International Journal of Scientific Research and Engineering Development-– Volume 7 Issue 2, Mar-Apr 2024

Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

Integrating IOT and Machine Learning for Advanced Agricultural Monitoring and Control

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Abstract

An IoT-based Crop Health Monitoring and Controlling gadget leverages the integration of machine learning algorithms to revolutionize agriculture. In this revolutionary system, IoT sensors are deployed throughout agricultural fields to accumulate real-time records on more than a few parameters such as soil moisture, temperature, humidity, mild intensity, and nutrient levels. Through machine learning algorithms, this fact is processed and analyzed to attain insights into crop fitness conditions, predict conceivable issues, and supply specific hints for optimizing crop growth. These algorithms can discover patterns, correlations, and anomalies in the data, enabling farmers to make knowledgeable choices and take proactive measures to decorate crop productivity. Automated structures built-in with IoT can alter irrigation primarily based on soil moisture ranges or observe fertilizers in accordance to nutrient deficiencies detected through the sensors. The computer studying thing of this IoT-driven device consistently learns from the incoming data, enhancing its accuracy in predicting crop diseases, pest infestations, or environmental stresses. Additionally, it assists in optimizing crop increase prerequisites through adjusting parameters such as water distribution, nutrient supply, and local weather manage in greenhouses or indoor farming setups.

Keywords: Soil monitoring, Humidity level, Temperature, Health monitoring, Machine Learning, Cloud Services.

1. INTRODUCTION

AI and the Internet of Things (IoT) are step by step altering agriculture in methods that may want to stop the hunger of over 815 million people, or 11% of the world's population. Agricultural Robots, Crop and Soil Monitoring and Predictive Analytics and IoT's utility in a wide variety of areas, together with related industry, smart-city, smart-home, smart-energy, linked car, smart-agriculture, related constructing and campus, fitness care, and logistics, amongst different domains, show up to be the three most famous purposes of AI in agriculture. In order to meet the world's foods demand in the upcoming years, the globe is turning to the utilization of AI, IoT, and records analytics (DA). By 2024, there will be ninetyfive million IoT system installations in the agricultural industry, up from 60 million in 2019. Smart agriculture will be made feasible through the use of IoT and AI and is predicted to produce a excessive yield and notable operational efficiency. Examples are beginning to abound when it comes to comprehending the conceivable have an effect on of all these technologies. Nature Sweet in the US raised their tomato harvest by using 4% in the first harvest after imposing AI to screen the crop. Even although agriculture is presently the primary supply of earnings for three-quarters of farmers, these techniques produce low yields. Yet, app creators like botanist and biochemist are supplying novel options that should amplify the continent's agricultural productiveness to reveal the transformation that is achievable.Farmers have used the platform over the years to extend crop yield and to decrease work load of farmers and to decrease crop yield failure. The monitoring of the provide chain and market placement are now made less complicated via AI. The Internet of Things, analytics, and cell technological know-how have all been used to set up a espresso traceability solution. In order to assist businesses, acquire truthful change and organic certification for their products, the answer is presently monitoring as many as 5 million baggage of espresso by way of each and every hyperlink in the furnish chain. The approach has supplied the espresso zone with a substantial boost, permitting farmers to compete greater efficaciously on the world espresso market and growing espresso exports. Machines that clear up troubles thru bodily interactions in an surroundings are a future possibility. Although these units have no longer yet made a vast influence on agriculture, they supply hope for notably accelerated soil administration and higher drought resistance techniques. The utilization of synthetic Genius and the Internet of Things in India presents the opportunity of several foods safety options as nicely as a greater productive zone throughout the whole continent.

1.1 MOTIVATION

The main motivation behind this work is that it aims to revolutionize agriculture by harnessing the power of cutting-edge technologies. Motivated by the pressing need to address food security challenges amidst growing populations and climate change impacts, this project endeavors to optimize crop cultivation processes. By leveraging IoT sensors, real-time data on environmental conditions, soil moisture, and crop health are collected, providing invaluable insights into field conditions. Machine learning algorithms analyze this data to predict optimal planting times, irrigation schedules, and pest management strategies, empowering farmers to make data-driven decisions for improved yields and resource efficiency. Additionally, by automating routine tasks and providing actionable recommendations, this system reduces labor costs and enhances overall productivity. Ultimately, this project aims to contribute towards sustainable agriculture practices, ensuring food security while minimizing environmental impact.

2. AGRICULTURAL IOT

Several lookup articlehave delivered the buildings for IoT-based agriculture. A microprocessor, a range of sensors (from fundamental temperature sensors to cameras), actuators, and wi-fi interfaces are generally covered in an IoT solution's sensor mote. These wi-fi interfaces may also use WiFi, LoRaWAN, Zigbee, or any other technology. The community layer is created via a nearby WSN gateway, which provides information via an Internet gateway. You ought to execute statistics processing duties along with records visualisation, information analysis, information storage, and informationsafety in order to understand the statistics obtained through the provider tier. The software layer, which permits give up customers to oversee and manage key farm methods and make fundamental choices primarily based on projections and market trends, is finally the most fundamental component. Data in the structure of voltage values, pictures, actuator states, and robotic areas have been created from a range of sources on and round agricultural farms as a end result of IoT-based agriculture. Good records produces good, correct information. You cannot use ML algorithms to construct prediction fashions except having dependable data. These more desirable datasets can be used to run ML algorithms for multiplied evaluation and particular prediction. Large quantities of sensor statistics can be accrued and managed with ease by using the IoT, which can additionally mix cloud computing offerings like agricultural maps and cloud storage. Access to real-time statistics at all instances and from any area approves for end-to-end connectivity and real-time monitoring.

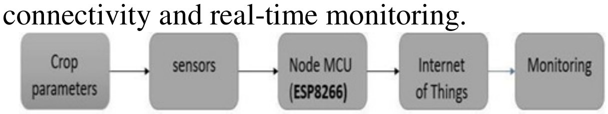

Fig.1IoT System Flow Diagram

3. MACHINE LEARNING APPLICATION IN IOT BASED ON AGRICULTURE

Machine mastering (ML) may additionally be seen as a contemporary approach for computer systems to mimic human gaining knowledge of processes, collect new information, constantly enhance performance, and enhance exceptional maturity. Using computer studying algorithms, theories, and purposes with different agricultural practices has validated to minimize crop fees and enlarge output over the preceding few years. ML functions in agricultural farms can be broadly employed in areas such as disorder detection, crop detection, irrigation planning, soil conditions, weed detection, crop quality, and climate forecasting. After harvest, ML can be used to investigate the freshness of produce (freshness of fruits and vegetables), shelf life, product quality, market analysis, etc. Support vector computer (SVM), naive Bayes, discriminant analysis, K-nearest neighbor, K-means clustering, fuzzy clustering, Gaussian combination models, synthetic neural networks (ANN), decision-making, and deep getting to know ought to be the key ML methods used in IoT-based agriculture.

3.1 PLANT MANAGEMENT

Plant management is about demonstrates that desktop studying (ML) structures can be built on the Internet of Things and can furnish guidelines Using greenhouse technology, a hybrid of ML and the IoT gives you an optimum and controllable surroundings for agricultural growth. Yet, standard agriculture and environmental legal guidelines discover it difficult to adapt to the boom of a range of plant sorts at a variety of phases of increase due to the spatio-temporal variability of crop boom environmental factors and their mutual influences in blanketed agriculture. Hence, from a monitoring and manipulate perspective, higher accuracy is required. There are several research that have been completed on creating and evaluating a number monitoring and manipulate structures for enhancing temperature and humidity, brightness, CO2 concentration, and different environmental parameters for the Internet of Things, technological, and monetary outcomes. It is recommended that IoT, sensors, and actuators can be used to manipulate the environmental stipulations for a specific range of plant. Here, Artificial Neural Networks (ANN) put up on IoT cloud can be used to manage situation rules.

3.2 CROP AND YIELD MANAGEMENT

Based on statistics gathered from yield monitoring related through a GPS-enabled IoT network, ML-based yield mapping might also be used in farms. The records that is gathered and exposes the yield records will be mapped in accordance to the one-of-a-kind kinds of farmland. Moreover, ML structures and the Internet of Things can be used to forecast and increase agricultural yields. When making decisions, farmers by and large seek advice from with agricultural professionals. These structures are used via these who have no prior laptop experience, such as farmers. Crop manufacturing can leverage ML systems. This method for generating understanding makes use of expertise that already exists. This makes it feasible for farmers to manipulate their plants in an good value manner. In mild of the success of professional systems, different comparable structures have been created. In agriculture, the Internet of Things is significant. Related find for the utilization of enter information gathered in actual time.

3.3 SOIL MANAGEMENT

Soil management can be performed the use of a range of ML-based techniques. Wireless sensor nodes mounted on website online can be used to collect information about the soil. Finally, the use of supervised desktop mastering algorithms, the acquired facts can be used to assume and analyze soil attributes or to classify the extraordinary sorts of soil. Moreover, the most extensively used computer gaining knowledge of (ML) methods, such as K-nearest neighbour, guide vector regression (SVR), Naive Bayes, etc., can be used to forecast soil dryness based totally on records from precipitation and evaporative hydrology.

3.4 DISEASE MANAGEMENT

In order to become aware of and manipulate ailments in agricultural fields, ML and IoT can be combined. To similarly defend vegetation from these ailments and reduce labour costs, ML processes in addition motivate the use of the appropriate pesticides. By gathering information and making suitable plans for irrigation, herbicides, and fertilisers, such a gadget aids growers. Grape visibility and quantity have grown, whilst severe pesticide consumption has decreased, as a end result of precision ailment identification, unique pesticide administration, and unique irrigation schemes. Moreover, structure with deep mastering methods for classifying and distinguishing distinctive plants' voice stages. These manufacturers' audio steps go round a variety of components of the farm the usage of IoT-based digital camera sensor nodes positioned in crop fields, which are based totally on real-time gathered visible information.

3.5 WEED MANAGEMENT

Managing weeds is critical to farming. There have beenresearch into weed mapping be use of ML.We endorse an unmanned flying automobile to take photos and map the weed in a area in order to maximize this.the place an IoT community can be used to manipulate a flying machine.NB-IoT is an instance of a superior IoT technological know-how that can manage and regulate large quantities of data.

3.6 WATER MANAGEMENT

A variety of structures have been put in location to control the water provide for agricultural fields and analyze the water great the usage of ML.With IoT sensors, shrewd structures can be developed to become aware of floor elements together with soil moisture, soil temperature, and ambient variables.Use the equal data to forecast outside relative humidity.To manipulate water temperature and intelligently react to environmental temperature, we can additionally use hybrid computing device gaining knowledge of and IoT systems.

3.7 ANIMAL TRACKING

It is very fundamental to tune animals in agricultural fields.Animal monitoring the usage of IoT-based sensors has been the difficulty of several studies, and unbiased research on animal kind classification are presently being performed.This trouble should be efficaciously solved by means of IoT and ML options working together.With IoT sensors, it is feasible to notice the presence of an animal.Using ML approaches, tracked animals can be label and/or their residing and motion habits studied.

4. PROPOSED SYSTEM AND WORKING METHODOLOGY

As partof the Smart Agricultural System, farmers can use a smartphone software and an IoT-based system. On the hardware end, we have a machine that makes use of the Internet of Things to+9 measure a range of parameters, along with soil moisture, temperature, and humidity. The software program section additionally aspects an Android app for farmers. We developed an Android app that signals the farmer and connects to the hardware device by way of IoT so that the farmer may also take a look at the present day country of temperature, humidity, and different discipline parameters at any time.

4.1 IOT SYSTEM

An IoT-based system is used to monitor various factors, including temperature-humidity (DHT11), soil moisture, and others (soil moisture sensor). The diagram below displays the circuit diagram for the IoT system.

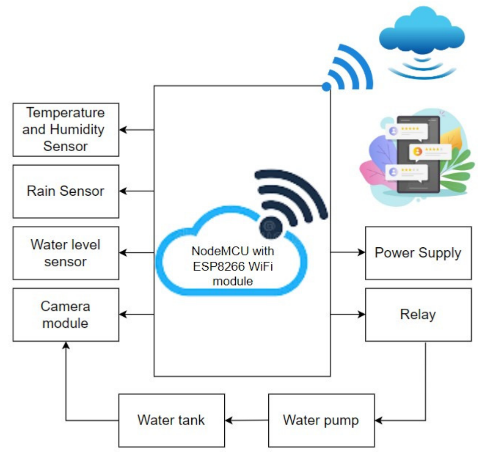

Fig.2IoT System Circuit Diagram

4.2 COMPONENTS

4.2.1 TEMPERATURE AND HUMIDITY SENSOR (DHT11)

The DHT11 is an inexpensive, simple digital temperature and humidity sensor. It generates a digital sign on the statistics pin after measuring the surrounding air with a capacitive humidity sensor and a thermistor. Although it is effortless to use, statistics series requires cautious planning. Dew factor is calculated as (C-(100-H)/5) Where, C stands for the Celsius temperature value, H = Value of Humidity.

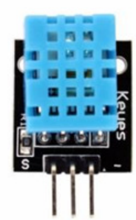

Fig.3 Temperature and Humidity Sensor

4.2.2 SOIL MOISTURE SENSOR

To calculate the volumetric water content material of soil, a soil moisture sensor is employed. The sensor does now not get rid of moisture; it as a substitute not directly measures the volumetric water content material of the soil. It wishes to be calibrated due to the fact exterior influences like conductivity, temperature, and soil kind may want to affect the results. Properties like as electrical resistance or conductance, dielectric constant, and interaction with different neutrons can be used to circuitously measure volumetric water content material except disposing of moisture. It wishes to be calibrated due to the fact exterior influences like conductivity, temperature, and soil kind may want to have an impact on the results.

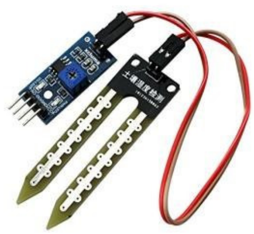

Fig.4Soil Moisture Sensor

4.2.3 NODEMCU

An open-source firmware is NodeMCU. Both the prototyping board designs and the firmware are accessible except cost.The firmware is primarily based on the eLua challenge and used to be developed the usage of the Espress if Non-OS SDK for ESP8266.It makes use of a quantity of open-source initiatives, such as SPIFFS and lua-cjson.Due to useful resource constraints, customers have to pick the factors fundamental to their task and construct a firmware particular to their requirements.Often used as prototype hardware is a circuit board regarded as a twin in-line bundle (DIP), which combines a USB controller with a extra compact surface-mounted board housing the MCU and antenna. The layout used to be based totally on the ESP-12 module of the ESP8266, an IoT application-friendly Wi-Fi SoC with a Tensilica Xtensa LX106 core.

Fig.5 NodeMCU

These sensors collect data about temperature, humidity, and moisture content material from the farms and transmit it to the Node MCU, the place the facts is saved (ESP8266). The Node MCU improvement board and opensource firmware are created completely for Internet of Things applications. It is made up of hardware primarily based on the ESP-12 module and firmware that utilizes Express if Systems' ESP8266 Wi-Fi SoC. The connection between the Node MCU and the IoT analytics platform provider ThingSpeak shops the sensor data.

4.2.4 RAIN SENSOR

Below is a image of the board with the rain sensor. This board in truth makes use of the resistance precept and has nickel plated lines. Using this sensor module, you might also measure moisture the usage of analogue output pins, and when the moisture threshold is exceeded, a digital output is provided.

Fig.6 Rain Sensor

Due to the reality that it has each an electrical module and a PCB, this module is similar to the LM393 IC. The rains are gathered in this case the use of PCB. Rain produces a parallel resistance route that the operational amplifier may additionally use to compute when it falls on the board. This sensor is a resistive dipole, and it fully shows resistance based totally on moisture. For instance, it well-known shows extra resistance whilst dry and lesser resistance when wet.

4.2.5 THINGSPEAK PLATFORM

ThingSpeak is a uncomplicated cloud-based IoT that allows you to aggregate, view, and analyze real-time facts streams for prototype and small-scale manufacturing applications. The Things Network integration approves you to without problems transport information from The Things Network to ThingSpeak for comparison and visualization.After you ship statistics to ThingSpeak from your units by MQTT or REST APIs, customers can right away visualize stay data.

Fig.7ThingSpeak Cloud Platform

5. PLANT DISEASE DETECTION

Plant sickness identification is a integral vicinity for lookup in laptop vision. Machine imaginative and prescient tools is utilized to perceive any sickness in the obtained plant pix via taking pictures of the same. Machine vision-based plant sickness detection technological know-how is presently in use in agriculture and has in general changed the normal approach of prognosis the use of simply the bare eye. Traditional photograph processing algorithms or human function diagram with classifiers are regularly used for computer vision-based plant disorder prognosis approaches. In order to produce pix with homogeneous illumination, this technique constructs the imaging scheme and chooses an fantastic mild supply and taking pictures attitude relying on the a number traits of plant diseases. While exact designed imaging schemes can drastically reduce the subject of establishing traditional algorithms,theyadditionally increase the implementation costs. In a real-world, difficult herbal setting, it can be difficult to perceive plant illnesses due to the fact there is little distinction between the lesion vicinity and the background, a large vary of sizes and kinds of lesions, and a lot of noise in the photo of the lesions. Many interruptions additionally show up when photographing plant ailments in stipulations of herbal light. At this point, traditional classical strategies regularly seem ineffective, and higher detection results are challenging.

Technologies used to observe plant ailments historicallyhave a range of shortcomings. In our sickness detection technique, we used a dataset from Kaggle to unravel this. The collection,which consists of about 895 images, is damaged up into three categories: bacterial spot, healthy, and early blight. For training, we appoint the convolutional neural community mannequin (CNN) VGG16 pre-trained model. This mannequin masses our dataset, resizes the images, and separates it into coaching and check data. 716 pix from each type are used for coaching and 179 pics are used for testing.

The mannequin has an output instruct loss of 0.22 and a instruct accuracy of 0.78, alongside with a validation loss and accuracy of 0.4 and 0.6, respectively. Upon completion of training, the mannequin is saved to the contemporary directory. The mannequin is then imported into the important sickness detection code. AWS's (Amazon Web Services) free tier is the place the foremost code is stored. The android software communicates with it via the http protocols. An photograph is commonplace by using the application, which then adjustments it to base64 structure earlier than sending it to the AWS server by means of a submit request the use of URL encoding. The trouble will be the disorder of the plant. A response of "healthy" will be provided if no illness is discovered.

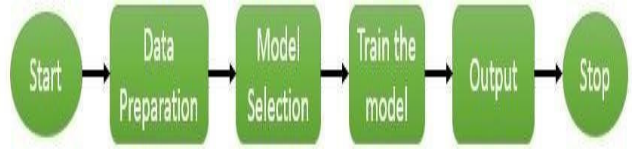

Fig.8 Flow Diagram of Machine Learning

When it comes to picture characteristic extraction, CNN gives a lot of advantages. By using a weight-sharing community topology, CNN, like a organic neural network, reduces the complexity of the community mannequin and the variety of weights. Compared to LeNet, AlexNet, and ZFNet, VGG16 has a deeper shape and is higher at extracting features. After every of the VGG structure's 5 convolutions is the most pooling layer.

6. RESULTS AND DISCUSSIONS

Temperature, humidity, and moisture degree are simply a few of the variables that the cellular app computes and shows. The strategies for measuring temperature, humidity, and soil moisture in this investigation are proven in the accompanying graphs. ThingSpeak, an IoT analytics utility that permits customers to capture, visualize, and analyze real-time records streams in the cloud, was once used to appear at the graphs.

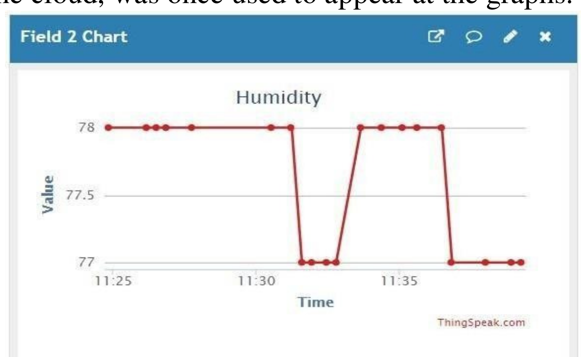

Fig.9Sample of output displaying humidity sensor measurements. According to estimates, the humidity was 77 percentage.

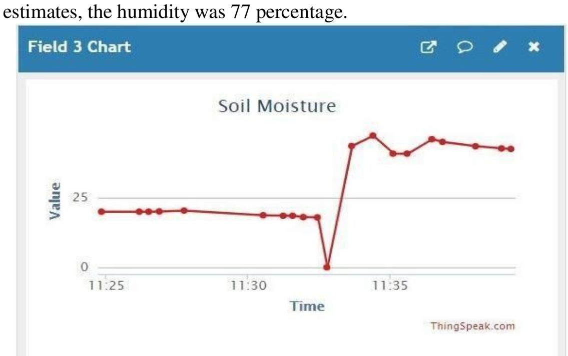

Fig.10 The readings from the soil moisture sensor are shown in an example of output. Estimates put the reading for soil moisture at 42.33 percent.

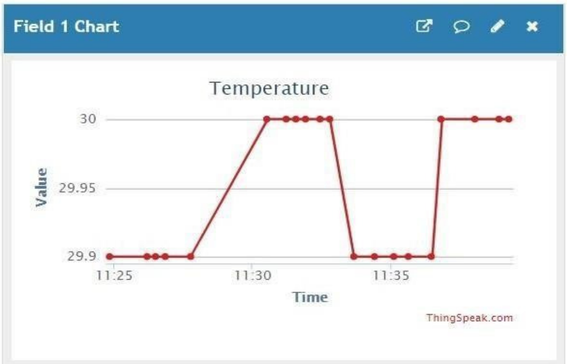

Fig.11 Sample of output displaying temperature sensor readings. It was estimated that the temperature was 30 degrees Celsius.

7. CONCLUSION

The next step in the increase of clever farming and agricultural practices is IoT-ML based totally agriculture. With the use of the agricultural IoT, ML algorithms might also be utilized to statistics gathered from numerous farm inputs to make the device smarter, provide conclusive information, and make predictions. In this paper, we take a look at the approach and consequences of cutting-edge ML functions in agriculture, every with special strengths and drawbacks. Eventually, suggestions have been made to put new functions on the IoT due to the fact the majority of ML functions required realtime information to educate predictive algorithms. By utilizing synthetic Genius (AI) applied sciences that provide increased thoughts and insights for following work choices and things to do with a vary of remaining manufacturing enhancements, farm administration structures are turning into a reality. This lookup examines laptop learning-based plant disorder prognosis as nicely as IoT-based clever farming technology. This technological know-how reduces the bodily effort required of farmers and producers whilst bettering productiveness in each way imaginable. For this, a thorough dialogue of wi-fi sensors, cloud computing, and conversation technologiesstrategies are presented.

REFERENCES

[1] A. A. Araby et al., "Smart IoT Monitoring System for Agriculture with Predictive Analysis," 2019 8th International Conference on Modern Circuits and Systems Technologies (MOCAST), Thessaloniki, Greece, 2019,(pp. 1-4)

[2] A. Adedoja, P. A. Owolawi and T. Mapayi, (2019) Deep Learning Based on NASNet for Plant Disease Recognition Using Leave Images," 2019 International Conference on Advances in Big Data, Computing and Data Communication Systems (icABCD), Winterton, South Africa, (pp. 1-5).

[3] Andreas Kamilaris, et al. (2016) Agri-IoT: A Semantic Framework for Internet of Things-enabled Smart Farming Applications," European Union.

[4] C. J. G. Aliac and E. Maravillas,(2018) "IOT Hydroponics Management System," 2018 IEEE 10th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management (HNICEM), Baguio City, Philippines, (pp. 1-5).

[5] Castelli, Mauro, et al., (2018) Supervised Learning: Classification, Reference Module in Life Sciences,in proc. Elsevier.

[6] M. Pérez-Ortiz, P. A. Gutiérrez, J. M. Peña, J. Torres- Sánchez, F. López-Granados and C. Hervás-Martínez, "Machine learning paradigms for weed mapping via unmanned aerial vehicles," 2016 IEEE Symposium Series on Computational Intelligence (SSCI), Athens, 2016, (pp. 1-8).

[7] M. T. Shakoor, K. Rahman, S. N. Rayta and A. Chakrabarty, 2017 Agricultural production output prediction using Supervised Machine Learning techniques, 1st International Conference on Next Generation Computing Applications (NextComp), Mauritius, (pp. 182-187).

[8] M. V. Ramesh et al. (2017), "Water quality monitoring and waste management using IoT," 2017 IEEE Global Humanitarian Technology Conference (GHTC), San Jose,CA, (pp. 1-7)

[9] N. Ananthi, J. Divya, M. Divya and V. Janani,(2017) IoT based smart soil monitoring system for agricultural production," 2017 IEEE Technological Innovations in ICT for Agriculture and Rural Development (TIAR), Chennai, (pp. 209-214)

[10] N. Materne and M. Inoue, (2018) IoT Monitoring System for Early Detection of Agricultural Pests and Diseases," 2018 12th South East Asian Technical University Consortium (SEATUC), Yogyakarta, Indonesia, (pp. 1-5).

[11] O. Pandithurai, S. Aishwarya, B. Aparna and K. Kavitha,(2017) "Agro-tech: A digital model for monitoring soil and crops using internet of things (IOT)," In proc. 2017 Third International Conference on Science Technology Engineering & Management (ICONSTEM), Chennai, (pp. 342-346)

[12] Prem Prakash Jayaraman, et al., (2018) Internet of Things Platform for Smart Farming: Experiences and Lessons Learnt,in proc Sensors, (pp 16, 1884)

[13] R. L. F. Cunha, B. Silva and M. A. S. Netto,(2018) A Scalable Machine Learning System for Pre-Season Agriculture Yield Forecast," 2018 IEEE 14th International Conference on e-Science (e-Science), Amsterdam, 2018, (pp. 423-430).

[14] R. N. Rao and B. Sridhar, (2018) "IoT based smart crop- field monitoring and automation irrigation system," 2018 2nd International Conference on Inventive Systems and Control (ICISC), Coimbatore, 2018, (pp. 478-483).

[15] S. Athani, C. H. Tejeshwar, M. M. Patil, P. Patil and R. Kulkarni, (2017) Soil moisture monitoring using IoT enabled arduino sensors with neural networks for improving soil management for farmers and predict seasonal rainfall for planning future harvest in North Karnataka — India," 2017 International Conference on I- SMAC (IoT in Social, Mobile, Analytics and Cloud) (I- SMAC), Palladam, (pp. 43-48)

[16] S. Dimitriadis and C. Goumopoulos, (2008)"Applying Machine Learning to Extract New Knowledge in Precision Agriculture Applications, " 2008 Panhellenic Conference on Informatics, Samos, 2008, (pp. 100-104).

[17] S. T., S. T., S. G. G.S., S. S. and R. Kumaraswamy, "Performance Comparison of Weed Detection Algorithms," 2019 International Conference on Communication and Signal Processing (ICCSP), Chennai, India, 2019, (pp. 0843-084).