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An Internet of Things-based Efficient Solution for Smart Farming

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Abstract

Agriculture is the major occupation and the main origin of income in India, and most of the population depends on agriculture for their living. The smart farming system's foremost goal is to monitor farmlands by automatically rinsing the lands with appropriate water and a pest detection framework. The conventional agricultural methods lack higher crop productivity with increased human efforts. Hence, the paper proposes an IoT-based solution for smart farming. The proposed system focuses on automatic irrigation of water and plant disease detection. It uses machine learning algorithms to accurately predict adequate water required by the fields and automatic pest identification based on the requirements of the farmland. K-Nearest Neighbour and support vector machine learning algorithms in the pest detection module are used to precisely predict plant diseases. The convenient features from the leaves of the plants were obtained. Then the obtained features are used for classification purposes. Extracting the suitable features and classifying them helps detect whether the plant is pest infected or not. The proposed system monitors, analyses, assesses and controls agricultural fields for the automatic irrigation of the water and disease identification of the plants. The numerical analysis of the machine learning algorithms and the significance of the classification with accuracy are investigated. From the numerical results, it is demonstrated that an accuracy of 84 % is achieved.

Keywords: Deep Learning; Neural Network; Farming; Internet of things; Classification; Feature extraction.

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1. Introduction

Water scarcity, the major crisis due to increased population, has affected people. The present world population is found to be approximately 7.2 billion. It is assumed to rise to nine billion by the year 2050. Agricultural processes mainly utilize most of the freshwater; irrigation takes more water. Developing countries lack the latest technologies and advanced equipment for farming compared to developed countries, leading to more water consumption, especially for irrigation. Therefore, there is a need to use the latest technologies for effective irrigation [1]. Plant disease is one significant problem faced by farmers. Early detection of plant diseases can help farmers make effective decisions and increase crop productivity. So, more precisely, there is a need to monitor the agricultural lands [2, 4].

Plants must be monitored continuously for any pests or other plant diseases simultaneously so immediate action can be taken accordingly [10]. Machine learning algorithms and IoT would be the best choice for detecting plant diseases to immediately take effective measures and appropriate irrigation without human intervention. Technological advancement has hugely impacted the world by proposing high precision crop control, advanced types of equipment, and obtaining useful data from sensors. These computerized techniques can solve all the problems to a greater extent. IoT can be vital in achieving smart farming methods and efficient farming. Using the IoT and combining the machine learning algorithms can effectively monitor the farms and higher yields. It is necessary to adopt advanced technologies and methods to address certain problems faced in the agricultural sector, like the water shortage problems and the availability of the farmlands. The world population is estimated to increase by 70% by 2050. There is an increased need and consumption of the resources. IoT can overcome these problems efficiently and appropriately using sources with reduced efforts. IoT plays a vital role in smart farming by using sensors designed to detect crop growth, soil moisture, and livestock feed levels to control and manage IoT-connected harvesting and irrigation equipment. IoT reduces human efforts and smartly monitors and controls farmlands accurately using the sensors. So far, IoT devices have proved to be inevitable in smart farming. However, some technical defaults remained, but they helped overcome the major problems faced in the agriculture sector. The smart farms had reduced water and power consumption rates to render higher crop yields than traditional farming methods. The soil status and plant health [12] were monitored more precisely, leading to the proper maintenance of the farmlands as effective measures were taken immediately when any issues were found.

The economy of India is highly dependent on agriculture and crop productivity. There is an urge to protect the farmlands using advanced techniques instead of conventional ones, lacking efficient, yielding methods. Mainly identifying the infection in plants is highly important in farming. The recognition of plant disease is significant in maintaining plant health [9, 11]. The quality and quantity of crop production can increase significantly when the plant diseases are identified in a preliminary phase [20]. Various machine learning algorithms, deep learning techniques, image processing techniques, and IoT have been implemented to deliver the expected outcomes in smart farming.

The paper suggests an IoT-based smart device for efficient farming by monitoring the agricultural lands for appropriate irrigation and pest detection using machine learning algorithms. Thus, saving water and power consumption and pest detection framework to increase crop productivity. Hence, the present paper presents an efficient IoT system for smart farming. The contributions are to investigate the concept of smart irrigation and plant disease detection system with the help of IoT and machine learning algorithms, and the contributions are 1) To build a system using an Arduino that processes the data from the soil sensor, which automatically waters the plant and analyzes the real-time condition of the soil, 2) The scope of this study is intended for farmers and the agricultural sector, 3) Monitoring and appropriate irrigation in the agricultural lands, 4) Machine learning algorithm (KNN) for accurately predicting adequate water required for farming fields, 5) Automatic irrigation along with automatic pest identification and spraying of pesticides. KNN and SVM algorithms for predicting plant diseases with precision, 6) The SVM algorithm automatically detects the pest-infected crops at the earlier stage. Arduino processes the data from the soil sensor and automatically waters the plant by analyzing the real-time condition of the soil.

2. Related Works

The smart farming work introduces a method to gather the real-time data of farms and then notify agriculturalists. The device helps the farmers by providing them with the necessary data of the soil, which are soil moisture, temperature, and soil nutrients level, to ensure the fertility of the soil. It helps to provide higher crop produce [1]. The work proposes a smart farming technique that obtains useful data using sensors for cultivating crops. The farmland conditions are maintained based on the values displayed by the sensors. Required enhancements can be incorporated by utilizing the data collected [2]. Work proposed an automated irrigation system that uses sensors to irrigate the soil based on moisture levels. A comparison between this system and manual irrigation is performed, and the proposed system is more efficient and consumes less power and water resources [3]. The work promotes the latest advancements in technologies for smart agriculture.

An intelligent smart irrigation model is built with the help of IoT technology and a machine learning method using the KNN algorithm. The main goal of the smart irrigation model is to provide adequate water required by crops by considering the soil's moisture and the climate conditions, thus preventing over-irrigation and under irrigation without human intervention [4]. It suggests and predicts the appropriate crop that can be grown in that particular farmland. A study on the cultivation of suitable crops is done [5]. It assists the farmers in knowing more about their farmland and the crops suitable for their agricultural lands. It leads to intelligent crop cultivation. Proper crops well grown in their farmlands are cultivated to increase productivity by a huge amount. The proposed study briefly describes the IoT-enabled agricultural environments for crop production. The energy requirements in farming are reduced using the proposed system [6, 13]. An innovative smart model is placed at the base station to calculate the energy required for the process. It proposed an algorithm for solving the energy requirement problem. The proposed algorithm was compared with existing algorithms, proved more accurate, and has improved performance [7].

The throughput is high, and the power consumed was less than the conventional method's power usage. A plant disease detection framework was implemented in [14]. Image acquisition, preprocessing, segmentation, and feature extraction was incorporated for accurate detection [10]. After the process, it can precisely conclude whether the plant is healthy or affected. A new method for detecting plant disease using deep learning was proposed [11]. Crop leaf images were used for detection purposes. The classifier was trained using the crop leaf images to differentiate the disease accurately.

It had improved accuracy and was consistent for varied epochs and filter sizes. A simulation environment is designed in [12] for taking snaps of the crop leaves. The nodes in the system obtain the data from the automatic module for crop disease detection and help the farmers take necessary actions [8, 9]. Hence, this leads to earlier detection of crop disease and appropriate action at the earliest stage. It can yield a high crop yield and minimize crop wastage. The performance of the implementation of this smart device had improved accuracy by 0.9156 [15]. The classification was done in different environmental conditions and still provided accurate results.

A plant requires enough water to grow; inadequate water can deter plant growth. The cell division, growth of different plant parts, cell division, and cell enlargement are all highly reliable on the soil moisture level. The quantity and quality of the plant produce are interrelated with the appropriate amount of watering and continuously checking the plant health. Also, environmental factors have an impact on the growth of plants. The work [15] presents a sensor cloud-based intelligent watering system for smart farming. IoT- based smart solution is built for cost-effective monitoring and watering farmlands based on environmental factors [12]. A cloud-based smart system was proposed, and alerts were sent to the farmers through a mobile app when the soil moisture level was low, and irrigation must be done. The flower blooming, size, and quality of the fruits and vegetables were increased when this system was deployed. The correct quantity of water was irrigated at the correct time based on these values obtained from the sensor network, and the sprinkler was activated. A timely alert is given immediately when the soil moisture is low.

The work [18] is one survey on potential applications of the IoT in the agriculture sector. This survey overviews all the advanced technologies widely employed to overcome the farmers' problems. It also describes the latest techniques, tools, and advancements to cultivate crop plants and other activities related to farming. The survey also describes a review that addresses the problems the plants growing in highly varying environments face. Smart farming techniques proved to be effective in a huge way by providing immediate remedies and timely action when abnormalities were found. It also discusses the challenges and possible smart solutions to precisely addressing them with reduced human efforts.

The earlier works [15, 17] explain a survey on IoT in arable farming and some enhancements that can be made more efficient. Currently, the issues faced are unavailability of mobile phones, connectivity issues, management of the sensors, middleware platforms, and the solutions to address these problems. The cost, energy consumption, bandwidth, privacy of data, and connectivity issues have been estimated as hurdles or challenges for encouraging smart farming and other advanced technologies. The farmer must be aware of the new advancements and operate them. The issues mentioned above have been reviewed in detail in [19].

IoT tends to be a significant technology in incorporating various techniques to provide smart solutions for all the identified problems. It helps establish communication between man and things effortlessly. IoT has solved many other industry problems but has a vital role in the agricultural sector [3]. The work suggests disease detection and crop cultivation information by analyzing the crops and terrain status using deep learning techniques, leading to improved productivity and quality for the crops cultivated in that particular land. Multi SVM algorithm, Random Forest, deep learning, and various image processing techniques were implemented in the proposed system. This method proved efficient for all the agricultural produce, from cultivation to consumption [7]. The IoT has allowed farmers to remotely monitor and maintain the soil and crops. The cheap and easy sensors monitor the soil fertility and alert when detected in the soil status. The farmers are aware of taking suitable steps to make the soil fertile. This method develops a system that allows the user a 24/7 visibility of the farmland to monitor the field without being physically present. It presents precision farming that promises an energy-efficient low-cost, intelligent model for irrigation and monitoring soil nutrient levels without reduced human efforts.

The IoT allowed farmers to cultivate the soil using easy-to-install sensors and cheap and abundant intuitive information offered by the sensors. Expanding on this yielding build-up of the IoT in agriculture, smart farming applications are increasing ground with the promise to deliver 24/7 visibility into soil and crop health [21]. A new research study on IoT-based precision agriculture has reported that designing the energy-efficient data aggregation at the base station is an open research problem. It is motivated by new developments in energy-efficient systems and the algorithms to maintain energy requirements at the base station. The base station is an energy-constrained device. It has to survive by maintaining energy requirements from different sensors and the gateway modules. The base station has different power requirements based on various wireless communication mediums. The various power consumption modes can be high power, low power, and medium power mode. The works [15, 21] present a novel model for estimating the power requirements of any base station. The algorithm developed and implemented in the work was the improved duty cycling algorithm. It increased throughput and energy consumption compared to other earlier algorithms and methods. The proposed system had increased throughput and reduced consumption of power resources. The proposed system accurately estimated the required amount of power, thereby reducing and preserving the power resources by implementing the proposed algorithm.

The soil moisture level decides the plant health and quality of crop production. A sensor network to collect the soil moisture data has been used. A prototype for analyzing the soil moisture level data from the sensor input and transmitting that data for future processes is deployed [26]. ARM7, a low-power processor, had been used as a controller. The sensor node includes the sensors required for collecting the soil status, signal conditioning circuit, module for communication, and the low-power processor. The user can set the time to scan the time regularly, and based on that, respective processes can be carried out. Here, the crops are watered if they require water so that the major water crisis, which is water scarcity, can be prevented. There is no possibility of over or under irrigation as the proposed system irrigated the required amount of water at the right time. A radio frequency transmitter was used for logging and display [17, 23]. After deploying this system for a long period, it proved highly flexible, efficient, and reliable. This system provided a method for creating a large-scale remote smart irrigation system.

Water scarcity is the major crisis faced by the world. The farming lands are becoming infertile and barren due to a lack of proper irrigation. The surveys state that around twenty per cent of farmlands turn into barren lands and are not fertile enough for cultivation. Thus, this research gives an idea of a smart irrigation system to overcome this issue. Water is considered to be the most significant resource available to humankind. Water is crucial for improving agricultural productivity, and water utilization in the most efficient manner is an important concept to be followed to upgrade farming in the nation. It aids the farmers in distributing water to crops by giving them water when required, which helps prevent wastage of the water and degradation of soil [3]. The economy of our nation is highly dependent on agriculture. Still, the farmers' major problem is battling various plant diseases that kill the crops and affect productivity. This problem is solved using machine learning algorithms and detecting the plant disease before the crops get affected.

Hence, smart farming requires the continuous availability of the internet. The rural part of the developing countries does not fulfil these requirements. So, there is a need to establish a stable internet connection for smart farming techniques using IoT [28-30]. Moreover, the internet is slower. Fault sensors or data processing engines can cause faulty decisions, leading to water overuse, thereby wasting resources. Smart farming-based equipment requires the farmer to learn and know the methods and techniques adopted in these types of equipment. It is an important challenge to adopt smart agriculture farming. In this paper, an automated smart monitoring and irrigation system was developed to help farmers know their plants' status and a pest detection framework that helps eradicate pests and plant diseases at the earliest and yields higher crop production.

3. Proposed System

The architecture design of the proposed system, shown in Figure 1, consists of two main modules. The two basic modules of this proposed system are the soil monitoring module and the pest detection module. The soil monitoring module contains different sensors like the DHT11 sensor, soil moisture sensor, and flow sensor to determine the amount of water in the soil and to know the status of the soil by checking the temperature level, humidity, and moisture level of the soil, which also indicates the soil conditions. It aids in estimating the water requirements of the soil for irrigation. An automated irrigation system is proposed to conserve water and power resources and avoid excess irrigation, and the first module of the system. Therefore, the soil monitoring module works by sensing the soil moisture level using different sensors, and the KNN algorithm is deployed based on the sensor input data. A model is built and trained to predict the right quantity of water required for irrigation based on the requirements, the water pump is activated, and irrigation is done appropriately.

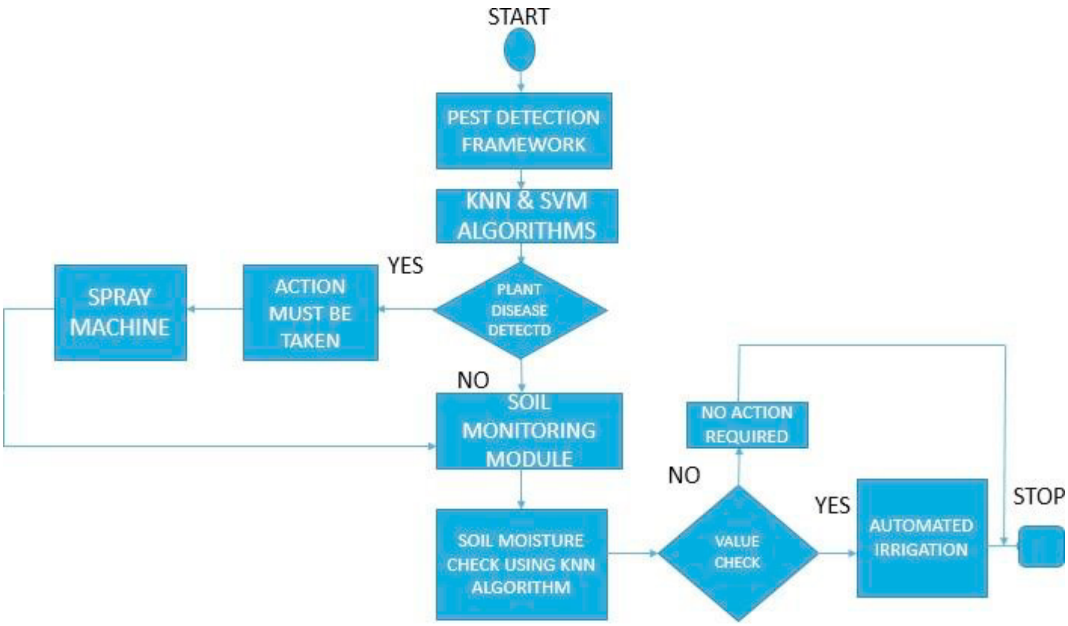

Fig. 1. Architecture of the proposed system.

The pest detection module takes crop leaf images as input. It uses image processing techniques and machine learning algorithms to detect whether or not the plant is affected by any plant diseases. KNN algorithm is used to classify the type of pests so that necessary action can be taken to eradicate them and protect the plant's health. Hence, the machine learning algorithms KNN and SVM were implemented to detect plant diseases accurately. KNN algorithm was used for classification, and the SVM algorithm was the decision boundary for determining whether the plant was infected. The images given as input were preprocessed, then suitable features were extracted, the algorithms were deployed, and the diseases were detected precisely.

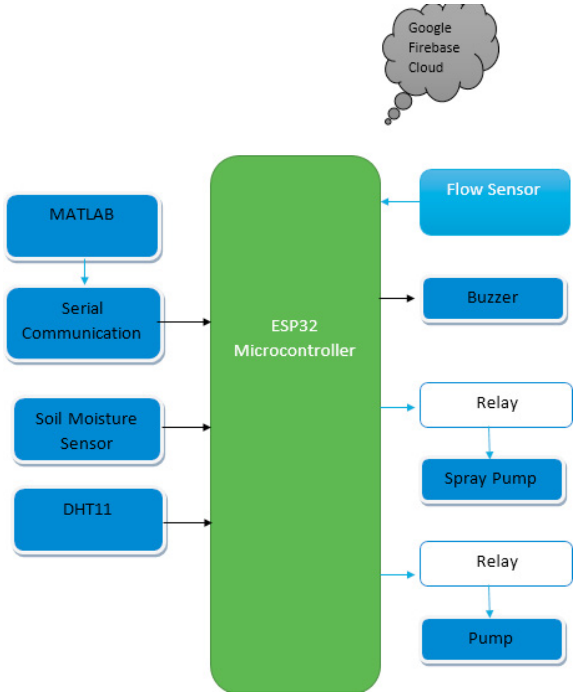

Fig. 2. Block diagram of the proposed system.

The soil monitoring module contains different sensors like the DHT11 sensor, soil moisture sensor, and flow sensor, as shown in Figure 2, to determine the amount of water in the soil and to know the status of the soil by checking the temperature level, humidity, and moisture level of the soil, which also indicates the soil conditions. It helps to estimate the water requirements of the soil for irrigation [8, 13].

The design of the proposed system consists of two main modules. The two basic modules of the proposed system are the soil monitoring module and the pest detection module. The first module of the system delivers a sustainable solution to irrigate the lands appropriately by predicting the exact amount of water required by implementing the KNN algorithm [23]. It is used in irrigating the lands with the right amount of water at the right time without human intervention. The module allocates water according to the crop water requirement [5]. A model is built based on the sensor values obtained from the sensors, and it is used to predict the right amount of water required by the crop; then, irrigation is done at the right time, which is not possible manually. Compared with manual irrigation, a huge water wastage could be reduced when this automated irrigation system [14, 16] is deployed. Therefore, the soil monitoring module works by sensing the soil moisture level using different sensors, and the KNN algorithm is deployed based on the sensor input data. A model is built and trained to predict the right amount of water required for irrigation. The water pump is activated, and irrigation is done appropriately based on the requirements. Also, this system is programmed using an Arduino microcontroller, reducing power consumption [24].

The pest detection module takes crop leaf images as input. KNN algorithm is used to classify the type of pests so that necessary action can be taken to eradicate them and protect plant health. Hence, the machine learning algorithms KNN and SVM were implemented to detect plant diseases accurately. KNN algorithm was used for classification, and the SVM algorithm was the decision boundary for determining whether the plant was infected or not [15]. The images given as input were preprocessed, then suitable features were extracted, the algorithms were deployed, and the diseases were detected precisely [22]. Once the disease is detected, necessary steps are taken based on the plant disease, and the spray pump is activated. Automatic spraying of pesticides is done appropriately.

The plant diseases like yellow vein mosaic, Mildew, Enation Leaf curl, Anthracnose, and Ascochyta blight can be prevented by using pesticides at the early stages of infection. Copper-based sprays are significant in controlling plant diseases and protecting the plants from bacterial pathogens, which cause various plant diseases. Hence these sprays are used in the proposed system to prevent crop diseases. Algorithms are implemented to have more precise results and improve the proposed system's efficiency. KNN for accurate prediction of water requirement for automatic irrigation. KNN and SVM for the automatic early detection of the pests in the plants.

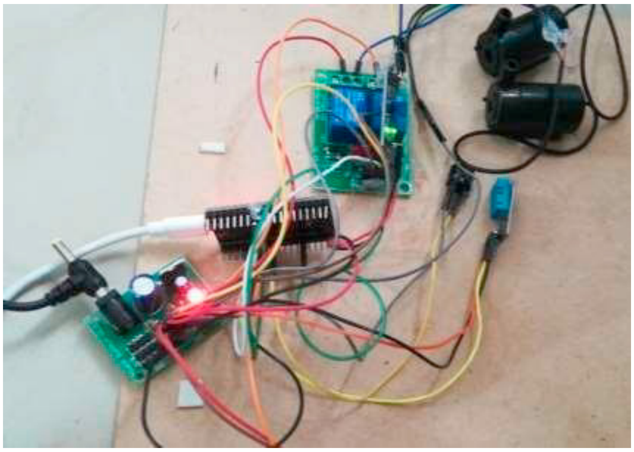

Fig. 3. Hardware setup.

The connection diagram includes the hardware components shown in Figure 3. The hardware used in the proposed smart system contains an ESP832 Microcontroller, a sensor network that consists of a DHT11 sensor, soil moisture sensor, flow sensor, buzzer, relay, water pump, and spray pump. The sensors in the system are for sensing the amount of water in the soil. Using the low-power-consuming microcontroller Arduino was more feasible for power-saving purposes. Irrigating the land irrigates, the water pump is activated when the water level is less than the predefined threshold. There can significantly impact the water conservation techniques if this system is deployed. The wireless sensor nodes were placed to collect the input data from the field for further processes. If any plant disease is detected, the spray pump is activated, and pesticides are sprayed. The data is stored in the google firebase cloud.

The sensor values from different sensors used in this proposed system indicate the sensor reading of the soil status for predicting the soil moisture level. Field A in the table indicates the temperature level in percentage; field B indicates the humidity in percentage; the C field shows the soil moisture level in percentage. The field D denotes the water level in centimetres (cm). A model is built using the KNN algorithm based on the values obtained from the sensors, and it is trained. When the temperature and moisture level decreases below the ideal range of 18-24 Celsius and 10 to 45 per cent for soil moisture, the model accurately predicts a need for irrigation. The water pump is activated for automatic irrigation. The feature columns of the table are temperature, humidity, soil moisture, and water level. The soil monitoring module in the proposed system constitutes the sensor network for obtaining the soil moisture level. The data obtained from the sensors were used for estimating the parameters that influenced the need for irrigation. The KNN algorithm is implemented on the sample values obtained from the sensors for training purposes. Then it can predict the appropriate amount of water required accurately. It classifies the input data into five classes: highly not required, average, and highly required. Based on the water requirements, automatic irrigation is done if required. Hence, it made an efficient decision for an adequate amount of irrigation, thereby avoiding excess irrigation that cannot be achieved manually.

4. Experimental Setup and Implementation Details

The dataset identified and used for the research work is Plant Disease Detection Image Dataset which is an image dataset that contains images such as "Powdery Mildew", "Enation Leaf Curl", "Cercospora Leaf", "Yellow Vein Mosaic", "Healthy", "Anthracnose", and "Bacterial blights". This dataset is primarily used to identify different types of plant diseases. Six different types of plant diseases are detected in the proposed system.

Machine learning algorithms can learn from data and improve from experience without human intervention. Machine learning algorithms are simply programs developed to learn from the input data and improve from experience without human supervision, which conserves time and increases the accuracy of predictions. The main goal of these algorithms is to build statistical models for the data fed as input for analyzing data and further decision-making processes. Not being developed for a specific task, machine learning algorithms perform excellently in learning new data and predicting accurately on their own without human interaction. When given new data, some supervised machine learning algorithms use labeled data to train a function that provides the expected outcome to make accurate predictions: Linear and Logistic Regression, Decision Trees, Support Vector Machine (SVM), K-Nearest Neighbor (KNN), and Naive Bayes. The KNN and SVM algorithms were implemented to detect soil moisture and plant disease. The classification of pests was also performed using the KNN. It is considered one of the significant algorithms for addressing classification and regression issues.

The methodology used in the KNN algorithm is clustering. That is, all the similar things which are nearby are grouped to form clusters. Then these clusters are used for making accurate predictions to deliver the desired output. The similarity concept (also known as distance, closeness, and proximity) is deployed in the KNN algorithm. The output of a regression problem is always a real number, and for a classification problem, the output is either true or false, and there is no middle ground. The K means clustering is used for effective decision making as it is classified by grouping the values into different clusters and then predicting the expected outcome.

The KNN algorithm is one of the best and simple classifiers that uses similarity for classification and is popularly deployed for classification purposes. This algorithm was discovered by Fix and Hodges in 1951 and then modified by Cover and Hart. The main aim of this algorithm is to solve both the regression and classification problems. It creates clusters of the data points in close proximities; after clustering is done, it makes correct assumptions. The Euclidean distance formula identifies the nearest neighbours of a data point. The k value represents the number of nearest neighbours. Deciding the k value is very critical for obtaining the desired output.

The k value decides the number of neighbours, which greatly impacts classification. Hence it has to be chosen with utmost importance as it is the deciding factor for this algorithm. The sample data points from the data given were grouped into a cluster of four as the value of k is four, and then the new data objects are added to the cluster of its nearest neighbour.

To find a suitable value ‘k’ for the data, the KNN algorithm is applied numerous times on various values of ‘k,’ and the ‘k’ value is chosen in a way that decreases the number of discrepancies while retaining the algorithm’s ability to effectively make predictions when given a new data it has never seen before. As this value of k is decreased to 1, the predictions become less stable with k=1 and the query point surrounded by several reds and one green, but green is the single nearest neighbour. Reasonably, it would be thought that the query point is red because k=1, KNN incorrectly predicts that the query point is green. Inversely, when the k value is reduced, the estimates become much more consistent because majority polling increases the probability of generating more correct predictions (to a certain extent).

Finally, an increasing number of errors are identified. Whenever a majority vote is necessary (example: choosing the mode in a classification problem), k is set to an odd integer to provide a majority. The limitation of this method is that when most instances and attribute parameters get increased in number, it becomes much slower. The major purpose of implementing this algorithm is to enhance the irrigation system more efficiently, time-saving, and profitable than existing systems. The KNN algorithm draws conclusions based on the real-time sensor data, enabling continuous water flow monitoring. This advanced system removes manual labour, relieves farmers from stress, eliminates over and under irrigation, minimizes water waste, and preserves soil moisture in the land.

5. Comparison Analysis and Results Discussion

The performance comparison of various machine learning algorithms is illustrated in Table 1. Algorithms compared are KNN, Decision trees, SVM, Random Forest, and Naive Bayes. The F1 score, accuracy, precision, training, and prediction time of the algorithms mentioned above are compared. It is found that KNN and SVM performed better by accurately predicting the expected outcome more precisely compared to other algorithms at a faster rate.

Table 1. Performance analysis of machine learning algorithms.

Algorithm	Accuracy	Fl-score	Precision	Training time (In seconds)	Prediction time (In seconds)
KNN	82.64	67.11	69.78	0.0008	0.0030
Decision Trees	79.22	57.32	63.19	0.0032	0.0009
SVM	82.78	68.21	74.35	2.0841	0.0008
Random Forest	84.23	66.66	69.79	0.0212	0.0020
Naive Bayes	78.99	64.46	67.45	0.0033	0.0011

Two-class classifiers are built into the SVM. One of these methods is the traditional multiclass classification with SVMs. As shown in Table 2, any SVM output value greater than or equal to the threshold is recorded as “true,” while any SVM output value less than or equal to the threshold is recorded as “false.” The binary classification of images is the basis of the SVM classifier. After k–means the classification of segmentation regions using machine learning approaches such as multiclass SVM in SVM Classifier, the pest infected area accuracy is calculated. The accuracy of the infected pest region can be calculated using the SVM classifier. The input image is manually captured with a digital camera, and the image is then preprocessed. The preprocessed image and the image are processed after using the k-means colour-based segmentation technique to classify the infected pest region. Finally, the SVM classifier calculates the accuracy of the infected region.

Table 2. SVM binary classification.

	Positive (+1)	Negative (-1)
Positive	True positive (TP)	False negative (FN)
Negative	False positive (FP)	True negative (TN)

The proposed system’s plant disease is a bhendi yellow vein mosaic virus, which results in yellow vein mosaic leaf disease, as shown in Figure 4. The disease affects by changing the whole vein network yellow in the leaf blade. It also affects plant growth by reducing the size of the plant. It is necessary to identify the disease at its earliest stage and to prevent plants from this disease. It can be effectively eradicated from the plant using sprays with leaf extracts of Prospos chilensis and Bougainvillea spectabilis.

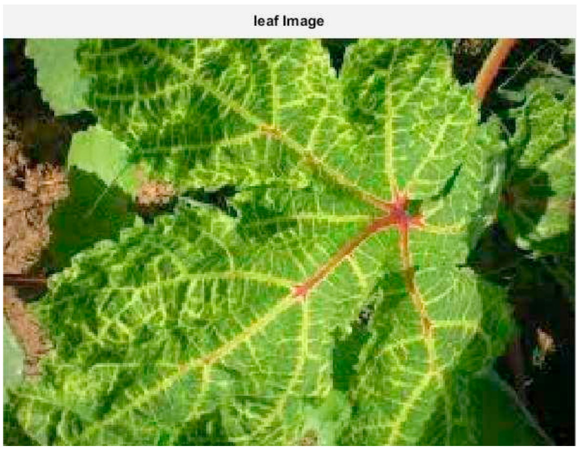

Fig. 4. Yellow vein mosaic disease.

Fig.5. Enation leaf curl disease.

Fig. 6. Cercospora leaf.

As shown in Figure 5, the enation leaf curl disease is an emerging serious plant disease in our country. It is transmitted by an insect vector called the whitefly, Bemisia tabaci. As shown in Figure 6, Cercospora leaf disease is caused by the fungal pathogen Cercospora beticola. It is considered an infectious disease-causing severe damage to the leaf spots and causes blight diseases for many crops. Many fungicides are available for treating the cercospora leaf spots. The main ingredients that must be present for treating the cercospora leaf spots are chlorothalonil and myclobutanil. Sprays containing these ingredients are used in the proposed system for treating this plant disease.

The plant disease powdery mildew shown in Figure 7 affects the plants by causing a powdery growth on some parts of the plant, especially on the leaf surfaces, buds, and shoots of the plant. It also causes powdery formation on the fruits and flowers. This disease is caused by the fungus Podosphaera xanthii. An effective remedy for treating powdery mildew is Potassium bicarbonate which is also less toxic. The environmental and other factors which are the causes of powdery mildew spores to develop are poor aeration, insufficient space and light, over-fertilization, and high humidity. The AHE image processing technique is applied to plant images infected by powdery mildew plant disease, as shown in Figure 8. One of the very important image processing techniques is AHE, which enhances the contrast in the images. It varies from the ordinary histogram equalization technique as it computes many histograms for each image section, enhancing its contrast. It can be applied to homogeneous regions of an image. The image's contrast is enhanced by applying AHE, which helps easier computation of extracting suitable features present in the image.

Fig. 7. Powdery Mildew.

Fig. 8. Adaptive histogram of plant infected by powdery mildew.

The fungi causing Anthracnose plant disease is the genus Colletotrichum. The plant affected by this disease contained dark, water-soaked lesions. This disease is very destructive in that it spoils the crops completely and makes the entire crop produce into rotted waste within a very short time. It must be detected earlier, and effective measures to eradicate this disease must be taken, like removing the plant from humid weather conditions. The ideal temperature must be present to prevent it from being affected more. Liquid copper sprays, and neem oil sprays, can effectively solve this disease. The image of the plant infected by Anthracnose disease is fed as input. The image preprocessing is done, adaptive histogram equalization, segmentation of the image, and classification is done using k means clustering. The system was able to detect the exact plant disease accurately.

Figure 9 denotes the classification of the leaf image affected by Anthracnose plant disease. K means clustering was performed on the image, and three clusters were obtained. After that, the plant disease was detected accurately by entering cluster number three, which contained the disease-affected part only. Figure 10 shows the contrast-enhanced image of the infected plant as this technique helps enhance the features of the image, which helps in the easy extraction of the exact features for further processing. The histogram of the contrast-enhanced image is shown in Figure 11.

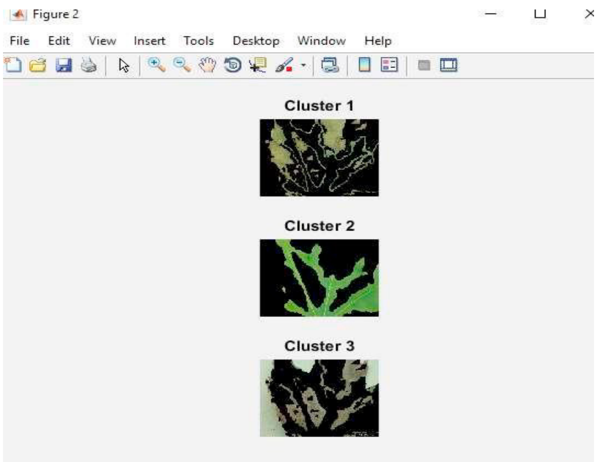

Fig. 9. Classifying using K-means clustering

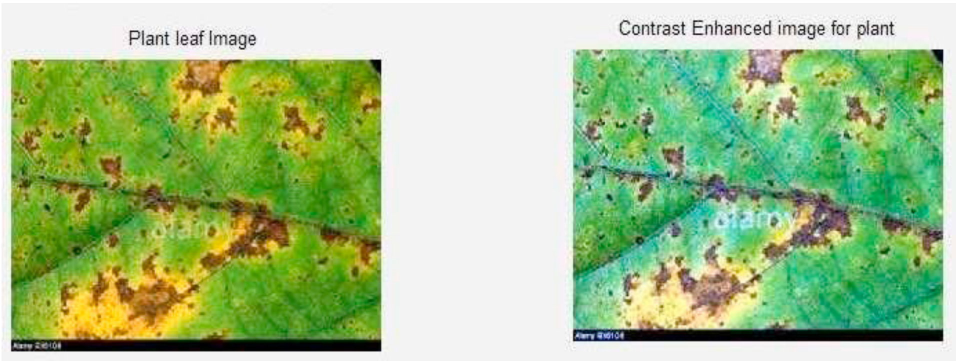

Fig. 10. Contrast-enhanced image of the infected plant leaf.

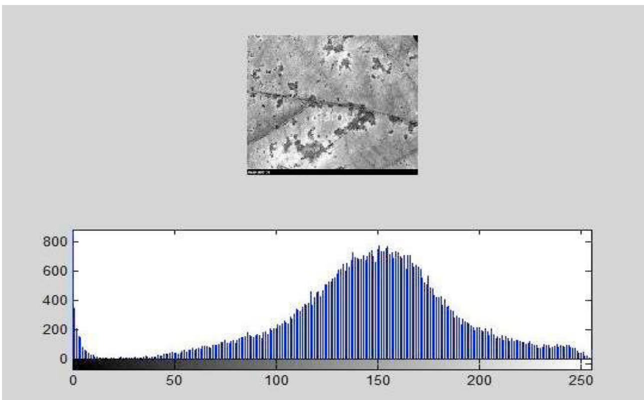

Fig. 11. Histogram of the contrast-enhanced image.

6. Conclusion

The proposed system employs KNN to predict the appropriate water amount for irrigation. It is primarily concerned with automatic water irrigation and plant disease detection. It makes precise predictions about how much water the crops need and uses machine learning algorithms to automatically identify pests depending on the farmland's needs. The pest identification module's support vector machine learning and KNN algorithms are utilized to precisely predict plant illnesses. The useful characteristics were extracted from the plant's leaves. The collected features are then put to use for categorization. Determining whether the plant is pest-infested or not is made possible by extracting the appropriate traits and classifying them. The proposed system in the paper regulates agricultural areas for automatic water irrigation and plant disease detection. The numerical investigation of the machine learning algorithms and the significance of the classification with accuracy is examined. For future work, along with the KNN algorithm, other clustering algorithms can be combined for better accuracy and accurate decision-making.

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