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ScienceDirect

Procedia Computer Science 165 (2019) 724–732

Procedia Computer Science

www.elsevier.com/locate/procedia

INTERNATIONAL CONFERENCE ON RECENT TRENDS IN ADVANCED COMPUTING 2019, ICRTAC 2019

Improvement of Crop Production Using Recommender System by Weather Forecasts

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Abstract

Establishing linkages between Meteorological and climatic data, and farming decision-making is a challenging task. The following paper addresses the challenges associated with this. A large amount of weather and climate information is presently available for farmers. A portion of the information is operational or already under development, and in particular, forecasting through climatic data and formation may not be suitable for farmers when it comes to the decision-making process. The best way to gain an advantage from natural factors is to consider them during decision-making and understand them in the best way possible. Meteorological information pertaining to agriculture, and climatic data, in particular, is an important aspect of planning in the context of agricultural production. Therefore, climatic conditions must be an integral part of the decision-making process. These factors can be determined by recording hourly, daily, and weekly temperature data, rainfall, solar radiation, wind speed, evaporation, relative humidity, and evapotranspiration. Artificial Neural Networks possess the capability of not just analysing the data but also learning from the data. This paper presents a predictive analysis to analyse the best crop which can be produced for specific weather conditions and also suggests a hybrid recommender system that adopts CBR - Case-Based Reasoning for enhancing the success ratio of the system. This proposed novel hybrid system is a combination of the collaborative filtering technique and case-based reasoning.The novelty of the model lies in the of district-wise agriculture data analysis for predicting future climatic conditions and recommending crops based on that climatic conditions and also considering the agriculture pattern of the district using a hybrid recommender system.

Peer-review under responsibility of the scientific committee of the INTERNATIONAL CONFERENCE ON RECENT TRENDS IN ADVANCED COMPUTING 2019.

Keywords:Artificial Neural Networks, Weather Prediction, Case-Based Reasoning, Collaborative Filtering

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Peer-review under responsibility of the scientific committee of the INTERNATIONAL CONFERENCE ON RECENT TRENDS IN ADVANCED COMPUTING 2019.
10.1016/j.procs.2020.01.023

1. Introduction

Weather and climatic conditions play a significant role in agricultural activities. Agricultural decision-making can either be spontaneous, allowing natural factors to take their course, or the agricultural decision-maker can consider their benefits and understand them in the best way possible or monthly rainfall data, temperature, climatological risks such as frost and hail, or solar radiation. This paper is focused on analyzing the predictions related to climatic change and weather checking of each district in the state of Tamilnadu. The novelty of the algorithm lies in the district wise prediction of climatic condition and analyzing their individual pattern of agriculture to create a recommendation model the quality of input can be improved through preprocessing of data which affects performance and analytical efficiency. Data preparation is an utmost significant step during this process. In the initial phase, all the assembled weather dataset undergoes preprocessing before the proposed model is applied and the cluster sets related to every season are formed. Every data set pertaining to a season is associated with dynamic formation of the cluster. ANN-based model is presented for anticipating the assembled daily precipitation in accordance with the subsequent day. An auto-encoder is included for capturing and encoding non-linear relations existing between attributes, for the purpose of prediction. ANN is valid in the context of big data and is equipped with the capabilities pertaining to the learning and generalization with respect to mass data. A series of multi-layer architectures form part of ANN and these architectures are trained through unsupervised algorithms. In this context, one of the main improvements is with respect to the process of learning which involves valid, compact, and non-linear data representation through the use of unsupervised methods. This ensures that new data representation adds value to the prediction task under consideration. Computer vision is one of the fields where this approach has been applied successfully [1]. A predictive analysis of ANN techniques is proposed in this paper to successfully analyze the best form of crop production on the basis of weather conditions. ANN techniques are suitable groups of algorithms used in the categorization process with respect to machine learning and data mining. The research work suggests a hybrid recommender system that adopts CBR - Case-Based Reasoning for enhancing the success ratio of the system. The research build's a system capable of suggesting the new users via collaborative filtering and methods in CBR (case-based reasoning). Later, there's a comparison of the accuracy of the recommendation Method taking the Conventional Collaborative Filtering into accord. The Recommendation Method relies upon the CBR (Case-based reasoning) method. HRS (Hybrid Recommender System) is adopted for the result assessment. The comparative assessment of the preciseness of the RS is portrayed within the paper relying upon the CBR (case-based reasoning), conventional collaborative filtering, and the suggested hybrid method by combining both the methods. Availability of the recommended system is reviewed via result assessment

2. Related works

The use of ANNs was proposed by Abhishek et. al. [2] to predict average rainfall in a month in any Indian terrain that exhibits monsoon climate. Data for eight-months per year was used in the study. The certainty of rainfall events is apparent during these months. Explanatory variables in the form of average wind speed and average humidity are used by authors for this purpose. Three separate networks were utilized for performing the experiments. These involved: Layer Recurrent networks, Feed Forward Back Propagation networks, and Cascaded-Feed Forward-Back Propagation networks. A comparison between the results obtained for each of the networks is performed and the network which realized the best form of results is ascertained. In this case, it is the Feed Forward Back Propagation network. An alternative is proposed by Liu et. al. [3] over the previous model. In this case, genetic algorithms are used in the form of feature selection algorithms and the predictive algorithm used is the Naïve Bayes algorithm. The Entire scenario is divided into two unique prediction problems: first, the rainfall event that depicts a binary prediction issue and second is the rainfall categorization that is the appearance of rainfall in the category of light, moderate, and strong rainfall. Genetic algorithms that are implemented to handle input selection symbolizes that for a particular dataset, complexity can be minimized for achieving somewhat equivalent or enhanced performance. Liu et. al. (2014) proposed a model on deep learning that relies upon DL- Deep learning. DNN - Deep neural networks are incorporated in the research work for huge data processing involving datasets that are 30 years old (1-1-1983 to 31-12-2012) belonging to the environmental records that being residing in HKO (Hong Kong Observatory). This model is compared to the former proposals and enhancement in its efficiency in the prediction of daily precipitation

assembled is demonstrated with respect to the next day [4] [5]. Deep Neural networks which are carefully selected perform better than their shallow counterparts. The use of input variable selection brings about a reduction in the complexity of neural networks and makes neural network training a simplistic task [6]. The predictive mean matching method is examined by Lawrence, R., et al., [7] to impute missing values with respect to continuous variables. The method imputes a random value from a selection of observed values in which values that are predicted being nearer to the predicted missing value. An algorithm is presented by Sawale & Gupta [8] based on an Artificial Neural Network (ANN) to predict atmospheric related conditions taking into account a dataset consisting of variable temperature, wind speed, and humidity. A hybrid architecture featuring a Hopfield Network (HN) and Back Propagation Network (BPN) was employed by the authors. The BPN output is fed into the HN to make the actual predictions. A model is presented by Luket. al [9] to identify Spatio-temporal data which is required to achieve accuracy in prediction of rainfall on a short-term basis ranging from 5 to 30 minutes. Rainfall prediction is carried out for a catchment area located in urban Sydney in Australia. Rainfall is predicted on the basis of historical patterns in rainfall through the use of an ANN and a sequence of measurements referring a basin study. The authors compared the prediction accuracy from ANN which was configured through the use of different variables to achieve this result. Variables were configured with respect to inputs and delays. The study found that better performance could be achieved through a network which used a lower lag [14]. . The error occurring amidst the computed result and the expected output is transferred back to the network in the training process, and therefore the algorithm is referred to as the backpropagation algorithm. ANNs have been used extensively in the fields of engineering and science, as per insights from paper [12] as they possess the ability to model non-linear as well as linear systems without the need for implicit assumptions as is the case of traditional statistical approaches. ANN tends to be an aggressive model in comparison to the simple linear regression models. Referring to this, ANN - Artificial Neural Networks are imbibed extensively when dealing with supervised data mining techniques. In paper [13], the model of backpropagation neural network was used to predict rainfall on the basis of humidity, pressure, and dew point in India. The training process made use of two-thirds of the data and the testing process employed one-third of the data. 250 training and 120 testing patterns were used for the purpose.

3. Proposed work

3.1 Architecture

Weather prediction is an implementation of science and technology for anticipating atmospheric state for a particular location and particular point in the future. Many industries and the agricultural sector are dependent on weather conditions. Warning about natural disaster from abrupt changes in climatic conditions is often available through weather predictions which is shown in figure 1.

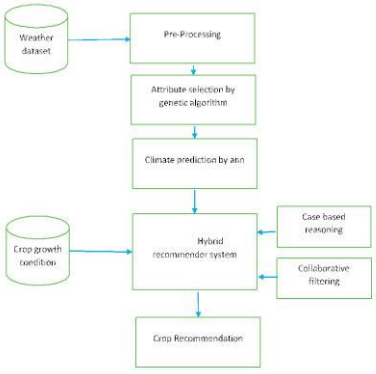

Fig. 1. Proposed Overall Architecture

3.2 Weather dataset

The data collected during the last three years pertains to the UCI dataset through the use of ANN for the prediction of weather, and based on the weather conditions, the recommended crop was a suitable crop. The prediction problem of accumulated weather precipitation is solved in this paper for the next day on the basis of data gathered from the previous days. About forty-seven explanatory characteristics are contained in the dataset available for model validation, which include barometric pressure, relative humidity, direction and speed of wind, sun brightness, and temperature in the form of the main variables. The data used in the research was used to make general predictions online. The set of meteorological conditions including snow, rain, sunshine, temperature, and wind at a specific time and place comprise weather. The term climate is used to describe the overall characteristics of weather on a long-term basis and is used to depict the weather characteristics for a specific place. The livelihood, ecosystems, agriculture, and settlement in a region depend on its climate. Therefore, climate is considered as a summary of weather conditions taken on a long-term basis, with information on average conditions and their variability. The procedures utilized at this stage of the research include Data Selection, Data Cleaning, Data Prediction, Data Recommendation, and Data Classification.

3.3 Pre-Processing

The quality of input can be improved through data pre-processing, which in turn affects performance and analytical efficiency. A mandatory step in this context is data preparation. This step converts prior data which was useless, into new data which can fit into the Data Mining process. Firstly, if prepared data is not available, it will not be possible for the Data Mining algorithm to receive it for successful operation, or for reporting errors at runtime. The algorithm works in the best case but the results will not be viable, or will not be considered as precise.

[1] The redundant data must be removed and only the data which is relevant for the analysis must be retained such as the membership number and name.
[2] The data is to be converted into the right format to enhance features including sales time in hours. The period must also be indicated.
[3] Next, the information which is not in line with the purpose must be identified and analysed.
[4] The next step is to delete the information which is undifferentiated.
[5] The missing values for the transaction categories must be noted.
[6] The next stage pertains to the reduction of the transactions into just the transactions which were performed by the customers.

At this level, a consistent format for the data model is built that handles missing data, detects duplicate data, and eliminates bad data. The cleaned data is then formatted as per recommendations, which is suitable for data retrieval.

3.4 Attribute selection

In order to get accurate results selection of attributes plays important role in the part of analysis Attributes like rainfall, temperature, humidity etc are taken and different attribute selection methods are tried to produce the better results among that genetic algorithm proved to be better one among other attribute selection methods[20].

3.5 Prediction using ANN

Computers are used in the field of weather forecasting to make viable forecasts. Forecast models are complex computer programs which are run on supercomputers and predictions are available for a number of atmospheric variables including pressure, wind, temperature, and rainfall [18][19]. It is possible to produce large data volumes as a result of the development of technology, and this data storage is efficient since it serves useful in the analysis and identification of data patterns [17]. The development of a big framework for data is useful when it comes to storing large data volumes. In this context, the prediction process is guided by Ann. The selection of neurons takes place on the basis of inputs supplied, which is followed by a trial and error methodology. The latest algorithm is deployed by the intelligent agriculture system for realizing improvements in the prediction of weather, and this

ensures that there is an improvement in the development of smart cities.

3.6 Time series

The performance of the prediction model is improved after the presentation of hidden features which result in an enhancement of the adapting capability. The present study considers features in the form of statistical indicators which are calculated for many different time frames as explained below.Data from the past three years is collected from the UCI dataset through the use of ANN for the prediction of weather. The recommended shout able crop based on weather conditions is also predicted in this case. 3 years of maximum, minimum and average weather conditions are substituted in time series equation.

Time series = (x(t-1) - x(t)) + x(t), this is Time series equation. (1)

$$F(x)= (\text{Max } \sum_{n}^{i=0} n_{Max}(t) - \text{Average } \sum_{n}^{i=0} n_{avg}(t)) + \text{Min } \sum_{n}^{i=0} n_{Min}(t) \quad (2)$$

F(x) = Accurate weather condition.

The time series prediction is then analyzed and the influence factors for the time series are evaluated. Later, research is performed on the factors which influence the target time series. Internet-based collection of the relevant factor time series data is performed and later analysis and preprocessing of the historical data is done. The neural network is trained for the influence factors, and their models are saved. Later, the time series neural network is trained and the model is saved. A perceptron is an artificial neuron, and the output of the neuron is calculated using the following formula:

$$y = f(\sum_{i=1}^{n} w_i x_i - \theta) \quad (3)$$

Here, the bias is θ and the output is y. n represents the number of inputs from ($x_1, \ldots x_n$) and the weights are represented as ($w_1, \ldots, w_n$). The activation function is represented by f. The sigmoid is the activation function used by the ANN as it is the most used activation function and is defined by:

$$(x)= \frac{1}{1+e^{-x}} \quad x \in (-\infty, \infty) \quad (4)$$

The weight values are updated through backpropagation, through the use of the output and the estimated output which make use of the gradient descent. To calculate error E, the following equation is used:

$$E = \frac{1}{2n} \sum_{i=1}^{T} \sum_{i=1}^{m} (p_i^t - v_i^t)^2 \quad (5)$$

Here, the number of patterns used in training are represented using T, and the number of outputs is shown by m. The desired output is P and the estimated output is v. The neural network predictive values are used in the form of influence factors, as a series representing input values for neural networks, and then multiple neural networks are used to obtain the predicted value in the form of an output.

3.7 Artificial Neural Network Classification

The reproduction of human intelligence and reasoning has been facilitated through a branch of AI-Artificial Intelligence, and is known as ANN- Artificial Neural Networks. Artificial Neural Networks can recognize patterns similar to weather and manage and learn data. The specified input-output function and the weights determine the ANN output. Artificial neural networks have the capability of solving problems with extreme complexity featured in conventional technologies. ANNs are therefore considered to be robust and precise classifiers. Weather classification experiments which are based on Artificial Neural Networks have been performed by meteorologists or researchers of weather data and events, and a huge controversy surrounds the way in which a priori knowledge can be used to determine attributes used in Classification. The results obtained are accurate and efficient.

3.8 Crop growth conditions

A framework for the analysis of a link between total farm or crop-specific revenue as well as climatic and weather-related variables is presented in this section. This framework maps the temperature distribution for the entire season for the yield of a specific year by constructing values for temperature which depict the number of days and hours expended in a three-degree range which is spread over a growing season. The approach extends to incorporate weather and climate measures at the same time in the form of determinants for farm level and crop-specific revenue, which is presented in equation 1.

The estimated relationship between the temperature, rainfall, and crop revenue is represented by:

$$y_{iht} = \delta_{iht} + \beta x_{iht} + \sum_{j=1}^{n} \gamma_j r_{hit} + \sum_{k=1}^{m} \mu_j s_{hk} + \vartheta w_{hit} + \varepsilon_{iht} \quad (6)$$

The i[th] crop in a specific farm household is represented by *iht*. The relation is true for the period t and farm household h. y_{iht} is the revenue of the farm household h for year t from the i^{th} crop. The time that is spent for degree range j over a growing season for household h and year t is represented by r_{hjt}. The time spent for each extreme degree ranges k for a household growing season h over three years is depicted by $s_{nk}.w_{hit}$ shows seasonal rainfalls and the physical and socioeconomic farm characteristics are shown by x_{iht}. Vector of parameter estimates are represented by the coefficients$\beta, \gamma, \mu, \delta$, and ϑ and the error term is represented by ε_{ht}. The composite error term is depicted by $\varepsilon_{iht} = a_{ih} + u_{iht}$ and represents a random error term which is normally distributed, and represented by u_{iht}. The unobserved household-specific effect is represented by a_{ih}.

A linear projection on the observed explanatory variables is an approximation of a_{ih}.

$$a_{ih} = \omega Z_{iht} + v_{iht} \quad (7)$$

In this case, the random error term is represented by v_{iht} and z_{iht} is the vector representing repressors which vary with time in a particular equation (2). For an observational unit h, averaging over t and substituting the resultant expression gives the following (1):

$$y_{iht} = \delta_{iht} + \beta x_{iht} + \sum_{j=1}^{n} \gamma_j r_{hit} + \sum_{k=1}^{m} \mu_j s_{hk} + \vartheta w_{hit} + \varepsilon_{iht} + \omega Z_{iht} + v_{iht} \quad (8)$$

3.9 Hybrid Recommender system

The component of the hybrid method is used to sort the recommendations which are obtained through case-based reasoning engine and collaborative filtering as per the weighting mechanism which is configurable by the administrator of the recommender system who ends a list to the end-users. The Data Ratio is considered as part of the hybrid component of the Algorithm which is the ratio pertaining to the track data of the user in the entire dataset. When the ratio is low in the computation of the results of the recommendations, the Case-Based Reasoning approach gains precedence, or else the Collaborative filtering is considered more important.
Input: User-id for the end-user for whom the suggestions are provided, Record-Dataset, Threshold values via lower limit, higher limit to find out the Ranking

Output: The list of ranked recommendations by their weights.

3.10Case-Based Reasoning (Inference) Capability:

The proposed method projects CBR cases through the use of RDF triples. Here, the query data that the user offers is utilized to build RDF triples by the CBR engine. The RDF triples are inferred by the CBR engine via utilizing the REASONER component which is running on the Case Ontology in context to the CBR. Unexplored information is hence achieved via reasoning from the ontology. This is unavailable within the query data which is gained from the user and inserted within the RDF triples that form the query. Secret relations can be projected depending on the hierarchical structure in the ontology, if reasoning capability is utilized to achieve the output as a result higher solution space can be obtained.

3.11Crop Recommendation

The system can draw out successful recommendations to the users who have missed interest data gained formerly depending on the user's demographics and the preference data via the use of recommendations of previous experiences to similar users. The proposed approach being hybrid in nature and offers a remedy for the issue of data scarcity that is a section of the RS (recommender systems) because of its influence feature. The approach of hybrid recommendation is functional relying upon the RDF triples and its running capability is linked with case ontology of the CBR that is being framed for all areas and allows a framework for the system that is area independent.

4. RESULTS AND DISCUSSION

An inspiring area of research for scientists is the weather prediction domain. The application of the Artificial Neural Networks model is presented in this paper and the prediction of weather data is proposed. Minimum and maximum temperature and relative humidity are predicted. To ensure that the key criteria are meticulous in nature, predictive modelling is executed. Future weather conditions are predicted based on the prediction model and are based on the specified parameters through the use of Artificial Neural Networks. The application of science and technology to predict atmospheric state for a time in future and for a given location is referred to as weather prediction. A number of industries and agricultural sectors depend on weather conditionsand these predictions are helpful in warning about disasters which occur naturally and are caused by abrupt changes in the climatic conditions. The dataset for the proposed system is taken from the Weather Underground for testing purposes. Real-time observations pertaining to weather for a specific period of cities are contained in the dataset. Many attributes are contained in the dataset including temperature in degrees centigrade (°C), percentage humidity (%), Sea Level Pressure (hPa), Dew Point (°C), Gust Speed (km/h), wind (km/h), Precipitation (cm), and Visibility (km).

Table 1 Performance of classification techniques

Techniques	Accuracy (%)	Time(sec)
Fuzzy c-Means	87%	0.12
SVM	89%	0.08
ANN	93%	0.3

Table 1 shows the output of the Classification Techniques over the Weather classification and shows a comparison between several existing techniques including Fuzzy C-Means, SVM, and ANN.Better output is obtained through the use of ANN weather classification when compared to the existing techniques.

Table 2. Performance of prediction techniques

Techniques	Accuracy (%)	Error Rate
C 5.0	87%	1.765
NWP	89%	1.34
ANN Prediction	93%	0.95

The output of the prediction techniques is produced by Table 2 over weather prediction and shows a comparison between various other techniques including Numerical Weather Prediction, ANN Prediction, and C5.0.ANN weather prediction produces better output when compared to the other existing techniques.Error performance for the output of ANN Prediction techniques over weather prediction depicts 93% accuracy and 7% error, as illustrated in figure 2.

Fig. 2. Error performance

The Hybrid recommendation model created also outperforms the collaborative filtering and case-based reasoning as individual. The accuracy percentage of hybrid model is high of 96% which is shown in figure 6 based on the relevance the precision and recall values are calculated and which is shown in table 3.When the collaborative filtering method and case-based reasoning combine together will produce better accuracy and relevance. In hybrid recommendation model 90% of crop recommendation are truly relevant and 93%of relevant crops were recommended from the list

Table 3. Recommendation model comparison

Technique	Precision (%)	Recall (%)
Collaborative filtering	80	73
Case-based reasoning	88	79
Hybrid recommendation	90	93

5. CONCLUSION

Weather prediction stands as a challenging outlook in the technology and scientific domain in accord with the dynamics of climate and theory of climate prediction. Artificial Neural Networks (ANN) are being adopted in the research for achieving weather prediction. The work employs the following methods: classification, recommendation, and prediction. The regularization of ANN (Artificial Neural Networks) is employed to imbibe the Hybrid approach via CBR to enhance the success ratio of the recommender system. In the near future, the prediction accuracy can be enhanced via various regression model. The modelrepresented performs a comparison amidst pattern recognition of meteorological parameters over a geographic area of small scale and projects remarkable performance and rational accuracy of prediction.

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