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Analysis of Smart Farming using Artificial Intelligence

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ABSTRACT

Techniques for Artificial Intelligence (AI) include a wide range of strategies and algorithms intended to make robots capable of carrying out tasks that normally call for human intelligence. AI and its applications are changing how data is processed and decisions are made, significantly affecting the global economy. According to the findings, farmers may make better decisions regarding the variables influencing crop development by analysing a variety of data gathered from fields and using real-time online Internet of Things (IoT) sensor data. Here experimental outcomes show how changing labels affects the accuracy of data analysis algorithms and discusses the current level of AI techniques in agriculture, highlighting important prospects and problems.

Keywords: Smart farming, artificial intelligence, agriculture prediction, internet of thing, deep learning, machine learning, feature selection and classification, random forest, naïve algorithm.

1. INTRODUCTION

Due to rising food costs that are causing food insecurity and poverty, agriculture is once again making headlines [1]. One essential component that plays a big part in feeding the world's expanding population is agriculture. Farmers must use them as efficiently as possible to maximize yields and minimize losses in order to meet the growing demand for food [2]. A significant aspect of contemporary agriculture is the prediction and analysis of harvest growth, and AI has emerged as a potent instrument to accomplish this objective [3]. Precision agriculture, often known as smart farming, is a contemporary farming practice that makes use of cutting-edge technology to maximize harvest yield and reduce waste. The goal of smart farming is to maximize yield while consuming the least amount of energy, water, and fertilizer possible [4]. Sensing/monitoring systems, data analytics, IoT sensors, and AI precision agriculture methods, remote monitoring, automated approach, big data management , cloud system, energy and farm control system programs are just a few of the many technologies that have been incorporated into the architecture of a smart farm over the years in an effort to improve farming practices and increase productivity [5]. The IoT is regarded as one of the main technologies that contribute to smart farming [6]. The optimal time to plant, irrigate, and harvest crops can be determined using the data collected by IoT sensors, which can also be used to monitor soil moisture, temperature, and other environmental factors [7, 8]. Farmers may ensure that reaps receive the proper quantity of water and nutrients by utilizing IoT sensors [9], which can enhance the quality and yield of the harvests [10].

In general, applying AI approaches to gather and analyse accurate data is crucial [11]. For precise results and high-predictions, data collection is essential in terms of both size and quality [12]. Large volumes of data from IoT devices and other sources can be analysed using AI algorithms [13]. It is a quickly expanding field that could revolutionize how we forecast and evaluate crop productivity and growth [14]. Without explicit programming, AI techniques allow to learn from experience by analysing data. It do predictions using statistical/mathematical wayouts [15]. AI approaches can be trained on extensive farm data, including soil information, weather patterns, crop growth systems and all disease/pests outbreaks. AI can accurately predict yield process/output and quality by analysing the data gathered [16]. In order to create thorough maps of crop growth, nutrition levels, and moisture content, AI's Machine Learning (ML) analyse large volumes of data from multiple sources, including soil sensors, satellite and drone footage. Based on climatic variables and market demand, AI can also assist farmers in determining which crops will yield the most profits [17]. AI can forecast the demand for various crops and recommend the best dates and places to plant by analysing past market data and weather trends [18]. By doing this, farmers can reduce the chance of crop failure and increase their revenues.

AI methods can analyse the quality of the harvested crops in addition to forecasting crop growth and yield [19]. To assess the maturity and quality of crops, AI's ML examine by color and texture/form. By using this information, the harvesting process may be optimized and consumers can be guaranteed to purchase only high-quality food [20]. Several classification techniques that can be used to create such models are covered in this paper, including Decision Tree (DT), Naïve Bayes Classifier (NBC/NB), Support Vector Machine (SVM), and Random Forest (RF). According to the authors, implementing AI-focused systems and solutions will greatly increase production and efficiency, leading to profound changes in the sector.

To give a thorough understanding, the introduction provided in Section 1. An overview of pertinent literature provided in Section 2. Crop analysis and methods employed presented in Section 3 (AI in smart farming). In Section 4, the experimental work done. Conclusion covered in Section 5.

2. RELATED WORK

The issue of how to create machines that get better on their own with experience is addressed by AI [21]. AI is used in crop yield prediction techniques to enhance crop quality and maximize farmer profits [22]. The economy as a whole benefits from the improvement in the quality of the agriculture sector [23]. The literature has covered this topic in great detail [24]. A overview of machine learning algorithms for palm oil yield prediction is covered in [25]. The authors analysed the relevant literature, concentrating on the benefits, drawbacks, and restrictions of the proposed methods [26]. Additionally, the authors offered a new machine learning-based architecture to forecast palm oil yield based on the review and analysis of previous research [27]. Given that soil characteristics have a significant impact on crop output, the authors in [28] concentrated on crop prediction and yield by examining soil quality. The scientists looked at a variety of soil characteristics, including temp., moisture, precipitation, humidity and PH value etc. Three machine learning algorithms are the subject of comparative analyses: RF, Regression and NB [29]. Also authors compared these algorithms in terms of accuracy. In order to assist farmers in poor nations who are still utilizing traditional methods and are unable to determine the correct market value of their products, a crop production models was suggested in [30] that attempt to manage the generated crop using ML [31]. Three scenarios serve as the foundation for the suggested system: first, selecting the best crops according to the farmer's location; second, offering advice on how to prepare the soil; and third, determining the most effective method of selling commodities from farmer to customer [32].

SVM, RF and accurate real-world climate, weather, and soil data were all used by the authors [33]. Because natural resources are limited globally, the authors in [34] suggested using supervised AI's ML techniques like SVM, RF and Artificial Neural Network (ANN) to assist farmers in choosing and producing crops in a way that will improve the nation's overall economic standing [35]. Using the AI's ML techniques like RF, SVM, DT, Gaussian Naïve Bayes (GNB), K-Nearest Neighbor (K-NN) the authors proposed a prediction. According to the authors, by identifying the optimal machine learning method for improved crop prediction and analysis, the study may aid in the smart-farming process. Thirteen districts were included in the soil prediction dataset that was gathered from Punjab Agricultural University (PAU), Ludhiana, India [36]. The authors asserted that by comparing various ML techniques including NB, SVM and Bayes Net (BN), they were able to assist farmers in choosing and producing crops in the best possible way. A three-stage structure was proposed by the authors, who suggested a variety of crop kinds for this study. The first step is data pre-processing and feature extraction, followed by classification and performance evaluation.

The authors concluded from the comparison that NB with an accuracy of 99.78%, is the best classifier. Given that crop diseases are the primary cause of yield losses, particularly in developing nations, and that crop monitoring is regarded as the primary domain in the smart-farming process [37]. The scientists asserted, based on the comparison and results, that deep learning-based agricultural monitoring systems are more potent and accurate than some traditional methods used in underdeveloped nations. A new SVM-based method for supplementary data on actual agricultural applications was put out [38]. This suggested methodology can be used by farmers to increase crop yields and by various government agencies to boost crop output.

The authors have proposed the use of ML approach in conjunction with rainfall data to assist farmers in making informed decisions about harvests even prior to planting [39]. The authors asserted that the suggested approach would help farmers enhance agricultural yield outcomes based on the results they had supplied. This study's primary goal was to forecast crop productivity loss using regression [40]. In this assessment, the authors used both the NB and DT methods. To help farmers anticipate crop yields, the authors created a web-based tool [39]. The various ML techniques used in literature were assessed. Based on the comparison results presented, the authors came to the conclusion that SVM, DT and NB etc. performed the best overall and were most extensively used for crop disease prediction. The authors used ML and the Convolutional Neural Network (CNN) to propose a system for the early prediction of crop diseases in plants. Dataset is used for testing and training. The classifier is trained to compare the accuracy of several diseases that are gathered in a database and select the most accurate one. The authors gathered web information. The dataset was clustered using SVM to make data analysis and NB technique used to determine which crop would be best to plant. It is evident from the literature study above that this topic has been covered in the literature from a variety of angles. AI's ML were used in the majority of this field's work to help farmers anticipate crops more accurately and increase overall production. Our goal is to enhance the effectiveness of AI in smart farming by presenting experimental findings that show how label changes affect data analysis systems' accuracy. According to the study's findings, farmers might analyse a variety of data gathered from farms, including real-time data from IoT sensors.

According to the analysis, AI exhibits a high degree of classification accuracy. These outcomes demonstrate how well and consistently AI classifies the provided data. Thus, results obtained can be utilized to help farmers make well-informed decisions about crop prediction to increase output, which would in turn boost the economy.

3. AI IN SMART FARMING AND MATHODOLOGY

Using cutting-edge technologies to boost sustainability, reduce environmental damage, and boost productivity, innovative farming practices have completely changed agriculture. A key element of this shift is AI's ML, which has made it possible for a number of applications that streamline farming operations and improve decision-making. Applications of AI are frequently employed in crop, soil, water, and livestock management. Through predictive modelling and real-time health monitoring, AI increases sustainability while improving livestock welfare and productivity [35]. AI is used to analyse a number of parameters to optimize irrigation/water management. Given the unpredictability of natural phenomena and the complexity of their interactions, this is particularly beneficial [36]. AI is used in soil management to analyse health, forecast nutrient requirements and determine the variables influencing soil distribution controls [37]. AI predicts crop yield, identifies species, assesses crop quality, and finds diseases and weeds, just like in crop management. For farmers, policymakers, food security-focused governments, and food marketing organizations, crop yield forecast is crucial [38].

A wide range of AI's ML techniques such as ANNs, SVM and RF can be used to forecast agricultural yield [39]. Accurate crop production estimates are made possible by these algorithms' capacity to process both historical and current data on weather, soil conditions, and crop health. GPS-based soil sampling and GPS guiding systems, autonomous vehicles, variable tools, automated hardware/software/sensors/cameras, drones, robotics and control systems are among the cutting-edge technologies that encourage farmers to employ them to gather data [40]. Educating farmers on how to use AI has the potential to revolutionize agriculture and boost output. There are ways to teach farmers about the advantages of smart farming and the application of AI techniques. AI-based analysis is shown in Fig. 1.

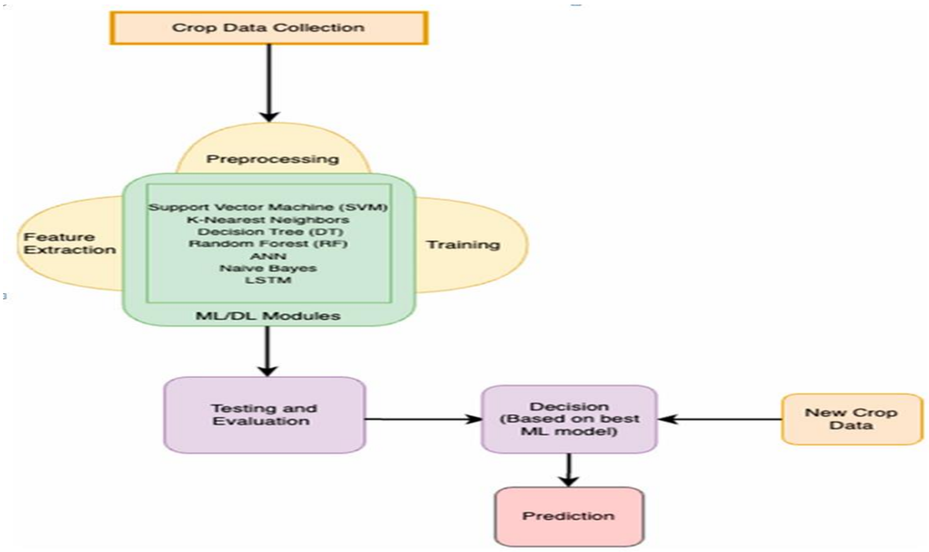

Fig. 1: AI-based analysis

Here, we used a wide range of seven different AI's ML techniques to build models using 1500 records of agricultural data. Figure 2 shows our crop analysis process, which follows the conventional steps of data analysis. The addition of several classifiers, which are adjusted and assessed to determine which are best suited for the incoming data, is a notable advancement. Additionally, our approach uses feature reduction and augmentation techniques, which are crucial for emphasizing relevant aspects that improve crop detection and farmers choose the best features.

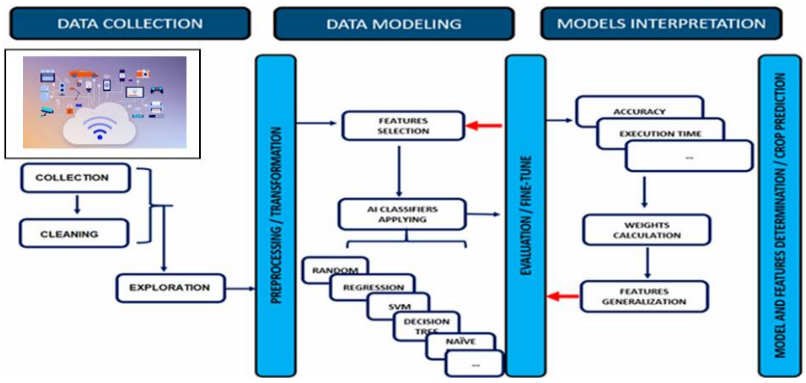

Fig. 2: Methodology using AI

These algorithms, which included the NBC, RF and SVM were carefully selected based on their special qualities and capabilities. We carefully examined the findings, focusing on the - Data Collection: For ML analysis, data collection from IoT devices on farms is essential. We stress the significance of data gathering and pre-processing, which includes operations like cleaning and transformation, to guarantee high-quality data. The NBC is a supervised algorithm that classifies objects using the Bayes theorem. It is employed in data mining and ML applications for tasks including medical diagnosis, spam filtering and text analysis. NB makes the assumption that a class's features are unrelated to one another. The NB algorithm works effectively in practice, particularly when there are a lot of features and sparse data. One kind of supervised ML used for classification and regression issues is called RF. DT is used in this ensemble learning technique to generate a prediction. To arrive at a final forecast, RF generates a large number of DT and aggregates their predictions. We sought to give farmers effective and efficient crop recommendations by combining various approaches.

4. EXPERIMENTAL OUTCOMES

Seven distinct AI's ML approaches are utilized to model agricultural data and suggest to farmers which crops would be best to grow on their land. The Kaggle database, an online platform that allows scientists to share their research data was taken [40]. The dataset contains a number of characteristics, including the soil's temp., potassium content (P) ratio, pH value, humidity, phosphorus and Nitrogen content (K and N) ratio. Training uses 62% of the data while testing uses the remaining data. The train and test times for each method are displayed in Table 1. The ANN algorithm takes longer to train than other as can be seen.

Table 1: Training and Testing Time for AI algorithms

Technique	*Training Time*	*Testing Time*
NBC	0.01	0.66
BN	0.41	0.21
ANN	16.66	0.01
Regression	2.1	0.02
DT	0.77	0.02
RF	1.55	0.11
SVM	1.68	0.12

Table 2 summarizes the findings of the experiment, where we examined the accuracy of different classification techniques. Table 2 demonstrates that certain classification techniques are more effective in forecasting.

Table 2: Comparative Analysis of Accuracies with Usage of AI techniques

Technique	*Accuracy (%)*	*Usage*
NBC	**99.78**	88.1
BN	99.71	91.1
ANN	98.31	98.1
Regression	98.11	99.1
DT	88.12	95.1
RF	98.32	99.2
SVM	99.73	99.3

5. CONCLUSION:

Our study demonstrated the value of using AI's ML and IoT sensors in contemporary agriculture to maximize harvest yield and minimize waste by making well-informed decisions. The opportunities and difficulties of integrating technologies in agriculture are identified. Along with accuracy, usage, training and testing time for each algorithm done, it includes experimental outcomes showing how label changes and affect data analysis. Using several AI approaches it was examined crops based features, yield with results. It obtained the maximum accuracy using the data set during analysis.

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