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Rice Crop Yield Prediction Study by Artificial Intellegence Techniques

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Abstract

Every country has agriculture as a vital factor for development in every field and so whole domestic fully depends upon it. Rice Crop‘s analysis fully depends upon the market rate of the rice, quantity produced and the quality of the rice with yield. Rice crop yield also depends upon the various suggestions and monitoring the production of crops timely. Monitoring of the crop in a timeframe with crop yield prediction gives an output in automatic manner by Artificial intelligence (AI). A study was done after analyzing some artificial intelligence techniques as Deep Learning (DL) with its hybrid approaches using Recurrent Neural Network (RNN), Deep Neural Network (DNN) and Artificial Neural Network (ANN). These techniques become helpful for identification and improvement in the rice crop yield prediction. It was observed that by analyzing the requirement of hybrid network approach and recurrent neural network approach gives a very useful idea for prediction of rice crop yield. A comparison was done after study and discussed the performance of convolutional neural network and artificial neural network. Analysis was done after discussing the outcomes from the study and also set the perspectives for future from the final optimized results.

Keywords: Rice Crop, Artificial Intelligence, Deep Learning, Recurrent Neural Network, Deep Neural Network, Artificial Neural Network, Conventional Neural Network, Regression, Hybrid Neural Network, Internet of Things

Introduction

In India agriculture industry plays a vital role for social development as well as for economic construction and so is the primary industry [1]. Population incrimination is an important factor for the use of agriculture crops. It creates a sustainable balance between population and agricultural crops. Rice crop is the important grain crops for research in crop production for growth of any country [2]. In India rice crop is the major ranking for this crop yield. Rice crop is a high yield crop in India because it is the largest producer and consumer of rice in the world after China. Rice crop yield has impact on agriculture outcome and development of the nation. Rice crop yield depends upon some factors like soil, climate, environment and availability of water [3]. Agriculture process was categorized in different parts as one is process of pre sowing and second one is process of post sowing. Process of pre sowing stage did an analysis on climate change for formulating soil texture, soil type, soil nutrient analysis and sowing period. Process of post sowing stage did crop management having some factors like harvest time management, irrigation management, weed management, fertilizer management, agricultural tool management and pest control management [4]. Note that every stage pre-sowing process and post-sowing process effect on rice crop yield. After setting all the steps in defining in a mannered way and following all procedures, rice crop yield can be achieved higher. Today using advanced technology at precision level in agriculture field optimization system helpful for agriculture to get high yield of rice crop. All the developed countries follow the latest automatic techniques and mechanisms using Internet of Things (IoT) for monitoring the pre and post sowing process with drone surveillance for controlling and managing the crops process [5].

Artificial intelligence is most powerful key component including machine learning and deep learning techniques which creates a simulation in human brain functioning and structure [6]. Most important neural network provides services for the foundation for machine learning and deep learning is processed using hidden layers to enhance learning [7]. Because agriculture is entirely a knowledge transformation and human work, we are all perplexed as to why it needs artificial intelligence. The primary reason is because biodiversity is vital to life on Earth. The agricultural industry is most crucial in maintaining biodiversity. During harvesting period artificial intelligence-based robots were first used and observed by employing drone technology under Internet of Things management, deep learning extends its service and identification of field done automatically. Crop harvesting was completed using a combination of IoT and deep learning as well as machine learning approaches [8]. Identification of the illness is crucial in the crop yield sector since fewer plant diseases will result in higher yields. The majority of the time right now and in the beginning, the plant's sickness was discovered through manual verification. As the transmission of knowledge decreased from generation to generation, new diseases emerged as a result of environmental

change. For those in agriculture, having access to all the information at once was really challenging. If agriculture had some sort of automatic system, it would be really helpful. From that perspective, deep learning is crucial for both the identification of plants and plant diseases. CNN algorithm can be used for detection of plant diseases. Here, photos of the diseased leaves are taken and then examined to identify the plant's illness [9]. R-CNN (Region-based Convolutional-Neural-Network) applied for identification of plant diseases, helping to provide highly accurate diagnoses by pinpointing the precise location of the affected portion [10]. CNN's deep learning technique aids in identifying the various plant parts and pests that are resting on it and so yield can be increased [11].

India is a tropical nation where irrigation and climate are completely dependent on agriculture. All food and cash crops are primarily categorized according to the season and type of soil. Climate prediction plays main role for sowing/harvesting period identification and for that purpose some remote sensing methods applied with DL techniques [12].

People in past were skilled at predicting weather conditions, and they chose their crops and take a chance to predict rice yield before harvesting season depending upon any bad weather occurrences and heavy monsoon of particular time period. With time this practice and knowledge reduced significantly and also as time pass, automatic systems using AI especially deep learning and machine learning were adopted by the farmers that use the neural network concept [13].

Environmental elements, such as temperature, weather conditions, vegetative index, rainfall, soil type, nutrients and texture have a significant influence in crop yield prediction and so depending upon some of environmental issues. DL algorithms will provide prediction using regression technique (compute estimated value numerically) or classification (identification of crop growth falls classes) that helps in crop yield estimation [14]. To determine classification/regression procedures for getting good rice crop yield, number of neural networks methods and their combinations applied [15]. Artificial neural networks were combined with the regression method in rice crop yield prediction to estimate the yield. An artificial neural network (ANN) was trained using environmental data and rice crop photographs. Analyzing the many environmental factors can help you to make a selection about rice crop yield and is more effective [16]. Multiple linear regressions (MLR) must be used to analyses environmental elements in order to increase crop production rates [17]. To anticipate crop yields with the greatest precision, environmental parameters like moisture, humidity and temperature are observed and examined on a regular basis in relation to the crops [18]. Its more challengeable job for finding a soil having valuable characteristics for any crop in the aforementioned environmental elements, thus its more effective using KNN (K-means Nearest-Neighbourhood) algorithm for clustering same features results and further suggestions were gathered for evaluation of rice crop yield prediction [19].

CNN is a technique that is mostly applied in DL to interpret cropped images. Images in CNN were analyzed using dots-by-dots-matrix (here dots and pixels are same) before being assembled into what is known as a convolution. Estimated value for rice crop yield prediction was computed when crop photos were taken at every step and validated with amount of progress depending upon regression methods with computation formulas. Crops were observed and rated on a scale of good, average, and best at each stage of their growth [20]. The trained CNN model would be used to determine the outcome. The analysis component of CNN's method can be further strengthened and made more successful by using a two-layered approach. The two-layered CNN technique was used to train and test the various paddy field picture stages [21].

An example of an ANN that includes numerous hidden layers in addition to the output layer is a deep neural network [22]. For the most part, DNN was utilized for complex terminals connectivity instead of multivariate data with different characteristics. In that approach, crop production is predicted by mapping plant-genotype having some plant-growing characteristics with climate change and change in genotype of crops entirely deals with the crop's chemical constituents, which form the plant's soul [23]. The genotype of the rice crop was mapped and the DNN was trained on it by using classification technique. Atmospheric parameters mapping and comparison was done using sensor technology and drone photos taken for further prediction using the regression method [24].

One sort of recurrent neural network (RNN) called long-short-term memory (LSTM) contains a feed-forward network with a back propagation loop. Benefit of LSTM is to retain values of prior outcomes for small time-period. Functioning is in little chunk of time-period in any evaluated network for getting feedback during analysis process [25]. Depending upon vegetative index, good or bad weather conditions and meteorological database, a mapping of all environmental parameters were done for rice crops yields observations [26]. An analysis of time-series based data using LSTM algorithm were computed. Afterwards a monitoring of all attribute variables were periodically evaluated for best rice crop yield estimation [27]. Adaptive depth LSTM is a deep neural network combination network where the picture and ambient elements are analyzed simultaneously. In order to analyze chemical composition of growing crops having high level accuracy, image analysis of some crop plants were examined. For obtaining higher yield estimation, LSTM process was then applied to time series data and environmental parameters [28].

A hybrid network is a network that combines machine learning methods with neural networks. Crop management involves keeping an eye on the rice crop using wireless based sensor method for tracking temperature as well as humidity level for rain forecasting and is useful for irrigation systems [29]. The self-mapping system used here to train the input data measured and predicted accuracy. The crop model and the meta-heuristic algorithm support agriculture's efforts to forecast rice crop yield. The external environmental parameters are given direction through reinforcement learning and Q-learning, which also raises the prediction value at a faster rate [30, 31].

A Survey:

A full study on prediction of rice crop yield was done having some major facts and findings that were classified in table 1 below.

Table 1: A survey of rice crop prediction Algorithms with input parameters

Algorithm Name	Country	Technique Used	Input Parameters
ANN [32]	India, Iran	Regression Analysis	Crop images, irrigation level, soil, climate and crop species
KNN+ANN [33]	India	Regression Analysis	Macro and micro nutrients, soil property
MLR+ANN [34]	India	Regression Analysis	Soil biomass, Soil resistance, Soil organic value
CNN [35]	India	Classification	Colour of soil, shape of seed, seed structure
CNN [36]	India	Regression Analysis	Crop image, leaf image, fruit image, crop type, climate
CNN with two layered [37]	India	Classification	Paddy field image, potassium, nitrogen, soil nutrient values
DNN [38]	India	Classification	Climate, geno type of plant, Growth of crop
DNN [39]	India	Classification	Growing session length, temperature, drone images
DNN with two layered [40]	India	Regression Analysis	Climate data and Vegetative index
LSTM [41]	India, Brazil	Regression Analysis	Climate data, weather index, Soil environment, vegetative index
LSTM two layered [42]	India	Regression Analysis	Climate and plant genotype
Depth adaptive LSTM [43]	India	Regression Analysis	Environment change
CNN+LSTM [44]	Brazil	Regression Analysis	Crop images through satellite
Deep Q network [45]	India	Regression Analysis	Crop data, climate and environment
Conv-id LSTM [46]	India	Classification Analysis	Crop economics
ML Linear deterministic algorithm [47]	India	Regression Analysis	CROP DATA
Multi task ML [48]	US	Regression Analysis	Climate data
Multi-layer neural network [49]	India	Regression Analysis	Weather analysis
SOM [50]	India	Classification Analysis	Crop cost, rainfall, soil type etc.
LDA [51]	US	Regression Analysis	Climate data
SVM [52]	Australia	Classification Analysis	Solar level, vegetative index
WSN [53]	India	Classification Analysis	Footstep vibration, climate
ML and Crop model [54]	China	Regression Analysis	Yield data, soil data, weather data

Discussion with Results

Some of ANN, DNN, CNN, RNN and HD (hybrid) networks were served as the sole inspiration for finding all the classes for best optimization of crop yield. Each network is tested from four approaches like classification, regression, two-layered approach and additionally hybrid method. From the collected data and after doing analysis of DNN and ANN techniques, it was observed that how much prediction can be done for high performance from 65% to 78%. Processing of Agricultural crops computed by monitoring the whole process in a timeline and examining the various crop images, plant images, leave images and various environmental factors for high yield. Accuracy level was computed and after comparing ANN, CNN and DNN, it was observed that CNN have high accuracy in range from 82% to 88% as compared to ANN and DNN. From the survey, it was investigated that CNN has some shortcoming for prediction from the learned data or computed data as compared to historical actual available information. Rice crop yield prediction was improved with RNN. It will reduce any loss in that period. RNN used for a practice by combining LSTMs and storage of data easily enabled by doing this process. After computation from the study, it was again observed that CNN has estimated 85% to 90% accuracy as compared to the ANN, DNN and hybrid networks. CNN out performs ANN after evaluating the given pictorial matrix from the available database from the survey and showed the 88% estimated accuracy as shown in the figure1.

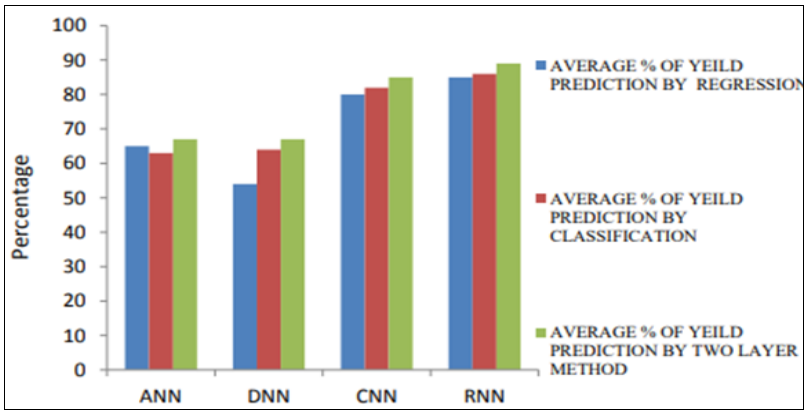

Fig 1: Yield Prediction Performance analysis of ANN, RNN, CNN and DNN

Further hybrid network approach was adopted (hybrid means combination of two or more different networks) for high yield prediction and high accuracy. From hybrid approach, an analysis was done on each process and a comparison was done for finding the percentage of yield prediction from the separate method or combined hybrid methods. Within hybrid network approach classifications were done separately in three distinct parts. Every classification has multivariate regression technique in different phases depending upon various algorithms. It was observed that rice crop yield produced has 88% accuracy and that was optimized percentage. At the different layers of the network, classification, regression and hybrid approaches were evaluated that produced the high level prediction regarding yield. Output was same as in RNN method. Note that it has an improvement in yield with 88%

accuracy. Also, another process naming as Reinforcement Learning (with multiple network) was adopted here for finding the yield prediction. It provides 90% rice crop yield prediction and accuracy level. The aforementioned study made it quite evident that RNN, hybrid networks beat other full networks and provide around 90% accuracy level. So as shown in the figure 2, again around 90% accuracy level obtained from hybrid network.

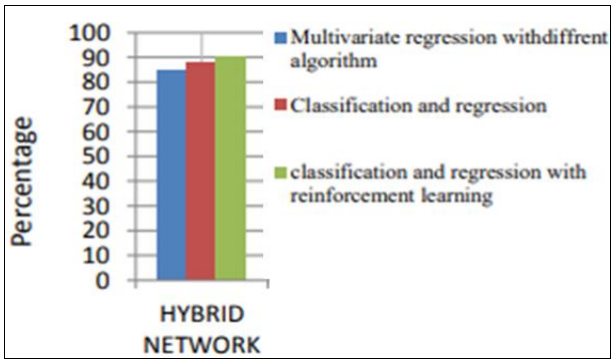

Fig 2: Yield prediction and accuracy in percentage from Hybrid Network Analysis

Conclusion

Prediction of rice crop yields using deep learning and related algorithms was studied and analyzed. RNN-LSTM, CNN, ANN and some of hybrid networks from these approaches were examined on the basis of some facts and findings. Range of ANN performance was from 65% to 78%. Note that networks having single layer and double layer showed a better output as compared to the individual approach. Note that matrix evaluation method using graphical data have 88% accuracy by CNN and was much better than ANN. Also 90% estimation accuracy was evaluated from RNN and LSTM. Also, some of hybrid network outperform better and have high yield accuracy as compared to other networks. It was also noted that RNN and LSTM provide major outcomes. Time series was inputted and outcomes stored for future purposes. Note that obtained output is better as compared to other outcomes by using hybrid networks and RNNs. Conclusion is RNN is best. From study and analysis, applications of artificial intelligence in various agricultural fields were predicted. Also, researchers can focus on real-time implementation on various crops for optimization. As agriculture has big database and fully depends upon real-time and time-series based available data. This will need more effort for RNN implementation. In future artificial intelligence will be more usable by using RNN with hybrid networks.

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