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A Comparative Study of the Efficient Data Mining Algorithm for Forecasting Least Prices in Oman Fish Markets

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Abstract

The economic growth is influenced by human reactions in various sectors. Fisheries sector is one of the sources that people can depend on it since a long-time. The customers and suppliers nowadays need a good application to assist them to overcome the issue of rising of fish prices. This study aims to help to forecast the future of least prices in Oman fish markets using data mining algorithms, by means of studying the history of data that will assist to make a proper decision. The study considered the fish markets in Sultanate of Oman where it selected 29 markets and 15 fish species in each market. In addition, the data mining algorithms, namely Linear Regression, SMOReg, Multilayer Perceptron, MLP Regressor, and Random Forest has been applied to forecast the prices weekly and monthly. The suitable algorithm, which provides good performance, has been chosen for developing an application. This research study will add to the literature in the area of technology development that will handle the fluctuations in the prices and will support the suppliers in a useful manner. This application model will help customers and suppliers to forecast the current least prices in Oman fish markets.

Keywords: Data Mining, Fish market, Forecasting, Sultanate of Oman.

INTRODUCTION

Fisheries Price-Forecasting is a vital topic with respect to economic sustainability and improvement. It helps to grow health and investment aspects of individuals and groups in different countries of the world. Obviously, the value behind this field lies on the livelihoods of more than half million people in the poor agricultural countries depend directly or indirectly on fisheries and aquaculture, as it is defined by the Food and Agriculture Organization (FAO) [1]. Forecasting is a process to provide opportunities to take advantage of historical time series data, in order to make a decision that can directly affect profitability or save a business from inevitable losses. Time-Series Data Mining is a complementary concept to the forecasting, where different algorithms has been used to solve the issues and to forecast the future (see details in [2][3]).

Many people and studies neglected the forecasting at the expense of the general concept, prediction. From scientific point of view, forecasting is modelled to be used with Time-Series problems. While, prediction is designed to be used with various types of data that is not considered the target value with respect to the sequence period. The main contribution of this research is to apply the classification model for a time series data, and then to compare the results of time series experiment to choose the best algorithm.

Figure 1: Gross Domestic Product Value of The Agricultural and Fisheries Sector [6]

OMAN FISH MARKET

Fisheries is regarded as one of the oldest Omani professions that contributes to the improvement of national economics and national income in particular; where many people, depend entirely on it as a source of income for living [4] [5]. It is clear that there are significant advances made in the area, where the average growth rate from 2011 to 2016 is increased by 12.1%, and the total GDP (Gross Domestic Product) of fisheries grew by 18.4% compared to 2015 as it is illustrated in Figure 1 [6]. In fact, the future of this sector is substantially fertile, more specifically in the direction of the government in future to activate other secondary renewable sectors and abandonment of oil and its derivatives as a major source.

Furthermore, the social aspect has an important impact on the fisheries sector, where a large segment of the citizens and residents depend on it and daily fluctuation in prices has direct influences. Evidently, there are different fish prices for the same species in different locations at the same time [7]. The reasons can be

attributed to several factors affecting the fish prices, for example, supply and demand, climate, oil, fuel, gas etc. [8] [9] [10]. Thus, forecasting has become a more important issue than normal other commercial products [11].

LITERATURE REVIEW

Nowadays, the research community has given more attention to the topics that is related to Price-forecasting, so the reason could be attributed to the active contribution in the growth of economies in governments and institutions. There are different approaches used to study the price forecasting, some of the research papers are highlighted here.

The research paper in [12] discusses a hybrid model that uses two algorithms: Wavelet Neural Network and Genetic Algorithm to predict the prices of aquatic products in some short-term periods, such as one day, one week and ten days. The results show that when the prediction range is expanded, the precision of prediction is on the downward trend.

In the agriculture area, there are different algorithms that has been used for price-forecasting, for instance, [13] presented a comparative study among Time-Delay Neural Network (TDNN) and ARIMA models. The authors used monthly collected data of wholesale price for the oilseed crops such as soybean and rapeseed-mustard. They concluded that TDNN model provides better results than ARIMA model, in particular the values of RMSE and MAD.

Moreover, in [14] presented a comparison of two models, BPNN and Genetic Based Neural Network (GANN). The models are assessed in terms of accuracy and Mean Square Error (MSE). It is concluded that the accuracy of GANN is better than BPNN. Therefore, GANN is good at prediction; however, BPNN is good at simulation. The ARIMA, artificial neural network and the linear combination models have been used in [15]. The obtained results have demonstrated the overall performance and robustness of ANN model compared to others used models.

Furthermore, there are several surveys that discussed different data mining techniques. For instance, [16] is focused on the electricity topic and analyzes more than 50 papers where several techniques have been used. It concludes that nearest-neighbors and genetic algorithms have been rarely used. There were two techniques extensively used in the prediction area, which are ANN and SVM. Another survey in [17] discusses different price-forecasting methodologies, which categorized them to three types, which are a statistical model, univariate models and multivariate linear models. The study concludes that the ARIMA models are less effective than DR and TF algorithms, which are multivariate linear models. In contrast, ANN models, linear models have given better results than DR and TF algorithms. In addition, it refers that the combination of ANN and ARIMA with the fuzzy logic and WT, which gives a good performance; however, this survey concluded that there is no clear evidence to show the superiority of one model among all.

In summary, the results show that the ANN models with the combination with other algorithms are the most used model in the price forecasting field. In this study, we are going to compare different data mining algorithms from the models Artificial Neural Networks (ANNs), Regression, and Decision tree, then measure the RMSE of each algorithm to decide which one is better in the performance for the implementation.

METHODOLOGIES

Many customers and suppliers face many issues with regard to varying price fluctuations in the fish markets without knowing the reasons or factors that affects the pricing. In the meantime, they are looking to find a solution among the proposed approaches, which is likely to predict least fish price to avoid any losses and to fulfill their needs as much as possible.

The important endeavor in this research is to conduct a comparative analysis for the commonly used models in data mining forecasting algorithms. The well-performed data mining algorithm will be chosen to build an application. Further, there are several factors could be behind the extreme and the outlier values that will be highlighted in the analysis and discussion section.

Proposed Application Model

The main idea of this model is to build an application that will help the customer to reduce the problem of rising prices as much as possible. As well as measuring the efficiency of these data mining algorithms in order to choose the best algorithm to build the proposed application. As indicated in Figure 2, there are five main phases, which are data collection, data pre-processing, forecasting process, evaluation and analysis, and finally developing the application. First, the data has been collected manually from 29 markets all over Oman during the period of November 2015 to October 2016, with prices of 15 fish species. Second, in the data preprocessing, data cleaning is done to organize the data to be used in the forecasting process. Third, the Weka forecaster is used to perform the forecasting process. Fourth, in the evaluation process, analytical study has been conducted based on the outcomes of RMSE (Root Mean Square Error) on the used models, which are Linear Regression, SMOReg, Multilayer Perceptron, MLP Regressor, and Random Forest. Finally, the well-performed algorithm, that has less RMSE has been selected to develop the application.

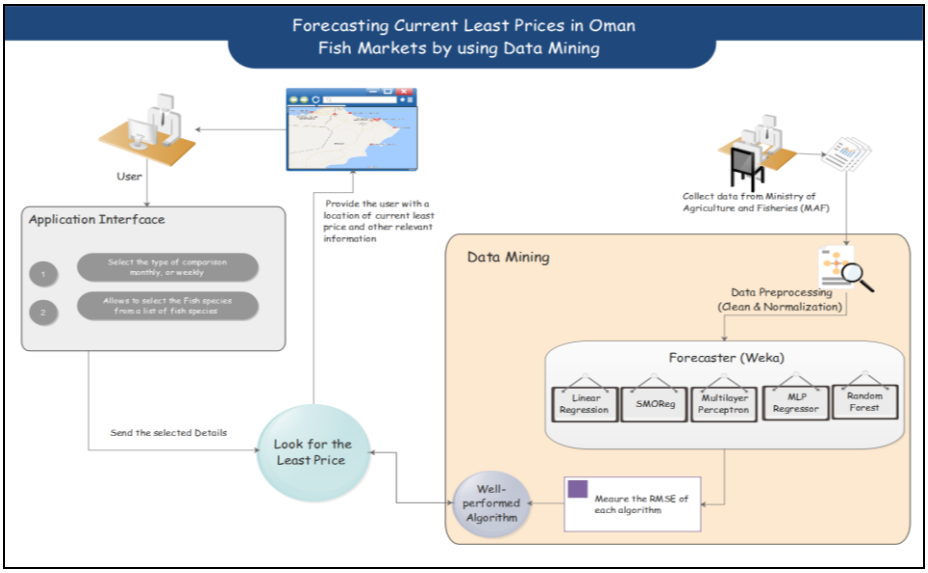

Figure 2: Application Model

TIME-SERIES FORECASTING ALGORITHMS IN WEKA

Weka [18] [19] is an open source tool that consists of a set of machine learning algorithms that used for data analysis and predictive modelling. It also gives a background of the common forecasting algorithms in Weka, which is applied in the implementation using Linear Regression, SMOReg, Multilayer Perceptron, MLP Regressor, and Random Forest algorithms.

Linear Regression

Linear regression is considered as one of the classical statistical algorithms that only supports regression type problems and consists of a numeric class not a nominal class. It clarifies the relationship among a scalar dependent variable, which refers to Y, and one or more independent variables, that denoted X. From the mathematical side, this model is responsible to calculate the weights of the linear expression, and the predicted value computes via the multiplication of the sum of each attribute value and its weight [20] [21].

SMOReg

SMOReg algorithm has developed for numerical input variables, will automatically convert nominal values to numerical values. The basic idea of SMOReg is to implement the Support Vector Machine (SVM) for regression. The first versions of the SVMs were created for binary classification problems, while the later versions, such as SMOReg or SVR (Support Vector for Regression) have been used to support multi-class classification and regression issues.

Multilayer Perceptron

Another important data mining algorithms is a Multi-Layer Perceptron [22] method which support both regression and classification issues. It is known as an Artificial Neural Network or shortly neural networks, which are sophisticated methods to use for predictive modeling.

MLP Regressor

MLPRegressor is another data mining algorithm used for regression purpose and it is an improved version of the Multi-Layer Perceptron algorithm. It uses WEKA's Optimization class in order to train a multilayer perceptron with one hidden layer. This type of optimization allows to reduce the given loss function and a quadratic penalty with the BFGS method.

Random Forest

This algorithm comes under the umbrella of the supervised classification algorithms. It creates the forest with a number of trees as described in Figure 3. Moreover, Random forest is an example for the commonly used algorithms that belong to decision trees in data mining which can support classification and regression issues. It is defined as "an ensemble learning method for classification, regression and other tasks, that operates by constructing a multitude of decision trees at training time and outputting the class that is the mode of the classes (classification) or mean prediction (regression) of the individual trees" [23].

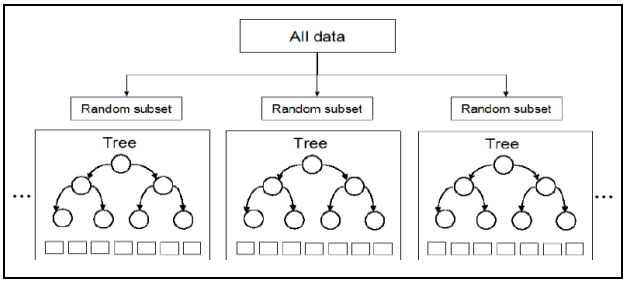

Figure 3: Example of Random Forest Algorithm

EXPERIMENTS

The experiment is done for (weekly and monthly), where the daily price for each fish species is calculated weekly and monthly. The evaluation is carried out through measuring the RMSE for each algorithm, considering the actual and predicted prices. The principal objective is to select an efficient algorithm among all proposed methods. The data has been collected manually via forms from 29 markets throughout Oman. Each form contains the price and quantity for 15 fish species, which are Kingfish, Yellow fin tuna, Long tail tuna, Rabbitfish, Seabream, Emperor, Jobfish, Groupper, Mulet, Shrimp, Cuttlefish, Indian Mackrel, Sardines, Sweetlips Silver Grunt, and Longfin trevally.

The collected data was inconsistent, and the data cleaning was done to avoid Null values to make the data compatible to work properly with Weka forecaster. After the data Pre- processing is done, there are only five markets that have a complete data, which are Barka, Muttrah, Quriyat, Seeb, and Shinas for four fish species, namely, Yellowfin tuna, Seabream, Emperor, and Longfin trevally. Also, we need to calculate the average for each fish species per each location for all files. Then, extract and remove the extreme and outlier values, which has a value greater or less than average by two points. The primary objective is to enhance the performance of forecasting as well as to avoid any fault.

The experimental work is done using Weka forecaster, where the training dataset forms 75%, while 25% is a test dataset. Further, there are three forecasted units have been chosen for the monthly forecasting; while five forecasted units for the weekly forecasting. The selected units depend on the forecasted prices of the training dataset in order to compare it with the actual prices of the test dataset. It also presents an evaluation of RMSE for the proposed algorithms, where the best algorithm is chosen with less RMSE.

Measure the RMSE of Each Algorithm

The calculation of the RMSE for each algorithm is presented separately. Before computing the RMSE, calculate the Error, Error Rate, Square Error and Mean Square Error, as it illustrated in Table 1 and 2. Table 1 shows monthly RMSE for Emperor fish species in

Table 1: Measure Monthly RMSE for Emperor in Barka

Date			8/1/2016	9/1/2016	10/1/2016	Mean Square Error	Root Mean Square Error	Algorithms
Actual Prices			1.936	1.910	1.892			
Forecasting Algorithms in Weka	Linear Regression	Predicted Prices	2.122	2.147	2.142			
		Error	0.186	0.237	0.250			
		Error Rate	0.096	0.124	0.132			
		Square Error	0.009	0.015	0.017	**0.014**	**0.12**	**Linear Regression**
	MLP Regressor	Predicted Prices	2.474	2.160	2.605			
		Error	0.538	0.250	0.713			
		Error Rate	0.278	0.131	0.377			
		Square Error	0.077	0.017	0.142	**0.079**	**0.28**	**MLP Regressor**
	Multilayer Percept	Predicted Prices	2.285	2.223	2.374			
		Error	0.349	0.313	0.482			
		Error Rate	0.180	0.164	0.255			
		Square Error	0.032	0.027	0.065	**0.041**	**0.20**	**Multilayer Perceptron**
	SMOReg	Predicted Prices	2.291	2.185	2.409			
		Error	0.355	0.275	0.517			
		Error Rate	0.183	0.144	0.273			
		Square Error	0.034	0.021	0.075	**0.043**	**0.21**	**SMOReg**
	Random Forest	Predicted Prices	2.160	2.153	2.188			
		Error	0.224	0.243	0.296			
		Error Rate	0.116	0.127	0.157			
		Square Error	0.013	0.016	0.025	**0.018**	**0.13**	**Random Forest**

Table 2: Measure Weekly RMSE for Emperor in Muttrah

Date			8/14/2016	8/21/2016	8/28/2016	9/4/2016	9/11/2016	Mean Square Error	Root Mean Square Error	Algorithms
Actual Prices			2.500	1.500	1.954	2.408	2.150			
Forecasting Algorithms in Weka	Linear Regression	Predicted Prices	2.248	0.856	2.724	2.380	0.825			
		Error	-0.252	-0.644	0.770	-0.028	-1.325			
		Error Rate	-0.101	-0.429	0.394	-0.012	-0.616			
		Square Error	0.010	0.184	0.155	0.000	0.380	**0.178**	**0.42**	**Linear Regression**
	MLP Regressor	Predicted Prices	2.301	2.063	2.293	2.239	2.146			
		Error	-0.199	0.563	0.339	-0.169	-0.004			
		Error Rate	-0.079	0.375	0.174	-0.070	-0.002			
		Square Error	0.006	0.141	0.030	0.005	0.000	**0.012**	**0.11**	**MLP Regressor**
	Multilayer Perceptron	Predicted Prices	2.722	2.714	2.420	2.102	2.734			
		Error	0.222	1.214	0.466	-0.306	0.584			
		Error Rate	0.089	0.809	0.239	-0.127	0.271			
		Square Error	0.008	0.654	0.057	0.016	0.074	**0.049**	**0.22**	**Multilayer Perceptron**
	SMOReg	Predicted Prices	2.088	2.226	2.485	2.049	1.996			
		Error	-0.412	0.726	0.531	-0.359	-0.155			
		Error Rate	-0.165	0.484	0.272	-0.149	-0.072			
		Square Error	0.027	0.234	0.074	0.022	0.005	**0.034**	**0.18**	**SMOReg**
	Random Forest	Predicted Prices	2.257	2.264	2.243	2.258	2.261			
		Error	-0.243	0.764	0.289	-0.150	0.111			
		Error Rate	-0.097	0.510	0.148	-0.062	0.051			
		Square Error	0.009	0.260	0.022	0.004	0.003	**0.009**	**0.10**	**Random Forest**

Barka. The same way, it is done for the rest of markets also as presented in the appendices. Furthermore, Table 2 shows the weekly RMSE for Emperor in Muttrah and the rest of calculations presented in the appendices.

RESULTS AND DISCUSSION

According to the weekly and monthly forecasting analysis, Shinas, and Barka are predicted with high prices; whereas Qurriyat holds the less prices in all fish markets. It is obvious that in all the fish species, Yellowfin tuna, Seabream, and Longfin trevally, Shinas predicted with the maximum price, while Qurriyat with the minimum price. The outcome is same except in Emperor, where Barka obtains the maximum price, while Qurriyat gains the minimum price.

As outlined in Table 4, the extreme values have appeared in two markets, Barka and Muttrah during the period of July, September, October, November and December for the species Yellow fin tuna, and Emperor. The extreme values are affected by several factors that would lead to a radical relationship to reduce the rise in prices. Obviously, the studies that conducted in the National Centre for Statistics and Information in Oman (NCSIO) shows that in the same period there are high prices of Crude Oil & Condensate, and Gas, Oil, M-95, and M-91, as illustrated in Figures 4 and 5.

Table 3: Extreme values

Market	Fish_code	Date	Price
Barka	2	30/11/2015	5
Barka	2	29/12/2015	5
Barka	2	20/10/2016	5
Barka	2	22/10/2016	5
Barka	6	30/11/2015	4.5
Barka	6	17/07/2016	4.5
Muttrah	2	2/1/2016	5.2

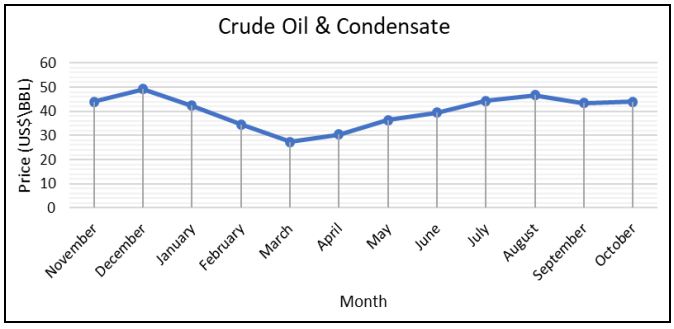

Figure 4: Monthly Prices of Crude Oil & Condensate

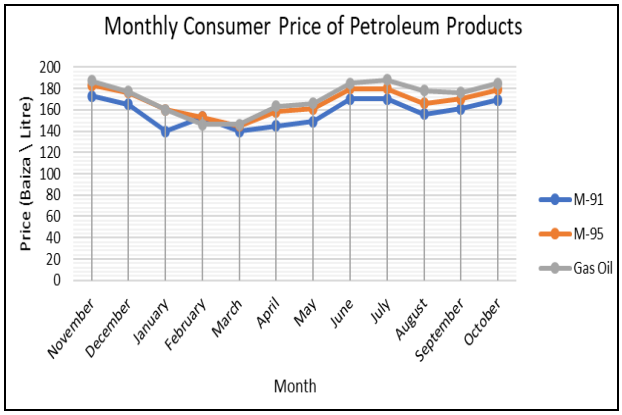

Figure 5: Monthly Price of Petroleum Products

In the error evaluation, the findings were presented that the Random Forest is better, where the RMSE average is 0.13 and the standard deviation is 0.12 as shown in Table 5. While, the RMSE average for Linear Regression, MLP Regressor, Multilayer Perceptron, SMOReg are 0.14, 0.18, 0.16, and 0.18 respectively. Moreover, in the weekly forecast, the results show that Random Forest is better, where the RMSE average is 0.17 and the standard deviation is 0.11. While, the RMSE average for Linear Regression, MLP Regressor, Multilayer Perceptron, SMOReg are 0.50, 0.26, 0.25, and 0.35 respectively, as illustrated in Table 5.

Table 4: Results of the Monthly RMSE

	Linear Regression	MLP Regressor	Multilayer Perceptron	SMOReg	Random Forest
Barka	0.10	0.18	0.12	0.13	0.12
	0.34	0.41	0.49	0.63	0.27
	0.12	0.28	0.20	0.21	0.13
	0.14	0.12	0.13	0.13	0.06
Muttrah	0.18	0.20	0.12	0.13	0.11
	0.27	0.33	0.27	0.31	0.11
	0.13	0.12	0.20	0.27	0.06
	0.45	0.33	0.35	0.37	0.52
Qurriyat	0.14	0.25	0.22	0.23	0.18
	0.27	0.35	0.31	0.27	0.23
	0.07	0.16	0.12	0.13	0.09
	0.02	0.21	0.09	0.11	0.03
Seeb	0.09	0.07	0.01	0.00	0.09
	0.17	0.23	0.19	0.19	0.18
	0.07	0.07	0.10	0.12	0.04
	0.09	0.11	0.06	0.08	0.06
Shinas	0.01	0.08	0.08	0.12	0.01
	0.05	0.05	0.04	0.04	0.05
	0.02	0.02	0.02	0.02	0.02
	0.09	0.04	0.06	0.06	0.13
Average	0.14	0.18	0.16	0.18	0.13
STDV	0.11	0.12	0.12	0.14	0.12

Table 5: Results of the Weekly RMSE

	Linear Regression	MLP Regressor	Multilayer Perceptron	SMOReg	Random Forest
Barka	0.41	0.22	0.24	0.27	0.18
	0.19	0.22	0.18	0.37	0.19
	2.54	0.10	0.33	0.17	0.14
	0.16	0.20	0.12	0.26	0.06
Muttrah	0.23	0.36	0.14	0.07	0.19
	1.69	0.47	0.33	1.12	0.17
	0.42	0.11	0.22	0.18	0.10
	0.10	0.31	0.39	0.24	0.34
Qurriyat	0.28	0.48	0.42	0.23	0.33
	0.33	0.19	0.29	0.27	0.42
	0.10	0.11	0.15	0.18	0.10
	0.43	0.30	0.45	0.60	0.33
Seeb	0.30	0.11	0.09	0.15	0.03
	0.37	0.35	0.24	0.26	0.23
	0.45	0.29	0.18	0.35	0.12
	0.92	0.45	0.40	1.00	0.10
Shinas	0.15	0.25	0.19	0.32	0.10
	0.05	0.13	0.17	0.20	0.08
	0.06	0.09	0.07	0.05	0.06
	0.74	0.43	0.43	0.64	0.11
Average	0.50	0.26	0.25	0.35	0.17
STDV	0.61	0.13	0.12	0.29	0.11

THE PROPOSED APPLICATION: FCLPOFM

FCLPOFM (Forecasting Current Least Prices in Oman Fish Markets) is an application that provides a least price for every fish species from a set that includes Yellowfin tuna, Seabream, Emperor, and Longfin trevally available on five markets Barka, Muttrah, Quriyat, Seeb, and Shinas. The well-performed algorithm 'Random Forest' has been chosen for developing an application. This application provides with two types of forecasting, which are monthly forecasting, and weekly forecasting, in order to get least price.

There are several interfaces in FCLPOFM application uses in the process of forecasting. The main interface gives general information about Oman fish markets and provided with a link in order to do a forecasting process according to the user needs, as shown in Figure 6. Furthermore, after the user click the link in the home interface, the forecasting page, forecasting fish prices using Random Forest algorithm. In this page, the user allowed to select the type of forecasting, which is monthly or weekly to predict the price as shown in Figure 7.

For the weekly and monthly forecasting with a list of fish species - Yellowfin tuna, Seabream, Emperor, and Longfin trevally, it allows to choose one of them and look for the least price among the markets. The derived results for weekly and monthly forecasting, and processed by CS file, as shown in Figures 8 and 9. It presents the least price among the markets - Barka, Muttrah, Quriyat, Seeb, and Shinas as indicated in the following figure. In addition, a graph which explains the growth of prices during the studied period and the predicted price, that allows the user to make a quick comparison.

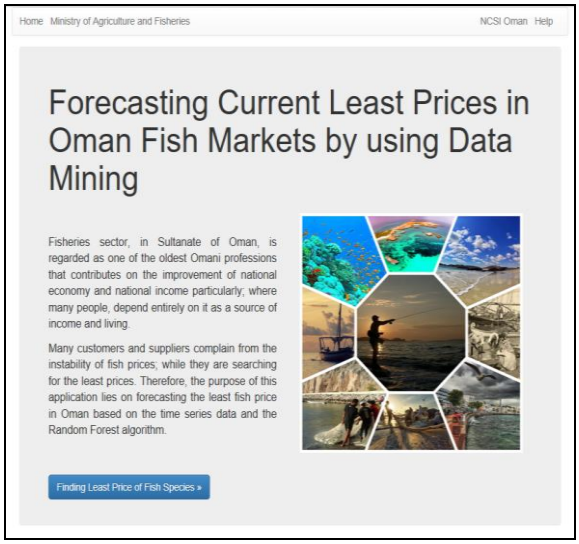

Figure 6: Main Interface

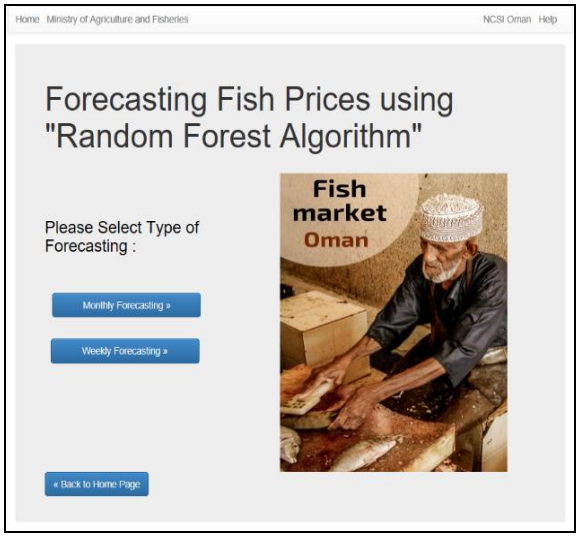

Figure 7: Types of forecasting

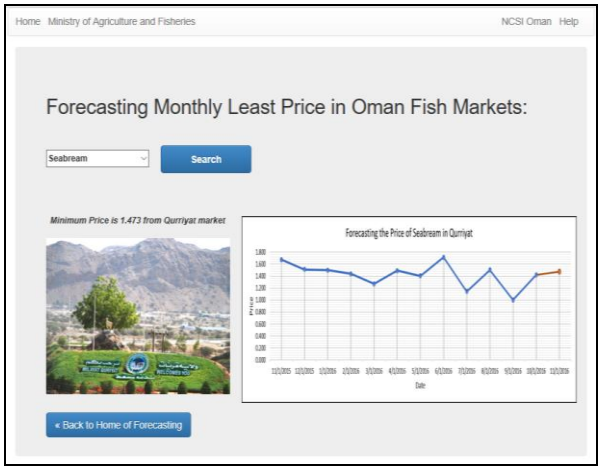

Figure 8: Weekly Results Interface

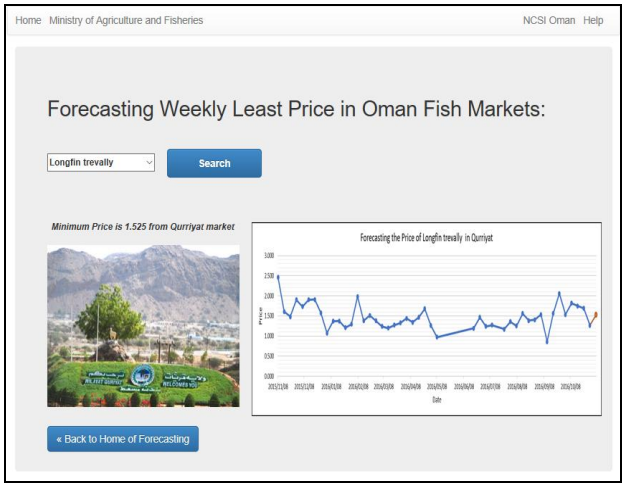

Figure 9: Monthly Results Interface

CONCLUSION

This research has been focused on the time-series forecasting for different fish species among different markets in Sultanate of Oman. There are a huge number of daily fish data which are collected in different ways to predict the least price for the benefit of customers and suppliers. The main contribution is to compare the forecast ability of different algorithms such as Linear Regression, SMOReg, Multilayer Perceptron, MLP Regressor, and Random Forest, via the data mining tool such as Weka. The outcome of this research reveals that Random Forest provides a good performance for the weekly and monthly predictions compared to other algorithms. Finally, the application has been developed based on the best performance compared to the other tested algorithms. In the future, we shall try to expand the period of collecting the data to be more than twelve months in order to expand the period to gain more optimal and efficient results. In addition, a dynamic database may be developed with an up-to-date data instead of a manually collected data.

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