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Crops Recommendation System Based on Rain Data Using Machine Learning Techniques

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Abstract

In agriculture, it is essential to make well-informed decisions regarding crop selection to guarantee the highest possible yield and usage of available resources. The parameters of the weather, particularly the rainfall patterns, play a considerable impact in defining the kind of crop being grown. As a result, the incorporation of machine learning strategies into creating a crop recommendation system founded on rainfall data becomes necessity. This importance comes form the fact that the world is confronted with challenges that motivate research to combine technologies to mitigate these issues in the agriculture sector such as global warming, draught and pollution. In this research, we released a review paper that examined the latest advancements in machine learning in the agricultural scientific domain. The primary objective of this research is to explore the benefits that can be derived from employing machine learning in recommender systems for agricultural purposes. This paper investigated various machine learning methodologies, such as support vector machines (SVM), kernel neural networks (KNN), and random forests. The research concluded that the current mechanisms used for creating the decisions in the recommender system are all based on the supervised machine learning techniques that require to train the knowledge based on the model. Thus, it is recommended that further research to be done in this domain for better accuracy and reduce the time needed for training the model.

Keywords: Agriculture, crops, recommender system

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نظام توصية المحاصيل بناءً على بيانات الأمطار باستخدام تقنيات التعلم الآلي

همام راضي عليوي [1] ، جمال مصطفى التويجري [2]

المستخلص

في الزراعة، من الضروري اتخاذ قرارات مستنيرة فيما يتعلق باختيار المحاصيل لضمان أعلى إنتاج ممكن واستخدام الموارد المتاحة. تلعب عوامل الطقس، وخاصة أنماط هطول الأمطار، تأثيرًا كبيرًا في تحديد نوع المحصول الذي تتم زراعته. ونتيجة لذلك، أصبح دمج استراتيجيات التعلم الآلي في إنشاء نظام توصيات المحاصيل بناءً على بيانات هطول الأمطار أمرًا ضروريًا. وتأتي هذه الأهمية من حقيقة أن العالم يواجه تحديات تحفز البحث على الجمع بين التقنيات للتخفيف من هذه القضايا في قطاع الزراعة مثل ظاهرة الاحتباس الحراري والجفاف والتلوث. في هذا البحث، أصدرنا ورقة بحثية تناولت أحدث التطورات في التعلم الآلي في المجال العلمي الزراعي. الهدف الأساسي من هذا البحث هو استكشاف الفوائد التي يمكن استخلاصها من استخدام التعلم الآلي في أنظمة التوصية للأغراض الزراعية. بحثت هذه الورقة في منهجيات التعلم الآلي المختلفة، مثل أجهزة المتجهات الداعمة (SVM)، والشبكات العصبية النواة (KNN)، والغابات العشوائية. وخلص البحث إلى أن الآليات الحالية المستخدمة في اتخاذ القرارات في نظام التوصية تعتمد جميعها على تقنيات التعلم الآلي الخاضعة للإشراف والتي تتطلب تدريب المعرفة القائمة على النموذج. وبالتالي، يوصى بإجراء مزيد من البحث في هذا المجال للحصول على دقة أفضل وتقليل الوقت اللازم لتدريب النموذج.

الكلمات المفتاحية: الزراعة، المحاصيل، نظام التوصيات

انتساب الباحثين

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معلومات البحث
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Introduction

The agriculture is considered as one of the most important sectors that subsidize the economy of any nation worldwide. Thousands of years ago, people depend on agriculture and farming for providing their daily life food and for trade. In order to maintain the agriculture, a continual attention must be given to this sector by the governments and farmers [1]. The fertilization, irrigation, soil management and crops managements and care are some of the tasks that must be considered carefully. Nowadays, special care and attention must be given to agriculture due to the global issues, facing the entire world such as the scarcity of the irrigation water, global warming, pollution, desertification and the increasing world's population. That can put a special pressure on this sector in order to fulfill the need to provide the basic food for the expanding populations [2]. Modern technologies are efficient tools that can be used in this domain to help to boost the agricultural sector. Thus, technology come to make life easier with more productivity. Agriculture is not far from the other sectors that benefit from technology [3].

Recommender system is considered as one of the most recent advances in the area of data mining and machine learning. It is a system that helps customers to select the best choice according to the input criteria provided by the user. The architecture of the system is based on an engine that prioritizes the recommended options to the users. It can be understood as an information retrieval system (IRS). However, it is more than an IRS. It is a system that filters the output and matches the output to the input directives which are provided by the user to retrieve the best match. Thanks to the machine learning techniques that allow the recommender system to have the capability to filter the information needed by the users [4,5]. There are several benefits that can be provided by the recommender system in corps development, disease avoidance and detection and the selection of the most suitable crop based on participation data using machine learning algorithms. In this context, the predication that can be delivered to the farmer is important economically. The suggestion of the best plant that can be more profitable according to the rain data is necessary for farmers. Therefore, the machine learning techniques are very important to be used for this purpose [6,7].

Machine Learning (ML), an Artificial Intelligence (AI) branch, has demonstrated significant promise in improving different facets of Agriculture. It is a computer program or system that can acquire knowledge and perform specific tasks without explicit programming [8]. The approach entails utilizing a computer to make judgments by considering several data sources. In this context, "data" refers to a collection of specific instances or examples [9].

Still, it is an essential investment to ensure the efficiency and dependability of machine learning applications in agriculture. In addition, cooperative endeavors and alliances with farmers, agricultural institutions, and research organizations can aid in the consolidation of data resources [10].

Despite the significant advancements in machine learning (ML) in agriculture, some unresolved issues still have common characteristics, even if the subject encompasses various sub-fields. Based on reference [10], the primary challenges related to deploying sensors on farms are primarily attributed to expensive information and communication technology (ICT), adherence to conventional methods, and insufficient access to information. Furthermore, most of the existing datasets do not accurately represent real-life scenarios. This is because they are typically created by a small group of individuals who collect photographs or specimens within a limited time and from a restricted geographical area [11].

Therefore, there is a need for additional datasets derived from various fields [12]. Furthermore, there is a recognized requirement for ML algorithms that are more efficient and for computational architectures that can scale, resulting in accelerated information processing [13]. The difficulty in acquiring media has been attributed to various factors, including alterations in lighting conditions [14], blind spots in cameras, surrounding noise, and simultaneous vocalizations [15,16]. An additional significant issue is that most farmers need more machine learning (ML) expertise, which hinders their ability to grasp the underlying patterns generated by ML algorithms entirely. In light of this, it is imperative to build more user-friendly systems. Specifically, uncomplicated, easily understandable, and manageable solutions would greatly benefit. For instance, a visualization tool with a user-friendly interface would be ideal for accurately displaying and manipulating data [17]. Considering the increasing familiarity of farmers with smartphones, specific smartphone applications have been suggested as a potential approach to tackle the difficulty above [18,19]. Lastly, it is essential to promote the advancement of practical machine learning approaches that integrate the expertise of several stakeholders, namely in computer science, agriculture, and the business sector. This will enable the creation of practical solutions [20, 21,22]. As mentioned in reference [23], the current focus is on individual solutions that are not necessarily integrated with the decision-making process, similar to what is observed in other fields.

This paper showcases the latest advancements in utilizing machine learning methods in recommender systems designed specifically for farming and agricultural applications. Although data-driven decision-making in agriculture is becoming increasingly important, there is a significant lack of scholarly research on the use of recommender systems in this field. The authors were motivated by the absence of comprehensive scholarly publications to undertake this task and publish a meticulous review study that aims to fill this gap. This paper offers useful insights into the potential of machine learning-based recommender systems to alter agricultural practices by integrating previous research, emphasizing key breakthroughs, methodology, and challenges. By conducting a comprehensive analysis of pertinent research and real-life instances, our aim is to provide clear direction and motivation for researchers, practitioners, and stakeholders who are interested in utilizing machine learning to improve farming efficiency, production, and sustainability. In addition, we analyze emerging patterns, possible areas for further study, and prospects for advancement in this quickly changing domain. In summary, this review paper functions as a thorough reference for enhancing understanding and promoting further progress in the convergence of machine learning and agriculture. In this context, machine learning serves the agricultural sector from different aspects. In this review, an extensive literature survey is presented to show the impact of using the machine learning techniques in farming.

This paper is organized as follows: in section, the preliminaries regarding the paper presented are given including the machine learning model in agriculture domain, and recommender System, while in section three the literature survey is given and finally the conclusion is presented in section four.

Preliminaries

In this section we present an overview about the aim concepts related to this current work:

Machine learning Model in Agriculture Domain

Machine learning techniques often involve acquiring information from training data or "experience" to achieve a specified goal. In machine learning, data consists of a set of examples [24]. A set of characteristics, attributes, or variables commonly defines a singular occurrence. An attribute, or characteristic, is a distinctive quality or feature associated with someone or something. The data can be categorized as nominal (enumeration), binary (0 or 1), ordinal (e.g., A+ or B-), or quantitative (integer, real number, etc.) [25,26]. The effectiveness of the machine learning model in a specific activity is assessed by using a performance indicator that shows improvement as experience is gained. Diverse statistical and mathematical models are utilized to evaluate the efficacy of machine learning models and algorithms. After the learning process, the trained model can classify, predict, or group new occurrences (testing data) using the knowledge acquired during training [27]. Figure (1) depicts a conventional machine learning methodology used in agriculture.

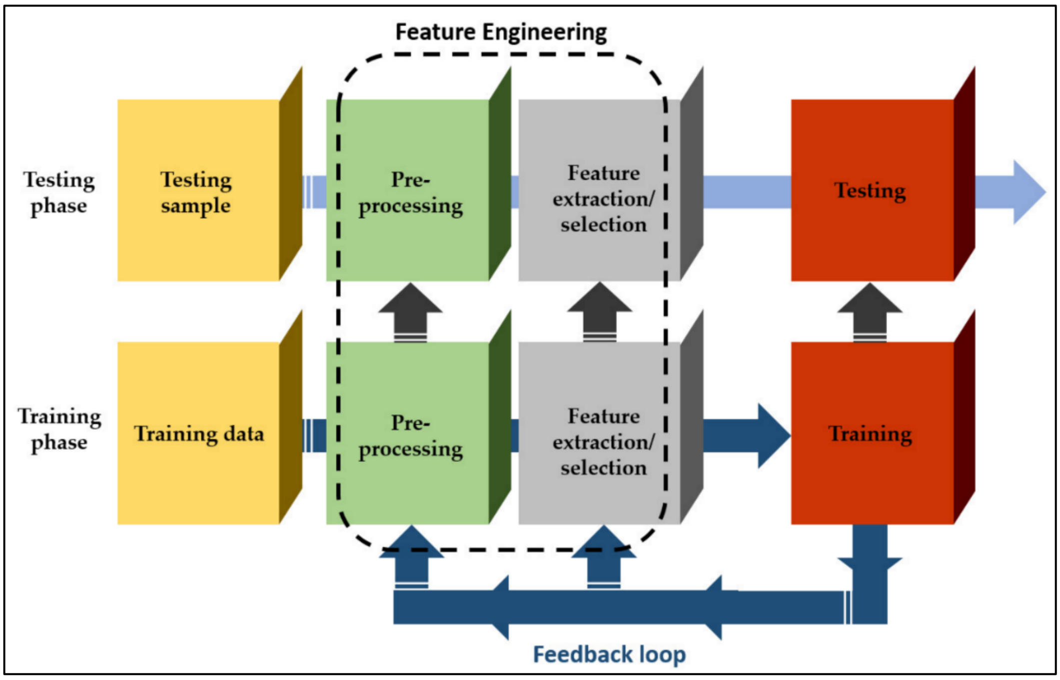

Figure (1) illustrates the general process for developing and using machine learning models in agriculture

The machine learning system in general is composed of two phases: the training and the testing phases [28,29]. Each phase has the following steps:

Phase (I) which is the training phase:

1- Input the agricultural data after preprocessing the data and resolving any inconstancies in it.

2- Training the model using the obtained data in the knowledge based of the model.

3- Apply the machine learning models such as the classification, clustering or the neural nets models.

4- The farmer request the information form the model.

Phase (II) the testing phase [30]:

1- Testing data by matching the input test exemplars with the registered in the knowledge base.
2- The evaluation step comes after testing the model.
3- Visualization of the obtained results.

Generally, machine learning algorithms aim to enhance a task's performance by leveraging examples or previous experience. Specifically, machine learning can create effective connections between data inputs and rebuild a knowledge framework. In this data-centric approach, the efficacy of machine learning improves as the quantity of utilized data increases. This is analogous to the proficiency with which a human accomplishes a certain task by accumulating additional expertise [28]. The primary result of machine learning is the assessment of generalizability, which refers to the ML algorithm's capacity to accurately make predictions on new data, based on previously learned rules from similar data [29]. Data, in a more precise sense, consists of a collection of instances defined by a set of attributes, commonly referred to as features. Machine learning systems generally function through two distinct processes: learning, which is utilized for training, and testing. To streamline the previous procedure, these characteristics typically combine to create a feature vector, which can be binary, integer, ordinal, or nominal values [30]. This vector is used as an input during the learning phase. During the learning phase, the machine acquires the ability to carry out a task through experience using training data. It concludes once the learning performance reaches a sufficient threshold, as determined by mathematical and statistical relationships. Afterwards, the model created during the training phase can be utilized for classification, clustering, or prediction purposes.

Figure 2 is a depiction of a typical ML system. In order to transform the obtained complex raw data into a suitable state, a pre-processing effort is necessary. The typical process has three main steps: (a) data cleaning to eliminate inconsistent or missing items and noise, (b) data integration to handle many data sources, and (c) data transformation, which includes normalization and discretization [31]. The extraction/selection feature tries to determine the most informative subset of features used in the training phase of the learning model [32]. The feedback loop, shown in Figure 2, is used to adjust the feature extraction/selection unit and the pre-processing unit, which in turn enhances the learning model's performance. During testing, novel samples are introduced to the trained model, typically expressed as feature vectors. Ultimately, the model makes a suitable choice, such as classification or regression, based on the features present in each sample. Deep learning, a subfield of machine learning, employs a different structure by transferring the task of transforming raw data into features (known as feature engineering) to the learning system it uses. As a result, the system does not have a feature extraction/selection unit, which means it may be fully trained. It takes a raw input and produces the desired output [33,34].

Recommender System

Recommender systems are software applications designed to forecast a user's interest in a particular item and offer them the most suitable goods (products or services). These systems are used by both individuals and businesses. This forecast is derived using pertinent data regarding the things, the users, and the interactions between items and users [35]. The purpose of building recommender systems is to alleviate the problem of information overload by extracting the most relevant information and services from a large amount of data, therefore providing individualized services. A vital feature of a recommender system is its ability to deduce a user's preferences and interests by analyzing the user's behaviors and other users' actions to generate personalized recommendations [36].

Recommender systems are a method for personalizing e-services that has garnered considerable attention in the past twenty years [37].

The inception of recommender systems can be traced back to early investigations in information retrieval and filtering [38]. In the mid-1990s, recommender systems emerged when academics started focusing on solving recommendation problems that largely depend on grading structures [39]. Commonly used recommendation algorithms include collaborative filtering (CF) [40], content-based (CB), and knowledge-based (KB) [41] methods. Every recommendation has unique benefits and constraints. Collaborative filtering (CF) has challenges such as sparseness, scalability, and cold-start problems [37,39]. However, content-based filtering (CB) is susceptible to providing too specialized recommendations [42]. Several sophisticated recommendation methods have been proposed to tackle these problems, such as recommender systems based on social networks [43], fuzzy recommender systems [44,45], recommender systems that consider context awareness [46], and group recommender systems [47]. The recommender system in the agricultural purposes can be designed as can be seen in figure (2) where there are three stages which are the input data collected by sensors or otherwise to be input to the machine learning recommender system. The machine learning methods mostly are unsupervised methods used for the classification, such as the Support vector machines, k nearest neighbors and others.

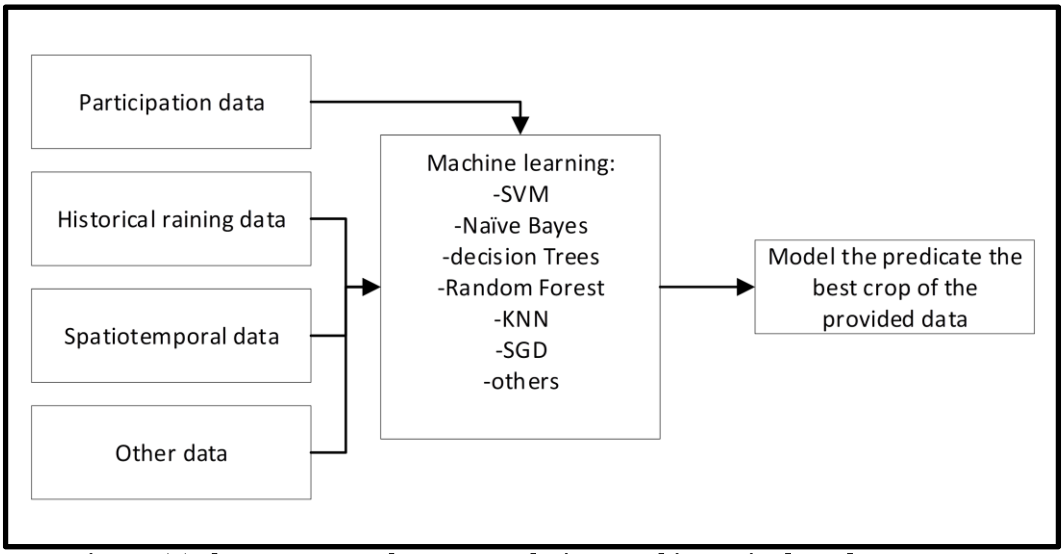

Figure (2) the recommender system design used in agricultural purposes

The flowchart begins with the collection of various datasets, including participation data, historical raining data, spatiotemporal data, and any other relevant data sources. These datasets are preprocessed to handle missing values, normalize features, and potentially extract relevant features. The preprocessed data is then split into training and testing sets. The training data is fed into several machine learning algorithms, including Support Vector Machines (SVM), Naïve Bayes, Decision Trees, Random Forest, K-Nearest Neighbors (KNN), Stochastic Gradient Descent (SGD), and potentially others. Each algorithm is trained on the data and evaluated using cross-validation to assess its performance in predicting the best crop. The algorithm with the highest accuracy or other appropriate evaluation metric is selected as the final model. This model is then used to predict the best crop based on the input data, providing valuable insights for agricultural decision-making.

Related Work

Crop Recommendation Systems utilize soil data such as nitrogen ratio, phosphorous ratio, potassium ratio, soil pH, and environmental conditions, including humidity, rainfall, and temperature.

In their work, Kiran Shinde, Jerrin Andrei, and Amey Oke introduce a crop recommendation system that evaluates the effectiveness of Naive Bayes, ID3, and Random Forest algorithms. The model uses the Random Forest methodology, which exhibits higher precision than the Naive Bayes and ID3 algorithms. In addition, the study presents two supplementary systems: one for providing fertilizer recommendations and another for aiding crop rotation. The crop rotation recommendation model is created utilizing the FP algorithm. The fertilizer recommender algorithm computes the optimal combinations of fertilizers that meet the unique requirements of the crop while minimizing costs. Agriculturalists can use the internet and mobile devices powered by the Android operating system to gain entry into the system.

S. Pudumalar, E. Ramanujam, R. Harine Rajashree, C. Kavya, T. Kiruthika, and J. Nisha developed a model that employs the well-established ensembling majority voting technique described in article [47]. The ensemble method enhances the precision of a model by incorporating multiple strategies rather than relying on a solitary approach. The technique employs various fundamental learners, including Random Forest Tree, Chaid, K-Nearest Neighbor, and Naive Bayes, to create a prediction model that combines the advantages of all the algorithms, leading to the highest level of accuracy.

The study [48] introduces an architecture that utilizes a majority voting technique, a frequently employed ensembling technique. The model employs fundamental machine learning algorithms such as Multi-layer Perceptron (Artificial Neural Network), Support Vector Machine, Random Forest, and Naive Bayes. Their aptitudes and capacity determine the selection of base learners to complement one another. This suggests that if one algorithm makes a mistake, the other algorithms have the power to correct it.

The work conducted by Zeel Doshi, Subhash Nadkarni, Rashi Agrawal, and Prof. Neepa Shah includes the incorporation of crop compatibility and rainfall predictions into the crop recommendation system [49]. The Linear Regression approach forecasts and visually displays the quantity of precipitation in a particular state over 12 months. The performance of various supervised learning algorithms, including Random Forest, Decision Tree, Neural Network, and K-NN, is evaluated to determine the algorithm that achieves the highest accuracy score. The crop recommendation system uses the Neural Network technique, which obtains a 91% accuracy score, to construct a model. The training model of the crop recommendation system utilizes monthly rainfall estimates to determine the most suitable crops for recommendation.

The research undertaken by Nidhi H Kulkarni, Dr G N Srinivasan, Dr B M Sagar, and Dr N K Cauvery [50] presents a crop recommendation system model that employs a majority voting technique, which is a type of ensembling technique. The ensemble model consists of three base learners: Random Forest, Naive Bayes, and Linear SVM. Every distinct sample from the dataset undergoes training and testing using the algorithms. Utilizing the ensembling technique resulted in an accuracy score of 99.91%. The research undertaken by Rushika Ghadge, Juilee Kulkarni, Pooja More, Sachee Nene, and Priya R L established a method that assesses the quality of soil to determine the most suitable crop for cultivation, considering the particular soil type. The system aims to optimize crop yield by supplying suitable fertilizer.

In [51], unsupervised learning methods, such as the Kohonen Self-Organizing Map, are differentiated from supervised learning algorithms like the Back-Propagation Network. The approach with the highest degree of precision is selected to construct the model for the system.

Patil, Panpatil, and Prof. Kokate employed supervised learning algorithms, including Decision Tree, Naive Bayes, and KNN, in their research [52]. Upon comparison, it is clear that the KNN algorithm demonstrates the highest precision; while the decision tree exhibits the highest level of accuracy. Decision trees exhibit suboptimal performance when a dataset has substantial variability.

Nevertheless, Naive Bayes surpasses decision trees in these situations. Ensemble classification techniques, such as Naive Bayes and decision tree classifiers, perform better than individual classifier models. The crop selection technique proposed by S. Jain et al. [53] is based on climatic variables. Firstly, the weather forecast for the particular season is analyzed, and suitable crops for cultivation are selected based on the weather forecast and dataset. An assessment is being conducted on the attributes of the Telangana state. A Recurrent Neural Network (RNN) is used for weather forecasting, while a Random Forest Classifier is deployed to predict the most suitable crop for cultivation. The suggested approach also advised a precise schedule for sowing the crops.

In [54], the study introduces a crop recommender system that is used to maximize the farms product during the seasons. The utilization of such a system has a positive reflection on the productivity per a season. The suggested method could enhance the crop's yield rates. In [55], the research presents and deployed an advanced crop recommendation system accessible to farmers across India. The suggested method aid people in charge to make studied decisions regarding crops selection according to various environmental and geographical parameters. In addition, the authors have incorporated a supplementary mechanism called the rainfalls predictors that predict the amount of the participation for the next year.

In [56], the authors discussed the development of a highly efficient agricultural output forecasting system that relies on real-time monthly meteorological data. Predicting agricultural crop production is challenging due to the unpredictable weather patterns and quick regional climatic changes caused by global warming. There is an urgent need to create a farming production forecasting system that utilizes up-to-date weather information.

In [57], the authors focused on the processing of data quantities on a monthly and daily basis, as well as the configuration of the prediction system. The authors construct a non-parametric statistical model using 33 years of agricultural weather data. Based on the implemented model, they used the monthly weather information to predict the final production. This document presents the outcomes of the simulation.

This study introduces a system that utilizes data mining techniques to forecast the category of the examined soil datasets. The anticipated category will represent crop production. Forecasting agricultural yield is formulated as a classification rule, employing the Naive Bayes and K-Nearest Neighbor techniques. The system employed multi-label classification algorithms to provide crop recommendations. Furthermore, their methodology includes a sub-system that forecasts precipitation state-by-state and graphically displays it on a map.

In [58] the authors provided an overview of different data mining frameworks that are used to analyze cultivating soil datasets in order to make fertilizer recommendations. In order to address soil nutrient deficiencies, fertilizers are used to maintain optimal nutrition levels in the soil. Indian agriculturists commonly face the challenge of manually determining and applying the appropriate quantity of fertilizers. Overapplication or underapplication of fertilizers can have detrimental effects on plant health and decrease crop productivity.

In [59], the authors provided a document that consolidated the research of multiple authors into a single source, making it a significant resource for professionals seeking information on the present state of data mining methods and applications in the field of farming. In [60], the authors presented the concept of developing AgroNutri, an android application designed to provide precise information on the optimal amount of fertilizer to be applied for different crops. The objective is to determine the appropriate amount of NPK composts to be applied based on the recommended requirements for the specific crop being cultivated. This application operates based on the product selected by the farmer, which is provided as input, thereby benefiting the farmers. The future potential of AgroNutri is the integration of GPRS technology to provide location-based nutrient recommendations.

After analyzing the research publications cited in the literature study, it was observed that most authors concentrated on a single indicator to forecast crop adaptation. Their suggestions for a specific crop were derived from their examination of either soil characteristics, weather patterns, or potential revenues. Each effort was limited to particular crops and soil types while selecting. Hence, given the substantial dependence of the Indian labor force on agriculture as their primary source of earnings, it is imperative to consider all the essential factors that influence the decision. The information should include soil characteristics, weather conditions, and fertilizer application to improve precision and expand the suggested crop range. Considering all these factors contributing to crop growth is crucial for accurate estimates. Various machine learning models should be evaluated to identify the best precise model for crop selection [59, 60].

Discussion

An analysis of academic literature examining machine learning and deep learning algorithms demonstrates their potential usefulness in assisting farmers. These algorithms have been used to construct several systems, such as Crop Recommendation, Crop Rotation Recommendation, Fertilizer Recommendation, and Rainfall Prediction. In all the papers there is motivation to generate a recommender system that depend on the incorporating machine learning.

Significantly, study [50] presents a remarkable forecast accuracy of 88% for the model being examined. Furthermore, as mentioned in Study [57], Neural Network models have the highest level of accuracy, reaching 91%, surpassing other techniques. The Study emphasizes the greater accuracy of the Support Vector Machine method compared to Logistic Regression, obtaining a fantastic 97%. There are many other examples that present the machine learning effects of the test results. In Study [58], the K-Nearest Neighbors method demonstrates superior performance compared to the Support Vector Machine technique, with an accuracy rate of 89% instead of 80%. Furthermore, according to Study [59], the K-Nearest Neighbors method demonstrates the highest level of accuracy, reaching 89.4%, after assessing multiple algorithms. This research focuses on the benefits of each classifier and evaluates their appropriateness for a crop recommendation system. It covers the entire process, from data collection to model construction, to accurately predict the most suitable crops for specific conditions. The prediction is based on the idea of the unsupervised learning and classification. The experiment also demonstrates the effectiveness of several computing methods in forecasting diverse climate phenomena, such as temperature variations, rainfall patterns, and precipitation amounts. It verifies the practicality of actual systems to precisely achieve these tasks.

Given the knowledge obtained from this Study, we strongly support conducting additional research in the agricultural industry to improve accuracy and effectiveness. Utilizing collaborative methods and incorporating a variety of datasets can significantly enhance the precision and dependability of agricultural decision support systems. By consistently exploring and innovating, we can guarantee that these frameworks are adapted to fulfill the changing requirements of farmers and support sustainable farming practices.

Conclusion

This study thoroughly analyzed the latest developments in applying machine learning methods in the agricultural field, namely in recommender systems for farming. There are different research papers reviewed in this survey. The majority of the papers published in this domain are supervised based methods.

The analysis emphasized the effectiveness of these algorithms in forecasting many climate phenomena which are essential for making agricultural decisions, including temperature variations, rainfall patterns, and precipitation amounts. Researchers have utilized machine learning to create advanced models that can reliably predict environmental variables. This helps farmers to make well-informed decisions regarding crop selection, irrigation timing, and pest management tactics. Other benefits of using such automated system is the way that farmers can make precautions about any decision related to the irrigation, fertilizing or any other farming task. Our review emphasizes the significance of continuous research endeavors in this domain, aiming to improve further and augment prediction models' precision. Through the utilization of collaborative methodologies and the integration of heterogeneous datasets, researchers can access novel perspectives and construct more resilient systems customized to the unique requirements of agricultural stakeholders.

In conclusion, the results of this study highlight the considerable capacity of machine learning to transform agricultural methods and promote environmentally friendly farming approaches. Researchers, practitioners, and policymakers must maintain ongoing partnerships to promote innovation and tackle the intricate issues in the agriculture sector.

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