Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 44 No. 3 (2023)

Enhancing Food Quality Improvement and Instigate Smart Agriculture Using Artificial Intelligence Technology

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Abstract

Agriculture is a critical sector for any nation. Due to the mounting global population and the increasing demand for food worldwide as well as challenges in weather conditions and the availability of water, Artificial Intelligence (AI) such as expert systems, natural language processing, speech recognition, and machine vision have changed not only the quantity but also the quality of work in the agricultural sector. Unfortunately, the agriculture market is explosive. AI is emerging in various major classifications in agriculture, namely crop and soil maintenance, predictive based analytics, and agricultural robotics. In this regard, farmers are increasingly adopting the use of sensors and soil sampling to gather data to be used by farm management systems for further examinations and analyses. Climate change, soil erosion, and biodiversity loss can cripple the business, as are customers' shifting tastes in food. The natural environment with which farming interacts continues to present its own set of problems. In addition to a growing population, sustainable agriculture is also threatened by urbanization. In recent years, there has been an increased interest in researchers within Smart Agriculture. This is when machine learning applications in agriculture step on the scene. By analyzing real-time sensor data and historical trends, this technology can empower farming decision-making. With artificial intelligence used in agriculture, manufacturers can better predict demand, improve crop yields and reduce food production costs. Machine learning in agriculture can optimize the way food gets to our table and revolutionize one of the most critical sectors of the economy.

Nations that have arid climate conditions would be informed how satellite imagery and mapping can assist them in detecting newer irrigation lands to assist their scarce agriculture resources. Some companies make use of AI software in agriculture by utilizing machine learning for various processes. These tools can make a real difference in agricultural productivity and profitability by reducing waste while enhancing product quality

Keywords: Soil Prediction, Labour reduction, Biophysical changes, Decision tree, Crop Management, Computer vision.

1. INTRODUCTION

The artificial intelligence (AI) is a creative tool that simulates the human intelligence and ability processes by machines, principally computer systems, robotics, and digital equipment. The Food and Agriculture Organization of the United Nations (FOA) has estimated that the world population will touch 9.73 billion by 2050 and will continue to rise until it reaches 11.2 billion by 2,100. The agriculture industry is one of the key sources of national income in developing countries. Hence, using new technology to improve the agriculture sector is critical to all countries' national economies. Biometric analyses on Smart Agriculture have also been conducted in the past.

1.1 DEEP LEARNING IN AGRICULTURE

Deep learning has got great potential for the agriculture industry. It offers modern techniques for accurate image processing and data analysis, enabling tacking various agricultural and food production challenges such as forecasting cost of cultivation, infertility prevention and crops management, herbicides and pesticides recommendation, manual labour reduction, and so on. Machine Learning applications in agriculture rely on real-time data to deliver exponential gains for farmers which is shown in figure 1.

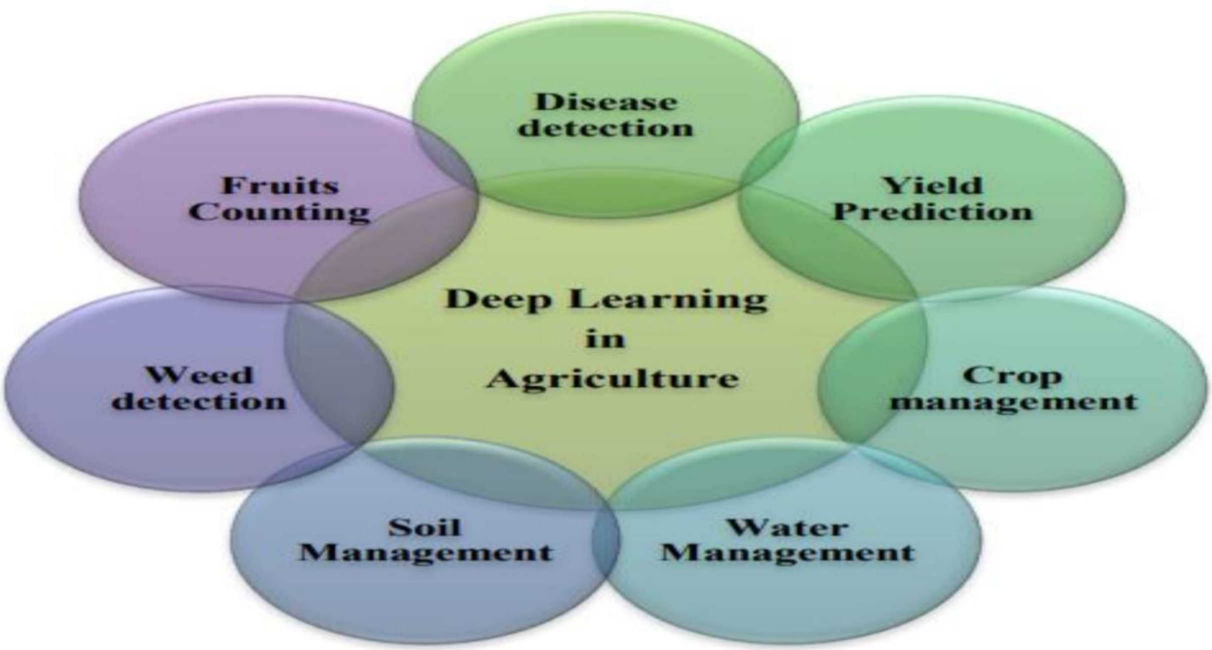

Figure 1: Deep Learning in Crop Management

Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 44 No. 3 (2023)

AI and machine learning prove to be strong catalysts driving 24/7 security of remote facilities, better yields, and pesticide effectiveness. Smart farms or automation in farms and the last one is Crop yield estimation and prediction.

1.2 CROP MANAGEMENT

The soil should be loosened and aerated properly during crop production. Manures and fertilizers need to be added carefully. Too much fertilizer damages the soil while too little makes the crop deficient in nutrients. The crops should be irrigated periodically. The main objective of the crop management system is to manage the details of Farm corps, corps details, pesticide used, insecticides used, amount of fertilizers used, or to be used. It contains Information about the Farm, cost, current market price, etc. The stages that plants go through are from seed to sprout, then through vegetative, budding, flowering, and ripening stages. For the crop management Random Forest Algorithm is used. It belongs to Supervised Learning Algorithm that is constructed from decision tree algorithms. The random forest can analyze crop growth related to current climatic conditions and biophysical changes. Random forest algorithm creates decision trees on different data samples and predicts the data from each subset. The process flow is shown in figure 2.

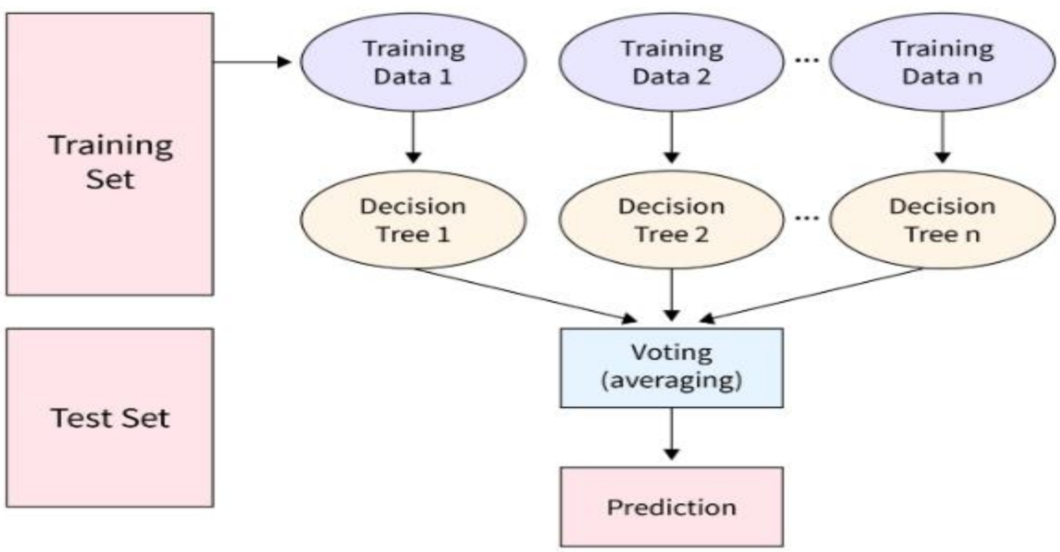

Figure 2: Random Forest Algorithm

1.2.1 STEPS IN ALGORITHM

1. Data Pre-processing step.
2. Fitting the Random forest algorithm to the Training set.
3. Predicting the test result.
4. Test accuracy of the result (Creation of Confusion matrix)
5. Visualizing the test set result

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1.2.2 ADVANTAGES OF RANDOM FOREST ALGORITHM

- It's more accurate than the decision tree algorithm.
- It provides an effective way of handling missing data.
- It can produce a reasonable prediction without hyper-parameter tuning.
- It solves the issue of over fitting in decision trees.
- In every random forest tree, a subset of features is selected randomly at the node's splitting point.
- Decision trees are the building blocks of a random forest algorithm.
- A decision tree is a decision support technique that forms a tree-like structure.

2. RANDOM FOREST ALGORITHM

Crop management is a huge layer of pre-harvesting activities that is responsible for future yields. However, this is one of the most challenging stages of the agricultural lifecycle. Increased frequency of drought, higher temperatures, unpredictable wetting, and drying cycles can influence crop resistance. Therefore, machine learning development is widely leveraged to amplify this stage. For example, crop variety selection is one of machine learning in agriculture applications and techniques shown in figure 3.

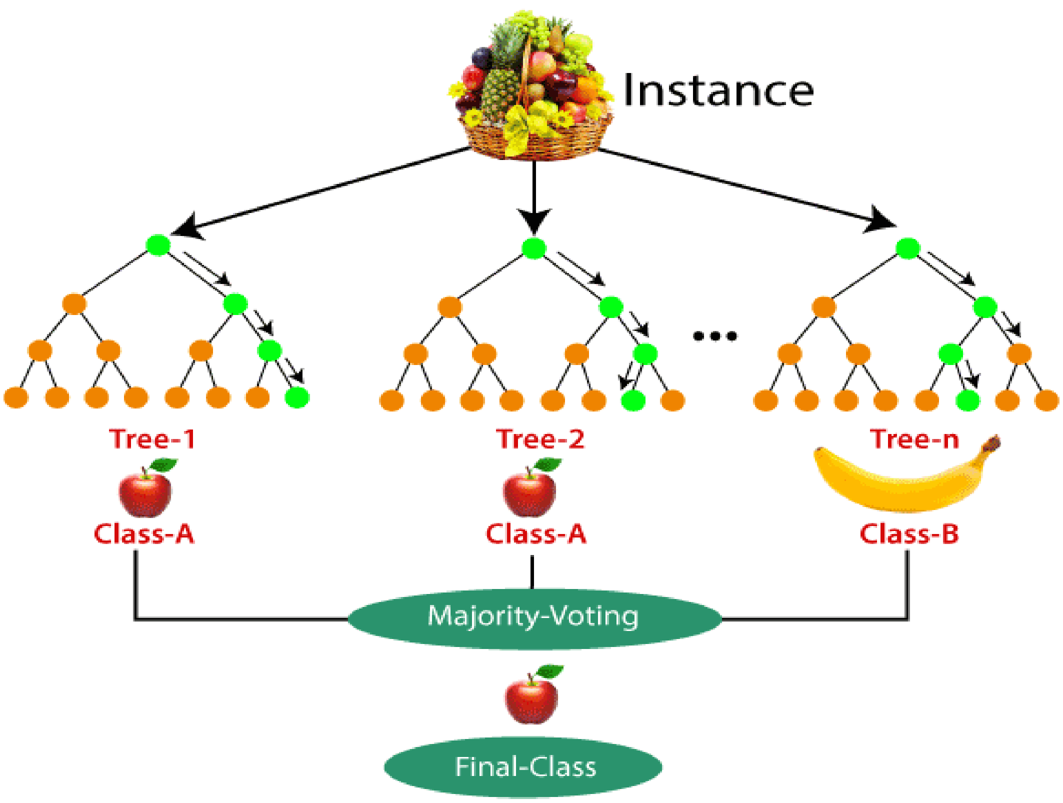

Figure 3: Random Forest Algorithm Process Example

To become disease- and weather-resistant, crops should have the right gene sequence. ML-based deep learning can simplify the task of crop breeding. Algorithms simply collect field data on plant behavior and use that data to develop a probabilistic model. Crop yield prediction is another instance of machine learning in the agriculture sector. The technology amplifies decisions on what crop species to grow and what activities to perform during the growing season. Tech-wise, crop yield is used as a dependent variable when making predictions. The major factors include temperature, soil type, rainfall, and actual crop information. Based on these inputs, ML algorithms like neural networks and multiple linear regressions produce forecasts.

2.1 PRECISION SPRAYING

Precision spraying, defined as the targeted spraying, obtains the target information such as size, shape, structure, and canopy density of the tree and then apply pesticides as needed. The objective of spraying is to deliver an effective, uniform dose of product to a target area in a safe and timely manner. Any product not deposited on the target is called "wastage". Wastage includes drift (vapour and droplet), run-off and any off-target deposition which is represented in figure 4.

Figure 4: Precision Spraying

2.2 TYPES OF SPRAYING

2.2.1 HIGH VOLUME SPRAY

The dilute liquids are applied by hydraulic machines. Based up on the volume of liquid handled sprayers are classified. High volume sprayer (more than 400 litres /hectares)
Low Volume Spray: It uses air stream from a fan as a pesticide carrier with small quantities of liquid. Low-volume spraying was particularly used for the application of herbicides, in which 10 or 20 gallons of water, transformed into fine drops, would carry the pesticide.

2.2.2 ULTRA-LOW VOLUME SPRAY

ULV sprayers dispense very fine aerosol droplets that stay aloft and kill flying mosquitoes on contact. ULV applications involve small quantities of active ingredient in relation to the size of the area treated, typically less than 3 ounces per acre, which minimizes exposure and risks to people and the environment as illustrated in figure 5.

Figure 5: Different Methods of Spray

3 ARTIFICIAL NEURAL NETWORKS

Artificial Neural Networks (ANNs) are artificial adaptive systems that are inspired by the functioning processes of the human brain. They are systems that are able to modify their internal structure in relation to a function objective. They are particularly suited for solving problems of the nonlinear type, being able to reconstruct the fuzzy rules that govern the optimal solution for these problems. The base elements of the ANN are the nodes, also called processing elements (PE), and the connections. Each node has its own input, from which it receives communications from other nodes and/or from the environment and its own output, from which it communicates with other nodes or with the environment. Finally, each node has a function f through which it transforms its own global input into output. ANNs are high in pattern recognition-like abilities, which are needed for pattern recognition and decision-making and are robust classifiers with the ability to generalize and make decisions from large and somewhat fuzzy input data. ANNs are modeling mechanisms particularly skilled in solving nonlinear problems. In technical terms, we can say that a system is not complex when the function representing it is linear. The process of ANN is shown in figure 6.

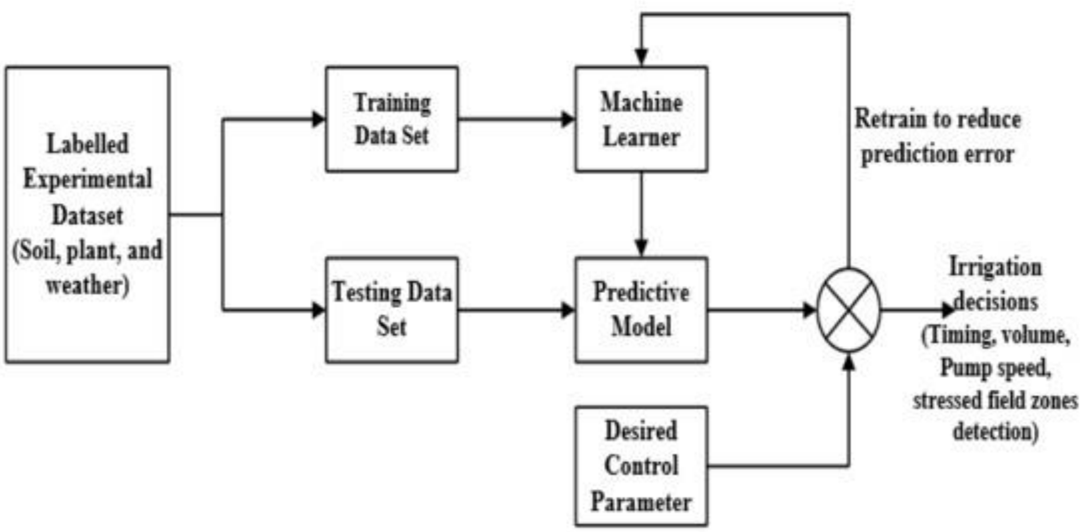

Figure 6: ARTIFICIAL NEURAL NETWORK

Artificial neural network (ANN) is a computational model that consists of several processing elements that receive inputs and deliver outputs based on their predefined activation functions.AI algorithms produce precise forecasts of crop yield potential by incorporating data from various sources, such as satellite photography and weather forecasts.

- Precision Soil preparation.
- Precision Seeding.
- Precision Crop Management.
- Precision Harvesting.
- Data analyses and evaluation.

The earliest and most commonly used, precision ag technique is for variable rate applications of inputs. Variable rate technology (VRT) is installed on seeders and fertilizers and is now being added to irrigation systems like center pivot systems. Crop health heavily depends on spraying to prevent the infestation of pests and diseases. Machine learning projects in agriculture address this area as well. Precision or targeted spraying is the technology that takes the best from intelligent software and computer vision in the agriculture sector. Thus, the technology obtains the target information such as the size and shape of the plant, and then applies herbicides as needed.

The benefit of this technique is that it allows for a more precise application of pesticides and fertilizers based on crop type. Precision spraying involves images and spectral signatures of plants, soil, and other substances to determine which chemicals should be applied. This technology minimizes the risk of crop damage while maximizing crop yield. Israelis Green eye Technology is a prominent example of this use case. Their AI-enabled precision spraying technology is proven to cut herbicide use by 78% and minimize costs by more than 50%. The software is compatible with any brand or size of the commercial sprayer which is highlighted in figure 7.

Figure 7: SMART AGRICULTURE

3.1 INSECT DETECTION

Insect detection is an important means to predict the detection of agricultural pests. Aphids including black fly, greenfly and white fly are found. Viruses can weaken the plant and cause stunted growth, leaf fall or other abnormalities to the flowers and leaves.

Steps in SVM

- Import the dataset.
- Explore the data to figure out what they look like.
- Pre-process the data.
- Split the data into attributes and labels.
- Divide the data into training and testing sets.
- Train the SVM algorithm.
- Make some predictions.

4. SUPPORT VECTOR MACHINE

Support Vector Machines (SVM) in data mining classification algorithms and analyzes and summarizes the research status of various improved methods of SVM. According to the scale and characteristics of the data, different solution spaces are selected, and the solution of the dual problem is transformed into the classification surface of the original space to improve the algorithm speed. The Support Vector Machine is a Machine Learning algorithm which may be used for acquiring solutions towards better crop management. The applications of SVM in precision agriculture (PA) are compared by identifying its interactions with variables, comparing its model performance, highlighting its strengths and weaknesses, as well as suggestions for improvements.

Agriculture is facing an imminent challenge towards ensuring food security as it struggles to balance between increasing food production and the environmental impacts arising from its intensification, including biodiversity loss, deforestation and carbon or greenhouse gas emissions. This pressing dilemma prompted the proliferation of Precision Agriculture (PA) as a potential discipline to explore methods for enhanced food production on existing lands shown in figure 8.

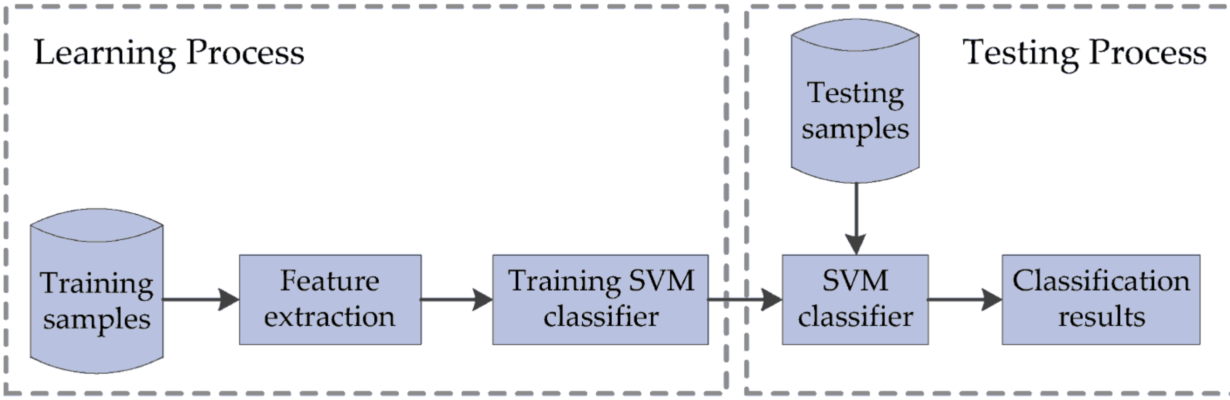

Figure 8: SUPPORT VECTOR MACHINE

Support vector machines (SVM) are a set of supervised learning methods used for classification, regression and outliers detection. A support vector machine (SVM) is a type of supervised learning algorithm used in machine learning to solve classification and regression tasks; SVMs are particularly good at solving binary classification problems, which require classifying the elements of a data set into two groups. The advantages of support vector machines are effective in high dimensional spaces.

Insects are a major threat to crops in agricultural facilities. Each year, between 20 to 40 percent of global crop production is lost to pests. To protect the facility, farmers use pesticides, but this not only kills the insects, but also the other small pests that live around the farm.Therefore, discerning the “bad actors” is difficult when done manually. The use of drones to detect insects in farming is not new, but the use of machine learning in this process has seen an increase recently. Thus, machine learning companies help farmers label pests to capture and identify them.To do that, data engineers first use real-time images of insects. In a research project, they then based the detection and coarse counting method on YOLO object detection, and the classification and fine counting on Support Vector Machines using global features. Combined, this data allows a computer vision model to accurately identify bees, flies, mosquitoes, moths, chafers, and fruit flies with an accuracy of over 90% and counts them with an accuracy of over 92%. The Insect Detection and diseases identification is shown in the figure 9 and 10.

Figure 9: Insect Detection

Figure 10: Hemiptera and Identifying Plant Pests and Diseases

5. LIMITS AND DRAWBACKS OF AI AND ML

However, despite all these advantages, the AI technology has also some drawbacks representing challenges. Firstly, the most important social challenge is the unemployment that could be a threat; in fact, smart machines and robots could replace the majority of the repetitive works and tasks; thus, human interference is becoming less, which will cause a major problem in the employment standards. Other technological challenges, for instance, machines can do only those tasks which they are programmed or developed to do, and anything out of that they tend to crash or give irrelevant outputs could be a major backdrop. In addition, the high costs of creation and maintenance of the smart machines as well as the cleaver computers could be considered as technological limits of the AI technologies, especially that AI is updating every day which is why the hardware and software need to get updated with time to meet the latest requirements. Machines need repairing and maintenance which is expensive. The creation requires huge costs as they are very complex machines. Other issues related to these applications are their high cost that could increase the price of the products. Moreover, beyond the opportunities afforded by smart and computerized technologies, some risks and apprehensions could be posed for sustainability, particularly the massive energy consumption, e-waste problem, market concentration, job displacement, and even the ethical framework.

6. THE FUTURE OF AI IN AGRICULTURE

Global population is expected to reach more than nine billions by 2050 which will require an increase in agricultural production by 70% in order to fulfil the demand. Only about 10% of this increased production may come from unused lands and the rest should be fulfilled by current production intensification. In this context, the use of latest technological solutions to make farming more efficient remains one great necessity. Present strategies to intensify agricultural production require high energy inputs and market demands high quality food. [74]. Robotics and autonomous systems (RAS) are set to transform global industries. These technologies will have great impact on large sectors of the economy with relatively low productivity such as agro-food (food production from the farm to the retail shelf). The UK agro-food chain generates over £108bn p.a., with 3.7m employees in a truly international industry yielding £20bn of exports in 2016.

7. RESULT AND DISCUSSION

Artificial intelligence techniques applied in the main fields of agriculture were identified, with the main benefits being the optimization of agricultural management systems, irrigation, and the identification of diseases and pests. It was observed that the increase in intelligence in agriculture could be related to the digitization and manipulation of large volumes of data, enabling the use of intelligent techniques in system optimization and planning. Computer vision was used in conjunction with robotics and Unmanned Aerial Vehicles (UAVs) for classifying crops and identifying diseases and pests. AI technologies can be applied in several areas of agriculture; it is necessary to understand the production chain of the crop analyzed to identify the best technique to be applied and its interrelationship with terms such as agriculture 4.0 and smart farming seek which can integrate these various technologies for the optimization of a production chain. Different comparison of performance analysis with different algorithms are stated in the figure 8.

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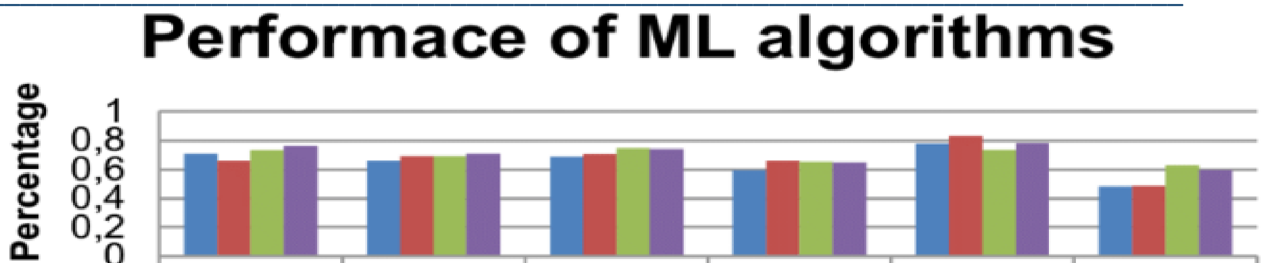

	AUC	AC	SN	SP	PPV	NPV
RF	0,708	0,658	0,689	0,594	0,777	0,481
SVM	0,657	0,69	0,704	0,658	0,83	0,484
ANN	0,733	0,691	0,745	0,651	0,734	0,628
LR	0,763	0,707	0,741	0,649	0,782	0,596

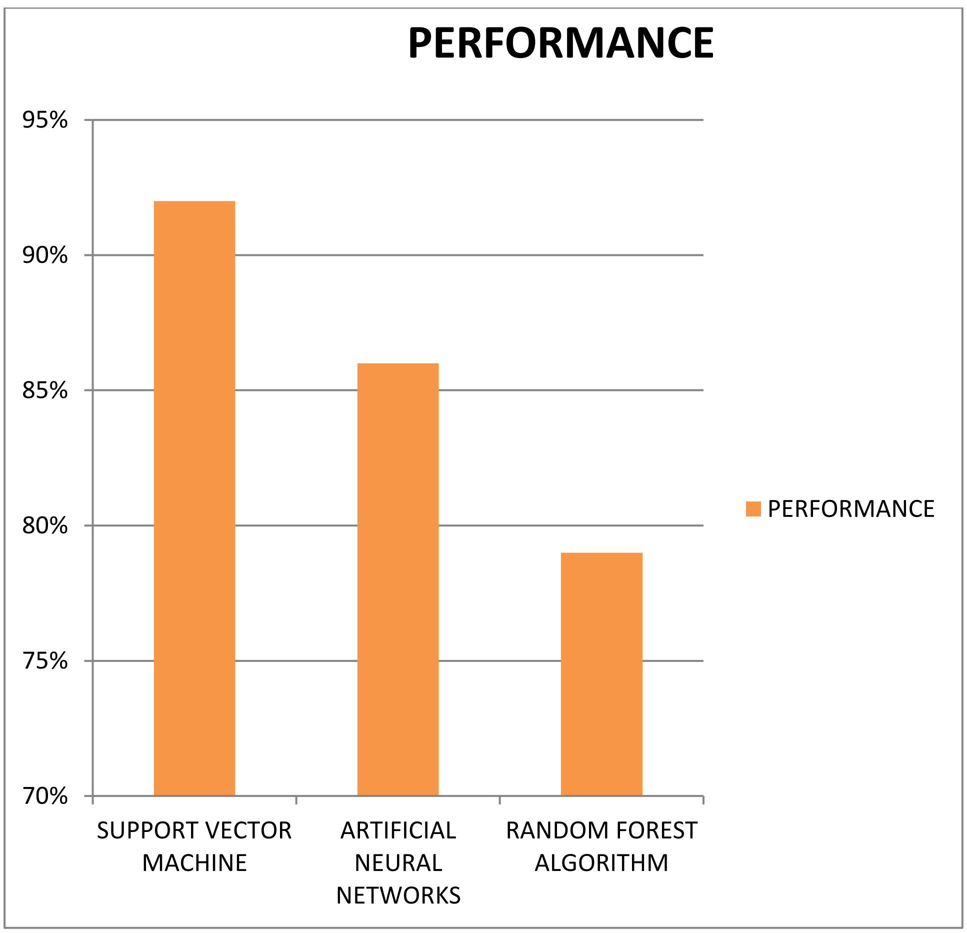

Figure 8: Performance Comparison of different AI Methods

8. CONCLUSION

Comparison of the performance of the various classifications used shows that all the algorithms have excellent performance in specificity, but in terms of classification sensitivity and accuracy, the support vector machine method has worked better. Global population is expected to reach more than nine billions by 2050 which will require an increase in agricultural production by 70% in order to fulfill the demand. Only about 10% of this increased production may come from unused lands and the rest should be fulfilled by current production intensification. In this context, the use of latest technological solutions to make farming more efficient remains one great necessity. They are versatile: different kernel functions can be specified, or custom kernels can also be defined for specific data types. Artificial intelligence including remote sensing techniques and 3d laser scanning are helpful to monitor crops throughout their lifecycle. AI solutions have made it possible for farmers to take immediate actions to restore soil health. AI is used now-a-days to predict advisories for sowing, pest control, input control can help in ensuring increased income and providing stability for the agricultural community. Using remote sensed data, high resolution weather data, AI technologies, and AI platform, it is now possible to monitor crops in a better way and provide additional insights to the extension workers/farmers for their farms as and when required. It works well in high-dimensional spaces and it's relatively memory efficient.

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