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Crop Recommendation Using IoT and ML

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Abstract**—**Certainly, with the constraints of limited space on domestic lands, the strategic selection of crops, taking into account the unique factors in the chosen area and the cur- rent demand, has become an essential consideration Modern agriculture is witnessing a paradigm shift as data-driven solutions intersect with traditional farming practices. This abstract presents an innovative project that revolutionizes crop cultivation and contributes to India's agricultural and economic welfare. By leveraging a robust database and advanced analytic, the project empowers farmers to make well-informed decisions regarding crop selection and production. The project's primary objective is to balance the demand and supply of crops by offering farmers insights into optimal crop choices. Through a comprehensive analysis of factors such as climate data, soil conditions, historical yields, and market trends, the project assists farmers in cultivating crops that match real-world demands. This strategic approach not just enhances crop cultivation, but also helps reduce the likelihood of unforeseeable results.

A notable outcome of the project is its ability to regulate crop production effectively. Through the project's predictive modeling and rigorous calculations, the program tackles concerns related to both excessive production and scarcity. Consequently, market prices become more stabilized, creating favorable conditions for both farmers and consumers. At its core, this project epitomizes the synergy between technology and agriculture, promoting sustainable practices and resource allocation. As India continues its quest for food security and economic prosperity, the integration of data-driven insights into farming practices emerges as a transformative force. By bridging the gap between traditional wisdom and technological advancement, the project paves the way for optimized crop growth, prudent resource utilization, and enhanced economic stability on a national scale.

Index Terms—Yield forecasting, Data-driven agriculture, Crop productivity, Fertilizer recommendation, Crop pricing, Machine learning, SVM, RANDOM FOREST.

I. INTRODUCTION

Agriculture is a major industry in India, contributing to 16.6% of the GDP and employing around 50% of the work-force. However, crop yield is declining due to a number of factors, including climate change, pests and diseases, and inefficient agricultural practices. To address this challenge, re-searchers have proposed a smart recommender system that can help farmers to make better decisions about crop production. The system uses historical data and weather forecasts to predict crop yield, and it also provides personalized recommendations for crops to plant, based on the farmer's location, soil type, and other factors. The proposed system has the potential to improve crop yields and reduce financial losses for farmers. It is a valuable tool that can help to ensure food security in India and other countries. [1]

Crop yield prediction and crop recommendation are two important tasks in precision agriculture. Precision agriculture is the use of information technology to improve agricultural productivity, sustainability, and profitability. [1]Crop yield pre- diction is the process of estimating the amount of crop that will be produced in a given area. It is a critical task for farmers, agricultural policymakers, and food security experts. Accurate crop yield predictions can help farmers to make better decisions about planting, irrigation, and fertilization, and can also help to ensure food security by providing early warning of potential crop failures. Crop recommendation is the process of suggesting the best crops to grow in a given area. It is also an important task for farmers, as it can help them to choose crops that are well-suited to the local climate and soil conditions. [5]

There are many factors that can affect crop yield, including soil type, weather conditions, crop management practices, and pests and diseases. Machine learning (ML) algorithms have been used to be effective in predicting crop yield, as they can learn to identify the patterns and relationships between these factors. In recent years, there has been a growing interest in using ML algorithms for crop yield prediction and crop recommendation. This is due to the increasing availability of data, the development of more powerful ML algorithms, and the growing need for accurate crop yield predictions and

crop recommendations. ML algorithms can be used to predict crop yield in a variety of ways. One common approach is to use supervised learning algorithms. In supervised learning, the algorithm is trained on a dataset of historical data that includes the crop yield and other relevant factors. The algorithm then learns to predict the crop yield based on these factors. Another approach to crop yield prediction is to use unsupervised learning algorithms. In unsupervised learning, the algorithm is not trained on a dataset of historical data. Instead, the algorithm is allowed to learn the patterns and relationships in the data on its own. This approach can be useful for predicting crop yield in new areas or for predicting crop yield under new conditions.ML algorithms can also be used to recommend crops to grow. One common approach is to use collaborative filtering algorithms. In collaborative filtering, the algorithm recommends crops to a user based on the crops that other users have liked. The algorithm learns the preferences of users by analyzing their past behavior, such as the crops that they have purchased or rated.[6]

Another approach to crop recommendation is to use content-based filtering algorithms. In content-based filtering, the algorithm recommends crops to a user based on the characteristics of the crops that the user has liked. The algorithm learns the preferences of users by analyzing the features of the crops that they have purchased or rated. The use of ML algorithms for crop yield prediction and crop recommendation is still a relatively new field. However, the potential benefits of this technology are significant. ML algorithms can help farmers to improve their yields, reduce their costs, and increase their profits. They can also help to ensure food security and sustainability.[7]

II. RECOMMENDATION SYSTEM

Recommender systems have played a significant role in helping users select items aligned with their preferences. These systems offer tailored suggestions to users based on their interests, and this concept can be effectively applied in agriculture as well. By considering various agricultural factors, farmers can receive guidance and recommendations to enhance their cultivation practices. This includes the introduction of innovative techniques to boost crop yields and the provision of advice on the selection of appropriate pesticides and fertilizers. Agaji Iorshase's Hybrid Recommender system, as described in [11], addresses challenges such as serendipity, ratio diffusion, and ramp-up, effectively assisting in recommending agricultural products to farmers. This system employs a combination of both collaborative and content-based filtering approaches, as outlined in [12], which are commonly used techniques in recommender systems.

III. LITERATURE REVIEW

Agricultural decision-making has been significantly enhanced through the application of machine learning techniques, with the Random Forest algorithm emerging as a prominent tool in crop recommendation systems. Namgiri Suresh's research explores the utilization of Random Forest in

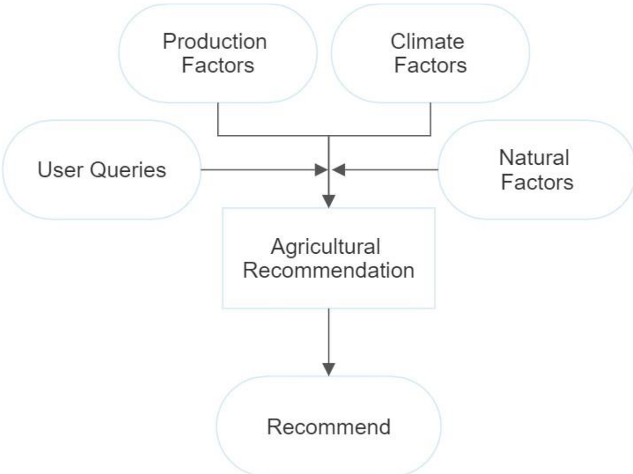

Fig. 1. Enter Caption

this context. By leveraging its ensemble learning capabilities, the Random Forest algorithm excels in predicting suitable crop choices based on various factors such as soil type, weather conditions, and historical yield data. Suresh's work contributes to the growing body of literature demonstrating the efficacy of Random Forest in optimizing crop recommendations, ultimately promoting sustainable and efficient agricultural practices.[8] Mummaleti Keerthana's research harnesses the power of Decision Tree Regressors to achieve impressive accuracy rates, notably reaching 95%. Decision trees are versatile algorithms known for their interpretability and ability to handle both categorical and numerical data. Keerthana's work underscores the effectiveness of Decision Tree Regressors The high accuracy achieved in her study highlights the potential of this algorithm to play a pivotal role in optimizing crop choices for farmers, ultimately contributing to increased agricultural productivity and sustainability.[9] DNNs have gained prominence for their capacity to extract intricate patterns from vast datasets, leading to a commendable accuracy rate of 97% in Gandhi's study. Her work highlights the ability of DNNs to process and analyze complex agricultural data, including soil properties, climate variables, and historical yields. This high level of accuracy underscores the effectiveness of DNNs in providing precise crop recommendations tailored to specific farming conditions.[10] Regression techniques have long been used for their simplicity and interpretability in modeling relationships between variables. Kumar's work explores the application of regression models in predicting crop suitability based on numerous elements such as soil attributes, climate conditions, and historical crop performance. While regression may offer a more straightforward approach compared to complex machine learning algorithms, Kumar's findings demonstrate its effectiveness in providing valuable insights into crop choices for farmers.[11] Sonal Agrawal's research into crop recommendation systems utilizing Support Vector Machines (SVM), Long Short-Term Memory (LSTM), and Recurrent Neural Networks (RNN) demonstrates the potential of advanced machine learning techniques in agriculture. Achieving an impressive accuracy rate of 97%, Agrawal's work illustrates the effectiveness of SVM, LSTM, and RNN in predicting optimal crop choices based on diverse factors such as soil properties, climate conditions, and historical crop performance.[12] Shruti Mishra's research focuses on the application of the Weka tool in crop recommendation systems. Weka, a popular data mining and machine learning software, has been employed to explore various algorithms for crop recommendation. In her study, Mishra reports the accuracy achieved by different Weka classifiers, such as J48 (78%), LWL (66%), LAD Tree (62%), and IBK (80%). These classifiers utilize diverse techniques, including decision trees, instance-based learning, and linear models, to predict suitable crop choices based on agricultural data. Mishra's work underscores the versatility of the Weka tool in crop recommendation, offering a range of algorithmic options to assist farmers in making informed planting decisions.[15]

IV. DATA SOURCES AND COLLECTION

A. *Data Collection for ML Model*

In order to cultivate a plant successfully, it is essential to maintain specific conditions such as temperature, soil, pH, humidity, sunlight, and soil moisture. Achieving these conditions is crucial for ensuring a bountiful harvest, although the precise requirements can vary depending on the type of plant being grown. The initial dataset used for training the crop recommendation model was gathered from various sources, including the Agriculture Department in Sri Lanka [8], agricultural books, agricultural websites [9], as well as reports and research papers. This dataset played a significant role in enhancing the accuracy of the recommendation model.

TABLE I
SAMPLE DATA SET

Crop	Temp.	Hum.	pH	Sun.	Moist.
Reddish	27	69	8	7	69
Onion	23.8	50	5.5	8	50
Ginger	29.5	92	6.5	9	92
Tomato	31.4	65	5.1	6	65
Spinach	29	89	3.5	6.5	29

B. *Collecting Environment Factors*

To facilitate the comparison and prediction of the initial dataset, it was necessary to gather environmental factors. For this purpose, Arduino microcontrollers [10] were employed. Given that both sensor (temperature and humidity) are integrated into a single microcontroller, four sensors were utilized for data collection. These sensors encompass sunlight intensity sensor, soil pH sensor, soil moisture sensor, as well as a humidity and temperature sensor. These sensors were interconnected with an Arduino Wi-Fi module, enabling the collected data to be transmitted to a database. Subsequently, the collected data underwent a cleaning and processing phase that involved the application of clustering and other algorithms. This processing step served to prepare the data for its transfer to the next component of the crop recommendation system, where it was stored in the database.

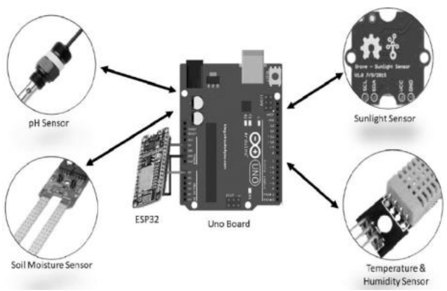

Fig. 2. Arduino Micro-Controllers Connectivity

C. Crop Production DataSet

Crop yields are influenced by various agricultural factors, including historical crop production data, which can guide recommendations for farmers regarding suitable crops to cultivate. When assessing production, farmers can also gain insights into which crops are experiencing high demand and market volumes in the current year. Armed with this information, farmers can make informed decisions about recent crop trends and adapt their planting choices accordingly.

A dataset comprising approximately 120,000 records from Tamil Nadu's agriculture sector was collected. This dataset encompasses various fields, including crop year, crop name, district, season, cultivated area, and crop production. Users were provided with recommendations based on crop production and the specific season during which these crops were cultivated.

TABLE II
SAMPLE DATA SET

Crop Year	Season	Crop	Atea	Production
1997	kharif	Banana	5619	183740
1997	kharif	Horse-gram	6849	3040
1997	kharif	Onion	2813	37188
1997	kharif	Sesamum	1598	580
1997	kharif	Small Millets	63	50

V. METHODOLOGY

A. Factors affecting Crop Yield

Any crop's yield may be forecasted using a number of different factors. These characteristics are ultimately what determine a crop's annual output. Here are a few of the most important elements: 1. Thermostat 2. Rain 3. Region 4. Span

B. Machine Learning Algorithm

Temperature and rainfall are the factors that have the biggest impact on crop output forecasts. Time series machine learning techniques are used to the temperature and rainfall data since they are sequential. The Algorithms are:

- Simple RNN: A kind of artificial neural network made for sequential data processing is called a Simple Recurrent Neural Network (RNN). It is known as "simple" because it exemplifies the most fundamental kind of RNN. Each neuron (or unit) in a Simple RNN takes information from the previous time step (or element in the sequence) and generates an output that might affect subsequent time steps. As a result, the network is able to preserve some type of context or memory across sequential data.
- LSTM: A recurrent neural network (RNN)[2] architecture used in deep learning, LSTM stands for long short- term memory. Conventional feed forward neural networks, in contrast to LSTM, absence of a feedback loop. Because of this, LSTM is beneficial for a "general purpose computer". The agricultural production dataset, which is used to forecast the crop's name and yield, is provided to classification and regression algorithms. Artificial Neural Networks, Logistic Regression, Linear Regression, and Random Forest Classifier and XGBoost are a few of the ensemble learning methods employed.

C. IoT devices

The demand for food to feed billions of people worldwide [14], changing weather patterns, less rain, and rapid societal development all have a significant impact on agriculture. This has a negative impact on conventional agricultural methods. In agriculture, I keep hearing about smart sensors. Using cutting-edge, intelligent technologies, agriculture must be made "smarter" in the current environment. In order to meet the expanding consumer demands of the global population, find ways to make the most of your resources. Farmers can monitor and improve their yields with the use of smart sensors in agriculture, which also help them keep up with changing environmental and ecosystem elements. Smart agricultural sensors locate and track animals while assisting with identification, detecting fever, and health monitoring, and helping unwell cows isolate and treat herds. Farmers can understand their crops and productivity, save resources, and manage or protect their crops from the environmental effects of disasters thanks to smart sensors in agriculture.

Smart Sensors: Utilizing cutting-edge technology like artificial intelligence (AI)[13], smart sensors, and crop classification, modern agriculture may enhance yields by properly evaluating crop quality, classifying crops, and measuring soil moisture. Modern sensors, cutting-edge AI methods, soil health monitoring systems, animal husbandry applications, and crop yield analyses are all used in the agriculture sector. In the agriculture, where productivity is increased and sustainable growth is also attained, Smart sensors play a crucial role. The Internet of Things (IoT) and smart sensors transform traditional agricultural methods into smart farming, which serves to empower farmers all over the world.

VI. Conclusion

This paper presented a comprehensive overview of the synergy between IoT and ML in modern agriculture. By referencing various research papers, machine learning and deep learning algorithms, and IoT concepts. Importance of machine learning algorithms, particularly Random Forest Regressor, Simple Recurrent Neural Networks (SRNN), and Long Short- Term Memory (LSTM), in predicting crop yields based on crucial factors such as temperature, rainfall, season, and area. The experiments conducted demonstrated the superior accuracy of Random Forest Regressor in yield prediction. Additionally, SRNN and LSTM showcased their prowess in rainfall and temperature predictions, respectively. Furthermore, the combi- nation of multiple parameters, including rainfall, temperature, season, and area, holds promise for precise yield predictions

. Notably, when these parameters are integrated, Random Forest emerged as the most robust classifier. In essence, our exploration has illuminated the path toward sustainable and data-driven farming practices. As we move forward, continued research and development in the realm of IoT and ML in agriculture will play a pivotal role in ensuring food security, promoting sustainable farming, and transforming the agriculture landscape for the better.

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