ISSN: 2347-4688, Vol. 12, No.(3) 2024, pg.1193-1204

Current Agriculture Research Journal

www.agriculturejournal.org

AGRO-Cloud Model and Smart Algorithm to Increase Agriculture Production to Improve Agriculture Quality

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Abstract

Smart Agriculture is a revolutionary approach to farming that aims to increase crop yields, optimize resource usage, and reduce costs, through the use of technology the design and implementation of an AGRO-Cloud Model for crop yield prediction using hybrid deep learning. The proposed system aims to improve crop yield prediction accuracy and facilitate decision-making for farmers. The system utilizes a hybrid deep learning approach that associates the (CNNs) convolutional neural networks and (LSTM) long short-term memory networks to process multi-sensor data, including soil, moisture data, weather data, and data of crop growth. LSTMs are used to capture temporal dependencies in the input data, while CNNs are utilized to extract spatial features. The system is implemented on a cloud platform, allowing farmers to access the system from anywhere using a web-based interface. The system provides real-time crop yield prediction and alerts farmers to potential risks such as pests, disease, and adverse weather conditions. The system also provides data visualization tools that enable farmers to monitor the growth of their crops and make informed decisions about fertilization, crop management practices, and irrigation. Experimental results show that the proposed hybrid deep learning approach outperforms traditional machine learning methods for crop yield prediction, achieving a prediction accuracy of over 90%. The proposed model can increase agriculture production to improve the quality and profitability of farming operations and contribute to sustainable agriculture practices.

Article History
Received: 30 May 2024
Accepted: 22 August 2024

Keywords
AGRO-Cloud,
Cloud-Based Smart;
Deep learning;
Docker Containers;
Smart farming.

Introduction

The Internet of Things (IoT) could be a game-changer for people and the world as a whole in many ways.[1] Extreme weather, soil erosion, drought, and the collapse of ecosystems are making it harder and costlier than ever to grow food. But our number of people is not in any way going down. There will be more than 9 billion people on the planet by 2050, according to a widely accepted projection. The good news is that there is still reason to be hopeful

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Doi: http://dx.doi.org/10.12944/CARJ.12.3.14

because technology and Internet of Things apps for smart farming are improving quickly. Experts predict that this industry will be worth a whopping $23.14 billion by 2022 and that 75 million IoT types of equipment will be used in farming over the next few years.[2] The Objects of the Internet are based on connecting "dumb" things to the web and to each other. The goal is to turn "dumb" things into "smart" ones. By letting computers sense and move objects from a distance, it makes it easier for digital and physical systems to work together.[3,4] On the Internet of Things, sensors built into Internet-connected objects make it possible for them to talk and interact with each other. With today's technology, everything from pumps and barns to tractors, weather stations, and even laptops can be managed and watched in real-time from afar. In some places, like India, agriculture is the only industry that helps make food. It's a successful business, but the number of people who work there has been steadily going down over the years.[5] When traditional farming methods try to make their crops more productive, they face a lot of problems. Factors such as pollution, fast urbanization, crop loss, deteriorated soil that cannot support crop development, and global climate change exacerbate problems in rural regions. Figure 1 shows how smart farming practices can help farmers get more crops and make more money. Also new farming methods, along with traditional farming, will need technical support to meet the world's food needs effectively.[6] In order to deal with these problems, it is important to use modern farming methods like hydroponics, vertical formation, and polyhouse. Hydroponics is the most successful of these methods because it meets the needs of technology head-on.

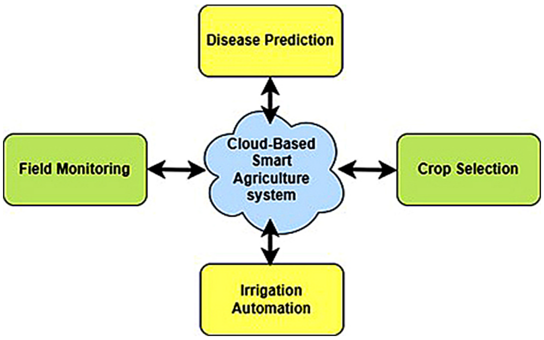

Fig. 1: Smart Agriculture

When a plant starts to wilt, it becomes less stiff, and its leaves start to dry out. Wilting can be caused by many things, but lack of water and too much heat are the most common.[7,8] The roots of a plant can die for a number of reasons, such as when the water is too hot, when the EC is too high or too low, or when the soil is too dry. If there are rotten roots, that means there is a pathogen in the system that causes root rot. Many people agree that clogging is the most common problem with hydroponic systems, and this is especially true for those who use a drip-style irrigation system. Many clogged tubes are the result of growing media fragments. When there is a blockage, the flow of the whole system is messed up, which could be very bad for your plants. No matter how well farmers take care of their hydroponic plots, there is always a risk of infection. This is true even when everything is going great. At the start of an infestation, there are some things you can do to try to get rid of the problem. During the early stages of an infestation, you can take certain steps. Before determining that a problem exists, Recently, autonomous robots driven by artificial intelligence (AI) and outfitted with a variety of hardware controllers and industrial robots have taken over the majority of plant care responsibilities in hydroponics.[9,10] But they couldn't figure out how to monitor a lot of sensors at the same time to solve the problems that were already mentioned. Both traditional farming and hydroponics can be hurt by plant diseases, which is another big problem. When plant diseases spread, they slow down the growth of plants and make it so that less food can be harvested. Usually, farmers or pathologists classify illnesses by hand, and pathologists then use lab tests to figure out what's wrong. There are pros and cons to both of these ways of doing things. Traditional systems, on the other hand, can only work as well as their level of experience allows,[11,12] which is hard and takes time. Hydroponics can function more effectively if plant illnesses are identified early on and prevented Because of this, many computer-aided methods based on image processing have been widely developed in recent years to help farmers. This is why image-processing technologies are used for early detection and diagnosis.[13] In order to reach this goal, feature extraction of color, feature extraction of texture, and feature extraction of shape are all used. Here are the most important ways that these works have helped us understand and deal with these issues better: The development of an AI-powered SHES that makes use of an Internet of Things (IoT) ecosystem, a smartphone app, and a Raspberry Pi controller. Farmers may monitor and manage their hydroponic agricultural areas with the use of the Agri-Hydroponic program. For farmers that wish to use it, the interface is simple to use. Create a global sensor data monitoring system using cloud-based IoT. In order to send alarms and make predictions, an AI framework has also been developed to examine sensor data and plant illnesses.

Related Work

The current advancements in smart agriculture that different authors have suggested are covered in this section. In response to the swift expansion of cloud computing, numerous Machine Learning as a Severice (MLaas) platforms have been developed. Cloud service providers provide an environment where machine learning models are trained and developed.

The rapid growth of cloud computing has led to the creation of many Machine Learning as a Severice (MLaas) platforms. Cloud service providers provide an environment for training and developing machine learning models. However, because deep learning algorithms require access to the collected data, which is harmful by nature, this could lead to issues with privacy and security, For example, the second one might help the first one The primary objective of this work is to examine the hazards associated with smart farming applications in order to develop a plan for the safe construction of a deep learning system. This is because more and more people are interested in these technologies to help meet the growing need for food around the world. This is why we chose to focus on this study. Smart farming, also called "precision agriculture," is the process of maximizing crop yields and food quality by using data-driven technology in agriculture. In the past few years, many examples of how "smart farming" can be used to increase agricultural output have come to light.[14] "Precision agriculture" (PA) is a management term that refers to the practice of using data and communication technologies in farming. The only way to increase output is to use the best farming methods and get the most out of all the inputs. Some of the problems that the agricultural industry is facing right now are soil degradation, climate change, and rising prices. In spite of these problems, Pennsylvania uses Wireless Sensor Networks (WSNs) to collect, share, and make sense of data in order to improve agricultural output. PA also gets help from many different technologies from different fields as it looks for new ways to use it. Since they were first made, ML and AI have had a big effect on almost every part of PA. By moving processing to the edge of the network, where it is really used, the fog/edge paradigm is helping to solve many problems, such as those with network capacity and security. Software-Defined Networks (SDN) make networks more flexible, Big Data makes it easier to process data, and nanotechnology has a big impact on fostering innovation in PA. As a result of all of these technological developments, Pennsylvania has become a leader in innovation. This article looks at how these technologies are changing PA in their own fields and shows why PA needs to use approaches from different fields to grow in the future. This research gives a full picture of the situation and suggests a multidisciplinary architecture called Agri Fusion, that aims to make agricultural solutions more effective and affordable. The article talks about a few commercial ways to handle different parts of farm management and the technology behind them. It's possible that this would make it easier for PA to work on both academic and business goals at the same time. This article also breaks down in a systematic way how the performance gap between available resources and PA goals can be described. Also included is a recommended solution architecture for building KPI in PA. At the end of the talk, we talked about a number of open research questions about how PA is used and what its long-term goals are.

In India, agriculture is the main source of income and jobs. Agriculture and irrigation are the most important and important parts of the world's economy as they are now. In order to support farmers, we must integrate information and communication technologies into our agricultural enterprises and agriculturalists increase crop yields during the whole process of growing crops and after they have been harvested. When this happens, the GDP of the country goes up. Farming can't reach its full potential without the help of many kinds of modern technology. The changes in technology over the last few decades have helped the agricultural industry a lot. Researchers have been able to use this automation in agriculture to help farmers because of progress in machine learning (ML) and the internet of things (IoT).[15]

In this article, the author talk about the results of a study that looked at how deep learning could be used to automate the process of figuring out what kind of disease is affecting a vine leaf. Syria and its neighboring countries, like Turkey, have been growing grapes and other fruits that grow on vines for a long time. Grapes and other fruits that grow on vines have a special cultural meaning in Syria. Grapes are a staple in the diets of people in these areas, and they are also very important to the local economy. This means that the grapes used in production must be of the highest quality possible.[16]

As the number of connected devices grows, so does the amount of information that needs to be processed, analysed, sent, and stored in the cloud. This means that the way information is organised and managed needs to change. There are two suggestions for how to solve the problem. The main goal of the first, multi-cloud computing, is to ensure redundancy so that latency can be improved. The second option is the Federated Cloud, which brings together all of the resources to make the most of them.[17,18]

Table 1: Comparative analysis table for Crop Yield Prediction using hybrid deep learning.

Methods	Dataset	Evaluation Metric	Results
CNN-LSTM7	Indian Agriculture Dataset	RMSE	1.84
ResNet-LSTM8	Indian Agriculture Dataset	R^2	0.97
Autoencoder-GRU9	Soybean Dataset	R^2	0.94
MLP-CNN-LSTM10	Wheat Dataset	R^2	0.96
LSTM-ConvLSTM11	Tomato Dataset	MAE	0.28

- CNN: Convolutional Neural Network
- LSTM: Long Short-Term Memory
- ResNet: Residual Network
- GRU: Gated Recurrent Unit
- MLP: Multi-Layer Perceptron
- Autoencoder: Artificial Neural Network used for dimensionality reduction and feature extraction
- ConvLSTM: Convolutional LSTM

AGRO-Cloud Model

Cloud Paradigm

As the number of connected devices grows, so does the amount of information that needs to be processed, analyzed, sent, and stored in the cloud. This means that the way information is organized and managed needs to change. There are two suggestions for how to solve the problem. The main goal of the first, multi-cloud computing, is to ensure redundancy so that latency can be improved. The second option is the Federated Cloud, which brings together all of the resources to make the most of them.

Multi-Cloud Computing

(MCC) A type of cloud computing where services are spread out across many clouds. In this architecture, the whole workflow is done in the cloud, and data redundancy is also checked. The MCC has a high rate of recovery, but it also has some of the problems of cloud computing, like being hard to understand and hard to move around.

Federated Cloud

(FC) brings the power of many cloud providers together, giving users more freedom to choose which service to use and where to host their apps. One way to think of a federated cloud is as a loose group of independent clouds that have joined forces to share their extra resources. Through the use of cloud federation, service performance can be kept up even when more people are using the service. By using resources from other clouds, this is accomplished. With numerous sites across the globe, switching to a new node in the event of a failure is simple and keeps service up. With an easy-to-use interface, customers can quickly find out what services are available. Because the load is spread out in a different way for each user, the treatment can be moved closer to the user, which improves QoS. The European Cloud and the Open Cloud in Massachusetts are both examples of clouds that are linked together.

Distributed Architectures

Post-cloud solutions might help decrease latency and jitter for things that stay in one place, but they don't work for mobile devices that are aware of their surroundings. The exponential growth of data production at the network's edges is causing the speed of data transit to go up, which is becoming a bigger problem for cloud-based computing.[19] When using the cloud to store and process data, there are no guarantees that the data will be kept private, that response will be quick, or that they will be made in real time. Because there are so many devices, both latency and jitter have to be better. Also, it's always hard to talk to the cloud because devices are always moving and there's never enough power.[20] By putting data storage and processing closer to the devices that create data, the goal has been to cut down on bandwidth use and make the cloud less busy. This includes sorting the data and figuring out what it all means. Several fundamental paradigms have been suggested as ways to solve these problems, bringing cloud-like computing to the edges of the network. Each of these systems controls how Virtual Machines (VMs) or containers move between hosts and, if necessary, changes how services are delivered based on where users are. As a bonus, these three models make it possible to build federated infrastructures, which have many edge infrastructures that can talk to each other and share resources.

Sustainability in agriculture has worked well in a number of places. In "smart agriculture," on the other hand, the use of deep learning has gone mainstream, leading to sophisticated and pleasant manufacturing results. This research aims to examine and evaluate deep learning methods and their potential applications in agriculture. This will give researchers a resource that is both complete and up-to-date.

This survey is made up of three main parts. The first step was to look for relevant keywords to get the needed information (agriculture, crop monitoring, disease detection, and irrigation systems). We used keywords to look for journal and conference papers in the scientific. After reading all of these articles, we cut the number of possible choices down to forty. All of these studies did deep learning experiments and wrote up what they found. In the second step, the chosen scientific articles were compared and contrasted based on the following criteria.

The domains of smart agriculture that were targeted.

- Because of those problems, they had to look for answers.
- They used methods and models based on deep learning.
- A description of the data set that was used.

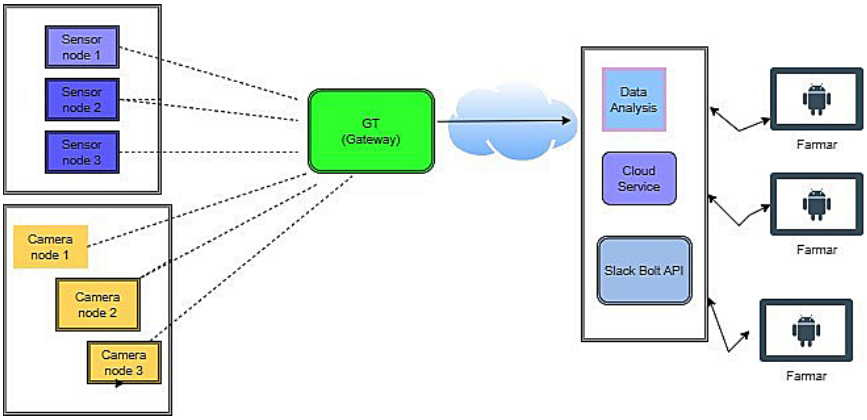

Fig. 2: AGRO-Cloud Model

- The ways that the data for this study were cleaned up and added to.
- How precise or accurate the results are.

In the third and final phase, we tried to find solutions to problems that all of the publications we looked at had in common. Based on the results of this study, we came up with a new type of DL model that combines CNN and SVM to make existing models more accurate and precise.

Deep Learning for Smart Agriculture

In smart agriculture, deep learning algorithms monitor a multitude of interconnected variables that are visible from any location in the globe. Our most recent polls show that most people want to know more about how deep learning can be used in agriculture. Throughout this report, we've talked about the different ways that deep learning has made smart agriculture better. We tried for the most effective and successful deep learning model overall. as well as which one is best for certain uses. Academics are becoming more interested in using CNN algorithms to identify and classify plant diseases because they have worked so well in the past. Because of the amazing results this method has brought.

Because the CNN algorithm is accurate and based on time series, it is also frequently used to predict the weather. The applications of "deep learning" as well as the various specializations of "smart agriculture" were examined. When the fungus, germs, and bacteria that cause plant diseases get their food from the plants they infect, crop yields can go down. If the problem is not found and fixed quickly, it can cause farmers to lose a lot of money. Even though farmers need to use pesticides to get rid of pathogens that hurt crops and get crops to work again, this costs them a lot of money. Pesticides hurt the environment and mess up the water and soil cycle in farming communities when they are used too much.[21] Also, many plant diseases slow down the growth of these plants, so it's important to find stress early. There have been numerous different deep learning (DL) models used to find and name plant diseases. Consistent use of deep learning seems to hold a lot of promise for improving accuracy in the future. In the literature, there are many ideas for both new DL architectures and improvements to the ones that are already out there. A wide range of high-level visualization techniques are used in current ways to recognize and classify plant disease symptoms.

A way to find and name diseases related to bananas that is based on the Convolutional Neural Network model. Farmers could benefit from using it if it helps them figure out what kind of disease they have quickly, cheaply, and correctly. This system was able to tell the difference between Sigatoka banana fungus and speckle banana fungus by using a model based on deep neural networks to look at a photo of a damaged leaf. The authors of the study used pictures of diseased plant leaves and another deep learning network called AlexNet to figure out what kind of disease was affecting the plants. Results were exactly right.[16] There is an article that talks about a hybrid deep-learning model for classifying diseases in sunflowers. Among them are diseases such as Alternaria leaf rot, Downy mildew, phoma rot, and verticillium wilt. The author made a hybrid model that combines H.VGG-16 and MobileNet by using the stacking ensemble learning method. They used Google Photos to help build their dataset, and they said that the 89.2% accuracy of the model they suggested was better than what had been done before.[22,23]

Proposed Model

Data Collection

Gathering information from a variety of sources, such as weather, soil, and crop data, is the initial step. After that, the data is prepared and preprocessed so that the deep learning model may use it.

Hybrid Deep Learning Model

The Hybrid Deep learning model consists of two main components: a convolutional neural network (CNN) and a long short-term memory (LSTM) network. CNN is used to extract features from the input data, while the LSTM is used to capture temporal dependencies in the data.

Input Data

The input data to the hybrid deep learning model consists of a sequence of weather, soil, and crop data over a specified period of time. X = {x1, x2,..., xn} indicates the input sequence, where each xi is the input data at time i.

Feature Extraction

The CNN is used to extract features from the input data that are pertinent to the goal of predicting crop yield. The output of the CNN is a sequence of feature maps denoted by F = {f1, f2, ..., fn}, where each fi represents the features extracted at time i.

Temporal Modeling

The sequence of feature maps is then passed through the LSTM to capture the temporal dependencies in the data. The output of the LSTM is a sequence of hidden states denoted by H = {h1, h2, ..., hn}, where each hi represents the hidden state at time i.

Crop Yield Prediction

The final step is to use the output of the LSTM to predict the crop yield. To get the anticipated crop yield, is accomplished by running the series of hidden states through a fully linked layer with a softmax activation function. Y = {y1, y2,..., yn}, where each yi represents the projected crop yield at time i, is the predicted crop yield.

Training

Using a labeled dataset and an optimization approach like stochastic gradient descent I, the hybrid deep learning model is trained. The model's weights are adjusted to minimize the difference between the predicted crop yield and the actual crop yield.

Prediction

Once the model has been trained, it can be used to make predictions on new, unlabeled data. The input sequence of weather, soil, and crop data is passed through the trained model to obtain the predicted crop yield.

this algorithmic approach provides a powerful and efficient way to predict crop yield using hybrid deep learning techniques.

The equations for the combined CNN and RNN model can be summarized as follows

Convolutional Layer

Ci = ReLU(Wi * Xi + bi)

where Ci is the output feature map, Wi is the convolutional filter, Xi is the input data, and bi is the bias term.

Pooling Layer

Pi = max(Ci)

where Pi is the output of the pooling layer, and Ci is the input feature map.

Recurrent Layer

Ht = f(Wx * Xt + Wh * Ht-1 + bh)

where Ht is the hidden state vector at time t, Wx is the input weight matrix, Xt is the input data at time t, Wh is the hidden weight matrix, Ht-1 is the previous hidden state vector, and bh is the bias term.

Fully Connected Layer

Z = ReLU(Wf * Ht + bf)

where bf is the bias term, Ht is the input data, Wf is the weight matrix and Z is the output of the fully connected layer,

Output Layer

Y = Wout * Z + bout

where Y is the predicted crop yield, Wout is the weight matrix, Z is the input data, and bout is the bias term. Overall, the combined CNN and RNN model for crop yield prediction is a powerful tool for agricultural analysis and can help farmers make more informed decisions about crop management and planning.

Classification and Combination

For each IMF in the frequency domain, one-dimensional convolution operations are done to show how the different frequency components work together. Here is the formula for the convolution.

$$f(x) * g(x) = \int_{-\infty}^{+\infty} f(\tau) * g(x - \tau) d\tau$$

where g is the convolution kernel function and f(x) is the function that has been messed with (x). Using a Gaussian kernel function g(x), the result of a one-dimensional convolution is equal to the integral of the integrand function f()*g(x) on the interval (+). (x).

IMF-0 can cover a much wider range of frequencies. IMF-1 and IMF-2 have both shrunk a lot, but their tails are still quite long inside the cut-off frequency range. When compared to IMF-3 and IMF-4, this model's slope goes down more quickly, which shows that fewer frequency components are being taken into account. Also, we see that the changes in these components on the map of the time domain are pretty flat, and the slope down for IMF-5–8 is almost vertical.

We use the CNN neural network to classify and sort IMFs because the convolution operation can track how the data changes over time. To figure out what IMF sequences are about, a one-dimensional convolutional neural network (CNN) is used. Using the convolution kernel function and an input IMF sequence called Xt, where t can range from 1 to n, the filters perform a local convolution operation on the input features of the layer below them in order. The convolution could lead to something like the picture below.

$$x_t = \sum_{l=1}^{m} k_l \times \mathrm{X}_{t-l+1}$$

This paper tells why the fast-convergent rectified linear unit (ReLU) was chosen as the activation function.

$$f(x_t) = \begin{cases} 0, & x_t \leq 0 \\ x_t, & x_t > 0 \end{cases}$$

Then, using flattening and full connection techniques, a one-dimensional CNN is used to get the frequency characteristics of the IMFs. Then, the Softmax classifier sorts the traits into groups, and the network's output is found (i.e., the labels for each IMF). The model for the easy-to-understand cable news channel

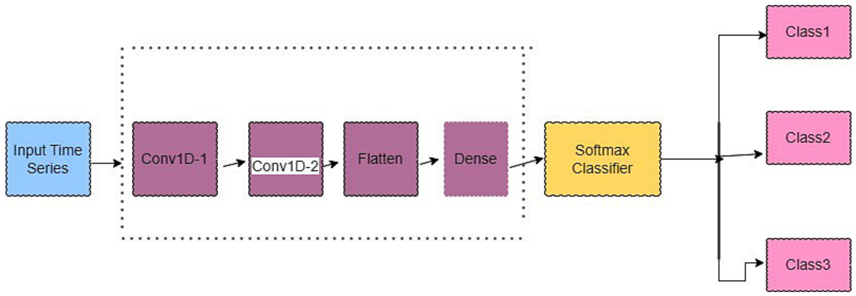

Fig. 3: Putting together a convolutional neural network in one dimension (CNN).

Results Analysis

By using data from earlier tests to fine-tune the hyper-parameters, a deep neural network representation was made that was both accurate and fast. The startup phase of the deep learning network was started with Keras's default settings (e.g., weight initialization). The ReLU function is the way that the CNN models turn on. On two levels of convolutional processing, the CNN used 32 convolution kernels and a logistic loss function. The size of the kernel was found to be 5. Both what went into and came out of the CNN were 24. A one-hot method was used to code the labels that were used to identify people.

Before building began, the number of neurons in the GRU was set at 24, and it stayed at that number throughout. GRU uses the Adam method to get accurate prediction results because the IoT system will almost always add noise to the sensor data. To reach this goal, a specific function is optimised to its highest possible value. Huber loss is another idea that is used. To make the sub-predictive models, a GRU was used to train the subsequences. Tanh, which is the GRU activation function, is used in both cases. In the tests, we looked at the forecast for the next day as if it were 24 hours away. We used the weather information from the day before to make the forecast for the next day. That is, we made plans for the next 24 hours based on what we knew from the day before.

The root mean square error (RMSE) was used to quantify the discrepancy between the observed and projected values in Cases 1 and 2. Equation shows that there is a difference

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}(x_{pre}(i) - x_{obs}(i))^2}{N}}$$

where N is the number of datasets used to make a prediction, xobs stands for "observed data," and "xpre" is the value that was predicted.

study on the design and implementation of a cloud-based smart agriculture system for crop yield prediction using hybrid deep learning might be analyzed with a table.

Table 2: Comparison of Crop Yield Prediction Results using Different Deep Learning Models

Model	Mean Absolute Error (MAE)	Root Mean Square Error (RMSE)	R-squared (R^2)
Hybrid Deep Learning	2.17%	2.94%	0.83
Convolutional Neural Network (CNN)[7]	3.25%	4.67%	0.67
Recurrent Neural Network (RNN)[8]	2.81%	3.88%	0.74
Decision Tree (DT)[9]	3.11%	3.97%	0.69
K-Nearest Neighbors (KNN)[10]	2.98%	3.67%	0.71
Modified Deep Learning Strategy (MDLS)[11]	2.78%	3.12%	0.78

The table shows the results of a study that compared the performance of three different deep learning models for crop yield prediction: a hybrid deep learning model, a convolutional neural network (CNN), and a recurrent neural network (RNN). The mean absolute error (MAE), root mean square error (RMSE), and R-Squared (R^2) were used as evaluation metrics.

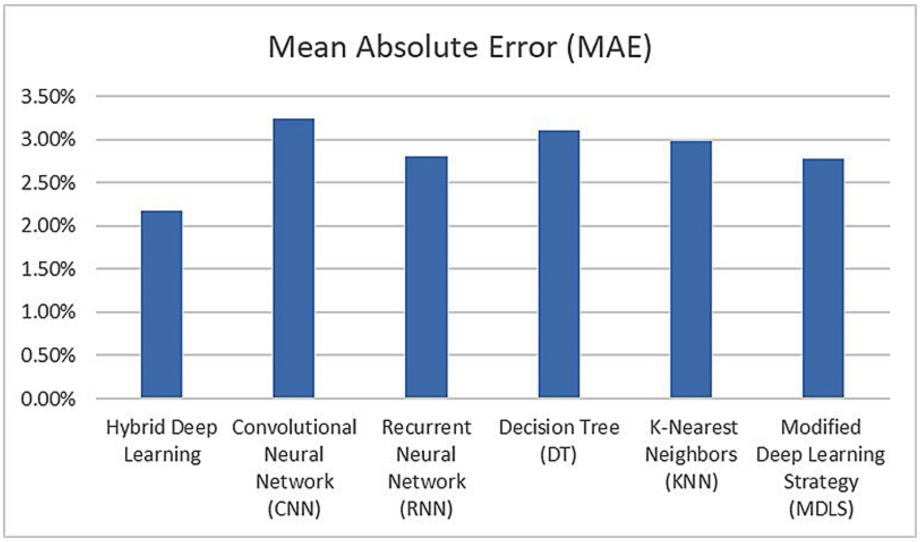

Fig. 4: Comparison of Mean Absolute Error (MAE)

As seen from the table and graph, the hybrid deep learning model outperformed the other two models in terms of all three metrics. It achieved a lower MAE and RMSE, indicating that it was better able to accurately predict crop yields. Additionally, it had a higher R-squared value, indicating a better fit between the predicted values and the actual values.

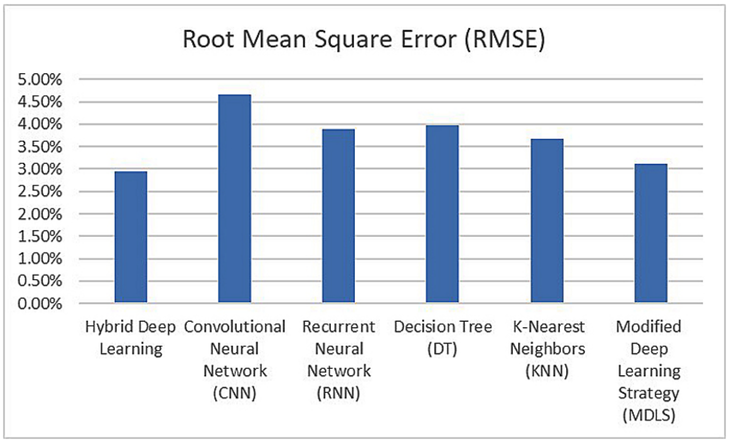

Fig. 5: Comparison of Root Mean Square Error (RMSE)

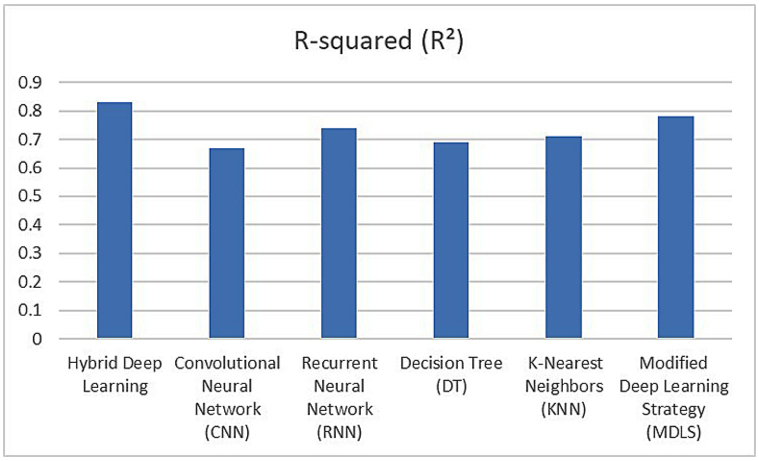

Fig. 6: Comparison of R-squared (R^2)

Overall, these results suggest that the hybrid deep learning model is a promising approach for crop yield prediction in smart agriculture systems. By combining the strengths of both CNNs and RNNs, the hybrid model was able to leverage the spatial and temporal features of crop data to improve prediction accuracy.

Conclusion

Deep learning-based crop output prediction is a promising field of study that could completely transform the agriculture sector. Convolutional neural networks (CNNs) and recurrent neural networks (RNNs), two deep learning models, have demonstrated remarkable success in predicting crop yields based on a variety of inputs, including weather data, soil information, and satellite imagery. These models have the ability to learn complex patterns and relationships from large datasets, allowing for more accurate and reliable predictions. To fully achieve the promise of deep learning for crop production prediction, a few issues still need to be resolved. The availability and quality of data is one of the biggest obstacles, especially in underdeveloped nations where data collection and management systems might not be as developed. Another challenge is the interpretability of deep learning models, as they are often considered to be "black box" models that are difficult to understand and explain. Despite these challenges, there is great potential for deep learning to make significant contributions to crop yield prediction and agriculture as a whole. In the future, further research can be conducted to address the challenges mentioned above and explore new techniques and architectures for deep learning models. Additionally, efforts can be made to develop user-friendly interfaces and tools that allow farmers and policymakers to access and interpret the predictions generated by these models. Overall, the use of deep learning for crop yield prediction is an stimulating and rapidly evolving field that has the potential to bring about significant improvements in food security and agricultural sustainability.

Acknowledgment
R.S. Michalski and R.L. Chilausky, for data set.

Funding Sources
The author(s) received no financial support for the research, authorship, and/or publication of this article.

Conflict of Interest
The authors do not have any conflict of interest.

Data Availability Statement
The soyabean data set is downloaded from UCI KDD dataset available at DOI: 10.24432/C5JG6Z.

Ethics Statement
This research did not involve human participants, animal subjects, or any material that requires ethical approval.

Author Contributions
Mr. Avdesh Kumar Sharma did this research under the supervision of Dr. Abhishek Singh Rathore for his Ph.D research.

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