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Futuristic prediction of price of agriculture commodities using enhanced exponential smoothing (EES) algorithm

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Abstract
Modernization in Agricultural practices is required, to meet the requirements. In the recent years there has been an inconsistency in the prices of multiple crops which in turn has increased the menace encountered by the farmers. This study has conducted a comparison between the various time series models like AR, ARMA, SARIMA and Exponential smoothing on the crop price dataset using PYTHON to predict the future price. The performances of these algorithms are analyzed based on metrics like ET, RMSE, MAE, R^2Score, and MDAE.

Keywords: AR, ARMA, SARIMA, PYTHON, RMSE, MAE, models

Introduction

India is an Agricultural country and the major occupation of Indians is farming. Agriculture plays a vital role in the growth of Indian economy. With a 16% contribution to the Gross Domestic Product (GDP), Agriculture provides livelihood support to about two-thirds of country's population. It provides employment to 58% of country's work force and is the single largest private sector occupation TNAU, (2019) [1]. 60% of the land is utilized for Agriculture which is adequate to satisfy the requirements of the Country's population. The main purpose of the Forecasting System is to ensure that the farmers make a better-informed decision and manage the price risk (Rachana *et al*, 2019) [6].

Rachana *et al*. 2019 [6] have used the dataset with Rainfall, Maximum-trade, Minimum Support Price (MSP) and Yield as the Parameters for Price Prediction. Paulo, 2017 has used five years rice dataset, and applied the typical ARIMA model and ARIMA-Kalman filter model on the dataset. Using advanced analytics models ARIMA and kNN, yarn price was predicted by Berry and Linoff, 2004 [2]. ARIMA model was used to predict the subsequent four years of agriculture food production value using R tool by Pavan and Bhramaramba, 2017 [3]. The validity of the predicted values is checked with the data for the lead periods. Xingyu *et al*., 2014 [9], have used nine types of infectious disease datasets pertaining to the period 2005 to 2012 and applied Auto regression, Exponential smoothing, ARIMA and SVM on the data from 2005 to 2011 to forecast 2012.

Historical data is used to predict future events in the Predictive analysis. The resultant predicted values are used for decision-making and planning in various areas such as finance, marketing and production, etc. Predictions can also be used in Agricultural decision-making Lakkana and Montalee, 2018. The main objectives of this work are:

1. To assist farmers in selecting a crop for cultivation based on the predicted crop price thereby increasing the profit.
2. To analyze the performance of Auto Regression (AR), Auto Regressive Moving Average (ARMA), Seasonal Auto Regressive Integrated Moving-Average (SARIMA) and Exponential Smoothing (ES) based on the metrics like Execution time, Root Mean Square Error (RMSE), Mean Absolute Error (MAE), R^2 Score, and Median Absolute Error (MDAE).
3. To propose an algorithm called Enhanced Exponential Smoothing (EES) to enhance the execution time of the traditional ES.

Materials and Methods

Data collection and pre-processing

The crop price data was collected from the internet. The crops taken are amla, broad beans, bottle gourd, ladies finger, radish and tomato.

The collected data was preprocessed by removing noisy, blank or unwanted data. The data was initially coded in EXCEL and finally converted to comma delimited CSV. In this chapter, daily price of some crops for 2047 days are taken to predict the future price. Time series analysis techniques are applied over the Crop Price dataset to predict the price of the corresponding crop.

Techniques like AR, ARMA, SARIMA and ES are deployed on six crop price datasets to predict their future price. The crops taken are amla, broad beans, bottle gourd, ladies finger, radish and tomato. The performances of the algorithms are analyzed based on metrics like Execution time, RMSE, MAE, R^2 Score and MDAE. As Exponential Smoothing is found to be a better one when execution time is compromised, Enhanced Exponential Smoothing is proposed to improve the execution time. The main problem is to perform a comparative study of these algorithms using the various six Crop Price datasets based on metrics like Execution time, RMSE, MAE, R^2score and MDAE and propose an Enhanced Exponential Smoothing algorithm.

Performance analysis of various time series analysis algorithm for crop price prediction

Techniques like Auto Regression (AR), Auto Regressive Moving Average (ARMA), Seasonal Auto Regressive Integrated Moving-Average (SARIMA) and Exponential Smoothing (ES) are deployed on six Crop Price datasets to predict their future price. The crops taken are amla, broad beans, bottle gourd, ladies finger, radish and tomato. The performances of the algorithms are analyzed based on metrics Execution time, Root Mean Square Error (RMSE), Mean Absolute Error (MAE), R^2 Score, and Median Absolute Error (MDAE). Sequence of observations taken sequentially in time is time series. Time series forecasting is choosing models, then fitting them on historical data and predicting the future observations using them. Therefore, for example, month(s) ago of the measurement is used as an input to predict the next month(s). Similarly, for seconds, day, hour, etc., are done.

In time series forecasting, a model is developed based on the collected past observations. The model captures the underlying data generating process for the series. Using the model, the future events are then predicted. Autoregressive (AR) and Moving Average (MA) are the two widely used linear time series models. Autoregressive Moving Average (ARMA) and Autoregressive Integrated Moving Average (ARIMA) models are proposed combining AR and MA. The Seasonal Autoregressive Integrated Moving Average (SARIMA) model is a variation of ARIMA for seasonal time series forecasting.

Removing rolling average from original time series is Smoothing. In Exponential Smoothing, exponentially decreasing weights are assigned as the observations get older, i.e., when compared to the older observations, recent observations are given relatively more weight in forecasting. The weights assigned to the observations are the same for moving averages, and are equal to 1/N. In exponential smoothing, the weights assigned to the observations are determined based on one or more smoothing parameters to be determined or estimated.

Experimental simulation

The various time series models were applied on the dataset and the various metrics were analyzed. The algorithms were executed on the processed six datasets in CSV file using PYTHON and the various metrics were analyzed.

Results and Discussion

Table 1 and 2 show the outcome of various algorithms on Bottle Gourd and Broad Beans datasets respectively. Similarly, the performance metrics for all the crops are taken.

Table 1: Performance of the algorithms on Bottle Gourd dataset

Algorithm	Time	RMSE	Mae	R^2Score	MDAE
SARIMA	2.0653	6.3419	2.9616	-4.8331	1.9450
ES	9.4164	2.6259	0.8118	0.0000	0.0000
AR	0.2296	2.6623	0.9662	-0.0280	0.2208
ARMA	1.3525	2.6656	0.9655	-0.0306	0.2102

Table 2: Performance of the algorithms on Broad Beans dataset

Algorithm	Time	RMSE	MAE	R^2Score	MDAE
SARIMA	2.4214	11.5789	5.2216	-17.5141	1.9956
ES	8.0350	2.6910	0.9588	0.0000	0.0000
AR	0.0824	2.7417	1.0887	-0.0380	0.1559
ARMA	0.7022	2.7379	1.0786	-0.0352	0.1487

Table 3: Algorithms sorted based on performance from best to worst on Bottle Gourd dataset

Time	RMSE	MAE	R^2Score	MDAE
AR	ES	ES	ES	ES
ARMA	AR	ARMA	AR	ARMA
SARIMA	ARMA	AR	ARMA	AR
ES	SARIMA	SARIMA	SARIMA	SARIMA

Table 3 and 4 show the performance of the algorithms on Bottle Gourd and Broad Beans datasets sorted out based on the metrics respectively. It is clear that AR is the fastest algorithm and ES results in the best for all other metrics for both the datasets.

Table 4: Algorithms sorted based on performance from best to worst on Broad Beans dataset

Time	RMSE	MAE	R^2Score	MDAE
AR	ES	ES	ES	ES
ARMA	ARMA	ARMA	ARMA	ARMA
SARIMA	AR	AR	AR	AR
ES	SARIMA	SARIMA	SARIMA	SARIMA

Table 5 shows the execution time of each algorithm on each dataset. Figure 1 is the corresponding chart. Table 6 shows the best algorithms for each crop based on various metrics. For all the six crops AR result in the best execution time. For all other metrics, in most of the cases, exponential smoothing is the best one. Hence in the following section, an Enhanced Exponential Smoothing (EES) algorithm is designed to improve the execution time alone.

Table 5: Execution time of each algorithm on each dataset

Algorithm	Amla	Broad Beans	Bottle Gourd	Ladies Finger	Radish	Tomato
SARIMA	2.3408	2.4214	2.0653	2.8118	2.7840	2.3408
ES	8.3510	8.0350	9.4164	7.9305	6.5844	8.3510
AR	0.0929	0.0824	0.2297	0.0727	0.0498	0.0929
ARMA	1.0121	0.7022	1.3525	0.5733	0.7229	1.0121

Table 6: Best algorithms for each crop based on various metrics

Metric	Amla	Broad Beans	Bottle Gourd	Ladies Finger	Radish	Tomato
TIME	AR	AR	AR	AR	AR	AR
RMSE	ARMA	ES	ES	ES	AR	ARMA
MAE	ES	ES	ES	ES	ES	ES
R^2SCORE	ARMA	ES	ES	ES	AR	ARMA
MDAE	ES	ES	ES	ES	ES	ES

Enhanced Exponential Smoothing (EES)
Exponential Smoothing
Exponential Smoothing is used to produce a smoothed Time Series by assigning the past observations exponentially decreasing weights. The recent observations are assigned relatively more weight than the older observations in forecasting (What is Exponential Smoothing, 2020) [8]. The algorithm for fitting the model in Exponential Smoothing is given below.

Enhanced Exponential Smoothing (EES)
As Exponential Smoothing (ES) is found to be a better algorithm when compromised on the execution time, the traditional ES algorithm is enhanced to improve the execution time. In the proposed enhanced algorithm, EES, the following changes are to be incorporated in the traditional ES.

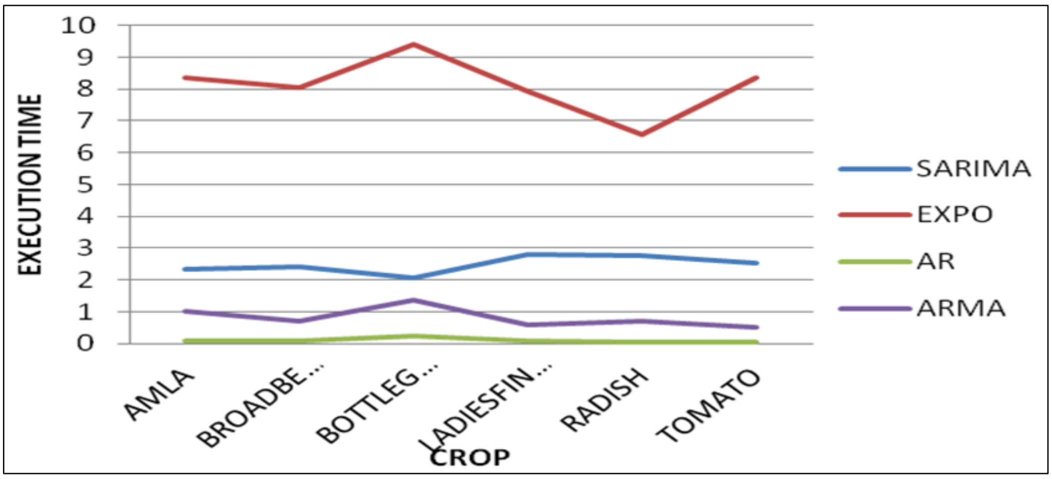

Fig 1: Comparison of algorithms based on the execution time EES Algorithm

Table 7: Performance of the algorithms for each crop based on the execution time

Algorithm	Amla	Broad Beans	Bottle Gourd	Ladies Finger	Radish	Tomato
ES	8.3510	8.0350	9.4164	7.9305	6.5844	8.3581
EES	6.3669	5.7199	6.1102	6.0516	5.0261	7.2437

Performance analysis of Exponential Smoothing and Enhanced Experimental Smoothing
Both the algorithms were executed on the taken six crop price datasets using PYTHON and the various metrics were analyzed. It resulted is same values for all metrics except execution time. Table 7 shows the execution time resulted by the ES and EES algorithms for the datasets. Figure 2 shows the comparison of the algorithms based on execution time. From table 7 and figure 2, it is inferred that EES algorithm is faster than ES.

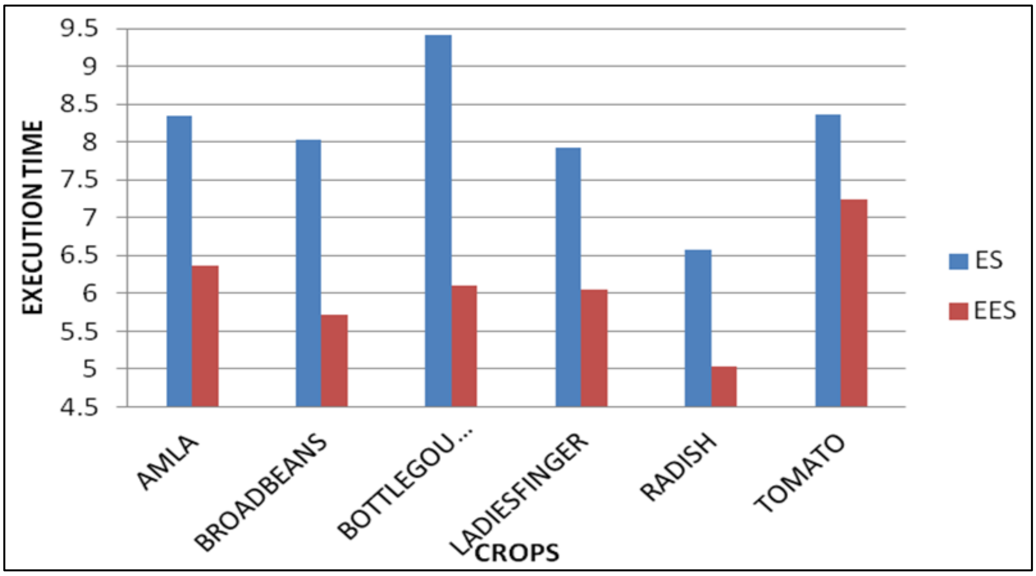

Fig 2: Comparison of algorithms based on the execution time

Conclusion
It is concluded that Exponential smoothing is found suitable for these datasets with little compromise in the execution time for finding the expected price of the crops to be cultivated. When execution time alone is given importance, AR can be used. To improve the execution time of ES, the EES algorithm has been proposed and its performance has been compared with that of traditional ES algorithm on the crop datasets for crop price prediction based on various metrics. The EES algorithm is faster than the original ES algorithm for crop price prediction.

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