Applicability of IoT and Machine Learning Approaches for Classification in Smart Farming

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Abstract:

Our country's economy is greatly aided by agricultural production. Civilization began with the invention of agriculture. Crop productivity is the backbone of India's economy, which is predominately agrarian. There is no doubt in our minds that agriculture is our country's backbone. The agricultural industry may take use of a wide range of new instruments and methods thanks to the rapid advancement of technology. Knowledge processing is the IoT preference in the agriculture sector. Low yields are a common side effect of conventional farming methods, which are nonetheless preferred by many farmers. In order for the economy to continue to grow and flourish over the long term, agriculture and allied industries are essential. Decision-making, cropping pattern, and supporting structures for increasing crop yields are all important aspects of agricultural production. Many environmental elements, like temperature, soil fertility and water volume are taken into account while making agricultural forecasts. As agricultural automation advances, a slew of new tools and apps have emerged to help farmers quickly learn new skills. Everyone, even farmers, is taking advantage of mobile technology. This study outlines a methodology for tracking and monitoring crops intelligently. Devices, IoT cams, mobile apps, and big data analytics all are discussed. All of it. Several sensors and a Wi-Fi device round out the hardware. This approach would lead to the most efficient utilization and the least amount of waste generated by agriculture.

Keywords- Internet of Things, Intelligent Agriculture, Smart Farming, Usage of IOT, Advantages of Agriculture.

1. Introduction:

The global economy cannot function without agriculture. As the human population grows, so will the strain on the agricultural system. A new field, "digital agriculture," has emerged to describe the widespread adoption of data-heavy techniques in the crop and precision farming industries. Because of the numerous sensors used in contemporary farming, it is possible to get more precise and timely data about both the surrounding operational atmosphere (the relations of constantly changing harvest, earth, climate circumstances), as well as the operations itself (machinery data). The concept of "smartness" was spawned by a number of technological developments, such as the Iot technology (IoT), Big Data, and Cloud Services. Monitoring, cameras, and computers all work together to help farmers do their jobs more efficiently. Self-sufficient computers would allow them to communicate with each other without the assistance of humans. Or, to put it differently, Information regarding the current state and the motivations for connecting to other parts of the system is stored in the devices beforehand[48].

Many farms have adopted IoT design for "smart farming" because it improves their capacity to produce and compete in a global market while also meeting other desirable criteria, such as requiring less time, money, and effort from their employees. Smaller, more advanced, and less priced sensors are becoming more widely available thanks to technological advancements. Smart farming may be done with total confidence thanks to the systems' ease of use and all-inclusive nature. As a response to the current issues faced by this industry, the focus of sharp cultivation is on empowering agricultural growth. Mobile phones and other Internet of Things (IoT) devices are helpful in many ways. A farmer can access whatever data or information he requires and keep tabs on his farm's progress[46][47]

Everything in the Web of Things (IoT) will be used in Smart Computing in the future (IoT). It is crucial to the development of "Next Generations Everywhere Computing," which will replace the current methods of computing in the home and workplace. Researchers around the world, particularly in the field of high-speed wireless communications, are increasingly focusing on "the Internet of Things". The Internet of Everything can be found everywhere in everyday life. It is helping to lay the groundwork for a wide range of products including smart health services and education in schools as well as smart homes. Its commercial use in numerous fields is illustrated in Figure 1, which includes production, public transit, agriculture, and corporate management[43][45]. Agriculture is the area of IoT that has seen the most investigation. Given the world's ever-increasing population, this is a vital subject for guaranteeing global food security. In this discipline, researchers first began adopting ICT-based strategies, which were effective in certain aspects but did not address our problem[44]. As a consequence, they are looking into IoT as an alternative to ICT for agriculture. Controlling the supply chain as well as the infrastructure layer is critical for farm products, as is monitoring soil moisture levels as well as the temperature and humidity of the surrounding air.

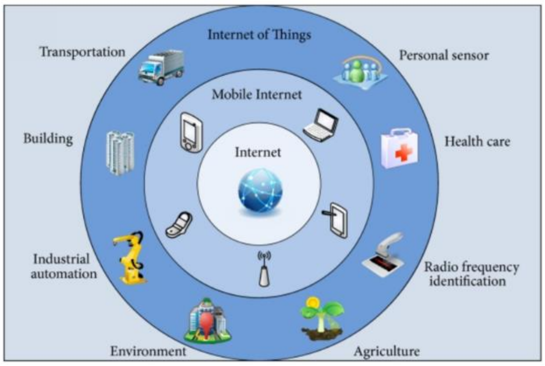

Figure-1: IoT Applications Everywhere

Precision agriculture is predicted to expand at a rate of 8 billion dollars by 2025. To help farmers increase their agricultural yields, Data analytics can be employed from sensors in the field. As a result, many problems in agriculture can be addressed with IoT-based smart farming. Farmers will be able to access real-time data thanks to the solution described in this study[41][49].

Machine learning relates to the capability to learn from previous experiences. ML has emerged in line with big data technologies and powerful computers, opening up new possibilities for unraveling, quantifying, and comprehending data-intensive operations in agricultural operating contexts. ML. According to some definitions, machine learning (ML) is a branch of science that focuses on developing computer programs that can learn on their own [1]. Bioinformatics, biochemistry, medicine, meteorology, economics, robotics, aquaculture, food security, and climatology are just a few of the domains where machine learning (ML) is being used more and more each year[42].

The algorithms that learn from of the input datasets using the predefined equations, train the sample, and improve their performance. Authors in [2] said that machine learning (ML) methods are more powerful in handling nonlinear issues based on sensor data or other sources. It helps real-world decision making with minimum human input. Machine learning algorithms are being used in many different contexts. However, accuracy is influenced by the information reliability. Consequently, the output format and variable play an important role in machine learning. One form of technique is supervised learning, while another type is called unsupervised learning. In supervised learning, the labels associated with the data are predetermined[40].

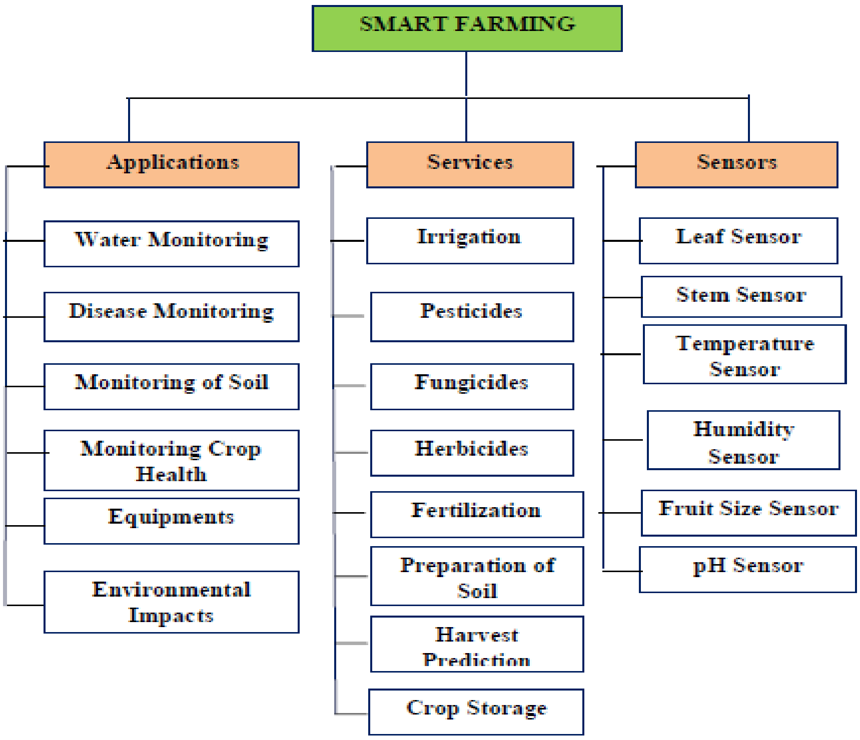

Figure-2: Machine learning in smart farming

Unsupervised learning, on the other hand, is based on the discovery of previously unknown patterns. Researchers in [3]proposed their algorithm decision on data insights they gleaned from the data (2018). However, in today's IoT smart data analysis, both learning methodologies are applied. WSN with IoT connected smart farming has been developed as a novel ML technique for measuring and analyzing large data applications. Figure2 represents the many forms of computer vision in intelligent agriculture. Predictable weather conditions such as soil and crop features and water levels must be taken into consideration when scheduling irrigation measures in precision agriculture. Using the system's intermission time to determine irrigation schedules drew attention to the distribution method being used. Irrigation schedules depend on the moisture content of the soil[39][51]. The field gets flooded when the defined threshold value is met. Authors in [4] found that conventional irrigation farming uses 90% of the freshwater in dry situations. In order to effectively manage water resources, precise agriculture provides an accurate estimate of water use in farming. The authors in [5] point out that it is difficult to describe irrigation tactics across a region due to the wide range of crops grown and the wide range of farmers[37][38].

Because of their efficiency and ease of use, advanced agricultural systems can help with IoT. Creating an automated system like this also aids in the watering of plants without the assistance of humans. It will also be able to plant seeds and measure the wetness substance of the earth. Figure 3 depicts the many components of precision agriculture[34][36]. Most of the work in pest control involves sensing, analyzing and treating disease-causing bugs. In recent years, image processing has emerged as a significant tool for characterizing insect kinds for pest management using raw photos taken in agricultural fields. Using IoT-based pest control devices, the overall costs have been decreased because they have helped restore the natural climate.

Figure 3: Functional Elements of Precision Agriculture

2. Literature Survey:

Using IoT technology, precision agriculture is a new farming management idea that aims to boost agricultural productivity. Farmers may boost the amount and quality of their crops with the help of smart farming techniques. Farmers aren't able to stay on the farm 24 hours a day, seven days a week. It's possible that farmers don't know how to use a variety of techniques to determine the ideal conditions for their crop. The Internet of Things (IoT) equips them with a fully automated system that can work independently of human oversight and alert them to potential problems they may encounter while farming in order for them to take appropriate action. A higher yield can be achieved through improved crop management made possible by this system's ability to contact and inform the farmer even when he or she is not physically present in the field[30].

An increasing number of industries are taking advantage of online of Things (IoT). According to Authors in [6] today's agriculture sector is also using IoT for smart farming. Farmers can benefit from IoT sensors' ability to foresee climate shifts, solve irrigation issues, and help enhance crop yields over time. A burgeoning population and increasing food needs necessitate new agricultural approaches. The goal of utilizing IoT in farming is to maximize output while minimizing costs. There have been numerous proposals for potential IoT implementations in agriculture by researchers[31][33]. According to Authors in[7] and [8], the introduction of IoT will boost agricultural growth by 28%.

Farmers are using IoT devices to make farming more innovative and high-tech by gaining benefits in a short amount of time, with minimal expenditure, using IoT devices in the agricultural field. According to [7] there has been a significant drop in mechanical and physical work as a result of the IoT use in irrigation. The irrigation fields are equipped with sensors that collect and store data for future use. The usage of cloud-connected sensors for monitoring is becoming increasingly common. According to the researchers [9] and [10], data collected by sensors is more precise and accurate, enabling the IoT cloud environment and allowing for more accurate forecasts.

Water monitoring, water usage limiting, crop monitoring, environmental impact pre-prediction, less human capital, increased crop production, improved harvesting yield, correct field management are just a few of the many benefits that the Internet of Things (IoT) may provide to farmers. The writer in[11] stated that IoT might help farmers with everything from planting seeds to choosing crops based on their environment. It aids the farmer in selecting the correct plant for a certain setting. Monitoring the entire field, the based On iot setup takes a survey of environmental parameters, discovering and reporting problems via triggers and alerting.

IoT and machine learning algorithms, as depicted in Figure 1.3, are becoming increasingly important in farming methods, as [12] and [13] have noted. In order to fulfill the rising demand for irrigation systems, machine learning contributes to their improvement and modernization. The smart irrigation management system can monitor irrigation water conservation. Precision Agriculture (ACRIS) Multi-parameter Optimization System.

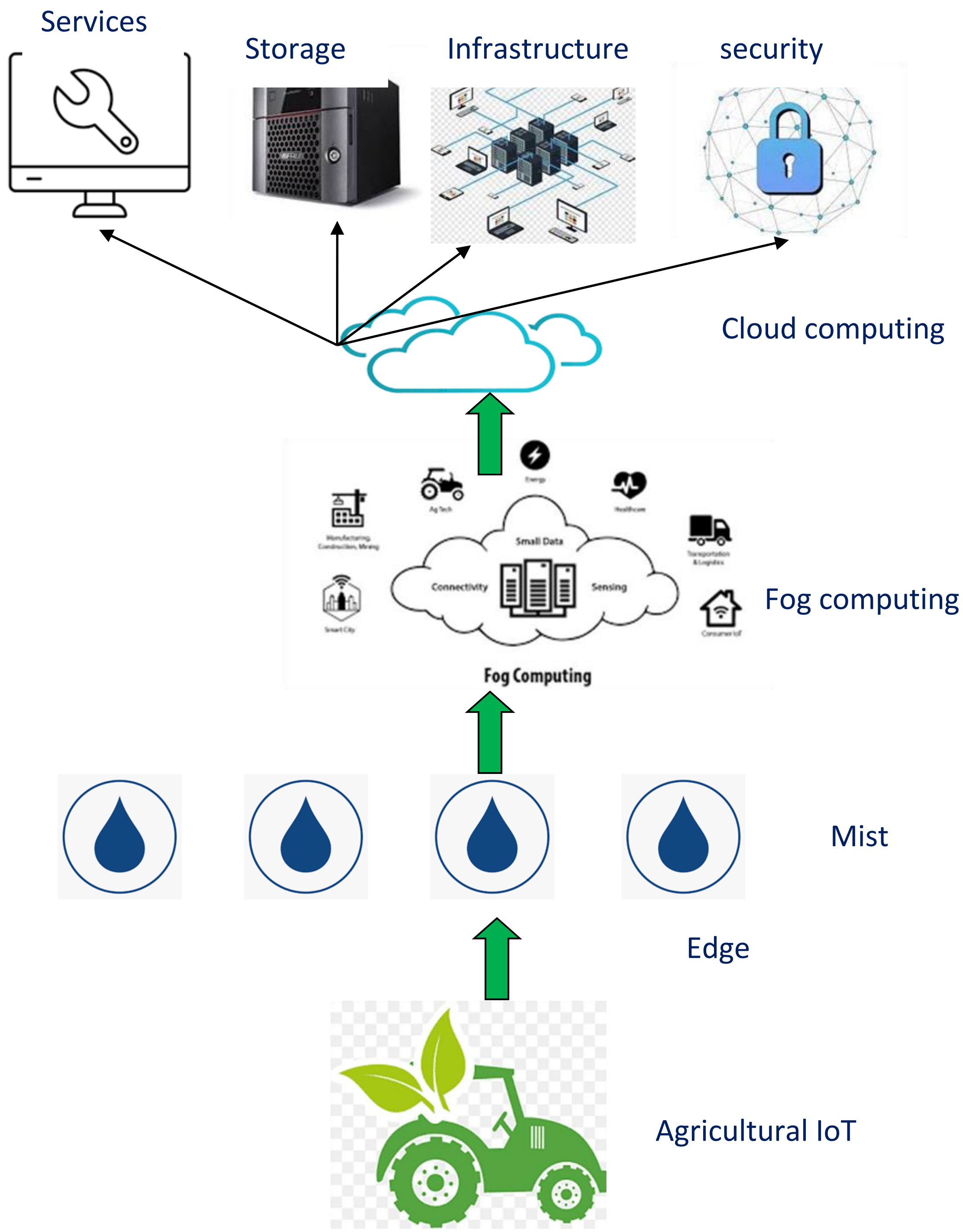

Figure 4. IoT Services for Smart Farming

As a means of increasing farm profitability and enhancing the environment at the same time, precision agriculture has been referred to as an enhanced input management approach that may be implemented by farmers. On the other hand, there is no data about farmers' behavior about the sampling extent. Farmer decisions and insights must be considered into description to promote and employ these effective irrigation solutions [14]. This research helps farmers better comprehend the benefits of implementing water-saving irrigation methods.

Crop consultants, school extension, media outlets, and government agencies are the key sources of precise agricultural information in the 14 fabric southern states of the United States, according to [15] Precision farming technology adoption is influenced by a variety of factors, including information from a variety of sources. The Internet, for example, has a considerable effect on the adoption of yield trackers with Satellite and soil survey maps. Contrary to popular belief, information from dealers has a substantial impact on the uptake of zone soil sample and soil classification map technology[29]. Farmers, for example, sometimes integrate the information acquired from precision farming with information from other sources, such as crop advice, trade show exhibits, advertisements, and so on [16]. Those in the commercial sector (such as crop advisors and input suppliers) spread precision farming as a means of providing knowledge about the rise in farming profits and recent capital investments in precise agricultural technology [17].

Farmers are drawn to precision agriculture approaches, as according [18], because of its potential to improve revenues and the environment on the farm. Today's major technologies for this agricultural activity include GIS and GPS; sensors; variable rate technology (VRT); Yield Monitoring; and Variable Rate Technology (YM). Precision farming was originally recorded in the corn belt of the Midwest, where it helped raise yields of maize, wheat, and soybeans while also lowering production costs. Precision farming has since spread to 14 Southern states, with adoption rates rising from roughly 83% in 2019 to 93% in 2021.

Grid and zonal soil sampling, variable interest rate lime, phosphorous, and potassium application, and soil survey maps are the most extensively used precision agriculture technology in the southern United States [19]. The southern United States, which includes Alabama, Florida, Mississippi, North Carolina, Carolina, and Texan, is the most important cotton-producing region in the United States [20]. When it comes to harvesting acres in some Houston counties, cotton accounts for as much as half of the yield. Precision agriculture practices are seen as critical in the majority of southern U.S. states by other farms, farm machinery dealers, crop consultants, school extension, the media, and government agencies [20]. Until now, there has been no method for determining the best irrigation procedures for large swaths of land.

According to an essay by prem Prakash [21], the global population is expected to hit 9 billion by 2050. For agriculture to feed such a huge population and effectively utilize farmland and other resources, IoT application is a necessity. Farmers are suffering huge losses as a result of unexpected weather patterns caused by global warming, and the Iot Based smart Farming app will start taking immediate action to avoid this. It has been outlined in detail by Gorli Ravi [22] why smart farming is crucial and how IoT may impact our future.

The Arduino mega and ESP8266 modules used by Nayyar Ananda and Puri Vikram [23] were replaced by the new ESP32 microprocessor and the Blynk mobile software because not every farmer has a PC. Because it's quicker, as well as more accurate. Additionally, we have a sleep mode to offer our self-monitoring system an extra boost of energy. Each and every time their product required the assistance of a human being.

Productivity rises as a result of advancements. S. Jegadeesan [24] claims that farmers might manage their livestock, such as cows, sheep, and other animals, and keep tabs on their health with the help of the Internet of Things (IoT). According to Vaibhavraj Roham and many others [25], WSN also incorporates routing methods for a network, such as more prototypes. Due to budgetary constraints, most farms will not be ready to use the more expensive methods, such as in [26] and [27], that can automate the agricultural process. Farmers may find our prototype, which costs less than two thousand Indian rupees, to be a better option because it includes sleeping mode, has a clock to have sent after each start time, and is protected from extreme weather conditions by the use of a appropriate bucket, which provides safety from severe climate. As a result, the solutions suggested in [26] and [28] are less sustainable than those with high-quality sensors, appropriate coding, routing algorithms, and proper design.

3. Methodology:

In the following section of this work , we will provide a strategy for intelligent crop management and tracing. Technologies like sensors, cameras, mobile apps, machine learning algorithms, plus big data analytics are all a part of this. The hardware consists of an Arduino Uno, a sensor, and a Wi-Fi enabled device.

The following elements make up the frameworks shown in Figure 5: In addition to an MCU Arduino mega 32u4 that is Arduino compatible, the Arduino Uno also features Wi-Fi, Area network, a USB plug, segments and sub card storage, and 3 reset catch. Atheros AR9331 can also be used to run Linux on the board. Moisture and humidity sensors, the DHT11/DHT22 is one of them. It's used to measure the land's humidity and moisture content in real time. Arduino Uno [29] is used to store the collected data in the cloud.

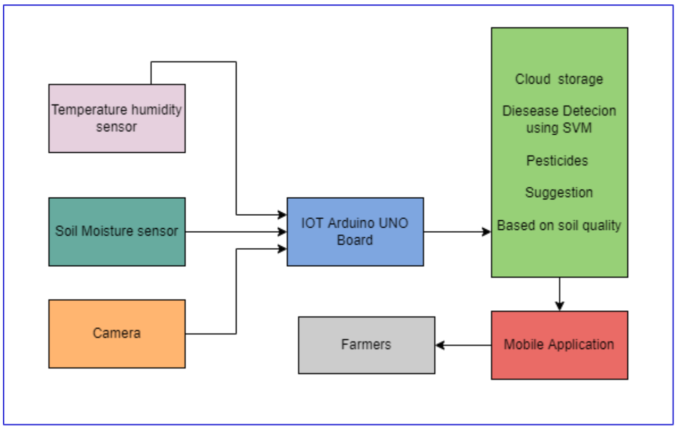

Figure5.IoT Enabled Precision Farming System

To find out how much water is in the soil, the YL-69 soil water sensor is employed. Water levels in the soil are precisely estimated using this technique, which is why it is frequently employed in agriculture, water systems, conservatories, and other research centers. The devices are mounted on an electrical board, and a dirt humidity test serves as a divider between the two zones. The permittivity of water is directly related to the potential distinction established by sensors. Dielectric permittivity changes can be interpreted as changes in the water levels due to voltage variations [31].

To store cropped photographs in the cloud, an IoT Arduino Uno is utilized to take images with the camera. For subsequent analysis to use an SVM classifier, all crop-related photos are hosted in the cloud. A K-means classifier can be used to further analyze soil-related data that is also saved in the cloud. The SVM classification method is employed in the identification of illness in crops. Cameras and an Arduino Uno are used to gather data about crops and upload it to the cloud. Afterwards, the images are preprocessed and features extracted. After that, the SVM method is used to classify the photos. In this case, the infection is predicted using a preexisting set of training data, since the system has soil details for a specific form. The system then recommends pesticide types and dosages based on the data collected and the quality of the soil.

• Mobile application: farmers can access their results via a mobile app. Landowners can log in and view all of the information linked to their property and crops using a mobile app.

4. Evaluation of the Proposed System By Existing ML Algorithms:

4.1. Support Vector Machine Approach:

Support vector machines (SVMs) are the method of choice when dealing with problems of two-class categorization. In addition, the SVM can be used to analyze data for classification or regression purposes. Finally, SVM employs a kernel occurrence to transform the data and settles on a reasonable divide between the most probable outcomes. A graph's decision line separating the two categories must also be sufficiently broad to encompass a diverse set of alternatives. SVM creates an ideal boundary for dividing and categorizing fresh data points. Therefore, the hyper plane is a term for this ideal boundary.

It can be summarized as follows:

n = number of training examples, K = number of support vectors, and d = dimensionality of the data.

Training time Complexity= $O(n^2)$ → (1)

Run-time Complexity=$O(K*d)$ → (2)

4.2 Random Forest:

A self-sampling stochastic process where each tree in the forest has the same variance, random forests construct a group of tree predictors that may be used to make predictions about the future. As the quantity of number of trees reaches an all-time high, the training error in the woodland comes to a head [27]. Tree classification forests' generalization errors are influenced by the strength of the individual trees and its comparison. An error rate that has a lower noise level can be achieved by using random selections of features. The reaction to increasing the number of features utilized in splitting can be demonstrated using internal measurements such as variance, frequency, and consistency. Parameter significance estimate is also based on external measurements. There are certain general principles that can be used to regression [28].

Random forest has the following levels of complexity:

Training time Complexity = $O(n * \log(n) * d * k)$ → (3)

k = amount of decision trees, n = amount of training examples, d = amount of dimensions.

Space Complexity = $O(\text{depth of tree} * k)$ → (4)

5. Results and Evaluation:

The experimental investigation used a dataset of 1000 photos. Images of Neem leaves are included in this dataset. There were 385 diseased photos and 615 healthy ones. SVM-Support Vector Machine, regression models, and random forest classifiers are three classification techniques used in experimental analysis. The following equations were employed to determine accuracy:

In order to create some widely used metrics for assessing our approach, we make use of test set vectors. Here are some metrics that were utilized to calculate these metrics before we go into the specifics of how they were calculated:

1. **True Positive (TP):** As a result of this, the average of the predicted successful simulation vectors can be seen.

2. **True Negative (TN):** Displayed is a weighted average of all test vectors that were correctly predicted to have failed simulations.

3. **False Positive (FP):** The average of all vectors that should have been successful simulations but wasn't are shown in this graph.

4. **False Negative (FN):** The median of lines that look like they would fail a simulation but end up succeeding can be seen in this plot.

We calculated the most well-known measures for evaluating classification algorithms using these metrics:

1. Accuracy :

The absolute amount of vertices properly identified divided by the original number of variables in the initial data is the accuracy estimate for classification.

Accuracy= TP+TN/TP+TN+FP+FN → (5)

Table 1 displays the classifiers' accuracy, precision, and recall values, which are shown graphically in Figure 2. The three techniques are also used to assess other efficiency-related metrics, such as precision and recall. Random forest and logic regression were shown to be inferior than SVM in terms of accuracy.

S. No	Name of the Algorithm	Accuracy (%)	Precision (%)	Recall (%)
1	SVM	92	89	88
2	Random Forest	82	79	81
3	Logistic Regression	78	73	76

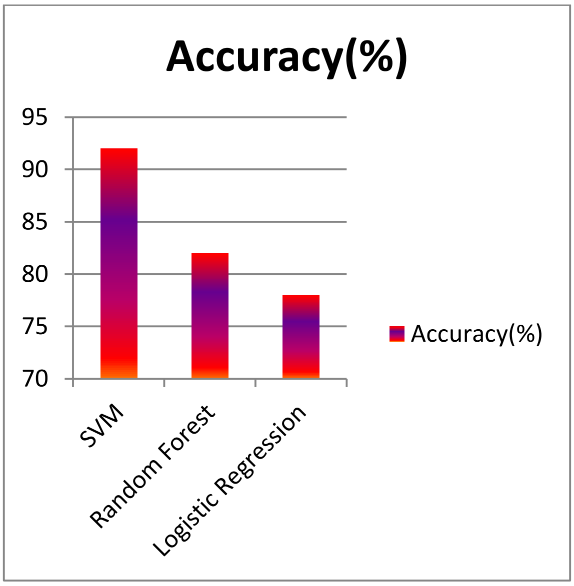

Figure6. Evaluation of Accuracy of the 3 Classifiers.

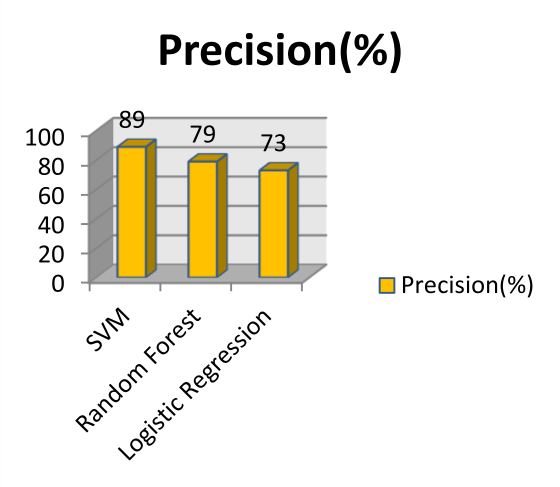

Figure7. Evaluation of Precision of the 3 Classifiers

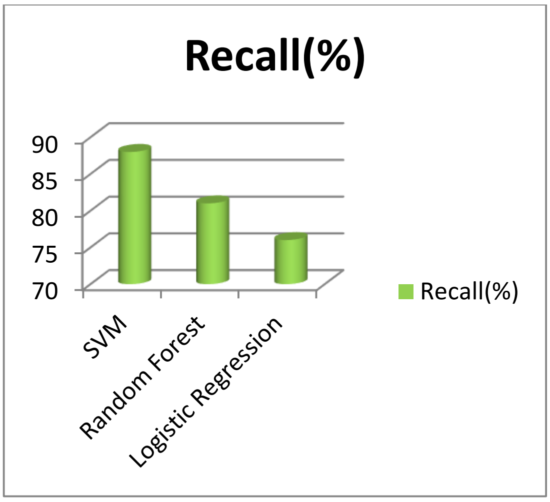

Figure8. Evaluation of Recall of the 3 Classifiers

The above 3 parameters clearly proves that our SVM Classifier performs well for classifying the Leaves in terms of Precision, Accuracy and Recall.

6. Summary:

As a result, efficient farming is required. In the future, smart agriculture will benefit from the Internet of Things. Improved efficiency, rainwater harvesting, crop monitoring and soil care are just a few examples of how the Internet of Things is being used in agriculture. Agricultural processes are deconstructed and smart farming implementation is improved as a result of the elimination of human labor. Agriculture is a career that has depended on traditional methods and experience up to this point in its development. Rural traditions, on the other hand, have been touched by time and are now beginning to shift with the times. Automating agriculture has led to the widespread development of information-gathering apps and hardware. Smart phones and tablets are becoming increasingly common place among all demographics, including farmers. This paper proposes a system for smart crop control and tracing. Big data analytics and sensors are all part of the package. Crop disease detection framework is proposed. An SVM classifier was used to classify this It identifies infection in crops and recommends appropriate pesticides based on soil data from a specific area.

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