department, Integral University, Lucknow, India
sadaf0620s@gmail.com[1]

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Abstract

The Internet of Things (IoT) has achieved an upset in a considerable lot of the circles of our current lives, like automobile, medical services offices, home automation, retail, education, manufacturing, and many more. The Agriculture and Farming ventures significantly affect the acquaintance of the IoT with the world. Machine learning (ML) is a part of artificial intelligence (AI) that permits software applications to turn out to be more precise at foreseeing results without being expressly customized to do as such. It uses historical data as input to predict new result values. In the event, a specific industry has sufficient recorded information to help the machine "learn", AI or ML can create outstanding outcomes. Farming is likewise one such important industry profiting and advancing from machine learning at large. ML can possibly add to the total lifecycle of farming, at all phases. This incorporates computer vision, automated irrigation, and harvesting, predicting the soil, weather, temperature, moisture values, and robots for picking off the crude harvest. In this paper, I'll work on a smart agricultural information monitoring framework that gathers the necessary information from the IoT sensors set in the field, measures it, and drives it, from where it streams to store in the cloud space. The information is then shipped off the prediction module where the necessary analysis is done using ML algorithms and afterward sent to the UI for its corresponding application.

Keywords

Internet of Things (IoT), Machine Learning, Smart Agriculture

1. Introduction

Machine learning is an approach to data evaluation that automates analytical system development. It is a department of artificial intelligence-based totally on the concept that systems can study from data, perceive patterns and make choices/decisions/predictions with minimal human intervention. Food Security is one of the most necessary for the developing food needs of an ever-increasing population. Due to the increasing populace, we can't produce meals to meet the requirement of 1.38 billion, and nonetheless increasing the populace will put a large burden on the Indian economy. Around the globe, India is having a massive agricultural hub and the mainstream of the Indian populace is established on the agricultural area for meeting their requirement. Agriculture accounts for a fundamental component of GDP (Gross Domestic Product) now not solely of developing countries. However additionally for many developed nations. Thus, improvising and optimizing the current farming technologies is the want of the hour. It will no longer solely assist in flourishing sustainable improvement of mankind, plant life, and fauna but will additionally assist in dealing with the global crisis such as local weather alternate and epidemics such as draught. Internet of things has upgraded due to convergence of greater than one technologies like machine learning, wireless sensors, and embedded systems, real-time analytics. Conventional fields of networking of wireless sensors, embedded systems, automation (including domestic and constructing automation), and many more make contributions to enable the Internet of Things. In the consumer market, IoT technological know-how is most synonymous with product pertaining to the thought of the smart home, gadgets and home equipment (such as lights fixtures, thermostats, domestic protections systems, and cameras, and different domestic appliances) that help one or greater frequent ecosystems, such as smartphones.

The home automation systems are being drastically lookup and developed however, this essential area of Agriculture and especially Smart Agriculture tends to lag at the back of different domains, and require pretty a lot of R&D to gain sustainable goals now not solely at the industrial stage, however, at the root degree of this agriculture industry. Automation of traditional irrigation methods can lead to many folds make bigger in crop yield. To form agriculture based on IoT, there are some needs that are to be fulfilled necessarily. In the first place, the particular sensors (e.g., temperature sensors, moisture sensors, pressure sensors, etc.) required for the IoT utility are to be decided smartly. Secondly, the algorithms must be developed maintaining in thinking all the feasible possibilities required for the quality prediction and machine learning to have to be utilized effectively. Seeing next, the sensors are extra likely to get damage in the fields, so pursuits monitoring of these is required timely. Considering that, the framework of the wireless data transmission has to be as per the needs of the devices to join over a precise land region in the field. Lastly and majorly, the safety, security, and privacy of the device must be ascertained through authenticating the setup system, assuring its concealment, candor, and managed admittance. The model proposed here in this paper is about how the Internet of things and machine learning used in the agricultural system. The proposed system may want to be such there will be no compromise between efficiency, security, performance, and safety of the system, and the favored effect has to produce exquisite precision and accuracy.

2. Literature Review

A thorough literature review has been done and a fragment of the effective powerful technologies and algorithms based on literature survey and observations are put forward in this paper for the benefit of smart agriculture. In this current digital time, IoT assumes a huge part in each association just as nation advancement, and horticulture is one of the fields in which most of the things should be automated through IoT devices. This new idea unified on farming data has been known with several different names like Smart Farming, Smart Agriculture, Digital Farming, or Agriculture 4.0, and was born when telematics and information management were combined to the already familiar conception of preciseness Agriculture, up the accuracy of operations [13]. The utilization of new technologies to improve crop profitability are shown by [21]. The utilization of new technologies will be useful to measure and break down the information. To store data identified with soil, the authors are using the Blynk application. The data it will save will be its humidity, moisture, temperature, etc. Its uses are shown by [1]. While applying these new technologies, the test for retrieving information from crops is to come out with something intelligent and important, on the grounds that information themselves are not helpful, simply numbers or pictures. Homesteads that choose to be innovation-driven somehow or another, show significant valuable advantages, such as saving money and work, having an expanded creation or a decrease of expenses with insignificant effort, and delivering quality food with all the more environmentally friendly things. [13] Ç. Ersin, R. Gürbüz, A.K. Yakut, 2016 proposed the micro-controller-based irrigation system which is very efficient and economical compared to different standard strategies, preciseness irrigation approaches are delineate by Liu [20]. [9], [23-34].

A farm vehicle and smart dispatching approach have been researched. [22] provided with associate interconnected approached towards smart agricultural. [J. Kwok, Y. Sun, 2018] work suggested plant detection using deep learning and so supported plant sort its applicable irrigation quantity required. Thus, once thorough study of presently out their literature, that deals with the current farming issues and their various answer, this paper highlights and provides a combined, precise view to the potential solution for smart farming).

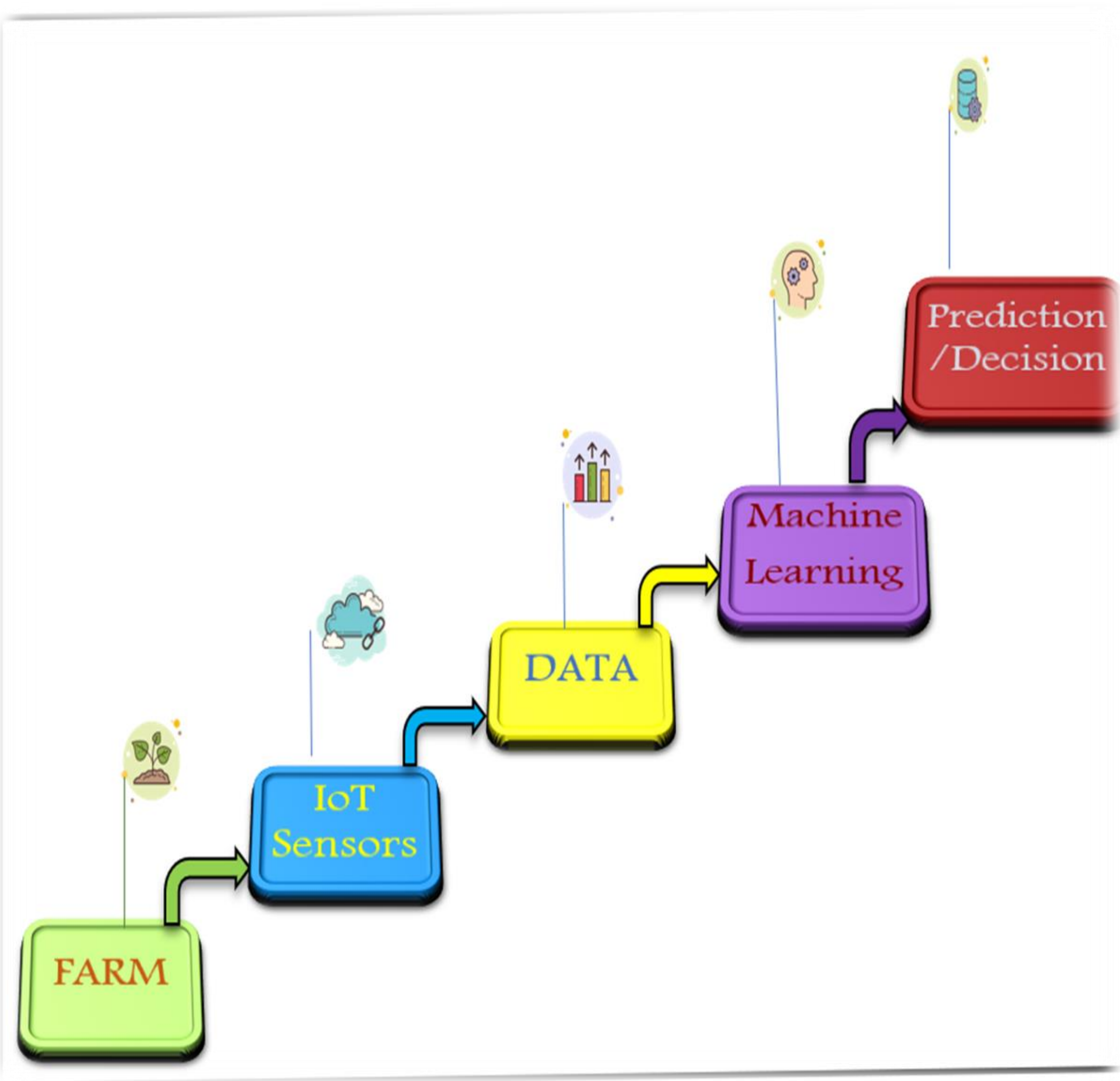

Figure 1. Flow Diagram of proposed work

Table 1. Literature review

Authors	System Design	Findings
[14] Veronica Saiz Rubio (February 2020)	From Smart Farming towards Agriculture 5.0: A Review on Crop Data Management	Optimized cost-effective decisions can be made by farmers while protecting the environment and transforming how food will be produced to match the coming up population growth using IoT and AI.
[7] G.Lavanya, S.Monika ,G.Sandra Karunya, A. Mathan Gopi4 , D. Rajini Girinath, (March2019)	IoT Enabled Assisting Device for Seizures Monitoring	Host Management System (HMS) which is fit for cloud service and checks that stores and controls the MEDIBOX usefulness.
Nikhilesh Wadhwa , Shikhar Tripathi , Chirag Agarwal , Rasika Yeolekar , Ashish Manwatkar (March, 2019)	Web based Intelligent Irrigation System	Methods to solve such problems like identifying crop suitable for which soil, level of water in soil, moisture etc. Mentioned Sensors and electronic devices.
[1] Hemlata Sahu, Prerana Modala , Anjali Jiwankar, Sonal Wagle, (March 2019)	Multidisciplinary Model for Smart Agriculture using IoT	Soil Monitoring for Precision Farming: Monitoring soil conditions is a simple use case but it can lead to a fantastic return on investment for farmers.
[17] Xiaohui Wang, Nannan Liu, (2017)	The Application of Internet of Things in Agricultural means of production supply chain management	Smart agriculture based on IoT and Cloud Computing Use of cloud computing for agriculture utilizing for storing details of agriculture data.
[18] Sanjit Kumar Dash, Subasish Mohapatra, Prasant Kumar Pattnaik, (2017)	A Survey on Applications of Wireless Sensor Network Using Cloud Computing	IoT device can be interfaced to soil and environmental sensors to collect soil properties and current environmental conditions. Analysis of the gathered information for interacting between environment, work and result for high grade work model construction.
[19] S. S. Sarmila (IEEE 2017)	Smart farming: sensing technologies	Model includes smart GPS based remote controlled robot to perform. Controlling of all these operations will be through any remote smart device or computer connected to Internet and operations will be performed by interfacing sensors, Wi-Fi or ZigBee modules, camera, actuators with micro-controller and raspberry.
John R. Dela Cruz (IEEE 2016)	Design of a fuzzy-based automated organic irrigation system for smart farm	Automated organic irrigation system in controlling and properly allocating the available water resources for the irrigation system and pumping water for irrigation on right time and use.

[20] Akshay Atole, Apurva Asmar, Amar Biradar, Nikhil Kothawad (April, 2017)	IoT Based Smart Farming System	Smart Farming System that uses advantages of cutting-edge technologies such as IoT, Wireless Sensor Network and Cloud computing to help farmers enhance the way farming is done.

3. Proposed Work (Framework and Algorithm)

The Internet of Things (IoT) has achieved an upset in a considerable lot of the circles of our current lives, like an automobile, medical services offices, home automation, retail, education, manufacturing, and many more. The Agriculture and Farming ventures significantly affect the acquaintance of the IoT with the world. Machine learning is an approach to data evaluation that automates analytical system development. It is a department of artificial intelligence-based totally In this proposed model IoT and machine learning is combined to create an efficient and effective smart faring model, which will increase the production save time, and resources as well. By the use of different types of sensors, various parameters being monitored for an interval of time best suit irrigation can be done on the farmland, crop management, field conditions management, appropriate use of fertilizers & pesticides all these can be done easily. The figure below gives a brief about the proposed work. It advances the significance and uses in dealing with the agricultural environment for food security. And underlines low energy utilization alternatives for minimal effort or cost and natural maintainability.

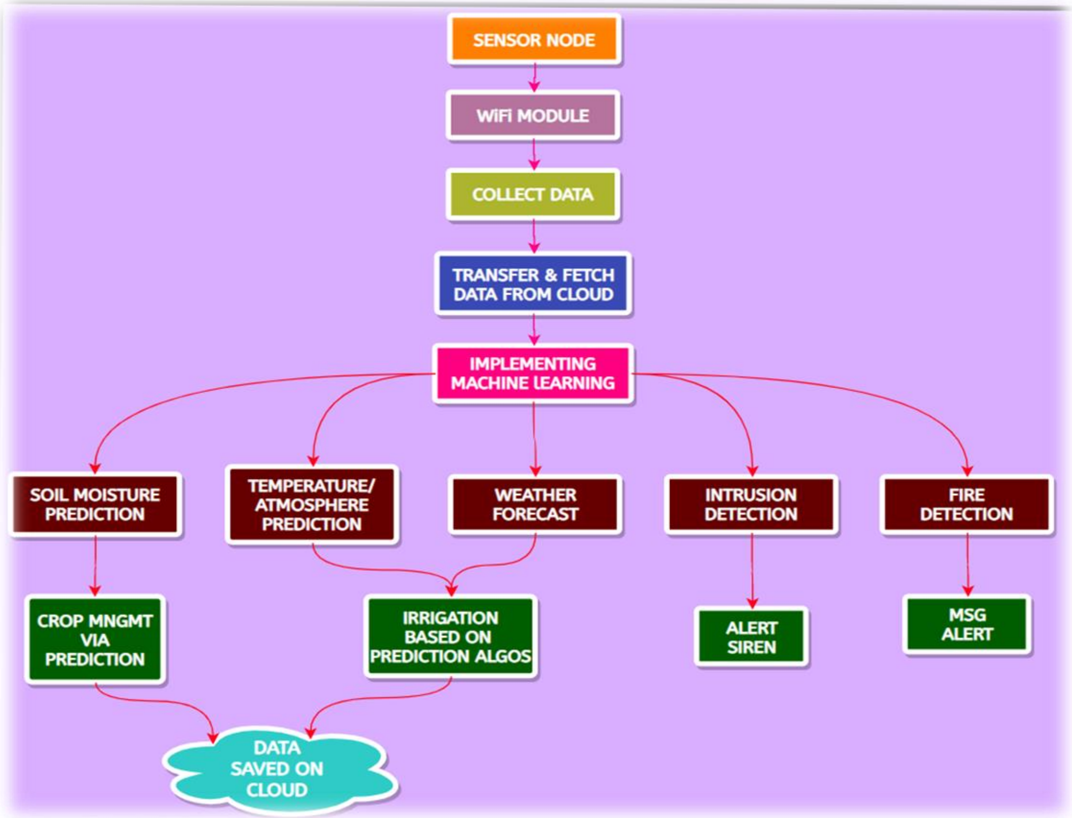

Figure 2. Flowchart for Proposed Work

3.1. Data Processing

As per Second Advance Estimates for 2019-20, complete food grain manufacturing in India is estimated at report 291.95 million tonnes which is greater with the aid of 6.74 million tonnes than the production of food grain of 285.21 million tonnes executed at some stage in 2018-19. However, the manufacturing throughout 2019-20 is greater by way of 26.20 million tonnes than the preceding 5 years (2013-14 to 2017-18) common manufacturing of food grain. To better understand the number of crops cultivated in India and their production volume a study on "Agriculture Production of Crop in India" the dataset is done obtained from the website "Kaggle". The dataset is training dataset. The data analyzation done is for training purpose.

```
plt.figure(figsize = (17, 5))
ax= plt.axes()
ax.set_facecolor("black")
crop_df['Production'].value_counts().head(8).plot(kind='bar'),crop_df['Crop'].value_counts().head(8).plot(kind='bar'
plt.xlabel('CROPS')
plt.ylabel('PRODUCTION')
plt.title("Crop PRODUCTION IN INDIA")
plt.show()
```

Figure 3. Code in python to plot bar graph

The evaluation is done using python language and visualizations are outputs of code executed for the dataset on Google Colab Notebook. This evaluation forms the basis of the importance and needs for automation in the zone to limit cost and enlarge productivity. The bar graph shown is an outcome of the analyzed data. Figure 3 represents the graphical analysis for few crops production. This shows the variety of crops with quantity of their production.

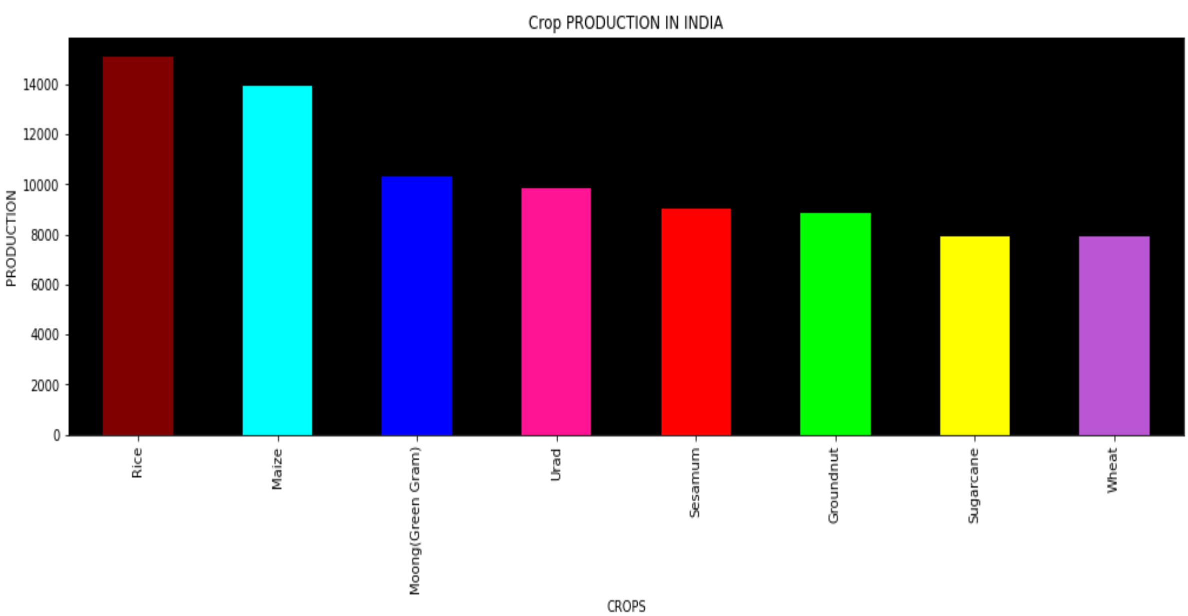

Figure 4. Production of different crops in India

```
[ ]
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
rice_df= pd.read_csv('/content/rice - Sheet1 (1).csv')
```

```
rice_df
```

	State_Name	Rice
0	Andhra Pradesh	165064
1	Assam	262347
2	Bihar	18112
3	Chhattisgarh	456491
4	Jammu and Kashmir	23727
5	Karnataka	176688
6	Telangana	418097
7	Uttar Pradesh	14515
8	West Bengal	780861

Figure 5. Rice Production data frame

```
plt.figure(figsize = (17, 5))
ax= plt.axes()
ax.set_facecolor("black")
rice_df['Rice'].plot(kind='bar',color=['maroon', 'cyan', 'blue', 'deeppink', 'red','lime','yellow','grey','mediumorchid' ]),rice_df['State_Name'].value_counts().plot(kind='
plt.xlabel('STATES')
plt.ylabel('RICE PRODUCTION')
plt.title("RICE PRODUCTION IN INDIA")
plt.show()
```

Figure 6. Code for plotting bar graph Rice Production Vs States of India

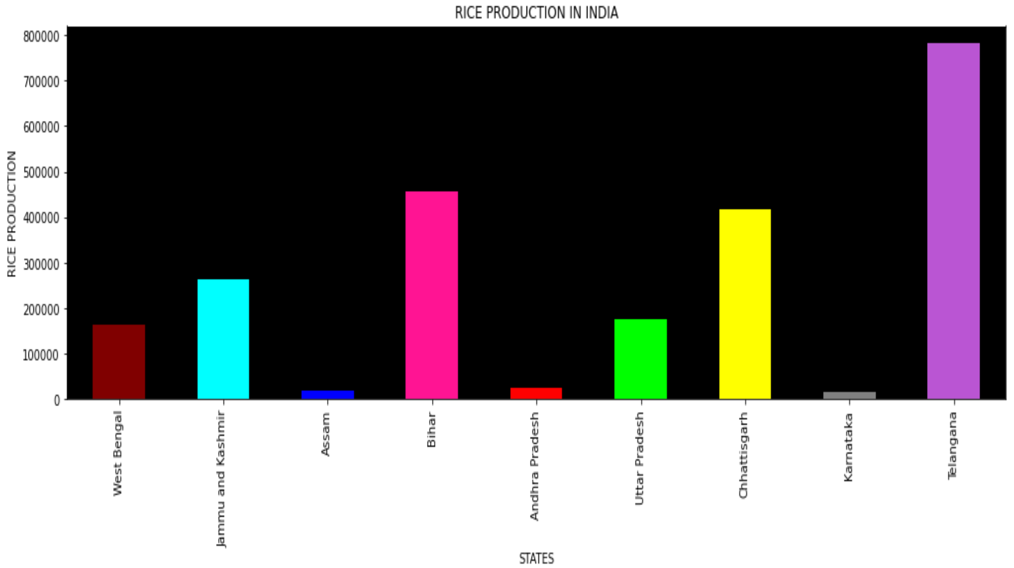

Figure 7. Bar graph for Rice Production in India

4. Implementation

The Internet of Things (IoT) portrays the network of physical connected smart devices that are embedded with sensors, other applied sciences technologies for the motive for interfacing and supplanting realities with various units and designs over the web. This proposed model is based on a farming land, each region consists of different kinds of sensors which will explore it's close by climate by which farmers will be able to act accordingly and the necessities can be executed as soon as possible.

4.1. 4-Layer Architecture

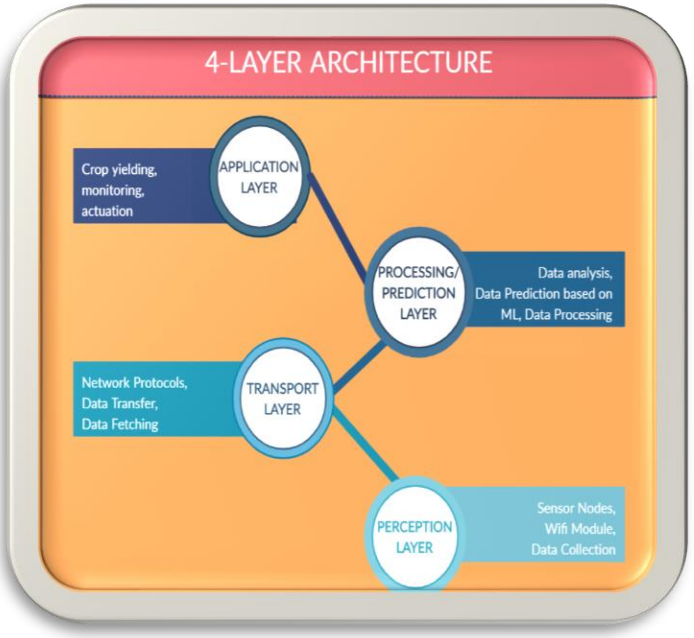

Figure 8. Four Layer Architecture of proposed model

The perception layer represents physical layer which has smart IoT devices. It identifies some physical parameters in the environment and how they communicate with one another and with the second layer transport layer. The IoT objects are responsible for gathering information/data, enabling the interaction between smart devices. This should be possible by utilizing sensor nodes or devices embedded with sensors, unmanned aerial vehicle and microcontrollers like Raspberry-Pi, Arduino to create sensor nodes and transmission gateways. Sensors are used to monitor soil moisture, atmospheric pressure, temperature, water level, fire detection, humidity, intrusion detection. The transport layer relates to network layer which is responsible for interconnecting other smart IoT devices, network devices, and servers. It is also used for processing of sensor data and transmitting it. The processing/prediction layer contains information storage, prediction, and visualizing assets. In this specific circumstance, big data helps store data in huge amounts and information handling, extraction of data in the briefest conceivable time. Such data are utilized as models by machine learning that is a data handling strategy through various algorithms to identify patterns and connections among perplexing and irrelevant information for the improvement of choices and decisions and automation of crop management, irrigation management, soil management, plant diseases monitoring. The application layer consists of Internet of things and machine learning applications with help and provided data from other previous layers, it lets farmers do management of production process in a very effective and efficient manner.

4.2. Interacting IoT

Basic Components:

Some major components for model:

1. Identification (ID): A unique technique for object identification strategy is needed. An ID can be allotted to an object dependent on examples like Internet Protocols (IPv6) id, machine address, a unique product code, or some other random technique.
2. Metadata: Alongside a unique ID, we need some meta data about the object depicts its structure and activity. This is needed to build up proper associations with the object and furthermore suitably place it in together.
3. Security: This is about controls on devices. A proprietor of a gadget may put limitations on the sorts of gadgets that can interface with it. He can decide settings and privacy of the device controlling.
4. Service: such sort of a framework resembles cloud service. A dedicated space should be committed for devices giving particular sorts of administrations. It turns out to be vital to stay up with the latest to such an extent that gadgets.
5. Interconnection- It is like relationship management between various devices. It additionally stores the kinds of gadgets that a given gadget should attempt to associate with dependent on the sort of administrations gave Headings, or heads, are organizational devices that guide the reader through your paper. There are two types: component heads and text heads.

IoT Structure:

1. Water Sprinkler supply water in the farm and water Level Monitor measures the level of the water if level of the water is high then Sprinkler turns OFF and Water Drain start working.
2. Temperature Monitor and Humidity Monitor measures the temperature, humidity present in the environment.
3. Atmospheric Pressure is placed which measured the pressure in the atmosphere.
4. Fire Monitor detected the fire in the farm when it detects fire Alarm turns ON.
5. Trip Sensor senses when any animal or thief try to enter in the farm then Siren starts.

6. Soil moisture sensor records the moisture of soil and it is sent on cloud and then fetched and applied machine learning algorithms for predictions.

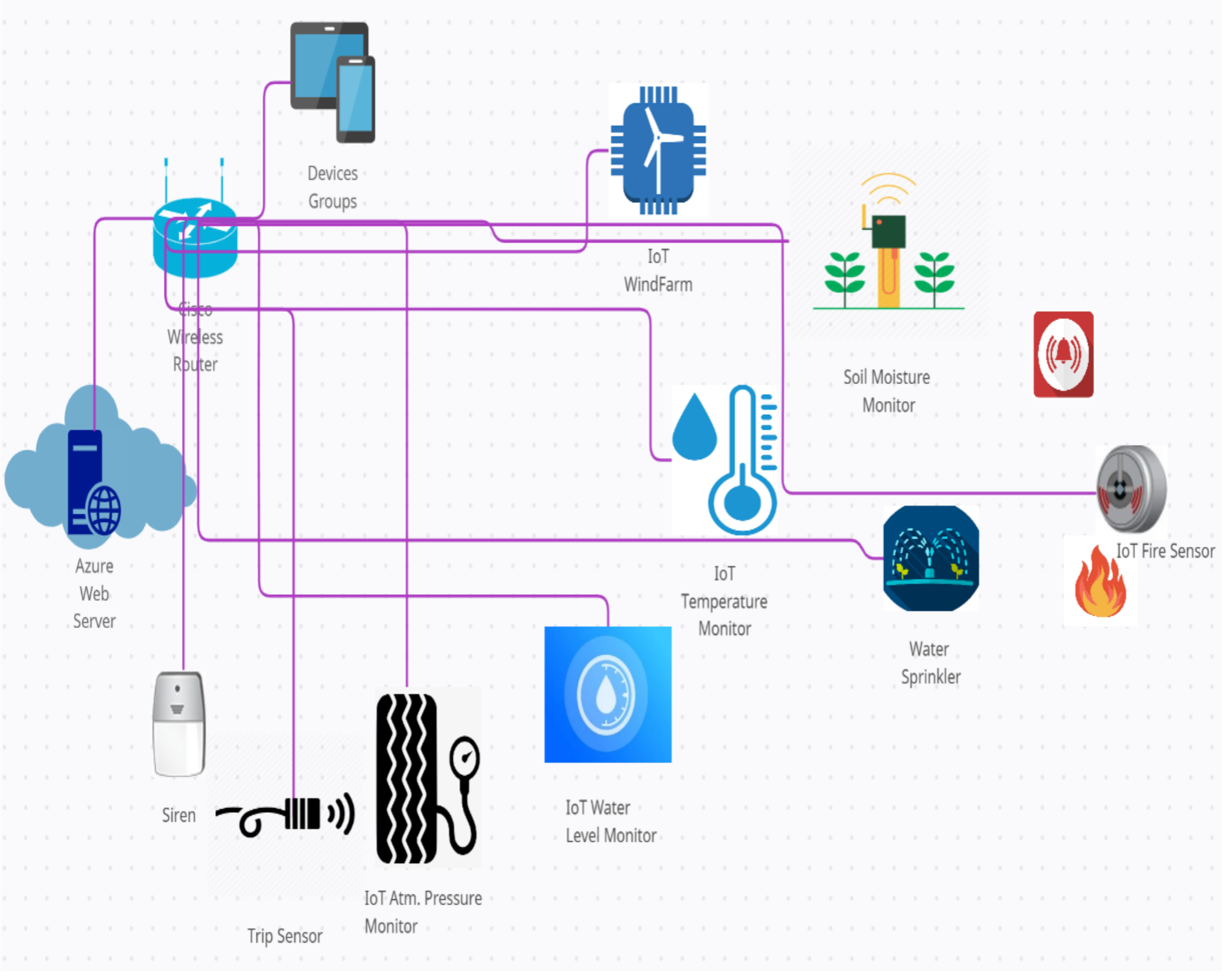

Figure 8. IoT framework in the farm field

4.3. Machine Learning Approach

Machine learning is an approach to data evaluation that automates analytical system development. It is a department of artificial intelligence-based totally on the concept that systems can study from data, perceive patterns and make choices/decisions/predictions with minimal human intervention. Successful farming comes down to recognizing the most powerful sections of land and harvests on a specific day. The present yield forecast advancements don't put together decisions exclusive with respect to chronicled information yet in addition use of computer software programming vision combined with shrewd climate investigation to meet the consistently developing farming interest. ML colossally affects the adequacy of yield arrangement and quality. IoT can be combined with machine learning algorithms to give effective results. Machine Learning algorithms like SVM (Support Vector Machine) and SVR (Support Vector Regression) with Radial basis function kernel, Random forest classifier and regression helps in predicting and classifying quantitative results for crop type, amount of water required for irrigation, soil type for variety of crops.

- Support Vector Regression Algorithm:

  Support Vector Regression is a supervised learning algorithm that is utilized to anticipate distinct values. Support Vector Regression utilizes a similar rule as the Support Vector Machines. The essential thought behind SVR is to locate the best fit line. In SVR, the befitting line is the hyperplane that has the most extreme number of points. Dissimilar to other Regression models that attempt to limit the blunder between the actual and predicted values, the SVR attempts to fit the most effective line inside a threshold value. The threshold value is the interval between the hyperplane and borderline. The analysis of Soil Moisture training dataset taken from kaggle is done and Support Vector Regression is applied on it to get the predicted values. The comparative study of various algorithms suggests that Support Vector Regression gives the accuracy approximately of 90.6%. Support Vector Regression is the correlation of SVM for regression problems. SVR recognizes the existence of non-linearity in the data and anticipates a effective prediction model. Smart farming with this machine learning algorithm will provide smooth flow of work for all kinds of different scales of farming. First soil moisture data will be collected from sensor then this algorithm will be applied on that provided data.

- Implementing Support Vector Regression

  Support Vector Regression (SVR) is implemented in python using Google Colab Notebook

```python
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
```

Figure10. Step 1: Importing the libraries

```python
dataset = pd.read_csv('/content/soil_moisture - Sheet1.csv')
X = dataset.iloc[:, 4].values
y = dataset.iloc[:, 5].values
y = np.array(y).reshape(-1,1)
```

Figure11. Step 2: Reading the dataset

```python
from sklearn.preprocessing import StandardScaler
sc_X = StandardScaler()
sc_y = StandardScaler()
X = sc_X.fit_transform(X.reshape(-1,1))
y = sc_y.fit_transform(y.reshape(-1,1))
```

Figure12. Step 3: Feature Scaling

```python
from sklearn.svm import SVR
regressor = SVR(kernel = 'rbf')
regressor.fit(X_train.reshape(-1,1), y_train.reshape(-1,1))
```

Figure13. Step 4: Fitting SVR to the dataset

```python
y_pred = regressor.predict(X_test)
y_pred = sc_y.inverse_transform(y_pred)
y_pred

df = pd.DataFrame({'Real Values':sc_y.inverse_transform(y_test.reshape(-1)), 'Predicted Values':y_pred})
df
```

Figure14. Step 5. Predicting a new result

```python
# Visualising the SVR results (for higher resolution and smoother curve)
X_grid = np.arange(min(X), max(X), 0.1)
X_grid = X_grid.reshape((len(X_grid), 1))
plt.scatter(sc_X.inverse_transform(X_test), sc_y.inverse_transform(y_test.reshape(-1)), color = 'cyan')
plt.scatter(sc_X.inverse_transform(X_test), y_pred, color = 'yellow')
ax= plt.axes()
ax.set_facecolor("black")
plt.title('SVR Regression For Soil Moisture')
plt.xlabel('MINUTES')
plt.ylabel('MOISTURE')
plt.show()

plt.plot(X_grid, regressor.predict(X_grid), color = 'deeppink')
ax= plt.axes()
ax.set_facecolor("black")
plt.title('SVR Regression For Soil Moisture')
plt.xlabel('MINUTES')
plt.ylabel('MOISTURE')
plt.show()
```

Figure15. Step 6. Visualizing the SVR results

- Random Forest Regression

  Random Forest Regression is a supervised learning algorithm that utilizes an ensemble-based learning paradigm for the regression approach. Ensemble learning is a technique that combines multiple several ML algorithms predictions to get extra precise predictions compared to any other single model. Random forest regression in order to obtain the result uses multiple Decision Trees. The comparative study of various algorithms suggests that Support Vector Regression gives the accuracy of approximately 92.49%.

  It follows the following steps:

  Step 1. Picking random K data points from the training set.

  Step 2. Put up a decision tree with respect to these K data points.

  Step 3. Select the number of trees needed to be created and then repeat the above steps.

  Step 4. For a new data point, make each of the selected number of trees to predict the values of the dependent variable for the provided inputs and assign that new point to the average value of the predicted values to the actual final result.

Smart agriculture with this machine learning algorithm will provide smooth progression of work to all sorts of various sizes of farming. First temperature data will be gathered from sensor then this calculation will be applied on Random Forest Regression algorithm for accurate predictions.

- Implementing Random Forest Regression

  Random Forest Regression is implemented in python using google colab notebook

```
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
```

Figure 16. Step 1: Importing the libraries

```
dataset = pd.read_csv('/content/temperature.csv')
X = dataset['Temperature'].values
y = dataset['Day'].values

dataset.head(8)
```

Figure 17. Step 2: Reading the dataset

```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.6)
```

Figure18. Step 3: Split the dataset into the Training set and Test set

```
# Fitting Random Forest Regression to the dataset
from sklearn.ensemble import RandomForestRegressor
regressor = RandomForestRegressor(n_estimators = 10, random_state = 0)
regressor.fit(X_train.reshape(-1,1), y_train.reshape(-1,1))
```

Figure 19. Step 4: Fitting the Random Forest Regression to the dataset

```
y_pred = regressor.predict(X_test.reshape(-1,1))
y_pred

df = pd.DataFrame({'Real Values':y_test.reshape(-1), 'Predicted Values':y_pred.reshape(-1)})
df
```

Figure 20. Step 5: Predicting the Test set results

```
# # Visualising the Random Forest Regression Results
X_grid = np.arange(min(X), max(X), 0.01)
X_grid = X_grid.reshape((len(X_grid), 1))
plt.scatter(X_test, y_test, color = 'yellow')
plt.scatter(X_test, y_pred, color = 'red')
ax= plt.axes()
ax.set_facecolor("black")
plt.title('Random Forest Regression')
plt.xlabel('Temperature')
plt.ylabel('Day')
plt.show()

plt.plot(X_grid, regressor.predict(X_grid))
ax= plt.axes()
ax.set_facecolor("black")
plt.title('Random Forest Regression')
plt.xlabel('Temperature')
plt.ylabel('Day')
plt.show()
```

Figure 21. Step 6. Visualizing the results

5. Result

An intelligence-based farm monitoring model is developed in this proposed work which will provide precise and sustaining solutions to various epidemics like food shortage, economic crisis, food security etc. Internet of Things and Machine Learning algorithms such as SVM (Support Vector Machine) and SVR (Support Vector Regression) with Radial basis function kernel, Random Forest Regression provides in predicting, classifying of water level, atmosphere pressure, soil moisture, weather forecast, irrigation system. The analysis is done on training datasets obtained from "Kaggle" for Indian Agriculture production about farming information such as crop production in various states, particular crop rice production in Indian states, soil moisture, temperature. The Support Vector Regression algorithm is applied on the soil moisture data as follows are the re-sults:

	Real Values	Predicted Values
0	0.52	0.682535
1	0.56	0.598449
2	0.84	0.674151
3	0.83	0.743037
4	0.51	0.627465
5	0.51	0.749360
6	0.54	0.560640

Figure 22. Data Frame of real and predicted values of SVR

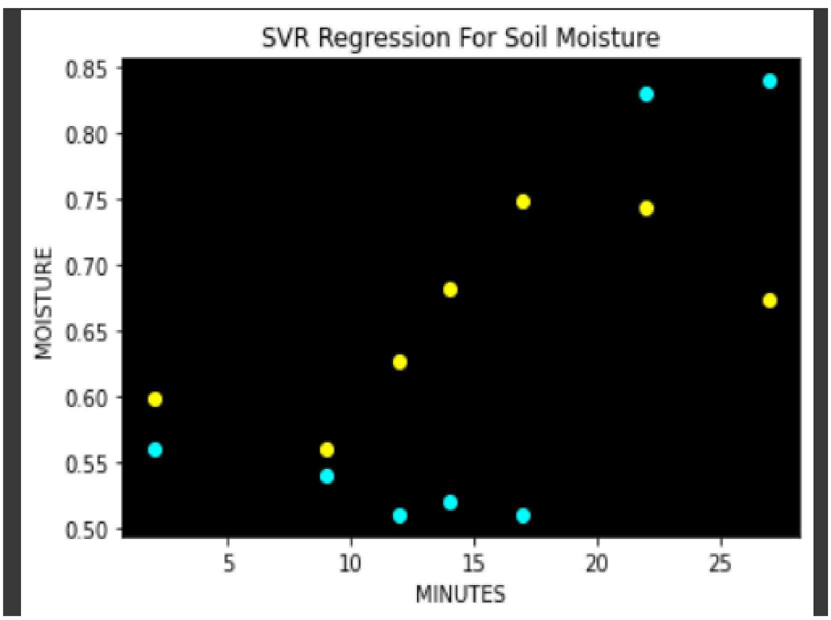

Figure 23. Cyan points are real values and yellow are predicted values

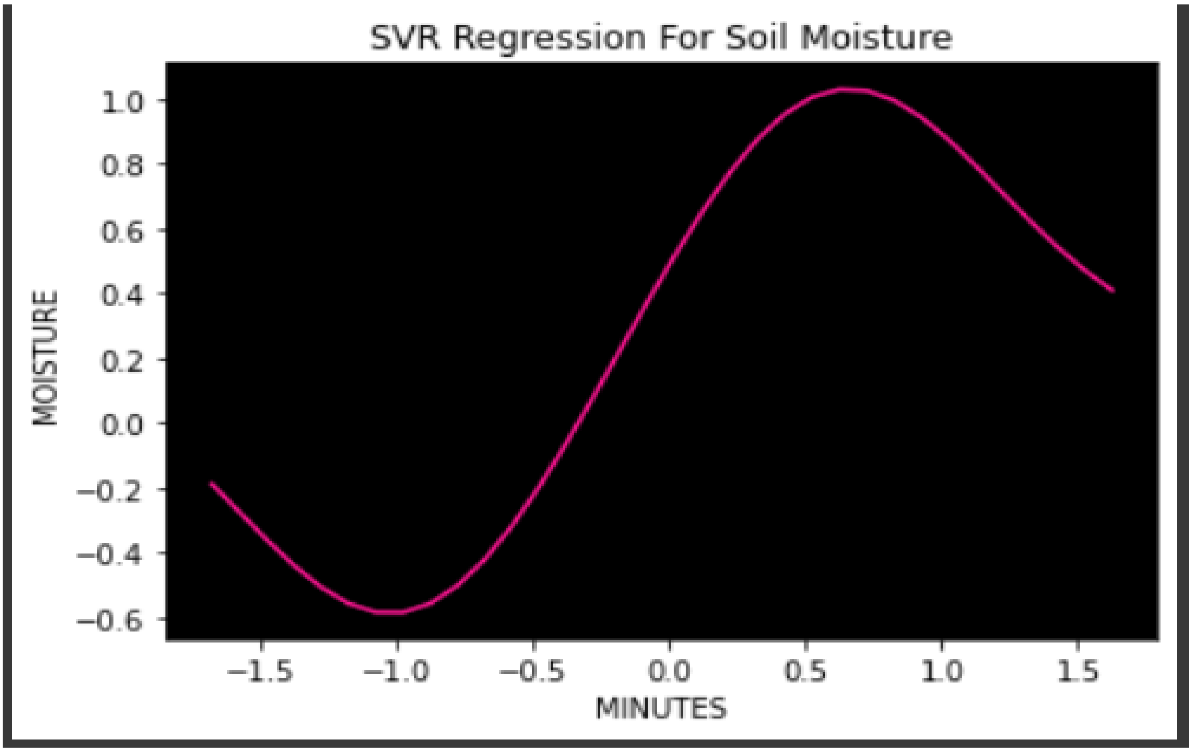

Figure 24. SVR curve

The Random Forest Regression algorithm is applied on the temperature dataset as follows are the results:

	Real Values	Predicted Values
0	23	25.9
1	20	22.4
2	21	22.4
3	18	22.4
4	25	25.9

Figure 24. Data Frame of real and predicted values of Random Forest Regression

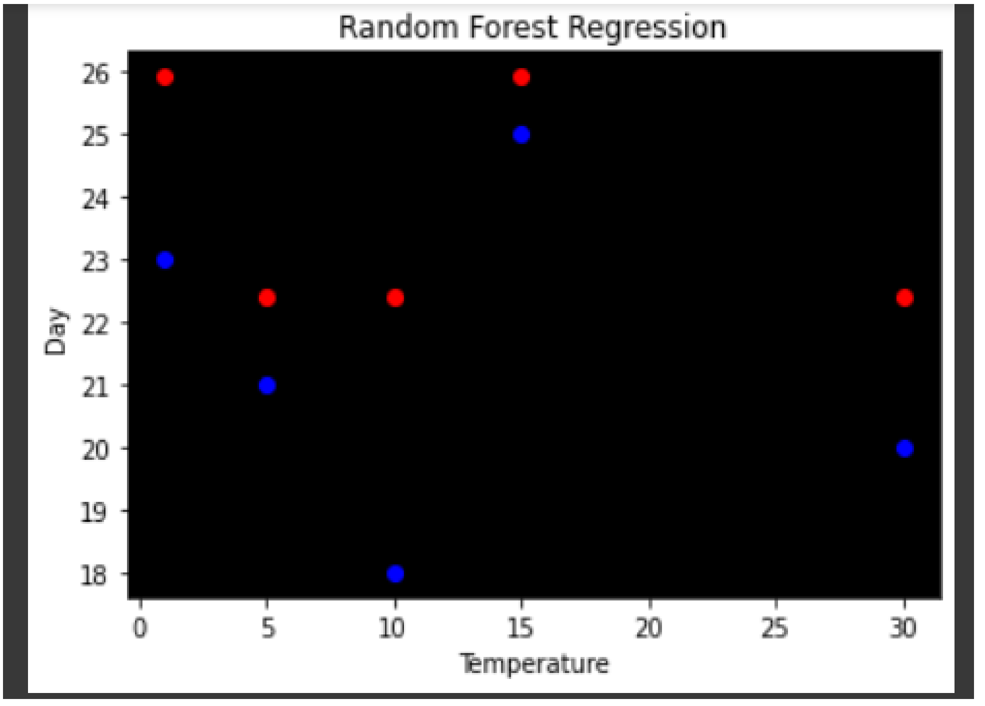

Figure 26. Blue points are real values and red are predicted values

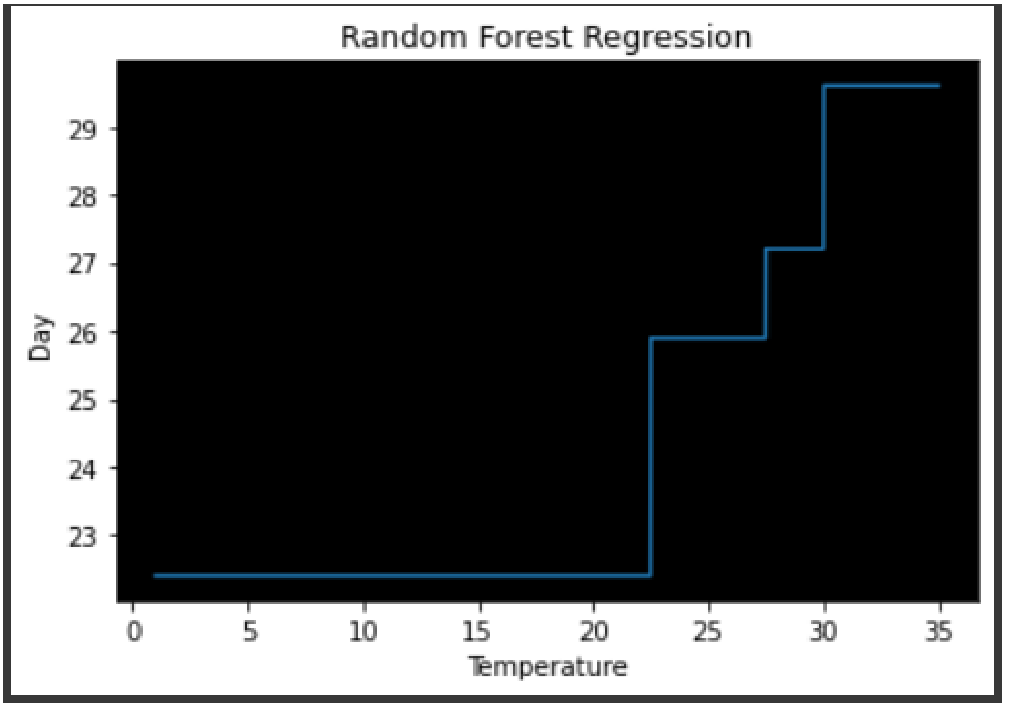

Figure 27. Random Forest Regression curve

6. Conclusion

This paper represents an economically efficient approach towards successful and powerful automated agriculture or we can say agriculture 5.0, Smart Farming, Smart agriculture. It utilizes the Internet of Things and a Machine Learning-based approach to obtain the best effective outcomes of farming production. Sensor nodes are interconnected with each other to monitor the fields completely. Then the data is being collected and transferred to the cloud. From the cloud, the data is fetched, and then machine learning algorithms like SVM (Support Vector Machine) and SVR (Support Vector Regression) with Radial basis function kernel, Random Forest Regression are applied to predict and make accurate decisions for farm fields. Which results in very effective and efficient outcomes of farming. Therefore, smart agriculture is conceivable to convey a more profitable, sustainable, and manageable type of farming productions, based on ensemble learning giving more exact precise, and resource-efficient methodology.

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Dr. Agostini Alessandro
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A Review on Integrative Decision Support Model for Smart Agriculture Based on Internet of Things and Machine Learning

Sadaf Saqib[1*], Faiyaz Ahamad[2], Mohd. Haroon[3] and Manish Tripathi[4]

[1,2,3,4]Computer Science and Engineering Department, Integral University, Lucknow, India
[1*]sadaf0620s@gmail.com

Abstract

The Internet of Things (IoT) has achieved an upset in a considerable lot of the circles of our current lives, like automobile, medical services offices, home automation, retail, education, manufacturing, and many more. The Agriculture and Farming ventures significantly affect the acquaintance of the IoT with the world. Machine learning (ML) is a part of artificial intelligence (AI) that permits software applications to turn out to be more precise at foreseeing results without being expressly customized to do as such. It uses historical data as input to predict new result values.

In the event that a specific industry has sufficient recorded information to help the machine "learn", AI or ML can create outstanding outcomes. Farming is likewise one such important industry profiting and advancing from machine learning at large. ML can possibly add to the total lifecycle of farming, at all phases. This incorporates computer vision, automated irrigation, and harvesting, predicting the soil, weather, temperature, moisture values, and robots for picking off the crude harvest. In this paper, I'll work on a smart agricultural information monitoring framework that gathers the necessary information from the IoT sensors set in the field, measures it, and drives it, from where it streams to store in the cloud space. The information is then shipped off the prediction module where the necessary analysis is done using ML algorithms and afterward sent to the UI for its corresponding application.

Keywords

Internet of Things (IoT), Machine Learning, Smart Agriculture

1. Introduction

Machine learning is an approach to data evaluation that automates analytical system development. It is a department of artificial intelligence-based totally on the concept that systems can study from data, perceive patterns and make choices/decisions/predictions with minimal human intervention. Food Security is one of the most necessary for the developing food needs of an ever-increasing population. Due to the increasing populace, we can't produce meals to meet the requirement of 1.38 billion, and nonetheless increasing the populace will put a large burden on the Indian economy. Around the globe, India is having a massive agricultural hub and the mainstream of the Indian populace is established on the agricultural area for meeting their requirement. Agriculture accounts for a fundamental component of GDP (Gross Domestic Product) now not solely of developing countries. However additionally for many developed nations. Thus, improvising and optimizing the current farming technologies is the want of the hour. It will no longer solely assist in flourishing sustainable improvement of mankind, plant life, and fauna but will additionally assist in dealing with the global crisis such as local weather alternate and epidemics such as draught. Internet of things has upgraded due to convergence of greater than one technologies like machine learning, wireless sensors, and embedded systems, real-time analytics. Conventional fields of networking of wireless sensors, embedded systems, automation (including domestic and constructing automation), and many more make contributions to enable the Internet of Things. In the consumer market, IoT technological know-how is most synonymous with product pertaining to the thought of the smart home, gadgets and home equipment (such as lights fixtures, thermostats, domestic protections systems, and cameras, and different domestic appliances) that help one or greater frequent ecosystems, such as smartphones. The home automation systems are being drastically lookup and developed however, this essential area of Agriculture and especially Smart Agriculture tends to lag at the back of different domains, and require pretty a lot of R&D to gain sustainable goals now not solely at the industrial stage, however, at the root degree of this agriculture industry. Automation of traditional irrigation methods can lead to many folds make bigger in crop yield. To form agriculture based on IoT, there are some needs that are to be fulfilled necessarily.

In the first place, the particular sensors (e.g., temperature sensors, moisture sensors, pressure sensors, etc.) required for the IoT utility are to be decided smartly. Secondly, the algorithms must be developed maintaining in thinking all the feasible possibilities required for the quality prediction and machine learning to have to be utilized effectively. Seeing next, the sensors are extra likely to get damage in the fields, so pursuits monitoring of these is required timely. Considering that, the framework of the wireless data transmission has to be as per the needs of the devices to join over a precise land region in the field. Lastly and majorly, the safety, security, and privacy of the device must be ascertained through authenticating the setup system, assuring its concealment, and managed admittance. The model proposed here in this paper is about how the Internet of things and machine learning used in the agricultural system. The proposed system may want to be such there will be no compromise between efficiency, security, performance, and safety of the system, and the favored effect has to produce exquisite precision and accuracy.

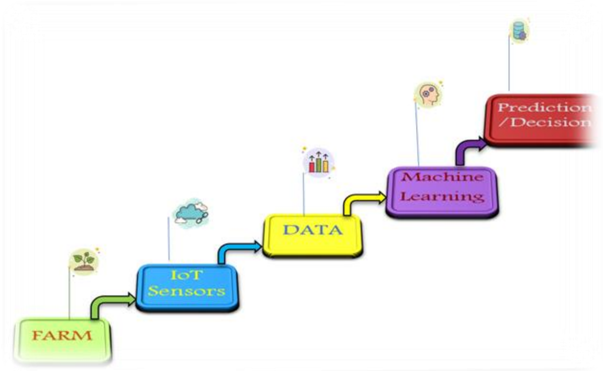

Figure 1. Flow Diagram of proposed work

The manufacturing throughout 2019-20 is greater by way of 26.20 million tonnes than the preceding 5 years (2013-14 to 2017-18) common manufacturing of food grain. To better understand the number of crops cultivated in India and their production volume a study on "Agriculture Production of Crop in India" is done. The dataset is obtained from the website "Kaggle". The dataset is training dataset. The evaluation is done using python language and visualizations are outputs of code executed for the dataset on Google Colab Notebook.

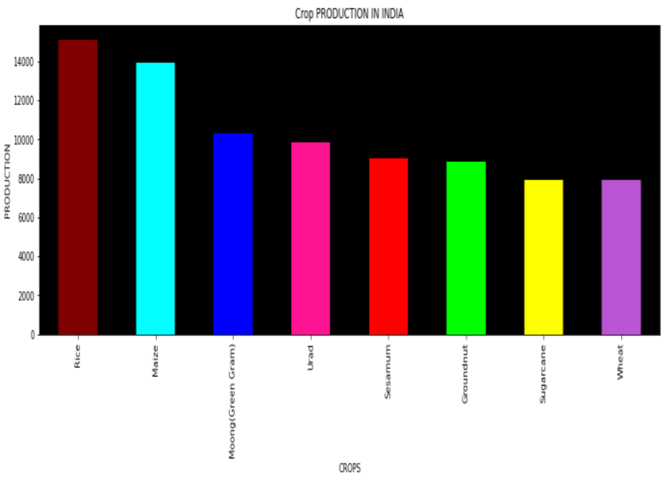

Figure 2. Production of different crops in India

Literature Review

A thorough literature review has been done and a fragment of the effective powerful technologies and algorithms based on literature survey and observations are put forward in this paper for the benefit of smart agriculture. In this current digital time, IoT assumes a huge part in each association just as nation advancement, and horticulture is one of the fields in which most of the things should be automated through IoT devices. This new idea unified on farming data has been known with several different names like Smart Farming, Smart Agriculture, Digital Farming, or Agriculture 4.0, and was born when telematics and information management were combined to the already familiar conception of preciseness Agriculture, up the accuracy of operations [10]. The utilization of new technologies to improve crop profitability are shown by [11]. The utilization of new technologies will be useful to measure and break down the information. To store data identified with soil, the authors of [1] are using the Blynk application. The data it will save will be its humidity, moisture, temperature, etc. Its uses are shown by [1]. While applying these new technologies, the test for retrieving information from crops is to come out with something intelligent and important, on the grounds that information themselves are not helpful, simply numbers or pictures. Homesteads that choose to be innovation-driven somehow or another, show significant valuable advantages, such as saving money and work, having an expanded creation or a decrease of expenses with insignificant effort, and delivering quality food with all the more environmentally friendly things. [3] Ç. Ersin, R. Gürbüz, A.K. Yakut, 2016 proposed the micro-controller based irrigation system which is very efficient and economical compared to different standard strategies, preciseness irrigation approaches are delineate by Liu[12]. [9] A farm vehicle and smart dispatching approach have been researched. [14] provided with associate interconnected approached towards smart agriculture. [J. Kwok, Y. Sun, 2018] work suggested plant detection using deep learning and so supported plant sort its applicable irrigation quantity required. Thus, once thorough study of presently out there literature, that deals with the current farming issues and their various answer, this paper highlights and provides a combined, precise view to the potential solution for smart farming.

Authors	**System Design**	**Findings**
Veronica Saiz Rubio (February 2020) [4]	From Smart Farming towards Agriculture 5.0: A Review on Crop Data Manageme nt	Paper states that optimized cost-effective decisions can be made by farmers while protecting the environment and transforming how food will be produced to match the coming up population growth using IoT and AI.
Rushika Ghadge (February 2018) [2]	Prediction of Crop Yield using Machine Learning,	Author compares the accuracy obtained by different network learning techniques like Kohonen Self Organizing Map and Back Propagation Network.
Nikhilesh Wadhwa (March/ 2019) [5]	Web Based Intelligent Irrigation System	Methods to solve problems like identifying crop suitable for which soil, level of water in soil, moisture etc. is done in this paper with the assistance of K-Means Algorithm.
Hemlata Sahu [1]	Multidiscip linary Model for Smart Agriculture using IoT	Model by author- Soil Monitoring for Precision Farming: Monitoring soil conditions is a simple use case but it can lead for farmers as a amazing return on investment.
T Raghav Kumar	Smart Manageme	In this paper, Machine Learning Algorithm (KNN)

(November 2018) [6]	nt of Crop Cultivation using IOT and Machine Learning	calculates the parameter to suggest the crop which is best to grow within the particular field supported the values received at real time.
Xiaohui Wang and Nannan Liu [12]	The application of internet of things in agricultural means of production supply chain manageme nt	It analyses the function and utility of the internet of things applied on the agriculture means of production supplying chain
Sanjit Kumar Dash (2017) [15]	A Survey on Application s of Wireless Sensor Network Using Cloud Computing	IoT device can be interfaced to soil and environmental sensors to collect soil properties and current environmental conditions. Analysis of the gathered information for interacting between environment, work and result for high grade work model construction.
Akshay Atole (April 2017) [7]	IoT based Smart Farming System	Smart Farming System that uses advantages of cutting-edge technologies such as IoT, Wireless Sensor Network and Cloud computing to help farmers enhance the way farming is done.
Akash Raj N (November 2016) [8]	IoT based Agro Automatio n System using Machine Learning Algorithms	It evaluates the crop quality factor based on pre-established weather conditions and nature of soil using the trained dataframe and implementing Supervised, Reinforcement models of machine learning.

Methodology

The proposed model is based on a farming land, each region consists of different kinds of sensors which will explore it's close by climate by which farmers will be able to act accordingly and the necessities can be executed as soon as possible.

3.1. 4-Layer Architecture

perception layer represents physical layer which has smart IoT devices. It identifies some physical parameters in the environment and how they communicate with one another and with the second layer transport layer. The IoT objects are responsible for gathering information/data, enabling the interaction between smart devices. This should be possible by utilizing sensor nodes or devices embedded with sensors, unmanned aerial vehicle and microcontrollers like Raspberry-Pi, Arduino to create sensor nodes and transmission gateways. Sensors are used to monitor soil moisture, atmospheric pressure, temperature, water level, fire detection, humidity, intrusion detection.

The transport layer relates to network layer which is responsible for interconnecting other smart IoT devices, network devices, and servers. It is also used for processing of sensor data and transmitting it.

The processing/prediction layer contains information storage, prediction, and visualizing assets. In this specific circumstance, big data helps store data in huge amounts and information handling, extraction of data in the briefest conceivable time. Such data are utilized as models by machine learning that is a data handling strategy through various algorithms to identify patterns and connections among perplexing and irrelevant information for the improvement of choices and decisions and automation of crop management, irrigation management, soil management, plant diseases monitoring.

The application layer consists of Internet of things and machine learning applications with help and provided data from other previous layers, it lets farmers do management of production process in a very effective and efficient manner.

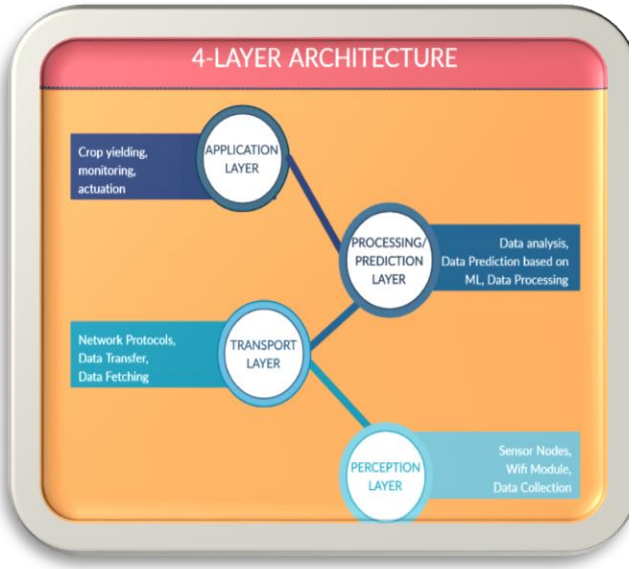

Figure 3. Four Layer Architecture of proposed model

- Firstly, the particular sensors (e.g, temperature sensors, moisture sensors, pressure sensors, etc.) required for the IoT utility are to be decided smartly.
- Secondly, the algorithms must be decided maintaining in thinking all the feasible possibilities required for the quality prediction and machine learning to have to be utilized effectively.
- Seeing next, the sensors are extra likely to get damage in the fields, so pursuits monitoring of these is required timely.
- Machine learning algo's like SVR and Random Forest will be used to predict the value using python via Google Colab Notebook.
- The proposed system may want to be such there will be no compromise between efficiency, security, performance, and safety of the system, and the favored effect has to produce exquisite precision and accuracy.

Result Analysis

An intelligence-based farm monitoring model is developed in this proposed work which will provide precise and sustaining solutions to various epidemics like food shortage, economic crisis, food security etc.

The analysis is done on training datasets obtained from "Kaggle" for Indian Agriculture production about farming information such as crop production in various states, particular crop rice production in Indian states, soil moisture.

The Support Vector Regression algorithm is applied on the soil moisture data as follows are the results:

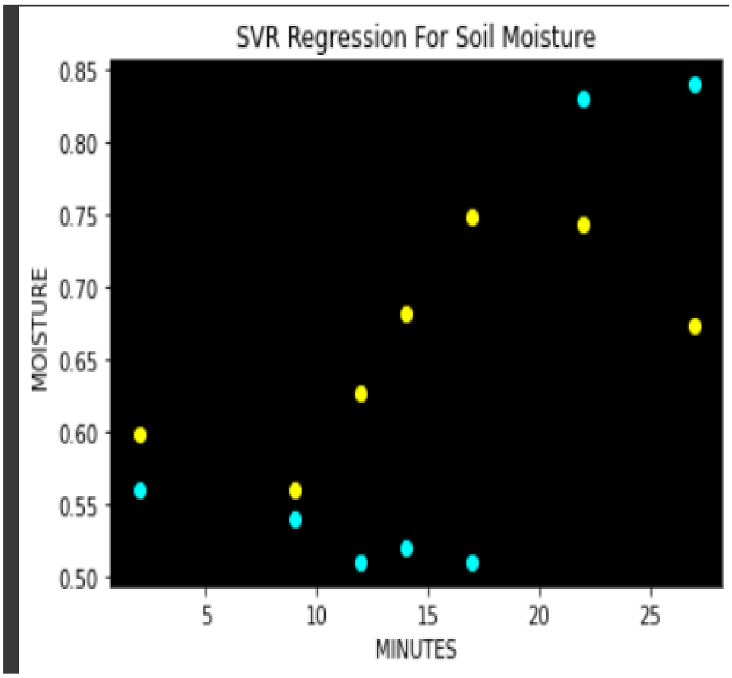

Figure 4. Cyan points are real values and yellow are predicted values

A mean negative MAE is of about -4.805. This is shown by box-and-whisker plot, SVR take cares of outliers in better way

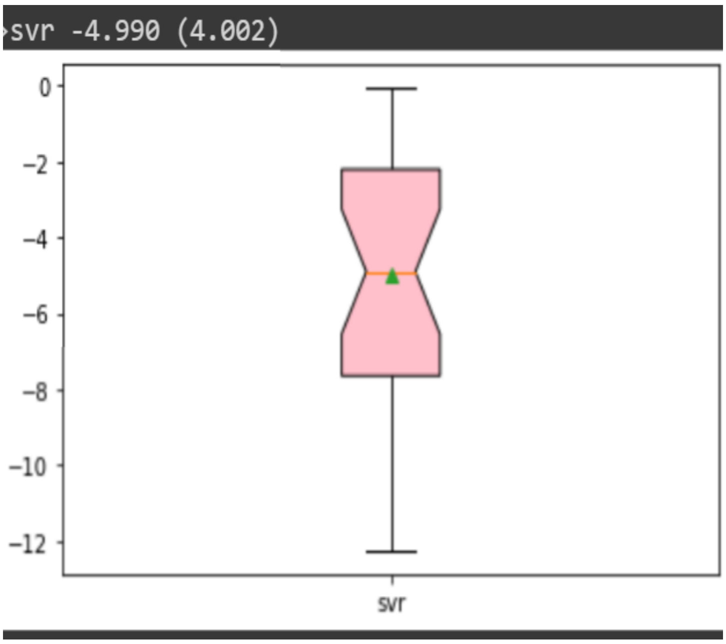

Figure 5. Mean Absolute Error is shown by box-whisker plot.

Conclusion

This paper represents an economically efficient approach towards successful and powerful automated agriculture or we can say agriculture 5.0, Smart Farming, Smart agriculture. It utilizes the Internet of Things and a Machine Learning-based approach to obtain the best effective outcomes of farming production. Sensor nodes are interconnected with each other to monitor the fields completely.Then the data is being collected and transferred to the cloud. From the cloud, the data is fetched, and then machine learning algorithms like SVM (Support Vector Machine) and SVR (Support Vector Regression) with Radial basis function kernel, Random Forest Regression are applied to predict and make accurate decisions for farm fields. Which results in very effective and efficient outcomes of farming. Therefore, smart agriculture is conceivable to convey a more profitable, sustainable, and manageable type of farming productions, based on ensemble learning giving more exact precise, and resource-efficient methodology.

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