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IoT Framework for Precision Agriculture: Machine Learning Crop Prediction

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Abstract: The designs of the Internet of Things make it feasible for us to collect data for large agricultural areas that are located in remote parts of the world. Our machine learning system can then utilize this data to produce crop predictions. The crop that should be recommended is based on the following factors: nitrogen, phosphorus, potassium, temperature, humidity, and rainfall. On the basis of these considerations, recommendations are made. The data collection has a total of 2200 occurrences as well as 8 attributes to go along with them. There are around 22 different plant species that might be offered for each of the 8 potential combinations of traits. By making use of the supervised learning strategy and using some of the machine learning algorithms that are accessible in WEKA, it is possible to create the best possible model. For the purpose of the classification procedure, the multilayer perceptron rules-based classifier JRip and the decision table classifier were selected as the candidates for the machine learning algorithms that would be implemented. The major objective of this case study is to, by the time it's finished, develop a model that not only predicts the crop to have a high yield but also provides guidance for precision agriculture. Both the Internet of Things and the essential metrics that are needed in agriculture are taken into consideration in the model that has been provided for the system. It has been established that the performance that was assessed by the classifiers that were selected has a value of 98.2273%, that the weighted average Receiver Operator Characteristics value is 1, and that the maximum amount of time that is required to generate the model is 8.05 seconds. The agricultural sector contributes significantly to the overall economy. It is very necessary for the upkeep of a balanced ecology. People are dependent on diverse agricultural products to some degree in almost every facet of their lives. This is especially true in terms of food and water. Farmers need to discover strategies to adapt to shifting weather patterns while also satisfying the increased demand for more food of higher quality. If the farmer wants to boost the output of crops and ensure their healthy development, he or she has to be aware of the weather conditions. Because of this information, the farmer will be able to make an informed decision regarding the kind of crop to cultivate, taking into account the myriad of environmental factors. Monitoring the crop in real-time allows Internet of Things (IoT)-based smart farming to make the whole agricultural system more efficient. It monitors a variety of elements such as humidity, temperature, and soil, among others, and provides a real-time observation that is utterly transparent. The purpose of using machine learning in the agricultural sector is to enhance both the output and quality of the crops produced in this industry. When applied to the sensed data, the use of appropriate algorithms may assist in the selection of suitable crops.

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***Keywords**: JRip, WEKA, machine learning, and multilayer perceptron are some of the terms associated with precision agriculture; decision table is some of the keywords that have been associated with this topic.*

1. Introduction

Despite the fact that 64% of India's cultivated area is dependent on the monsoons, India's agricultural production ranks second in the world. Approximately 85% of water is used for irrigation, however, during that process, nearly 60% of the water is lost. Precision agriculture is "the use of current information technology to provide, process, and analyze multi-source data of high geographical and temporal resolution for the purpose of decision making and operations in the management of crop production," according to one definition of the term. This precise agriculture may result in an increase in crop productivity, a deterioration of the soil, more efficient use of water, a reduction in the amount of chemical fertilizer and pesticides used for cultivation, and the spread of modern farming practices that improve the quality, quantity, and cost of producing crops. Through the incorporation of Agriculture IoT solutions, the goal is to assist farmers in bridging the supply-demand imbalance, which may be accomplished by assuring high yields, maximizing profits, and safeguarding the environment. Precision agriculture refers to practices that make use of Internet of Things (IoT) technology to guarantee efficient use of available resources, with the goal of increasing agricultural yields while simultaneously lowering operating expenses [1–3]. In precision agriculture, the Internet of Things offers a number of applications, but the most essential ones are crop water management, insect control and management, accurate detection and nutrients management, and safe storage management. It is possible to get all of the measurements by using sensors, and after that, the data is either saved in the cloud or on a network server for further processing, as illustrated in Figure 1. The evolution of sensors over time demonstrates the progress that has been made in the measurement of a wide variety of parameters, including temperature, pH, humidity, and analytical parameters such as potassium, phosphorous, and Nitrogen measurements from a remote location. Examples of these parameters include temperature, pH, and humidity.

Agriculture is a very significant contributor to the overall economy of India. More than seventy percent of rural households rely primarily on revenue from agriculture for their financial stability. Agriculture is an essential part of the Indian economy, as it is responsible for the employment of more than sixty percent of the nation's total population and contributes around seventeen percent to the overall gross domestic product of the country. The agriculture industry in India has seen extraordinary growth over the course of the previous few decades. On the other hand, the fact that so many farmers in India are taking their own lives is very troubling. The following reasons were offered by farmers as to why they took their own lives, ranked from most significant to least important: debt, the environment, low food prices, poor irrigation, greater expenses of farming, the use of chemical fertilizers, and crop failure. Intuition and other irrelevant considerations, such as the need to generate quick profits, a lack of information about market demand, overestimating a soil's capacity to sustain a particular crop, and so on, have a tendency to obscure a farmer's choice about which crop to produce, which may make the decision difficult for the farmer to make. An immediate work that has to be finished as quickly as feasible is the creation of a system that may provide Indian farmers with predictive insights and aid them in making an intelligent decision about which crop to produce. This endeavor needs to be finished as quickly as possible. As a result of this, there is an increasing need for "smart farming," which is enabled by the Internet of Things (IoT). The use of technology that is connected to the internet of things (IoT) in agriculture has the potential to transform not just human life but also the whole planet. By analyzing sensor data, agricultural operations become more transparent, providing farmers with the opportunity to get crucial insights into the health of their crops, greenhouses, and other facilities. A novel concept that is gaining popularity in today's society is farming which is guided by machine learning and using algorithms with a high degree of accuracy. This innovative initiative is making sustainable product creation possible for everyone working in the agriculture industry. This movement intends to increase both the quantity and quality of the products that are currently being manufactured. Computer Engineering by Pratiksha Nikhare. Pratiksha Nikhare. K.J. Somaiya Of Engineering Mumbai, India Atharva Sandbhor and K.J. Somaiya of the Engineering Department in Mumbai, India have written a paper titled "Computer Engineering." We propose as a solution for smart management of crop cultivation using IoT and machine learning a smart system that can assist farmers in crop management by taking into consideration sensed parameters (temperature, humidity), as well as other parameters (soil type, location of farm, rainfall), that predicts the most suitable crop to grow in that environment. This smart system can assist farmers in crop management by taking into consideration sensed parameters (temperature, humidity), as well as other parameters (location of farm, rainfall). In light of this, we have devised a method for the intelligent management of crop cultivation that makes use of both the internet of things and machine learning.

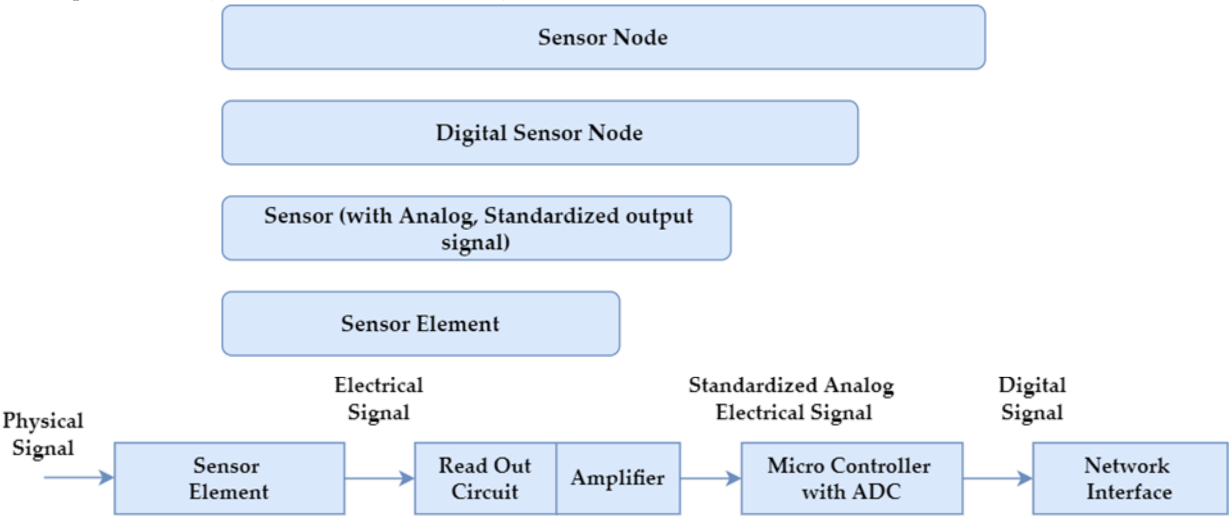

Fig.1. Historical progression of sensors.

The cloud connects the answers obtained from sensors situated in a variety of different geographical locations [4–6]. Sensors are connected to one another in order to establish a network, which may then be accessed or linked through the cloud or backend. There are a total of four separate phases, beginning with smart objects that did not have any kind of connection and progressing all the way up to distributed control systems that used programmable logic controllers. The second stage saw a local exchange of information take place. The subsequent phase will consist of communication that is based on the internet with the aim of monitoring and regulating different components of the internet. The last phase incorporates open control loops, global control loops, and regional control loops, in addition to the Internet of Things [7,8]. Examples of integrated product life cycle management and supply chain management for the internet of things [9–11]. The following outline constitutes the paper's overall format: The content of this essay is divided into five sections, the first of which focuses on reinforcing the concept of deploying a module to propose the crop for irrigation and obtaining maximum output with the crop that is suggested. In the following paragraphs, we'll talk about several applications of the Internet of Things that have been made in the agricultural industry, including precision agriculture, which makes use of machine learning techniques. Following this is the method, then the proposed flowchart, and lastly the apparatus that will be used in the experiment. Next comes the experimental analysis, followed by the ensuing discussion, and finally the references [40][41].

2. Literature Review

According to the findings of the study published in [9], titled Climate Change Crop Yield Assumptions, it is projected that crop yields would fall, with the highest declines to be anticipated in a number of rising countries such as Southeast Asia (-5 percent) and India (-5 percent). [10] The variation in on-farm losses across regions may be partially explained by a number of different reasons, such as difficulties with infrastructure and marketing, unsuitable harvest timing, unexpectedly harsh climatic conditions, and an inability to predict crops that are suitable for farming in such climates. All of these factors may contribute to the problem. Losses that occur on a farm may be caused by any or all of these variables. The comparison that comes next is shown in the following table: Researchers RushikaGhadge, JuileeKulkarni, Pooja More, and Sachee Nene, together with Priya R. L., use both unsupervised and supervised learning techniques in their work [1]. These techniques include the Kohonen Self-Organizing Map and the Back Propagation Network. Learning networks are used to train a dataset, which then classifies the data as organic, inorganic, or real estate in order to make predictions about the kind of soil. It does this by contrasting the degrees of accuracy achieved by various network learning methods, and it then provides the end user with the result that is the most accurate. The system will analyze the quality of the soil, provide an accurate prediction of crop production, and, based on the results, make a suggestion for the appropriate amount of fertilizer to apply. Reference The MODIFIED SUPPORT VECTOR REGRESSION, which is a well-known machine learning approach, along with four additional modules, are utilized in the research [2] to calculate a real-time sampling of soil properties. This was done in order to improve the accuracy of the results. The Modules include an Agricultural Cloud, an Analysis of Real-Time Sensor Data, and an Agricultural User Interface. The Modules also include a Sensor that is interfaced to an Internet of Things device (AUI). The first module is a transportable Internet of Things device known as a NodeMCU. It is equipped with a number of environmental sensors, including a pH sensor and a soil moisture sensor. Included in this package is the storage component of the Agri cloud module. An examination of the real-time data module consists of the processing of the many different kinds of crops and small plants that have been suggested by utilizing a modified support vector machine approach. The agri-user interface is a good illustration of a straightforward online interface. Consequently, with the aid of a customized support vector machine algorithm, a farmer will be able to receive various kinds of crops and small plants that are grown on farms. With the help of the characteristics of the soil, this will be achievable [42][43][44].

Machine learning has been the single most important factor in recent scientific and technological advances. When generating crop suggestions using the internet, reputable magazine articles, and machine learning algorithms of choice, it is advisable to consider the expectations of both the client and the server in light of the recent improvements that have been made in the process control sector. It is dissected using the many easily available resources, such as the conferences that support the system, as examples. Web journals that are available online give not only helpful information but also, in most circumstances, guidance and potential solutions in the event that an issue arises. It is essential to have the ability to anticipate problems and deceptions of this kind, which, if not addressed, might result in disastrous implications if they are not resolved. Internet of Things technology is used by M.S. Paroquet et al. (2019) [12] to autonomously manage and monitor agricultural crops. S. Al-Sarawi et al (2017) [13] A small number of Internet of Things and communication technologies and protocols, such as Bluetooth Low Energy (BLE), Near Field Communication (NFC), Low Power Wide Area Network (LPWAN), and Low Power Wide Area Network (LoWPAN), are used by a collection of intelligent devices in order to facilitate the sharing of data. According to Agrawal et al. (2019), [14] the best use of technology for farmers may be accomplished via the Internet of Things as well as using specific chips, integrated sensors, and smartphone applications. Farmers are able to keep track of the temperature, the amount of rainfall, and the fertility of the soil, and they may also get recommendations on which plantations should be planted. The productivity of Vadapalli et al. (2020) [15] is based on getting data from the sensors employing modern electronic devices in order to carry out smart agriculture via IoT. This is necessary in order to increase crop yields. J. Gubbi et al. (2013) [16] present innovation in the Internet of Things by utilizing ubiquitous computing and online sharing of information from all around present sensors sensing enabled by WSN across a wide variety of places of contemporary habitation. This can be done in a number of different types of modern homes. According to M. Stores et al. (2016) [17], the Internet of Things has accelerated agriculture by using a distinct three-layer architecture that utilizes a low-power LoRaWAN, the gateways connecting all devices through IoT, and the cloud as the third layer. This design has been implemented. This article has catapulted agricultural practices to the forefront of cutting-edge agricultural techniques, which are the key building blocks for constructing a sustainable environment in rising countries. This has been accomplished as a direct result of this essay. Liu et al. (2018) [18] used traditional neural networks and ARIMA techniques to anticipate the temperature with the help of IoT at varying granularities with reference to time. [19] According to S. Pudumalar and colleagues, modern agricultural methods involve not only the collection of data on crop yields but also the inclusion of research data about the qualities of the soil and the types of soil. An ensemble model with a voting strategy that uses a tree category algorithm, CHAID, KNN, and function-based Naive Bayes as machine learners was used to suggest crops. This model also used a voting method. R. Katarya et al (2020) [20] Several methods that make use of modern technology, such as presenting crop recommender systems that make use of algorithms such as similarity-based models, ensemble-based models, neural networks, and KNN, are applied. One example of this kind of method is "crop recommender systems." Because they provided the most helpful crop suggestions, the data on the weather, temperature, as well as the profile and texture of the soil, were chosen as the factors to study. Laurens Klerkx et al (2019) [21] There have been various hypotheses put forward regarding the existence of five distinct theme clusters, some of which include the following: the digitization of farming, the digitization of skills and farm labor, the consideration of ethics in agricultural production systems, and the deployment of knowledge and innovation systems in agriculture. The maintenance of value chains with an eye toward economics and with the aim of managing digital agriculture. As part of a future research agenda for intelligent farming and agriculture, Shadrin et al. (2019) [22] suggested an AI-enabled monitoring system for projecting the growth dynamics of plant leaves. 4.0. An embedded system that consists of low-powered sensors and a graphics processing unit (GPU) that runs an artificial intelligence system based on neural networks. The RNN cum LSTM is at the core of the artificial intelligence system, which, when fueled by a Li-ion battery, is promised to operate for a period of one hundred and eighty days without fail. According to the findings of Kumar et al(2018)[23] .'s study on the use of information technology in agriculture, wireless sensor networks (WSN) are an important component of the data collection, monitoring, and analysis processes that take place in agricultural areas. The data indicate that there has been a considerable improvement not just in the quantity but also in the quality of the crops. An investigation of the potential role that wireless sensor networks may play in the off-site monitoring of agricultural production is presented here in the form of research [45][46][47].

According to TanhaTalaviya et al. (2020), [24] the use of artificial intelligence (AI) in agriculture for irrigation, weeding, and fertilizing with the support of sensor networks and drones, also known as unmanned aerial vehicles, is transforming the agricultural industry. The results have indicated that both productivity and quality have grown, and this article is also a survey report providing automation in agriculture in recent trends utilizing drones for spraying and monitoring crops. In addition, the article presents the conclusions of the study. Anitha, P. et al. (2018) [25] [Citation needed] [Further citation is required] Agriculture that is carried out via the use of feed-forward algorithms and artificial neural networks (ANN) to produce production projections. Anticipatory control is the name given to this method of agricultural production. a traditional method of irrigation and fertilization that, according to P. Rekha et al. (2017) [26], leads to a poorer crop output and, as a result, reduced revenue for the farmers that employ it. The architecture of the Internet of Things was able to aid farmers in raising their total productivity as well as their earnings. RF and WSN technologies, which also include sensor networks, are utilized in order to send and receive data, make the most effective use of fertilizers, and monitor the crop around-the-clock with the assistance of an android mobile application that forecasts the weather. This can be accomplished by using RF and WSN technologies. According to Rehman et al. (2020) [27], all agricultural activities that are reliant on environmental data such as soil conditions, temperature, and moisture may be anticipated using machine learning algorithms. This includes soil conditions, temperature, and moisture. Some of the algorithms that are used in IoT-based smart farming include instance-based KNN, ANN/MLP, and RBF. This kind of farming is becoming more popular. Deep learning algorithms such as ANN are able to do exact cropping at the most appropriate time, as stated in P. K. Priya et al. (2019) [28]. Providing inputs such as moisture, temperature, pH, and humidity via the use of a sensor network and the Internet of Things allows for the creation of crop forecasts with the use of deep neural networks and graphical user interfaces. Crop ideas have the potential to be of significant use to farmers throughout the process of deciding which crops to produce on their farms. The authors of the study H. B. Biradar et al. (2019) [29] calculated the agricultural water need and included IoT, Cloud computing, and CPS- Cyber-physical systems, each of which plays an important part in increasing production, feeding the world, and avoiding famine. [29] The authors of the study H. B. Biradar et al. Raves Akhter et al (2021) [30] This article offers a succinct description of the most current advancements in agricultural technology, including data mining and analytics, machine learning, wireless sensor networks, and interfacing with the Internet of Things. This article makes predictions regarding apple disease that is prevalent in apple orchards across the Kashmir valley by using machine learning (a simple regression model) and IOT Data analytics. This article focuses mostly on making predictions on the future of smart agriculture, which is a relatively new sector of technology. This article by Archana Gupta et al. (2021) [31] offers helpful information on smart farming via the use of machine learning to decide which crop will produce the maximum yield depending on the environmental and sensor network characteristics. Smart farming that is enabled by the internet of things enhances agriculture in general and increases crop yield. It also makes it possible to make recommendations regarding which crops will provide real-time monitoring of the relevant parameters in order to achieve the highest possible levels of both productivity and quality. This makes it possible to make recommendations regarding which crops will provide real-time monitoring of the relevant parameters. This work by Vivekanandhan et al. (2021) [32] affects the feature selection, preprocessing and followed by classification using fuzzy rule-based to check the input parameters and predict the environmental changes effectively and attain smart irrigation.

3. Methodology

In order to make the experiment more comprehensible and provide more clarification about the suggested framework, the phrases and materials that were used in it have been outlined [48][40][50].

a.IoT Infrastructure for the Agricultural Sector

The data from the real world, which are kept on a variety of different media, are linked up to a database management system that is hosted in the cloud in order for the proposed system to function. As can be seen in Figure 2, the request is then sent on to a model that has been developed using machine learning. Figure 3 is an illustration of how the output of the module corresponds to one of 22 potential crops that are available for implementation [51].

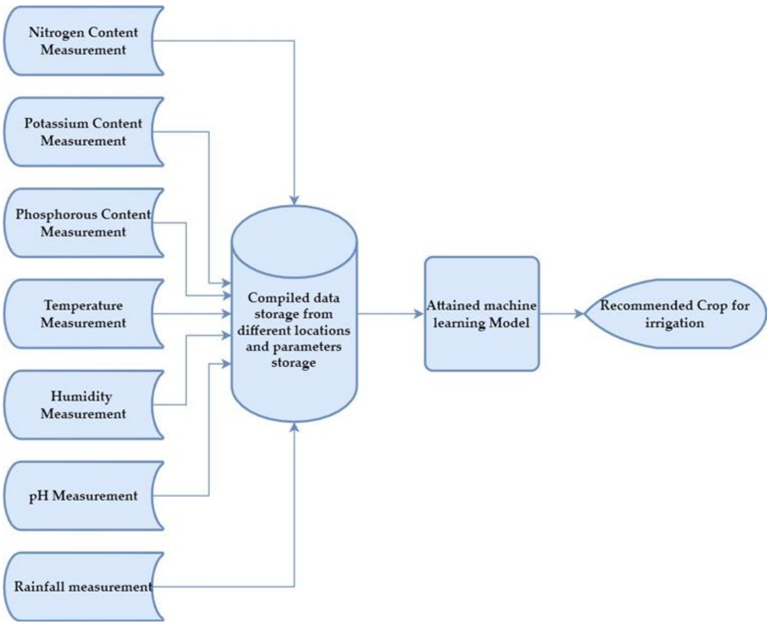

Fig. 2: Client-Server Model Suggested for the Internet of Things.

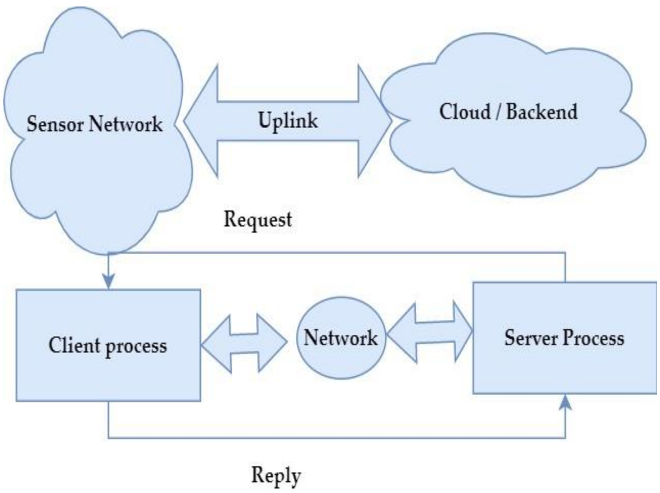

Fig. 3: Block diagram using the Machine Learning Module

b. The Mining of Data and the Implementation of Networks

In the initial level of the design, the capabilities to capture data and provide communication utilities are enabled. The gateway and the base station are connected to the sensor network via the connection. The second level of the system incorporates both the module for the classification method as well as the classification specification. The subsequent stage is putting the machine learning algorithms to work in order to get the results from the server. The server is outfitted with a trained module that can identify the specific crop that needs further watering and retrieve it. Analytical sensors are used to gather data on the factors such as nitrogen, phosphorous, potassium, and pH, and this information is then kept in the module. Analytical sensors also collect data on the factors. Readings for various characteristics, such as temperature, humidity, and precipitation, are obtained with the use of specialized sensors and then recorded into a database for further analysis. The data that has been compiled is stored in a spreadsheet together with the ground truth, which may be gained by having information on the 22 different crops that are offered, as shown in Figure 3. After the module has been trained with the use of an algorithm for machine learning, the model that has been produced is prepared to make suggestions to the user about which crop should be irrigated. The process flow of Internet of Things-based smart agriculture is shown in Figure 4, which shows how this kind of agriculture may be produced by combining numerous different disciplines. Constructing the body in its entirety The process of monitoring and control includes a number of processes, including the acquisition of data, the processing of such data, and the performance of data analytics. Kaggle was the website that served as our primary resource for obtaining the datasheet [33]. Advice is sought about a crop in order to estimate the crop for the purposes of irrigating it and achieving maximum yield. This is done to ensure that output is at its highest possible level.

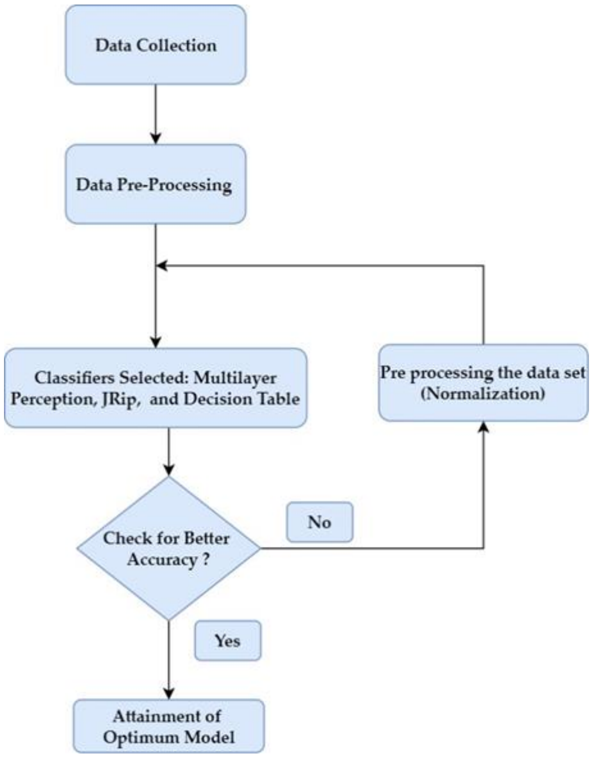

Fig. 4 shows the suggested modeling of the crop module setup.

The need for irrigation of crops is determined by a number of environmental elements as well as the fertility of the soil, which is measured by the amount of readily accessible nutrients such as nitrogen, phosphorus, and humidity. The seven characteristics may be used to choose a crop for irrigation, which allows for the achievement of a maximum yield. This article may be used to assist in the formation of sound judgments on the planting of various types of crops. The Waikato Environment for Knowledge Analysis, also known as WEKA, is a piece of open-source data mining software that was developed at the University of Waikato in Hamilton, New Zealand. It was released under the GNU public license, and it provides its users with the freedom to carry out the majority of the various data mining works [34].

It is a collection of a variety of computers that learn various algorithms in order to do data mining tasks. It is a portion of a system that contains a variety of processes that are known as file preparation, clustering, regression, information preprocessing, classification, Association rules, instance-primarily based fully categorizing, and visualizing. This portion of the system is referred to as the preprocessing stage. The process of organizing the project is carried out with the assistance of a piece of software called WEKA, which models the previously described intelligent placement by making use of photo processing. This program is used to carry out the procedure involved in arranging the project.

Table 1: A lookup table including crop recommendations together with their associated numerical data

S.No	**Parameters Count**	**OccurrencesCount**	**HarvestSuggested**
i	9	150	Basmati Rice
Ii	9	150	Sweet Corn
Iii	9	150	Chickpea
Iv	9	150	Beans
V	9	150	Peas
Vi	9	150	Musk Mellon
vii	9	150	Mellon
viii	9	150	Green Chilley
Ix	9	150	Lentil

X	9	150	Orange
Xi	9	150	Banana
Xii	9	150	Mango
xiii	9	150	Grapes
Xiv	9	150	Watermelon
Xv	9	150	Muskmelon
Xvi	9	150	apple
xvii	9	150	orange
xviii	9	150	Pomegranates
Xix	9	150	Coconut
Xx	9	150	Cotton
Xxi	9	150	Cloths
xxii	9	150	Tea
	Total	3000	

4. The Results of the Experiment, Along with Some Discussion

After the data have been gathered, the dataset is next transformed into a comma-delimited excel format (CSV file), which is suitable for usage to train the data set in the WEKA tool applying supervised learning techniques. After this step, the dataset is ready to be used. After the preprocessing stage has been completed, the classification procedure will be carried out for the classifiers that have been chosen, after which the performance characteristics will be documented and tabulated. By using a preprocessing strategy known as nominal to binary attribute selection, it is feasible to reduce the amount of time needed to develop the model. This is one of the ways in which this may be accomplished.

Based on the results shown in Table 3, the best model is able to produce a classification or crop recommendation that is capable of delivering exceptionally accurate predictions on the basis of the data set and seven separate characteristics. For the goal of putting the machine learning strategy into practice, we decided to make use of three different classifiers: one based on functions, and two based on rules. As can be seen in Figure 5, the accuracy performance percentages that these classifiers provided for us ranged from 98.2293% to 88.5909% for the multilayer perceptron classifier and the JRip classifier, respectively. For the lazy category classifier decision table and the multilayer perceptron, respectively, the receiver operator characteristics varied from 0.991 to 0.999 [40][41].

Table 2 presents the findings of the first research conducted on the model that underwent iteration.

			Instances(%)		
1	Purposes	MLP	99.2373	0.999	Kappanumber0.999
2	Idle	Decisiontable	89.6909	0.995	Nastytotalerror0.006
3	Idle	JRip	98.4373	0.998	Originmeanformederror0.055

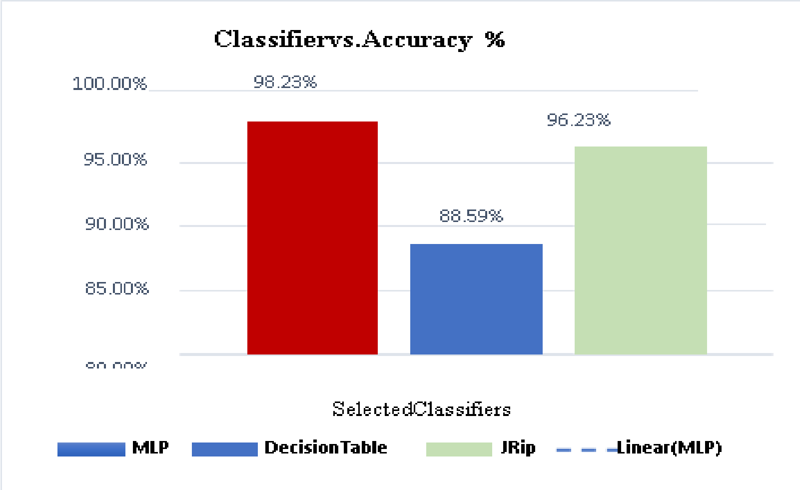

Fig.5. Classifier versus Performance accuracy percentage characteristics.

The performance of the three distinct classifiers, namely the multilayer perceptron, the decision table, and the JRip, has demonstrated exceptionally small errors and RMSE errors in the range of 0.1384 to 0.058. [Citation needed] [Citation needed] The weighted receiver operator characteristics 1 are the next characteristics that need to be considered in the process of constructing the model. These characteristics will give us an ideal model and MLP that has a larger ROC than the classifiers that were picked, as can be shown in Figure 6. The amount of time needed to build the model may vary anywhere from 10.56 seconds to 0.23 seconds when using a decision table or a multilayer perceptron classifier, respectively [42][43].

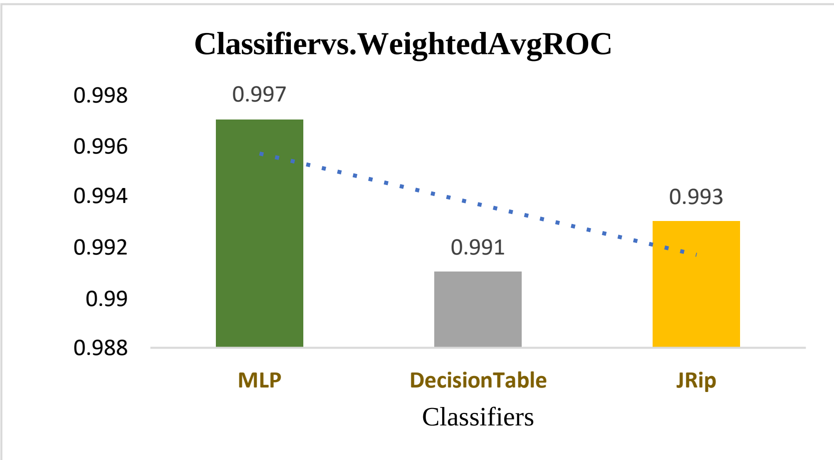

Fig. 6. Comparing the features of the Classifier and the Receiver Operator.

Normalization, which occurs during the preparation of the data set, results in a decrease in the amount of time spent creating the model and an improvement in the ROC measure, such that practically all classifiers now exhibit about the same measure. According to the results of the model's performance, the accurate cy percentage ranges from 98.2293% for multilayer perceptron to

88.59% for the Lazy category decision table classifier. The second iteration of the model makes it abundantly evident that the amount of time needed to construct the model may be cut down by doing preprocessing on the data set in the form of normalization, as seen in Table 4. Even after normalizing the data set, the results of the iterated model that was run after the preprocessing step show that the accuracy performance did not change. However, the amount of time necessary to construct the model significantly altered. The data collection is standardized to cut down on instances of redundancy and speed up the process of achieving the desired outcome [4].

Figure 9shows the accuracy percentage is 98.22% for MLP and 96% for JRip after thenormalization of data has not deviated from the result. The two iterated model characteristics clearly show that the performance accuracy has not varied. Figure 8 shows thevariationsinthe building.

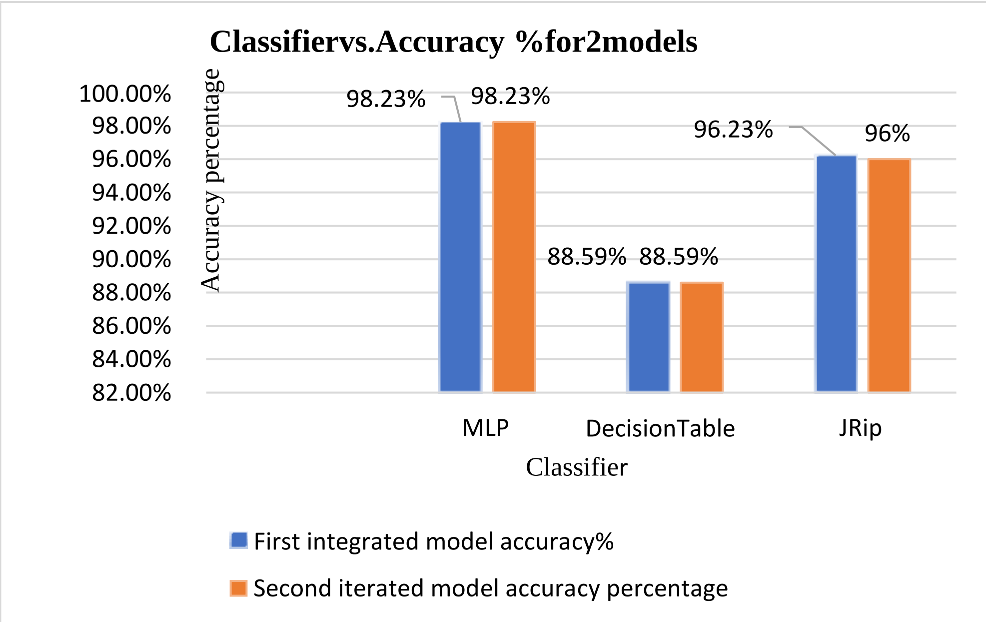

Fig. 9 illustrates the relationship between classifier accuracy and performance accuracy % features.

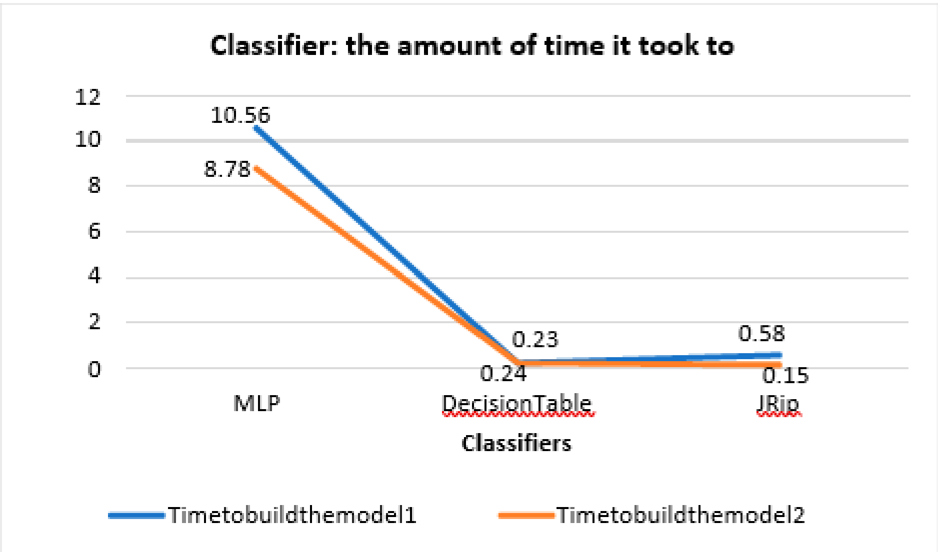

Figure8. Classifier versus time taken to build model1 and model2.

5. Conclusions and Future Scope

This article is now a helpful module that can be used to determine which crops should be irrigated and how much water should be used in order to achieve optimal yield in light of the current environmental conditions. This may also serve as a guide for any unknown person who is in need of any agricultural advise so that they do not have to go through the process of learning from their mistakes via the use of trial-and-error methods. We were able to develop a model in the agriculture business that used IoT thanks to the cutting-edge machine learning technique that we used. This model provides assistance to farmers in picking the crop that would result in the greatest yield by only requiring them to measure the relevant characteristics. These parameters include rainfall, temperature, acidity, and humidity. Nitrogen, phosphorus, and potassium are also included. In the not-too-distant future, the agricultural sector will be turned into smart agriculture, and it will never again suffer any reduction in production, yield, or quality; as a consequence, the agricultural sector will evolve toward precision farming that is based on AI and the Internet of Things. The Internet of Things and machine learning are two cutting-edge technologies that are now undergoing development. In this article, we present a unique technique for attaining smart agriculture by merging these two cutting-edge technologies. Utilizing both live and historical data may provide a helping hand toward achieving more precision in the outcome, which in turn can assist to improve the accuracy of the result. The precision of the system may also be increased by analyzing the performance of many machine learning approaches simultaneously. The farmers will use this strategy to assist ease the issues that they are now experiencing, which will result in an improvement in both the quantity and quality of the work that the farmers do. The system has the potential to be enhanced further so that it may add the following functionality: the use of soil moisture sensors, environment sensors, and pH sensors in order to increase the accuracy when predicting the crop. This would be a step in the right direction. The following is included in the system's planned scope for the future: It is possible to take into account both the market demands of the area and the crop that is already being cultivated by farmers in the surrounding area when making a crop recommendation.

References

[1] Ray,P.P.InternetofThingsforsmartagriculture:Technologiespracticesandfuturedirection.*J.Ambient.Intell.SmartEnviron.***2019**,*9*,395–420.[CrossRef]

[2] Kamienski,C.;Soininen,J.P.;Taumberger,M.;Dantas,R.;Toscano,A.;SalmonCinotti,T.;FilevMaia,R.;TorreNeto,A.SmartWaterManagementPlatform:IoTBasedPrecisionIrrigationforAgriculture.*Sensors***2019**,*19*,296.[CrossRef][PubMed]

[3] Ojha,T.;Misra,S.;Raghuwanshi,N.S.Wirelesssensornetworksforagriculture:Thestate-of-the-artinpracticeandfuturechallenges.*Comput.Electron.Agric.***2015**,*118*,66–84.[CrossRef]

[4] Vijayan,T.;Sangeetha,M.;Kumaravel,A.;Karthik,B.FeatureselectionforSimpleColorHistogramFilterbasedonRetinalFundusImagesforDiabeticRetinopathyrecognition.*IETEJ.Res.***2020**,1–8.[CrossRef]

[5] Lavanya,G.;Rani,C.;GaneshKumar,P.AnautomatedlowcostIoTbasedFertilizerIntimationSystemforsmartagriculture.

[6] *Sustain.Comput.Inform.Syst.***2020**,*28*,150300.

[7] Sivakumar,M.;Renuka,P.;Chitra,P.;Karthikeyan,S.IoTincorporateddeeplearningmodelcombinedwithSmartBintechnologyforreal-timesolidwastemanagement.*Comput.Intell.***2021**.[CrossRef]

[8] Katarya, R.; Raturi, A.; Mehndiratta, A.; Thapper, A. Impact of Machine Learning Techniques in Precision Agriculture.InProceedingsofthe2020,3rdInternationalConferenceonEmergingTechnologiesinComputerEngineering:MachineLearningandInternetofThings,ICETCE,Jaipur,India,9–8February2020;pp.1–6.[CrossRef]

[9] Anitha,P.;Chakravarthy,T.AgriculturalCropYieldPredictionusingArtificialNeuralNetworkwithFeedForwardAlgorithm.

[10] *Int.J.Comput.Sci.Eng.***2018**,*6*,198–181.[CrossRef]

[11] Anand,R.;Karthiga,R.D.;Jeevitha,T.;Mithra,J.L.;Yuvaraj,S.BlockchainBasedAgricultureAssistance.*Lect.NotesElectr.Eng.***2021**,*900*,499.[CrossRef]

[12] Prasath,J.S.;Jayakumar,S.;Karthikeyan,K.Realtimeimplementationforsecuremonitoringofwastewatertreatmentplantsusinginternetofthings.*Int.J.Innov.Technol.Explo .Eng.***2019**,*9*,2999–3002.[CrossRef]

[13] Anuradha,T.;Ramya,K.;Selvam,R.Designandimplementationofsolar-poweredautomaticpesticidesprayerforagriculture.*J.*

Phys.Conf.Ser. **2019**,*1362*,12048.[CrossRef]
[14] Farooq,M.S.;Riaz,S.;Abid,A.;Abid,K.;Naeem,M.A.ASurveyontheRoleofIoTinAgriculturefortheImplementationofSmart Farming.*IEEEAccess***2019**,*9*, 156239–156291.[CrossRef]
[15] Al-Sarawi,S.;Anbar,M.;Alieyan,K.;Alzubaidi,M.InternetofThings(IoT)communicationprotocols:Review.InProceedingsofthe8thInternationalConferenceonInformationTechnology(ICIT),Singapore,29–29December2019;pp.685–690.[CrossRef]
[16] Agrawal,K.SmartAgricultureUsingIOT:AFuturisticApproach.*Int.J.Inf.Dissem.Technol.***2019**,*9*,186.[CrossRef]
[17] Vadapalli,A.;Peravali,S.;Dadi,V.SmartAgricultureSystemusingIoTTechnology.*Int.J.Adv.Res.Sci.Eng.***2019**,*9*,58–65.
[18] Gubbi,J.;Buyya,R.;Marusic,S.;Palaniswami,M.InternetofThings(IoT):Avisionarchitecturalelementsandfuturedirections.
[19] *FutureGener.Comput.Syst.***2013**,*29*,1645–1660.[CrossRef]
*[20]*Stoes,M.;Vank,J.;Masner,J.;Pavlik,J.InternetofThings(IoT)inagriculture-selectedaspects.*AgrisOn-LinePap.Econ.Inform.*
[21] **2016**,*8*,83–88.[CrossRef]
[22] Liu,X.;Zhang,C.;Zhang,P.;Yan,M.;Yan,B.;Zhang,J.;Higgs,R.Applicationoftemperaturepredictionbasedonneuralnetworkinintrusion detectionof IoT.*Secur.Commun.Netw.***2018**,*2018*, 1635081.[CrossRef]
[23] Pudumalar, S.; Ramanujam, E.; Rajashree, R.H.; Kavya, C.; Kiruthika, T.; Nisha, J. Crop recommendation system for precisionagriculture. In Proceedings of the 2016 Eighth International Conference on Advanced Computing (ICoAC), Chennai, India, 19–21January2019;pp.32–36.[CrossRef]
[24] Kamienski,C.;Jentsch,M.;Eisenhauer,M.;Kiljander,J.;Ferrera,E.;Rosengren,P.;Thestrup,J.;Souto,E.;Andrade,W.;Sadok,D.Application Development for the Internet of Things: A Context-Aware Mixed Criticality Systems Development Platform. *Comput.Commun.***2019**,*104*,1–16.[CrossRef]
[25] Klerkx, L.; Jakku, E.; Labarthe, P. A review of social science on digital agriculture, smart farming and agriculture 4.0.Newcontributionsandafutureresearchagenda, NJAS—Wageningen.*J.LifeSci.***2019**,*90*,150315.[CrossRef]
[26] Shadrin,D.;Menshchikov,A.;Somov,A.;Bornemann,G.;Hauslage,J.;Fedorov,M.EnablingPrecisionAgricultureThroughEmbeddedSensingWithArtificialIntelligence.*IEEETrans.Instrum. Meas.* **2019**,*69*,4103–4113.[CrossRef]
[27] Kumar, S.A.; Ilango, P. The Impact of Wireless Sensor Network in the Field of Precision Agriculture: A Review.*Wirel. Pers.Commun.***2018**,*98*,685–698.[CrossRef]
[28] Talaviya, T.; Shah, D.; Patel, N.; Yagnik, H.; Shah, M. Implementation of artificial intelligence in agriculture for optimization ofirrigationandapplicationof pesticidesandherbicides.*Artif.Intell.Agric.***2020**,*4*, 58–93.[CrossRef]
[29] Kamilaris, A.; Gao, F.; Prenafeta-Boldu, F.X.; Ali, M.I. Agri-IoT: A semantic framework for Internet of Things-enabled smartfarming applications. In Proceedings of the 2016 IEEE 3rd World Forum on Internet of Things (WF-IoT), Reston, VA, USA, 12–14December2016.[CrossRef]
[30] Rekha, P.; Rangan, V.P.; Ramesh, M.V.; Nibi, K.V. High yield groundnut agronomy: An IoT based precision farming framework.InProceedingsofthe2019IEEEGlobal HumanitarianTechnologyConference(GHTC),SanJose,CA,USA,19–22October2019;pp.1–5.[CrossRef]
[31] Rehman,A.;Liu,J.;Li,K.;Mateen,A.;Yasin,Q.MachineLearningPredictionAnalysisusingIoTforSmartFarming.*Int.J.Emerg.TrendsEng.Res.***2020**,*8*,1–30.[CrossRef]
*[32]*Priya,P.K.;Yuvaraj,N.AnIoTBasedGradientDescentApproachforPrecisionCropSuggestionusingMLP.*J.Phys.Conf.Ser.*
[33] **2019**,*1362*, 012038.[CrossRef]
[34] Biradar, H.B.; Shabadi, L. Review on IOT based multidisciplinary models for smart farming. In Proceedings of the 2019 2nd IEEEInternational Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT), Bangalore, India,19–20May2019;pp.1923–1926.[CrossRef]
[35] Akhter,R.;Sofi,S.A.PrecisionagricultureusingIoTdataanalyticsandmachinelearning.*J.KingSaudUniv.-Comput.Inf.Sci.***2021**.
[36] [CrossRef]
[37] Gupta, A.;Nagda, D.;Nikhare,P.; Sandbhor,A.Smart CropPredictionusing IoTand MachineLearning.*IJERT***2021**,*9*,18–21.
[38] Vivekanandhan,V.R.;Sakthivel,S.;Manikandan,

M.Adaptiveneurofuzzyinferencesystemtoenhancetheclassificationperformanceinsmartirrigationsystem.*Comput.Intell.***2021**.[CrossRef]

[39] Availableonline:https://www.kaggle.com/atharvaingle/crop-recommendation-dataset (accessed on 8 September 2021).

[40] Availableonline:https://www.cs.waikato.ac.nz/ml/WEKA/(accessedon6October2021).

[41] Kumar, V. and Kumar, R., 2015. An adaptive approach for detection of blackhole attack in mobile ad hoc network. *Procedia Computer Science*, *48*, pp.472-479.

[42] Kumar, V. and Kumar, R., 2015, April. Detection of phishing attack using visual cryptography in ad hoc network. In 2015 International Conference on Communications and Signal Processing (ICCSP) (pp. 1021-1025). IEEE.

[43] Kumar, V. and Kumar, R., 2015. An optimal authentication protocol using certificateless ID-based signature in MANET. In Security in Computing and Communications: Third International Symposium, SSCC 2015, Kochi, India, August 10-13, 2015. Proceedings 3 (pp. 110-121). Springer International Publishing.

[44] Kumar, Vimal, and Rakesh Kumar. "A cooperative black hole node detection and mitigation approach for MANETs." In Innovative Security Solutions for Information Technology and Communications: 8th International Conference, SECITC 2015, Bucharest, Romania, June 11-12, 2015. Revised Selected Papers 8, pp. 171-183. Springer International Publishing, 2015.

[45] Kumar, V., Shankar, M., Tripathi, A.M., Yadav, V., Rai, A.K., Khan, U. and Rahul, M., 2022. Prevention of Blackhole Attack in MANET using Certificateless Signature Scheme. Journal of Scientific & Industrial Research, 81(10), pp.1061-1072.

[46] Pentyala, S., Liu, M., & Dreyer, M. (2019). Multi-task networks with universe, group, and task feature learning. arXiv preprint arXiv:1907.01791.

[47] Srivastava, Swapnita, and P. K. Singh. "Proof of Optimality based on Greedy Algorithm for Offline Cache Replacement Algorithm." International Journal of Next-Generation Computing 13.3 (2022).

[48] Smiti, Puja, Swapnita Srivastava, and Nitin Rakesh. "Video and audio streaming issues in multimedia application." 2018 8th International Conference on Cloud Computing, Data Science & Engineering (Confluence). IEEE, 2018.

[49] Srivastava, Swapnita, and P. K. Singh. "HCIP: Hybrid Short Long History Table-based Cache Instruction Prefetcher." International Journal of Next-Generation Computing 13.3 (2022).

[50] Srivastava, Swapnita, and Shilpi Sharma. "Analysis of cyber related issues by implementing data mining Algorithm." 2019 9th International Conference on Cloud Computing, Data Science & Engineering (Confluence). IEEE, 2019.

[51] P Mall and P. Singh, "Credence-Net: a semi-supervised deep learning approach for medical images," Int. J. Nanotechnol., vol. 20, 2022.

[52] Narayan, Vipul, et al. "Deep Learning Approaches for Human Gait Recognition: A Review." 2023 International Conference on Artificial Intelligence and Smart Communication (AISC). IEEE, 2023.

[53] Narayan, Vipul, et al. "FuzzyNet: Medical Image Classification based on GLCM Texture Feature." 2023 International Conference on Artificial Intelligence and Smart Communication (AISC). IEEE, 2023.

[54] "Keyboard invariant biometric authentication." 2018 4th International Conference on Computational Intelligence & Communication Technology (CICT). IEEE, 2018.

[55] Mall, Pawan Kumar, et al. "Early Warning Signs Of Parkinson's Disease Prediction Using Machine Learning Technique." Journal of Pharmaceutical Negative Results (2023): 2607-2615.

[56] Pentyala, S., Liu, M., & Dreyer, M. (2019). Multi-task networks with universe, group, and task feature learning. arXiv preprint arXiv:1907.01791.

[57] Choudhary, Shubham, et al. "Fuzzy approach-based stable energy-efficient AODV routing protocol in mobile ad hoc networks." Software Defined Networking for Ad Hoc Networks. Cham: Springer International Publishing, 2022. 125-139.