

A Machine Learning Based Solution for Predicting Land Values

E-Valuer Land value predictor

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Abstract - Real Property are the most valuable possession of most of the common people. Getting the proper valuation for these real properties is very much important. This document analyses an innovative solution proposed to facilitate land valuation based on recent sales, prediction of future price and the effect of proposed development work on the land, so that real-estate customers and owners of real estate companies can be benefitted and make smarter property related decisions. This intelligent tool can help people to identify the land they are going to buy in terms of current value and future value. Machine learning, and optimization are the main research components of this system. The system utilizes LSTM model as well as KNN and MLR model in making predictions. LSTM model can make predictions with an accuracy of over 0.75 in current value prediction and also future value predictions with reasonable accuracy. This paper discusses about the research methodology we have used in identifying the most suitable algorithms which can serve our intended purpose.

Keywords- Valuation, AI- Artificial Intelligence, ML- Machine learning, ANN- Artificial Neural Network, LSTM- Long Short Term Memory, RNN- Recurrent Neural network, MLR- Multivariate Regression, ARIMA- Auto Regressive Integrated Moving Average, MAE- Mean Absolute Error, MSE- Mean Squared Error, RMSE- Root Mean Squared Error

I. INTRODUCTION

Real Property are the most valuable possession of most of the common people. In Sri Lankan culture, most of the people tend to think that owning a real estate is a better investment than having that money saved in a bank. Therefore, getting the proper valuation for these real properties is very much important.

Land valuation is the process of assessing the characteristics of a given piece of land based on experience and judgment.[1] The determination of a land parcel value depends on several physical and economic characteristics

which must be taken into consideration very carefully in a land valuation procedure.[1] These values can be affected by various social factors too. For example, if there is a crime happened in that land, it can cause a negative effect on the value.

Hence, real estate appraisal it is a challenging multidimensional problem that involves estimating many facets of a property, its neighborhood, and its city.[2]

Since, Sri Lanka is lacking a good data platform to gather all these data, considering all these factors can take ages to do proper valuation considering all these factors. The manual process is a time-consuming slow task which needs to be done by an experienced professional valuer. The valuation approaches used by those professionals are limited due to the lack of digital data in Sri Lanka. Also, it is a known fact that the valuation process can be so subjective to the person. Ideally, the systematic process of valuation consists of four different stages as physical and legal identification, identification of property rights to be valued, gathering and analysis of market data, applying convenient valuation approach. The major convenient valuation approaches are, Sales Comparison Approach, Income Approach, Cost Approach [3]. Analyzing the previous land sale details and trends in those fluctuations and considering those data to predict the valuation is called the sales comparison approach.[3]

The task of automatically estimate the market value of houses can be seen as a regression problem, where the price (or the price per square meter) is the dependent variable, while the independent one is the available information that could help to determine the price correctly. [2] When the neighborhood economical value is combined with effect of neighborhood

factors such as walkability etc. we believe it is possible to give a accurate, fair prediction of the value of the land.

The influence of technology on daily life of the Sri Lankans has increased immensely. People tend to use traffic data, online shopping more than ever.

Since the manual process is too slow and dependent to make a quick better decision of the worthiness of the land and suitability of it for the purpose of the customer, our attempt is to digitally assist the people in property related decision making by providing them accurate predictions of the values and future studies of the land. The main research problem is to develop an automated system to evaluate the land based on its neighborhood economical value and identify the possible effects of development work on the value of the land in the future. This requirement of a solution to predict the current value and future value came from an expertise. While reviewing the literature, by means of supervisor meetings, we identified another aspect as an improvement, which is to predict the effect of future development work on a particular land, since Sri Lanka is a developing country, although the rate of development may vary, infrastructure development projects are carried out frequently.

We can never underestimate the duty of a valuation officer as the estimations are affected by numerous factors of particular to the area. But these factors are subjected to perception of each other's experience, according to Vaz J.[4], the discretionary and the appraisers' subjectivity that characterize traditional real estate valuation are still allowed to take part in the formation of the asset price even when respecting international standards (EVS, IVS) or Appraisal Institution's regulations (TEGOVA, RICS, etc.). For example, an experienced valuer who is familiar with the area maybe biased towards the effect of regional factors, social factors, than the physical factors compared to a fairly new valuer who still sticks to the land valuation theories and follow the proven procedure. Therefore, manual valuation can be considered as a more sensitive approach.

Our intention is to provide people with fair accurate prediction of the land they are going to buy, so that they can decide the investment is fruitful for them. We believe this is an area improvement is needed because we can assist people in making decisions related to property, which would be the largest investment most probably in many people's lives.

During the AI Asia Summit 2018, the summit panelists Dr. Yasantha Rajakarunanayake, Dr Rukshan Baduwita , Dr. James Shanahan and Dr. Chrisantha Fernando agreed that Sri Lanka is behind in terms of AI startups[5], despite the fact software industry is vastly growing area. According to the survey conducted under research done by Karunanda et al[6], carried out in 2014, this is due to the lack of popularity, knowledge, experts, requirements and sponsorship for the AI related software projects[6].

But when analyzing local news, we can see that AI based applications has become a trend. For Example, Dialog has its own AI powered voice service to support its product service framework.

There are researches that have been conducted to predict the Stock prices of Sri Lanka with the usage of Artificial Intelligence and Machine Learning approaches, tilted A

recurrent neural network approach in predicting daily stock prices an application to the Sri Lankan stock market[7], and Comparison of Support Vector Regression and Artificial Neural Network Models to Forecast daily Colombo Stock Exchange[8]. According Li et al, [1]to the real estate valuation researches evaluating the use of GIS technology have been conducted. But there is no information regarding application of AI technology in real estate value prediction in Sri Lankan context.

The use of AI for residential value forecasting has been suggested in the literature from 1990s. [9]. Although Sri Lanka is lacking an automated land valuation system, many up and running, reliable solutions have been implemented in developed countries like New Zealand, England and Wales, USA etc. It is obvious with the well-structured digital data infrastructure of those countries, they can implement very accurate systems.

Zillow is an online real estate database company that was founded in 2006, and was created by Rich Barton and Lloyd Frink, former Microsoft executives and founders of Microsoft spin-off Expedia. [10] Zillow.com supports United States of America (USA) and Canadian property listing. Zestimate determines an estimation for 12 months for a house based on neighbourhood comparable houses. Accuracy of zestimate depends on the amount of data used as the underlying approach is Hedonic regression analysis based proprietary algorithm [11] which analyses of several features of the house. The forecasted value is interpolated using cubic spline to connect to current value. [11]

Trulia is also a product offered in USA, which offers a range of services for real estate sector. The price estimates are based on publicly available information the home's physical characteristics (e.g. location, number of bedrooms, etc.), Property tax information, Recent sales of similar nearby homes.

It involves more community interaction, for example, Trulia Neighbourhoods provide photographs, drone footage, etc. so that who are interested about the neighbourhood can refer. Trulia provides price using public data which shows the price fluctuation of a house, comparative to the other homes with same ZIP code.

Quotable Value (QV) provides independent and authoritative information on any home in New Zealand on or off the market [12] QV.co.nz and their mobile App QV homeguide is known to be providing more accurate values of real estate property and key details to assist people to make instant decisions regarding property. QV with CoreLogic, a company which analyzes information assets and data to provide clients with analytics and customized data services provide a range of reports valuable to the user.

Creating a methodology that would bring more sophisticated information, greater accuracy and analytical rigor to the United Kingdom (UK) residential property market is the motivation behind HousePrice.ai. Their proprietary model provides a combination of multi-disciplinary experiences of AI and Big Data to provide most accurate estimations. HousePrice.ai has Horizon app, which calculates capital, rental and gross development values for a single property or an entire portfolio. [13] it produces accurate

property valuations both in the present time and can offer future predictions. Valuations are based on objective measurable values, creating a fact-based result as opposed to a subjective one [14]. This tool allows the user to adjust, add and remove factors within the surrounding areas to determine how external changes will affect property prices.

Our intention is to identify the ways to use their underlying methodology in a suitable manner in Sri Lankan context.

II. METHODOLOGY

A. Data Collection

The study focuses on Colombo which experienced relatively high infrastructure development.

Primary data have been collected through questionnaires, interviews and personal visits to land area to know the present situation of the market and the secondary data are collected mainly through various survey department, land estate agents, newspaper advertisements, and land sale website contents. The data are useful for assessing the performance of property as a key to predict land price.

The cross-sectional data collected for current price prediction to be used with non time-series algorithm were collected through a questionnaire where residents in Colombo district responded and by means of including publicly available data in newspaper and website advertisements. The questionnaire mainly asked for price of the land, location of the land, nearest bus route, and distance to the nearest bus route, along with the buying price and details of valuation history with above 200 samples. The time series data collected to predict the current value from a land sale company which had monthly land values from the same area over a period of 10 years, containing above 200 samples.

Dataset used for future value prediction has Land price in places in Colombo district from 20012 to 2018 which the algorithm is going to predict the future price for 10 years with features state, city, zip code, price, pollution index, hospital distance, tourist score, bank/ATM, distance to school, distance to town, population index, bid date having above 500 samples. Each places has 8 or more than 8 samples.

B. Design

When a customer goes to a land he is willing to buy, they can input the current location through the application. Based on that location, the suitable recent sales data are selected. Then those data will be analyzed by the AI model to predict the current value. That predicted value is optimized to produce the most accurate current value. Then the future value will be predicted by collaboration of two units, one which considers the fluctuation rates of past pricing values and weather effects, while the other calculates the effect of proposed development projects in the area. All these units generate a report which depicts these two types of data with relevant other data in a simpler way anyone can understand. The application of machine learning, and deep learning algorithms have been tested in each of the components with suitable data.

C. Prediction Models

In the prediction system there mainly two components, namely, current value prediction and future value prediction. Each of the components were tested with several algorithms to provide a most accurate prediction to the user. For that, first of all, we need to train the algorithm using suitable dataset containing the factors and actual market value changes information. Using the past information selected models are trained.

1) Multivariate Linear Regression

MLR is an algorithm used in both the components of current value prediction and future value prediction. Simply, it is assuming that there is linear relationship between price predictions and other contributing factors.

$$y = b_0 + b_1 * x_1 + b_2 * x_2 + \dots + b_n * x_n$$

Figure 1. Multivariate linear model

MLR has several advantages than other algorithms. The ability to determine the relative influence of one or more predictor variables to the criterion value. multivariate techniques provide a powerful test of significance compared to univariate techniques.[15] multivariate techniques to give meaningful results, they need a large sample of data; otherwise, the results are meaningless due to high standard errors. [15] Standard errors determine how confident you can be in the results, and you can be more confident in the results from a large sample than a small one.

MLR model implementation finds the best fitting line using model coefficients. Process of optimizing the model is to minimize the error of the predicted value.

The MLR algorithm used for current value prediction component analyzed the factors location, distance to the main bus route, accessibility index, size of the land during testing.

MLR used for future value prediction unit analyzed relationship between land price and latest other factors such as state, city, zip code, price, pollution index, hospital distance, tourist score, bank/ATM, school distance, distance to town, population index and weather conditions.

2) Random forest regressor

Random forest regressor operates by constructing a multitude of decision trees to fit the observations into groups based on their attribute values and outputs the mean prediction of the individual trees. As the name suggests, "decision tree" model builds a reversed tree-like structure, where the "root" is at the top, followed by multiple branches, nodes and leaves. The end of each branch is a decision leaf, which is the model's predicted value, given the values of the attributes represented by the path from the root node to the said decision leaf.

This model was tested for current value prediction component with the same features tested with MLR model.

3) Artificial Neural Networks

ANN design concept is based on human brain. The purpose of ANN is to imitate human learning process. This model consists of mainly three types of layers namely, input layer, hidden layer and output layer, each layer having artificial neurons contribute in adjusting weights for the input features and attempt making conclusions just like the human brain is doing.

The ANN was also trained for the current value prediction with same dataset used for MLR. Through a trivial trial and error process suitable model was identified and compared with the others.

4) LSTM – Recurrent Neural Network

Considering the fact that time has a direct influence on land prices time-series algorithms were also tested for selecting best prediction model for current price. What makes LSTM different from typical neural network is that it has feedback connections.

To test this model , timeseries dataset having monthly land values from the area over a period of 10 years was used. The dataset was having lags of unknown duration hence out of available RNN types, LSTM was the best option.

5) ARIMA model

ARIMA standing for Auto Regressive Integrated Moving Average is the most popular and commonly used statistical method for time series prediction. This model was utilized in both current value prediction and future value prediction units.

Procedure to follow with this model is split the training dataset into train and test sets, use the train set to fit the model, and generate a prediction for each element on the test set. A rolling forecast is required given the dependence on observations in prior time steps for differencing and the AR model. A crude way to perform this rolling forecast is to re-create the ARIMA model after each new observation is received

6) KNN algorithm

KNN can be used for both classification and regression problems. The algorithm uses ‘feature similarity’ to predict values of any new data points.

This model was used to predict future values with categorized data being used as training sets and test sets (40% allocate for test data). First, initialize the model. After that fit the train data to store RMSE values for different k values, fit the model. Then make the prediction on test data set and calculate the RMSE value and store the RMSE value.[16]

III. RESULTS AND DISCUSSION

The results obtained by testing the above models in the two different domains of current value prediction and future value prediction is discussed here.

A. Current Value Prediction

This was carried out as two phases testing time-series algorithms and vice versa. As mentioned above in II, machine learning models LSTM and ARIMA were tested with time series data while MLR, Random forest regressor, and ANN was tested with cross sectional data. These models were evaluated in terms of mean absolute error (MAE), mean standard error(MSE) and root mean squared error (RMSE).

Test results for these models can be summarized as follows.

	MAE	MSE	RMSE
MLR	12578.2076	37057375442	192502.923
Random Forest Regressor	69388.61903	17241415729	131306.572
ANN	495306.848	351944183254.44	593248.838
LSTM	12150.774	1834424960	42830.187
ARIMA	26549.4523	9730956580	98645.6111

Table 1. Test results for current value prediction algorithms

According to above results, time series algorithms predicted values with comparatively less error than the others. Finally, it can be concluded that LSTM model has outperformed all the other machine learning models in price prediction.

Surprisingly ARIMA model displayed lower performance in this case than the LSTM model.

The below figure depicts how loss metric for the keras model was reduced with the time. The error has become less than 0.01 according to this.

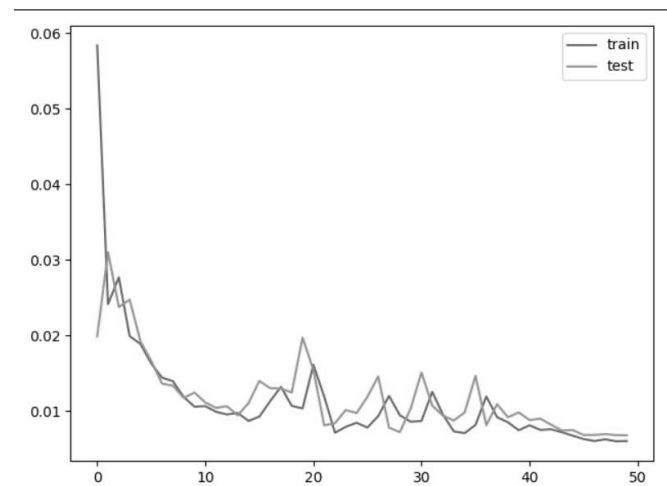


Figure 2. LSTM loss function

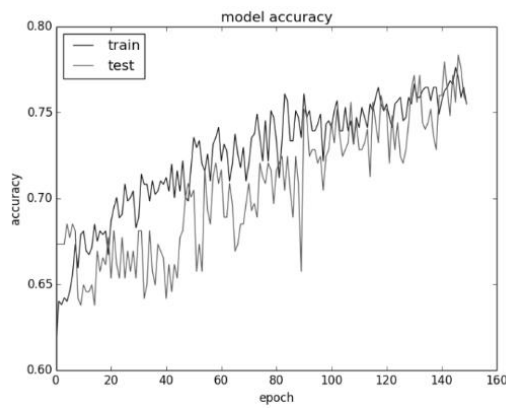


Figure 3. LSTM accuracy function

Based on the above functions we can conclude that the LSTM model predicts the current value with approximately an accuracy over 0.75.

B. Future value Prediction

Future value prediction was carried out based on two approaches. Then the specific values for each sector are coming as the output. Then the output will be compared with other machine learning algorithms. Extracted structured data are gained by the fellow members and then the data are fed into the algorithm. After that a comparison runs between these data and price with aid of the algorithm. Hereafter, the output which comes from this algorithm and other algorithm is compared. Finally, the decision is made which the most trustworthy prediction is.

First approach was based on features of the land and historical data of price fluctuation rates. There has been used a combination KNN and MLR versus ARIMA model. Results can be concluded as follows. These two models when evaluated, displays MSE value for multivariant linear regression is 590293123907492.1, MSE value for ARIMA model is 605023251112851.9. Therefore, MLR and KNN combination can be seen as a more accurate option for future price prediction.

Below Figure 4 shows the results obtained by ARIMA model.

ARIMA Model Results						
Dep. Variable:	D.y	No. Observations:	998			
Model:	ARIMA(5, 1, 0)	Log Likelihood	-18426.140			
Method:	css-mle	S.D. of innovations	25231482.665			
Date:	Sun, 04 Aug 2019	AIC	36866.279			
Time:	11:00:00	BIC	36900.619			
Sample:	1	HQIC	36879.332			
	coef	std err	z	P> z	[0.025	0.975]
const	-2253.6727	2.27e+05	-0.010	0.992	-4.47e+05	4.43e+05
ar.L1.D.y	-0.8700	0.031	-27.770	0.000	-0.931	-0.809
ar.L2.D.y	-0.7050	0.041	-17.356	0.000	-0.785	-0.625
ar.L3.D.y	-0.5085	0.043	-11.691	0.000	-0.594	-0.423
ar.L4.D.y	-0.3001	0.041	-7.372	0.000	-0.380	-0.220
ar.L5.D.y	-0.1418	0.031	-4.519	0.000	-0.203	-0.080
Roots						
	Real	Imaginary	Modulus	Frequency		
AR.1	0.5117	-1.3305j	1.4255	-0.1916		
AR.2	0.5117	+1.3305j	1.4255	0.1916		
AR.3	-1.5044	-0.0000j	1.5044	-0.5000		
AR.4	-0.8177	-1.2800j	1.5189	-0.3405		
AR.5	-0.8177	+1.2800j	1.5189	0.3405		

Figure 4. ARIMA model results

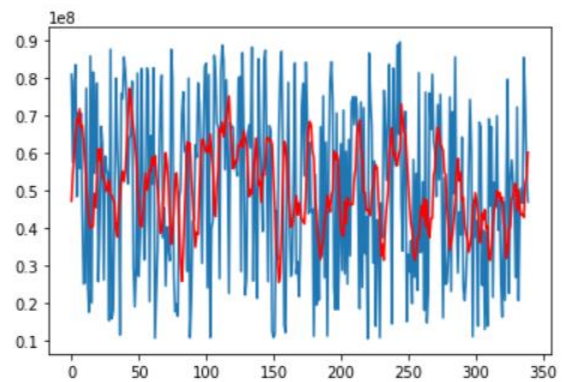


Figure 5. ARIMA model forecasts

Below is the variation of RMSE with K value as concluded by the KNN model used for price prediction.

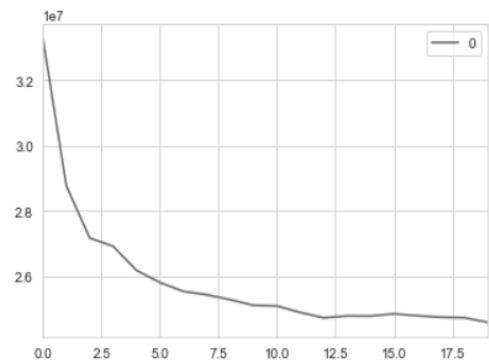


Figure 6. RMSE versus K values

Second approach of predicting future values is based on infrastructural facilities. The prediction is made with relative to the future development projects in the area. This includes the infrastructure facilities such as school, hospitals, highway, and apartment. The commercial value of a land in future is calculated based on the percentage ratio. Each of these infrastructure facilities are given a specific percentage value based on studies made on the effect on land value with emerging facilities. The dataset collection plays a major role here which involves the percentage calculation. The machine learning field is to be used in order to predict the land value. In order to achieve these objectives, the machine is trained and tested with the dataset to predict the future commercial value of the land with effect of different infrastructural additions. For example, being the current land price Rs.2000, assuming after five years to have school, a hospital so land value percentage increased by school is 20% and by hospital 40%, hence future land value will be $2000 + 20\% + 40\%$ kind of prediction is done. In the prediction system there mainly use one algorithm to predict the data that is MLR the purpose of the using two algorithms is to provide a most accreted point. In doing that thing, first of all, need to train the algorithm using future infrastructure dataset using the past information collected.

Here, Score Model segment that attempts to anticipate the test information. The train model gives a prescient calculation that a score model employments. The Score Labels segment characterizes the expectation of Sales Amount.

For the straight relapse, we will take a gander at "Coefficient of Determination". This worth educates us about the exactness regarding the model and can change somewhere in the range of 0 and 1. In the event that the worth is close 0.8 or 1, the straight relapse model is dependable.

Score Bin	Positive Examples	Negative Examples	Fraction Above Threshold	Accuracy	F1 Score	Precision	Recall	Negative Precision	Negative Recall	Cumulative AUC
(0.900,1.000]	76767	11	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.719
(0.800,0.900]	0	0	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.719
(0.700,0.800]	0	0	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.719
(0.600,0.700]	0	0	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.719
(0.500,0.600]	0	0	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.719
(0.400,0.500]	0	0	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.719
(0.300,0.400]	0	0	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.719
(0.200,0.300]	0	0	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.719
(0.100,0.200]	0	0	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.719
(0.000,0.100]	0	0	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.719

Figure 7. Prediction and prediction probability calculation.

Experiment created on 6/25/2019 ▶ Evaluate Model ▶ Evaluation results	
Metrics	
Mean Absolute Error	3156.034607
Root Mean Squared Error	3842.607571
Relative Absolute Error	1.075045
Relative Squared Error	1.279317
Coefficient of Determination	-0.279317

Figure 8. MAE,MSE for the given model

When we run our model, we will see a coefficient of assurance about 0.9. It implies that our model is practically more accurate.

IV. CONCLUSION

Based on the observations above, we can conclude that LSTM model has the least error among the other tested models and it can achieve an accuracy of around 0.75 in predicting current value. But there can be tradeoffs, depending on the dataset being used and its sample size. In predicting future values, the combination of KNN and MLR was identified to be outperforming the ARIMA model with lower MSE value. Again, same as in LSTM, tradeoffs are possible.

Hence further work on these models are recommended with different features considered based on different valuation models and with greater sample size.

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