IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Vol. 10, Issue 12, December 2021

DOI: 10.17148/IJARCCE.2021.101238

Survey of AI Enabled Smart Agricultural Techniques

Dr. Sreeraj R.[1], Akhilkumar K.S.[2], Jaefer[3], Prayagdev E.[4], Vishnu Murali[5]

Head of the Department, Department of Computer Science and Engineering, Universal Engineering College, Vallivattom, Thrissur, Kerala, India[1]

B. Tech Student, , Department of Computer Science and Engineering, Universal Engineering College, Vallivattom, Thrissur, Kerala, India [2, 3 ,4, 5]

Abstract: In India, Agriculture is undoubtedly the backbone of the nation. India, is the second-largest producer of agricultural products in the world, produces more than 280 million tonnes, contributing to more than 15% of India's GDP. Today, about 40% of the projected total yield is lost due to lack of proper care. Decline in the agricultural yield results increased commodity prices, slowing productivity and so on. Smart agricultural techniques using machine learning and deep learning, can help farmers to boost the crop yield and productivity. This paper explores various techniques for the implementation of smart agriculture.

Keywords: Smart Farming, Agriculture, Deep Learning, Machine Learning, CNN.

I. INTRODUCTION

In India, agriculture is one of the major sectors that support its economy. Agriculture has been supporting the Indian mass for thousands of years. Besides, agriculture is not just a way to earn livelihood but a way of living. Agricultural sector in India is a major contributor to GDP. Today about the major portion of the projected yield is lost due to many numbers of factors like, plant diseases, weeds, and failing to identify the right crop for specific locations, timely weather alerts and so on. Hence, farmers are giving up their agricultural profession because of the losses they face. So, by introducing efficient and cost effective smart farming techniques, one can do farming in a smart way, increasing both productivity and yield. There are a lot of techniques that utilizes, machine learning and deep learning algorithms and IoT in the field of agriculture to detect plant disease at an early, identification of weeds, crop recommendation systems, crop monitoring systems and so on.

II. THEORY

Here we introduce, various studies based on smart farming technologies.

A. Decision Tree

A decision tree is a commonly used tree like supervised machine learning model. Decision tree algorithm can be used for both regression and classification. Decision tree analysis is helpful in solving real world problems like decision making in cost management, operations management and so on.

B. Random Forest Algorithm

Random forest is a supervised learning algorithm. The "forest" it builds, is an ensemble of decision trees, usually trained with the "bagging" method. The general idea of the bagging method is that a combination of learning models increases the overall result. One big advantage of random forest is that it can be used for both classification and regression problems, which form the majority of current machine learning systems. This algorithm imitates the process of human thinking, hence it is easy for researchers to understand and interpret results.

C. Support Vector Machine

Support Vector Machine (SVM) is a supervised machine learning algorithm used for both classification and regression. The aim of SVM is to create the best decision boundary that can separate n-dimensional space into classes so that one can easily put a new data point in the correct category in the future. The best decision boundary is known as a hyperplane. SVM algorithm chooses the extreme points/vectors which help in creating the hyperplane. These vectors/points are known as support vectors, hence the name Support Vector Machine.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Vol. 10, Issue 12, December 2021

DOI: 10.17148/IJARCCE.2021.101238

D. Convolutional Neural Network

A convolutional neural network, or CNN, is a deep learning neural network designed for processing structured arrays of data such as images. Convolutional neural networks are widely used in computer vision and have become the state of the art for many visual applications such as image classification, and have also found success in natural language processing for text classification. CNNs are very good at picking up on patterns in the input image, such as lines, gradients, circles, or even eyes and faces. It is this property that makes convolutional neural networks so powerful for computer vision. Unlike earlier computer vision algorithms, convolutional neural networks can operate directly on a raw image and do not need any preprocessing. A convolutional neural network is a feed-forward neural network, often with up to 20 or 30 layers. The power of a convolutional neural network comes from a special kind of layer called the convolutional layer.

E. Internet Of Things

The Internet of Things (IoT) is a network of physical objects that are fitted with sensors, software and other technologies. Connected to the Internet, these 'things' are able to exchange real time data with other connected devices and systems over networks. These connected devices combine with automated systems to gather IoT data that can be analysed to assist with tasks or learn how to improve a process.

III. LITERATURE SURVEY

Here we introduce, various studies based on smart farming technologies.

A. Plant Disease Recognition

The study [1] proposes a Random Forest Classifier using image processing techniques to classify the plant diseases. The study involves loading images and performing image pre-processing, image segmentation, feature extraction and classification of disease. The study states that the development of automatic plant disease detection systems, using advanced technologies like computer vision and image processing, can support farmers by identifying diseases at an early stage and supplying necessary steps for its management. One drawback with using random forest is that the algorithm is substantially slower because, it uses multiple decision trees to make classification.

The authors of study [2] suggests using SVM (Support Vector Machine) algorithms for achieving good accuracy in disease detection in tomato leaves. The main aim of the study is to identify the disease affected area of tomato leaf. Initially, noise present in the dataset is reduced with the help of pre-processing. Then Haralick algorithm is used to extract the most optimal features in the data and finally, different machine learning algorithms like logistic regression, random forest and SVM are used. Among the three, SVM out performs all other algorithms. The authors suggest that this study can be used in real life application to identify diseases in plants.

In the study [3] a deep learning approach is used in the field of plant disease detection. The deep learning is done using CNN (Convolutional Neural Network) with the help of transfer learning. Two models namely ResNet 34 and ResNet 50 are used with the help of transfer learning in the experimentation. The main goal of the study is to reduce the professional help in detecting plant diseases.

Three plants namely Potato, Tomato and Bell Pepper have been considered for this study. In particular, the diseases considered are early blight, mosaic virus, late blight, leaf mold, bacterial spot, leaf curl, target spot and spider mite. Additionally healthy plants are also considered as a class. The classes are divided based on plant and disease type. The dataset contained over 4000 images. The dataset is pre-processed (also involves data augmentation). Both Resnet 34 and ResNet 50 are state of the art models achieving 99.1% and 99.44% accuracy respectively, but the size of the models are so large to be kept in a mobile device.

A CNN based model us suggested in [4]. The suggested CNN algorithm can be used to detect disease in plant leaves. The study states that with the help of CNN, maximum accuracy can be achieved if the image data is good. For this study, Plant village dataset (which contains 54303 healthy and unhealthy leaf images divided into 38 categories by species and disease) is used. The image pre-processing stage involves image augmentation in order to reduce overfitting of training data. The images are rescaled to values in the range of 0 to 1.Then a special deep learning model (consisting of Conv. Layer having 36 filters with 3 x 3 core and Relu activation and applying batch normalization, maximum aggregation and a 27% reduction) has been developed.

In the paper [5] an automated IOT based system has been proposed to determine whether a plant is normal or diseased. The normal growth of the plants, yield and quality are seriously affected due to plant disease. This study attempts to develop an automated system which detects the disease in the plants. An automated disease detection system has been

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 10, Issue 12, December 2021
DOI: 10.17148/IJARCCE.2021.101238

developed with sensors like temperature, humidity and colour based on variation in plant leaf health condition. The values based on temperature, humidity and colour parameters are used to identify the presence of a plant disease.

The study proposes algorithms to classify whether a leaf is healthy or not by utilizing input from sensors. The idea behind this approach is that, there will be significant changes in the properties of leaves like color, humidity and temperature, when the plant gets affected by some disease. The DHT11 temperature sensor gives the temperature and if the value lies between the fixed thresholds, leaves are considered to be healthy. Similarly, TCS3200 RGB colour sensor records RGB values for the leaves, and DHT11 humidity sensor measures the humidity of the leaf. These values are also checked to be within the specified constant threshold values in order to classify the leaf as healthy.

The study can be considered as a binary classification problem. The system classify whether a plant has a disease or not. But the system fails to identify the type of disease, in order to take necessary steps.

In [6], Deep CNN based deep learning models are used to detect diseases in apple leaves. This study make use of EfficientNet and DenseNet models to detect Apple plant diseases from images containing apple plant leaves and accurately classify them into one of the 4 classes: healthy, scab, rust and multiple diseases.

Most of the popular CNN models have more pooling layers that help to reducing the parameters and increasing the accuracy of the model. However, this leads to loss of some features and information. The significance of this DNN based system using EfficientNet and DenseNet tries to overcome these issues. The system proposed will take into account RGB values of the images and individual channel distribution. After EDA to draw insights, the system will augment the data using different augmentation and annotation techniques (for better accuracy and less overfitting), like Canny Edge detection, Flipping, Rotations, Blurring and Brightness adjustment. EfficientNet-B7 and DenseNet – two DNN based ImageNet pre-trained models trained with this augmented dataset. EfficientNet-B7 and DenseNet models achieve accuracy of 99.8% and 99.75% respectively. Hence EfficientNet-B7 models are considered to efficient.

[7] proposes a Smart Agriculture System that uses cutting-edge technologies like IoT, Android, Wireless Sensor Networks, and ML. Monitoring climatic conditions and early detection of plant diseases are two critical components of increasing yield. A feature of the proposed system is the ability of a system to monitor temperature, humidity, and wetness through sensors using Node MCU and send warnings using SMS and a notification on the application intended for the same on the farmer's smartphone.

For this study, the publicly available dataset is taken from Kaggle. The proposed system uses VGG-16 pre trained model (using transfer learning), based on CNN for classification. VGG16 has a deeper architecture than LeNet, AlexNet, and ZFNet, and it can extract features more efficiently and effectively. The backend of the system is hosted in AWS Free tier available for students and HTTP protocols are used by android application for communication with the backend hosted in AWS. The image is transmitted from application to server in base64 format via POST request with URL encoding and the classification is performed there. And the result is sent back to the application as a response to the request from the application.

B. Seedling Classification

The paper [8] proposes a Convolutional Neural Network for training and does data augmentation to detect 12 plant species using a various image transforms like resize, rotate, flipping, scaling and histogram equalization. The paper proposes using AlexNet. AlexNet was one the first Neural Network based model which can be trained using a GPU, thus reducing a large amount of training time. The authors propose the use of Stochastic Gradient Descent with Momentum (SGDM) optimizer with an initial learning rate parameter of 0.001, mini-batch size of 64 and a maximum of 100 epochs. The final layer of the model is customized to learn the features specific to the dataset. The AlexNet achieved validation accuracy of 99.697%.

In the paper [9] the authors do a performance comparison of state of the art models AlexNet, Googlenet and Resnet 50, on the Philippine indigenous plant seedling dataset containing 5 plant species namely: Adlay, Bignai, Achuete, Agosip and Lipote. These plants were one to four months old, during the data gathering phase.

In here, the datasets are randomly divided into training set (70%) and validation set (10%). In order to reduce the overfitting of the training data, data-augmentation is used. The last three layers of the three models were fine-tuned to accurately learn and predict the data. This is done by extracting all the layers of the models except the last three layers. These layers were replaced with fully connected dense layers, a softmax layers and a output layer. The study uses the concept of transfer learning. For faster learning weight and bias learning factors of fully connected layers were adjusted

DOI: 10.17148/IJARCCE.2021.101238

to 20. The results of experiments were: AlexNet achieved an accuracy of 97.73%, GoogleNet achieved an accuracy of 94.93% and ResNet 50 achieved an accuracy of 98.93. So ResNet 50 outperforms the other two models.

The study [10] consists of comparison of two traditional Machine Learning algorithms and a Convolutional Neural Network. The study uses a plant seedling dataset containing of 4275 images of approximately 960 unique plants belonging to 12 species at several stages of its growth. Three algorithms used in the study are: SVM, K-Nearest Neighbours and CNN. Grid search method is used to find the optimal parameters of the model. KNN model achieved an accuracy of 56.84% with number of neighbours = 5. The SVM achieved an accuracy of 61.2% with parameters, C=5, kernel=linear and gamma value=auto. The CNN model has 6 convolutional layers, each followed with a ReLU activation. The model also uses max pooling layer for dimensionality reduction 10% dropout to prevent overfitting. The output layer of the model uses softmax activation and uses adam optimizer with a batch size of 32 and a weighted cross-entropy loss to handle imbalanced number of pixels for each class. The findings of the study show that CNN-based seedling classification applications, when used in farming automation have the ability to increase crop yield and productivity.

The study [11] aims to develop a deep learning model to classify the plant seedling images. The deep learning model architecture composed of seven layers: five convolutions and two fully connected. The dataset used in this study also contains the images belonging to 12 plant species. The authors propose a CNN based model whose architecture is identical to AlexNet by Krizhevsky. The model is trained on GPU. The aim of the study is to develop a model which consumes only less space and faster processing time. For training purpose, the dataset is split into 70% training, 20% validation and 10% for testing. The steps included in processing: feature extraction, image resize and classification. The proposed model achieved an overall accuracy of 90.15%. the authors also suggest that an architecture with reduced number of weights performs well, specifically with relatively small amount of data.

In [12] the authors also propose a deep learning approach towards plant seedling classification. The authors developed a convolutional neural system by utilizing the deep plant phenomics stage. The study involves the use of dataset that contains a picture of around 800 exceptional plants having a place with twelve categories at various development stages is utilized. This model can help in recognizing and separating a weed from different plants. The benchmark of the proposed framework gives a precision of roughly 84%. The proposed system can be used to work with automated arms for performing genuine weed removal activities in an enormous plantation.

The authors of [13] states that weed control is a challenging problem in the field of agriculture, because they lead to reduced crop yield. Hence, they propose a CNN based model to detect plant seedling at an early stage. The dataset contains the images of 12 plant species (3 crops and 9 weeds). The proposed CNN model consists of an input layer, hidden layers, and an output layer. The entire convolutional layers use ReLU activation. This decreases the overall training time and provides non-linear rectification. Since the dataset is too small, 10-fold cross validation is used by randomly choosing 10% of training set to represent the validation set at each successive fold. The proposed system achieved an accuracy of 94.38% approximately.

C. Crop Recommendation

The study [14] involves the development of an Intelligent Smart Farming device based Internet of Things and Artificial Intelligence. Each crop requires different environmental factors for its suitable growth. The factors are precipitation, temperature, humidity, pH and solar light intensity. Hardware modules like ESP8266, Arduino UNO R3, temperature and humidity sensors are used for implementation of the proposed system.

The data from sensors connected to Arduino UNO R3 is fed into ESP8266 which sends a HTTP POST request with these data to the hosted apache server. The sensor readings are published in a MySQL database and a flask based application written using python draws these sensor data from the database and makes real time crop prediction. Decision Tree algorithm is selected by the authors for the purpose of implementation. Decision tree can be used to visually and explicitly represent decisions and decision making. It uses a tree-like model of decisions. Though a commonly used tool in data mining for deriving a strategy to reach a particular goal, it's also widely used in machine learning.

In [15] the authors proposes a recommendation system which makes use of different machine learning techniques such, that it recommends the suitable crops based on the soil parameters given as input. This system helps in reducing the financial losses faced by the farmers due to planting the wrong crops and also it helps the farmers to find the types of crops that can be cultivated in their area. The study suggests using a model which can predict the crop based on the soil nutrient values (NPK values) and pH given as the input. The study experiments with Machine learning algorithms like K-Nearest Neighbours, Decision Tree, K Nearest Neighbours with cross validation, Naive Bayes, Support Vector

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 10, Issue 12, December 2021
DOI: 10.17148/IJARCCE.2021.101238

Machine and out of which K Nearest Neighbours with cross validation worked best with an accuracy of 88%. The study also suggests that integrating Internet of Things with the proposed system can make farming smart.
The study [16] helps the beginner farmers in such a way to guide them for sowing the suitable crops by deploying machine learning, one of the advanced technologies in crop recommendation. The proposed system uses the application of supervised machine learning approach, the class with the very best chance is taken into account as the possibly class. Here the category is nothing but the crop which gets predicted for the given input parameters. Once the crop is predicted, it will facilitate the farmers to use the affordable crop for their individual land. Then, the farmers are guided with a mobile application which helps to make them understand that what seeds should be sown in land to induce higher yielding. Within the past data, crop prediction was calculated by analyzing farmer's previous expertise on climatic condition. So, the correct data regarding history of climatic condition is a vital factor for making accurate predictions in choosing crops. This paper proposes a system to predict the affordable crop for the given input parameter for the farmers using machine learning. Thereby this proposed work will suggest the farmers with effective solutions for more profitable cultivation.

In the study [17] the authors state that, data mining in agriculture can be used to analyze the various biotic and abiotic factors. Agriculture in India plays a vital role in economy and employment. The common problem present among the Indian farmers is they don't choose the right crop based on their soil requirements. Due to this they face a serious setback in productivity. This problem of the farmers has been addressed through precision agriculture. Precision agriculture is one of the modern farming techniques which uses the data of soil characteristics, soil types, crop yield data collection and suggests the farmers the right crop based on the parameters specific to their sites. This helps in reducing the wrong choice on a crop and increase in productivity. This study proposes a recommendation system using an ensemble model with majority voting technique using Random tree, CHAID, K-Nearest Neighbour and Naive Bayes as learners to recommend a crop for the site-specific parameters with high accuracy and efficiency.

The study [18] proposes that soil with necessary nutrients is capable of supporting crop cultivation. But some nutrients level in the soil may decline because of the over usage of fertilizers. Due to this, the crop production is falling. Hence, in order to increase the crop yields, the proposed methodology explores all the micro and macronutrients of the soil to predict the crop suitability for a specific region. During the data categorization, beyond rough set, the fuzzy logic is used to handle the boundary values of the numerical features to increase the accuracy of the prediction. Rough set based rule induction method is used to generate the rules and the crop suitability is predicted according to the fuzzy rules.

The data for this study is collected from the soil health card website and the feature selection is performed. The dataset is divided into training (80%) and testing (20%). The suggested methodology is to make use of fuzzy logic principle with 5 linguistic variables to process the border conditions more effectively. In order to process the uncertainties, the Rough set based rule induction method is induced. The Rough set based rule induction methods predict the suitable crop for the land according to the rules created. The data is also preprocessed by discretizing all the attributes and then the discretized output is given as input to the rule induction methods. For the purpose of analysis, 10 cross-fold validation is done. The 10 cross-fold validation is analyzed for different rough-set based rule induction methods. Different rule induction methods are implemented and analyzed to find the best rule induction method. The rule induction method is classified as local and global. The methods like CN2, AQ, and LEM2 were used for generating the fuzzy rules for this purpose.

[19] proposes a system consisting of two main modules namely soil and weather monitoring module and a machine learning module. First module composes of circuit interconnections and characterization of various soil sensors. Soil moisture is detected by using moisture sensor. The temperature and humidity can be measured by DHT 11 (Digital Humidity Temperature). The second module (Machine Learning), which deals with extracting the information from all the above data values gathered from sensor. An android application has been developed, which provides proper awareness and guidance regarding the cultivation of preferable crops to farmers. The, proposed system seems to be a perfect combination of IoT, Machine Learning and Android Application. And it is also useful for low-income household farmers to focus into smart climate farming practice. The machine learning model in the proposed system achieves an accuracy of 98.1818%.

The study [20] consists of a theoretical and conceptual platform of recommendation system implemented using integrated models of collecting environmental factors using microcontrollers like Arduino, Supervised machine learning techniques such as Naive Bayes (Multinomial) and Support Vector Machine (SVM), and unsupervised machine learning algorithm such as K-Means Clustering and also Natural Language Processing (NLP). The system is concerned with the Artificial Intelligence to recommend a crop for the specific land with site-specific parameters with high accuracy and efficiency. It has been a major problem for any man having adequate space in the land to identify

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 10, Issue 12, December 2021
DOI: 10.17148/IJARCCE.2021.101238

which crop to grow. Not only domestic lands but also for farming lands. There are four steps proposed in the system, namely dataset collection, collecting environment factors, prediction of crop and monitoring and feedback. The proposed system uses an Arduino UNO with ESP32 Wi-Fi module, soil moisture sensor, pH sensor, sunlight sensor and temperature sensor and other sensors. Once the plant is cultivated, the farmer is asked to give feedback regularly with a time interval of one month. From this feedback, the system is self-trained, and the accuracy is improved with time and data collected. From this system, the guidance of a specialist is not needed, and the maintenance is less.

IV. CONCLUSION

Agriculture is one of the main occupations in India, supporting two-third of its population. Today, most of the farmers are giving up their lands and agricultural profession, because of the yield losses due to a variety of factors. Many of the farmers fail to identify plant diseases or weeds on their fields at an early stage and similarly, they plant unsuitable crops leading to fewer yields than predicted. Such issues can be overcome using different machine learning and deep learning algorithms efficiently and cost-effectively. It has been found that the usage of advanced technologies like image processing or computer vision in the field of agriculture can help transform, traditionally used approaches into smart ones.

ACKNOWLEDGMENT

We utilize this opportunity to convey our gratitude towards all those who have helped us directly or indirectly for the completion of our work. We deeply and wholeheartedly thank Dr. Sreeraj R. – our Guide and HOD, Computer Science and Engineering, UEC for his extreme valuable advice, guidance and encouragement. We would like to extend our sincere gratitude to all faculties of Department of Computer Science and Engineering for the support and suggestions that helped us in the development of our work to what it is now. We thank our parents and friends for the mental support provided during the course of our work at the times when our energies were the lowest.

REFERENCES

[1]. Abirami Devaraj, Karunya Rathan, Sarvepalli Jaahnavi and K Indira, "Identification of Plant Disease using Image Processing Technique", International Conference on Communication and Signal Processing, April 4-6, 2019, India.
[2]. Debasish Das, Mahinderpal Singh, Sarthak Swaroop Mohanty and S. Chakravarty, "Leaf Disease Detection using Support Vector Machine", International Conference on Communication and Signal Processing, July 28 - 30, 2020, India.
[3]. Anjaneya Teja Kalvakolanu "Plant Disease Detection Using Deep Learing", 2020.
[4]. Sumit Kumar, Veerendra Chaudhary, and Ms. Supriya Khaitan Chandra, "Plant Disease Detection Using CNN", Turkish Journal of Computer Science and Mathematics Education Vol.12 No.12 (2021), 2106-2112.
[5]. Rajesh Yakkundimath, Girish Saunshi, and Vishwanath Kamatar, "Plant Disease Detection using IoT", International Journal of Engineering Science and Computing, September 2018.
[6]. V V Srinidhi, Apoorva Sahay, K. Deeba, "Plant Pathology Disease Detection in Apple LeavesUsing Deep Convolutional Neural Networks", Proceedings of the Fifth International Conference on Computing Methodologies and Communication (ICCMC 2021).
[7]. Arathi Nair, Gouripriya J, Merry James, and Sumi Mary Shibu, "Smart Farming and Plant Disease Detection using IoT and ML", International Journal of Engineering Research & Technology, NCREIS - 2021 Conference Proceedings.
[8]. Catherine R. Alimboyong, Alexander A. Hernandez and Ruji P. Medina, "Classification of Plant Seedling Images Using Deep Learning", Proceedings of TENCON 2018 - 2018 IEEE Region 10 Conference (Jeju, Korea, 28-31 October 2018).
[9]. Jolitte A. Villaruz, Julie Ann A. Salido, Dennis M. Barrios II and Rogelio L. Felizardo, "Philippine Indigenous Plant Seedling Classification Using Deep Learning", DOI**:** 10.1109/HNICEM.2018.8666412
[10].Daniel Nkemelu, Daniel Omeiza, and Nancy Lubalo, "Deep Convolutional Neural Network for Plant Seedling Classification", 2018 https://arxiv.org/pdf/1811.08404.pdf.
[11].Catherine R. Alimboyong and Alexander A. Hernandez, "An Improved Deep Neural Network for Classification of Plant Seedling Images", 2019 IEEE 15th International Colloquium on Signal Processing & its Applications (CSPA 2019), 8 -9 March 2019, Penang, Malaysia.
[12].M.Kavitha, Nithiesh Kumar N, Lalith Kumar.V, Mathan S, and Mohankumar M, "Categorization of Plant Sapling using Deep Learning", International Journal of Engineering and Advanced Technology (IJEAT), August 2019.
[13].Heba A. Elnemr, "Convolutional Neural Network Architecture for Plant Seedling Classification", (IJACSA) International Journal of Advanced Computer Science and Applications, 2019.
[14].Manikrao Mulge, Manish Sharnappa, Anjali Sultanpure, Divya Sajjan, and Monika Kamani, "AGRICULTURAL CROP RECOMMENDATION SYSTEM USING IoT AND M.L.", The International journal of analytical and experimental modal analysis, 2020.
[15].Kevin Tom Thomas, Varsha S., Merin Mary Saji, Lisha Varghese, and Er. Jinu Thomas, "Crop Prediction Using Machine Learning", International Journal of Future Generation Communication and Networking, 2020.
[16].M.Kalimuthu, P.Vaishnavi, and M.Kishore, "Crop Prediction using Machine Learning", Proceedings of the Third International Conference on Smart Systems and Inventive Technology (ICSSIT 2020).
[17].S.Pudumalar*, E.Ramanujam*, R.Harine Rajashree , C.Kavya , T.Kiruthika and J.Nisha, "Crop Recommendation System for Precision Agriculture", IEEE Eighth International Conference on Advanced Computing (ICoAC), 2016.
[18].A.M.Rajeswari, A.Selva Anushiya, K.Seyad Ali Fathima, S.Shanmuga Priya, and N. Mathumithaa, "Fuzzy Decision Support System for Recommendation of Crop Cultivation based on Soil Type", Proceedings of the Fourth International Conference on Trends in Electronics and Informatics (ICOEI 2020).
[19].Velmurugan Sathya Narayanan, Kavin N Raj, Kishore Kumar and Manoj Kumar, "Soil and Weather Monitoring System with Crop Prediction for Farmers Using IoT and Machine Learning" 2021.
[20].Pradeepa Bandara, Thilini Weerasooriya, Ruchirawya T.H., W.J.M. Nanayakkara, Dimantha M.A.C, and Pabasara M.G.P, "Crop Recommendation System", International Journal of Computer Applications (0975 – 8887), Volume 175– No. 22, October 2020.