A Regression Approach for Forecasting Vendor Revenue in Telecommunication Industries

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Abstract—In many telecommunication companies, Entrepreneur Development Unit (EDU) is responsible to manage a big group of vendors that hold contract with the company. This unit assesses the vendors' performance in terms of revenue and profitability on yearly basis and uses the information in arranging suitable development trainings. The main challenge faced by this unit, however, is to obtain the annual revenue data from the vendors due to time constraints. This paper presents a regression approach to predict the vendors' annual revenues based on their previous records so the assessment exercise could be expedited. Three regression methods were investigated; linear regression, sequential minimal optimization algorithm, and M5rules. The results were analysed and discussed.

Keyword- Linear Regression, Sequential Minimal Optimization Algorithm, M5rules

I. Introduction

In telecommunication industries, companies have to strategize in developing successful contractors because they represent the company's reputation. One common strategy is by monitoring the vendor's achievement based on their revenues and profitability. The company, in turn, will plan remedial actions for cases of non-performance or under-performance. Managing a big group of vendors is not without challenge. Reporting has always been the hindering block because it is a time-consuming manual affair. To expedite the planning process, a data mining approach is proposed to predict the revenues for current year based on the availability of revenue data from previous years. This will complement the tedious exercise of chasing figures from the vendors.

Among many data mining techniques such as the classification, rule mining, sequential pattern discovery, clustering, and anomaly detection, a prediction technique is most suitable for this very task. In the past, Kotsiantis [1] attempted to predict the students' placement from 354 Hellenic Open University (HOU) student records. The research applied three algorithms, which were Linear Regression, Sequential Minimal Optimization Algorithm and M5rules. From these algorithms, the research concluded that M5rules had the highest performance in predicting students' performance with the lowest mean absolute error. Following [1], this paper is also set to predict the vendors' revenue for the current year of 2014 using the same regression algorithms.

The remaining of this paper is organized as follows. Section II presents three regression methods that will be used in this research, which are Linear Regression, Sequential Minimal Optimization Algorithm (SMOReg) and M5rules. Section III presents the experimental setup, including the dataset. Section IV discusses the results and finally Section V concludes the research.

II. Regression Methods

Regression analysis is a data mining technique that is used to extract models for predicting numbers. It predicts a certain numerical outcome based on a set of given input. One common example is to predict house value based on location, number of rooms, lot size, and other factors. In this research, the revenue for current year is predicted based on revenues from previous years. Following [1], the regression algorithms under study include the Linear Regression, Sequential Minimal Optimization Algorithm, and M5rules.

A. Linear Regression

Linear regression is the simplest yet powerful algorithm for predicting values of a variable from the existing values of another variable. There are two lines of regression (X and Y). The formulae for this algorithm is represented by $Y = a + bX$ where a (coefficient) and b (constant value) are known as intercept and slope of the equation, respectively. They are used to predict the new value of variable Y when value of variable X is known as shown in Equation 1.

$$Y = a + bX_1 + bX_2 + bX_3 \tag{1}$$

where

$$b = \frac{N\sum XY - \sum X \sum Y}{N\sum X^2 - (\sum X)^2}$$

and

$$a = \frac{\sum Y - b\sum X}{N}$$

B. Sequential Minimal Optimization Algorithm for Regression (SMOReg)

Sequential Minimal Optimization Algorithm for Regression is an effective method for training support vector machines (SVMs) on classification tasks as well as regression problems. The formula for this algorithm is shown in Equation 2.

$$\sum_{i=1}^{m} \alpha_i \, y^{(i)} K\left(x^{(i)}, x\right) + b \qquad (2)$$

C. M5Rules

M5Rules algorithm produces propositional regression rules in IF-THEN rule format using routines for generating a decision list from M5Model trees [3]. The algorithm is able to deal with both continuous and nominal variables, and obtains a linear model of the data. The models created by M5 are multivariate linear models. M5Rules algorithm generates a decision list for regression problems using divide-and-conquer. This technique identifies a rule that covers instances in the class, separate them and continues with those that are left.

III. Experiments

This paper attempted to assess the best regression algorithm in predicting the vendors’ revenue for the year 2014. The result will help EDU to formulate a plan for the vendor development. All three regression algorithms; Linear Regression, Sequential Minimal Optimization Algorithm (SMOReg) and M5rules were executed using an open source software tool, which is the Waikato Environment for Knowledge Analysis (WEKA) [2].

A. Dataset

In this study, data were sourced from the vendor database in a telecommunication company that covers financial records from 2011 until 2013. A total of 527 instances of vendors’ records have been extracted from Vendor table. The original table consists of 13 attributes. Some of the unnecessary attribute have been removed during pre-processing stage. The final set of attributes is shown in Table I.

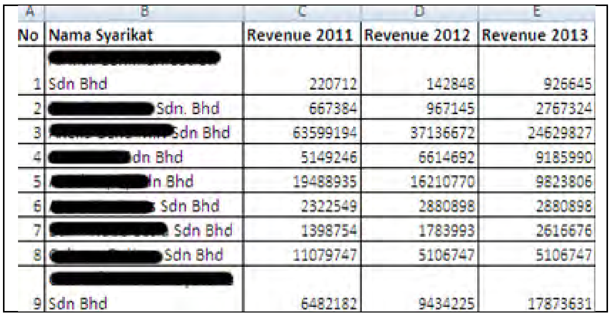
B. Data Pre-processing

Before pre-processing, the raw data were incomplete, inconsistent, and contain many errors. In this research, the first step executed was data cleaning, whereby data is cleansed by smoothing the noisy data, resolving the inconsistencies in the data, and filling in missing values. A number of attributes such as contact person, identification number, position, address, state and other unnecessary attributes were removed during data reduction step in pre-processing.

TABLE I
Dataset Attributes

No	Attribute Name	Description
1	companyname	Name of companies
2	rev2011	Revenue for year 2011
3	rev2012	Revenue for year 2012
4	rev2013	Revenue for year 2013

The final data after pre-processing is shown in Fig, 1. Note that the details for company name have been concealed.



A	B	C	D	E
No	Nama Syarikat	Revenue 2011	Revenue 2012	Revenue 2013
1	[redacted] Sdn Bhd	220712	142848	926645
2	[redacted] Sdn. Bhd	667384	967145	2767324
3	[redacted] Sdn Bhd	63599194	37136672	24629827
4	[redacted] dn Bhd	5149246	6614692	9185990
5	[redacted] n Bhd	19488935	16210770	9823806
6	[redacted] Sdn Bhd	2322549	2880898	2880898
7	[redacted] Sdn Bhd	1398754	1783993	2616676
8	[redacted] Sdn Bhd	11079747	5106747	5106747
9	[redacted] Sdn Bhd	6482182	9434225	17873631

Fig. 1. Actual dataset after pre-processing

C. *Comparison Criteria*

The comparison of results was made on the basis of the following criteria:

1) Correlation Coefficient (CC): This indicates the relationship between independent variables of power and direction. The value should be between -1 and +1. The positive value means a direct directional relation and the negative values means a reverse directional relation. If the *CC* value is zero it indicates that there isn't any relationship between variables. The formula is shown in Equation 3.

$$CC = \frac{S_{PA}}{\sqrt{S_P S_A}} \tag{3}$$

$$S_{PA} = \frac{\sum_i (p_i - \bar{p})(a_i - \bar{a})}{n-1}$$

$$S_P = \frac{\sum_i (p_i - \bar{p})^2}{n-1}$$

$$S_A = \frac{\sum_i (a_i - \bar{a})^2}{n-1}$$

2) *Mean Absolute Error* (*MAE*)*:* This is the average of the difference between predicted and actual value in all test cases [3]. The formula for calculating MAE is shown in Equation 4, assuming the actual output is *a* and the expected output is *c*.

$$\frac{|a_1 - c_1| + |a_{12} - c_2| + \cdots + |a_n - c_n|}{n} \tag{4}$$

3) *Root Mean Squared Error (RMSE):* This is used to measure the differences between values predicted by a model and the actual values [3]. It is just the square root of the mean square error as shown in Equation 5.

$$\sqrt{\frac{(a_1 - c_1)^2 + (a_2 - c_2)^2 + \cdots + (a_n - c_n)^2}{n}} \tag{5}$$

For numerical prediction, RMSE is one of the most commonly used measures. The result is produced by calculating the average of the squared differences between each computed value and its corresponding correct value. The RMSE is simply the square root of the mean squared error. It gives the error value the same dimensionality as the actual and predicted values. In the experiments, both MAE and RMSE were calculated for each regression algorithm. If MSE and RMSE values are close to zero, error rate becomes the minimum. However, for each case study, acceptable error rates of MSE or RMSE are different.

IV. RESULTS AND DISCUSSIONS

Data mining is a process to analyze data for further analysis or for predictive analytics [4]. The statistical analysis for Linear Regression, SMOReg, and M5Rules algorithms are presented in Table II. From the table, M5Rules has produced the smallest mean absolute error of 605315.07 with 1295415.90 root mean squared error and 21.18% relative absolute error. This is followed by the SMOReg algorithm with 824643.03 mean absolute error, 2005074.40 root mean squared error and 28.85% relative absolute error. Finally Linear Regression algorithm produced 1004060.34 mean absolute error, 1432905.33 root mean squared error and 35.13% relative absolute error. Graphical presentation of the results is illustrated in Fig. 2.

TABLE III
Comparison of Results

Analysis	Linear Regression	SMOReg	M5Rules
Correlation coefficient	0.9776	0.9818	0.9684
Mean absolute error	1004060.34	605315.07	824643.03
Root mean squared error	1432905.33	1295415.90	2005074.40
Relative absolute error	35.13%	21.18%	28.85%
Root relative squared error	21.04%	19.02%	29.44%

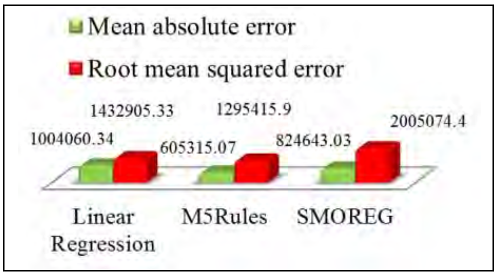
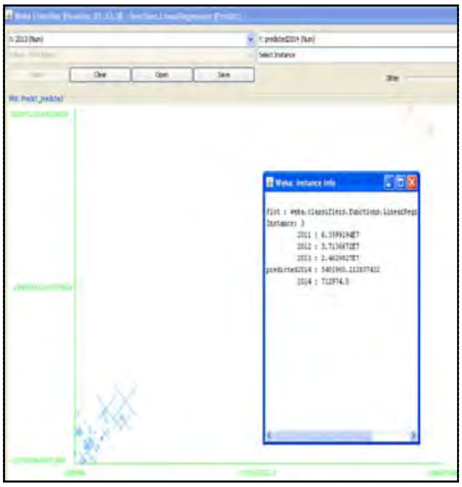


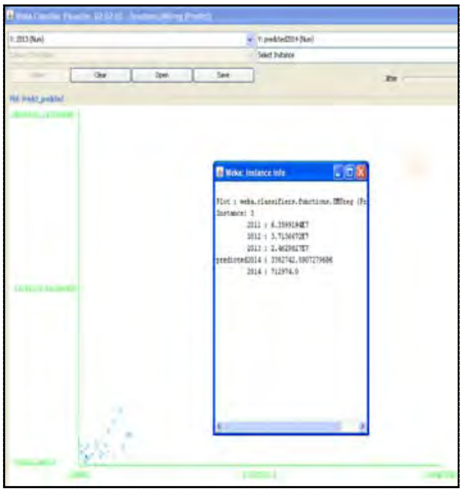
Fig. 2. Results comparison

The regression line resulted from the Linear Regression will always contain error because independent variables are never perfect predictors of the dependent variables. There are many uncontrollable factors that might affect the results. The visualization views for all three algorithms are presented in Fig. 3(a) – 3(c).



```
Plot : weka.classifiers.functions.LinearRegr
Instance: 3
         2011 : 6.3599194E7
         2012 : 3.7136672E7
         2013 : 2.4629827E7
predicted2014 : 5401960.212837432
         2014 : 712974.0
```

Fig. 3(a). Linear Regression



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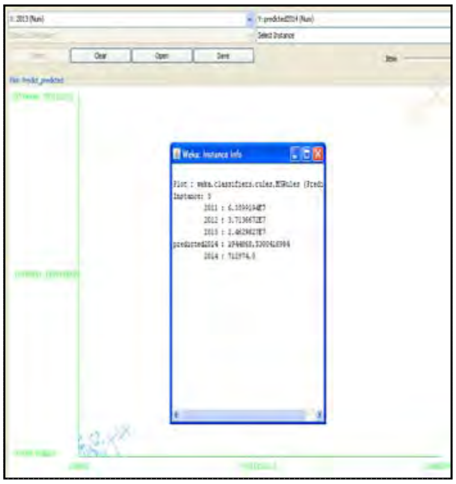
Plot : weka.classifiers.functions.SMOreg (Pr
Instance: 3
         2011 : 6.3599194E7
         2012 : 3.7136672E7
         2013 : 2.4629827E7
predicted2014 : 3362742.5907279686
         2014 : 712974.0
```

Fig. 3(b). SMOReg



```
Plot : weka.classifiers.rules.M5Rules (Predi
Instance: 3
         2011 : 6.3599194E7
         2012 : 3.7136672E7
         2013 : 2.4629827E7
predicted2014 : 1946958.5200416984
         2014 : 712974.0
```

Fig. 3(c). M5Rules

In addition, to prove that M5Rules is the most appropriate algorithm to use for predicting vendors' revenue for year 2014, the variances between the actual and predicted revenues are recorded in Table III. M5Rules is able to deal with both continuous and nominal variables, and obtains a linear model of the data [5]. From the result shown in the table, M5Rules produced the nearest value to the actual compared to Linear Regression and SMO. Hence, it is proven that M5Rules is the most appropriate algorithm for predicting the revenue 2014 compared to the other algorithms.

TABLE IIIII
Variance analysis between actual and predicted revenue

		Predicted Revenue 2013		
Revenue 2012	**Revenue 2013**	**Linear Regression**	**SMOReg**	**M5Rules**
2948078	2275477	3206347	3256752	2946437
	Differences	930870	981275	670960

V. Conclusion

This paper analyzed vendors' performance by using three different regression algorithms, which are Linear Regression, Sequential Minimal Optimization Algorithm (SMOReg), and M5rules. The results showed that the ability of data mining tasks in helping EDU to predict vendors' performance and to identify groups of non-performance and under-performance. This will in turn help to improve their performance in earlier stage.

From the results of the analysis, it is proven that M5rules is the most appropriate for predicting vendors' performance with the lowest mean absolute error and lowest relative absolute error. Further study that focuses on the criteria that affect vendors' performance can be done in future with more relevant and better data.

References

[1] S. B. Kotsiantis, "Use of Machine Learning Techniques for Educational Proposes: A Decision Support System for Forecasting Students' Grades," Artificial Intelligence Review, vol. 37, pp. 331–344, 2012.

[2] I. H. Witten, F. Eibe, and M. A. Hall, Practical Machine Learning Tools and Techniques, Burlington: USA, 2011.

[3] H. Duggal and O. Singh, "Comparative Study of the Performance of M5-Rules Algorithm with Different Algorithms", Journal of Software Engineering and Applications, vol. 5, pp. 270-276, 2012.

[4] E. Osmanbegovic and M. Suljic, "Data Mining Approach for Predicting Student Performance", Journal of Economics and Business, vol. 10, no. 1, 2012.

[5] S. Kotsiantis, A. Kostoulas, S. Lykoudis, A. Argiriou, and K. Menagias, "Using Data Mining Techniques for Estimating Minimum, Maximum and Average Daily Temperature Values", World Academy of Science, Engineering and Technology International Journal of Computer, Information, Systems and Control Engineering, vol. 1, no. 2, 2007.