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Neural Network Based Model for Predicting Housing Market Performance

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Abstract: The United States real estate market is currently facing its worst hit in two decades due to the slowdown of housing sales. The most affected by this decline are real estate investors and home developers who are currently struggling to break-even financially on their investments. For these investors, it is of utmost importance to evaluate the current status of the market and predict its performance over the short-term in order to make appropriate financial decisions. This paper presents the development of artificial neural network based models to support real estate investors and home developers in this critical task. The paper describes the decision variables, design methodology, and the implementation of these models. The models utilize historical market performance data sets to train the artificial neural networks in order to predict unforeseen future performances. An application example is analyzed to demonstrate the model capabilities in analyzing and predicting the market performance. The model testing and validation showed that the error in prediction is in the range between –2% and +2%.

Key words: artificial intelligence; decision making; housing; neural networks

Introduction

The US housing market is currently facing difficult times due to a number of problems, including past inappropriate crediting practices by lenders and fears of recession. The condition of the market in 2007 is significantly worse than that of 2006[1]. The fourth quarter results of 2007 showed a declining trend in most of the housing market indicators, including the numbers of new building permits, construction starts, construction completions, and housing sales. This slowdown in the housing market continues to act as a drag on the (GDP) in the fourth quarter of 2007[1]. The most affected sectors by the declines in the housing market are real estate investors and home developers who are currently struggling to break-even financially on their investments. It is of utmost importance to these investors to be able to evaluate the current market situation and predict its future performance in order to implement corrective actions and make appropriate financial decisions when necessary. In this paper, artificial neural networks (ANNs) are examined as decision support tools that could help investors predict the performance of the housing market in the short-term. The main hypothesis herein is that the available input variables would be sufficient to predict the performance of the housing market, represented as the ratio between the average sale price and the average asking price, three months in advance.

ANNs are mathematical network-based algorithms that are designed to mimic the neural system behavior of human beings in making decisions based on generalization ability. ANNs are trained to recognize the outputs of a system given its inputs. ANNs have been

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used extensively as robust tools for estimation and prediction in several research fields including real estate valuation. For example, Quang Do and Grudnitski used an ANN to examine the effect of age on a house's value[2]. The study showed that a house's value declines significantly with its age during the first sixteen to twenty years as a result of physical deterioration. Shaaf and Erfani used an ANN to explore the impact of air pollutants and air pollution controls on the median price of houses in Jacksonville, Florida[3]. The findings of the study showed that property owners and buyers take air pollution and pollution controls into account when buying a house.

Kershaw and Rossini used a series of housing data sets to develop constant quality house price indices using neural networks and econometric techniques[4]. Their analysis indicated that neural networks could be a real alternative to econometric methods. Nguyen and Cripps compared the predictive performance of ANNs and multiple regression analysis (MRA) for single family housing sales[5]. They concluded that the ANN outperformed the MRA when a moderate to large data sample size is used. Despite the contribution of these models, there is little or no evidence that there are any models that could predict the change in the value of real estate with time. As such, there is a need for practical and automated models that would help achieve this important goal.

The main objective of this paper is to present the development of ANN models that would help real estate investors and home developers predict the change in house prices in the short-term. To this end, the present model is designed to provide a number of unique and practical capabilities, including: (1) utilizing artificial neural networks in order to build generalized knowledge about the past and current performance of housing industry; and (2) predicting the ratio between house averages sale and asking prices. The following sections present the decision variables considered, design methodology, outputs, and an application example to illustrate how the model works.

1 Decision Variables

The main variables considered in the design of the ANN models in this study are: the time (Mn, Yr), the average interest rate (i), percentage change in sales volume compared to previous year (SlCh), percentage change in median house price compared to previous year (MdCh), average days a house spends on the market (D), the volume of inventory (Inv), and the inventory months supply (InvT). These variables are considered the main indicators of the possible change of a house's price in the near future and are represented by eight input neurons in the ANN structure. The output of the ANN is designed to be the ratio between a house's selling and asking prices (PrDf).

Figure 1 illustrates the structure of a typical ANN using this problem formulation.

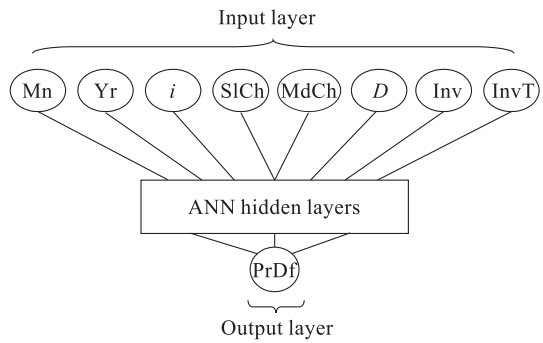

Fig. 1 Artificial neural network model formulation

2 Model Design

The ANN models are designed as feed-forward back-propagation multilayer perception networks using NeuroSolutions[6]. The main reason for selecting this design formulation is that this type of neural networks is believed to be very robust in approximating almost any input/output[6]. Several network structures are trained, cross-validated and tested by varying the number of hidden layers, the number of neurons in each hidden layer, the transfer function, the learning method, the cross-validation sample size, and the testing sample size.

3 Application Example and Results

The developed models were trained and tested using data that was obtained from the Orland Regional Realtor Association[7]. These data spanned the last 9 years and included the monthly sales, the average monthly interest rate, the average median house price, the average list price, and the average sales price, the average number of days a house spends on market, the current inventory, and the inventory months supply. The data was arranged in columns and stored in an ASCI input

text file to be accessed by the ANN software. The first eight columns represent the input decision variables and the ninth column represents the desired output (three-month ahead forecast).

Several network structures were tested to select the best structure of the ANN that would facilitate obtaining good forecasts with minimum training. Figures 2, 3, 4, 5, and 6 illustrate the results obtained from the best 5 examined network structures. These structures are: a network with 1 hidden layer of 3 neurons (Fig. 2); a network with 1 hidden layer of 4 neurons (Fig. 3); a network with 1 hidden layer of 5 neurons (Fig. 4); a network with 2 hidden layers of 6 and 4 neurons (Fig. 5); and a network with 2 hidden layers of 6 and 4 neurons (Fig. 6). The best results were obtained from the network with 1 hidden layer of 4 neurons using sigmoid transfer function, momentum learning rule, step size of 1.0, and momentum of 0.7.

After training and learning, the model was tested on unforeseen cases. The error in estimating the output for testing data fell in the range between –2% and +2%.

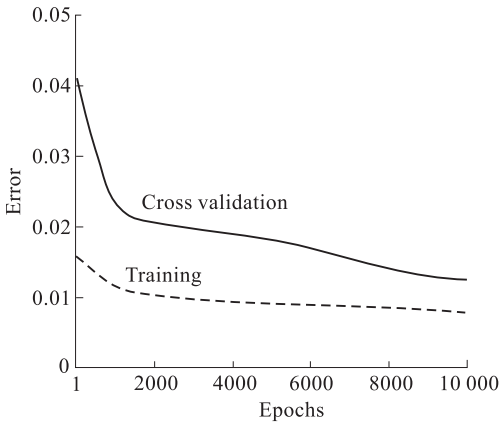

Fig. 2 Model 1 (1 hidden layer, 3 neurons) training and cross validation error

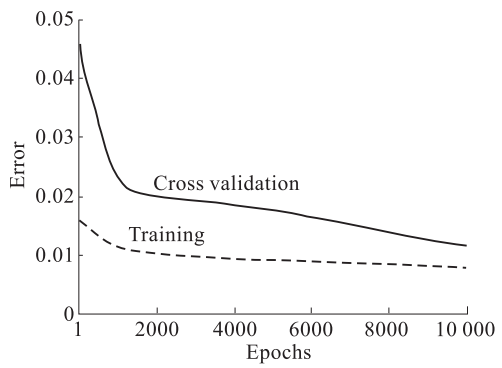

Fig. 3 Model 2 (1 hidden layer, 4 neurons) training and cross validation error

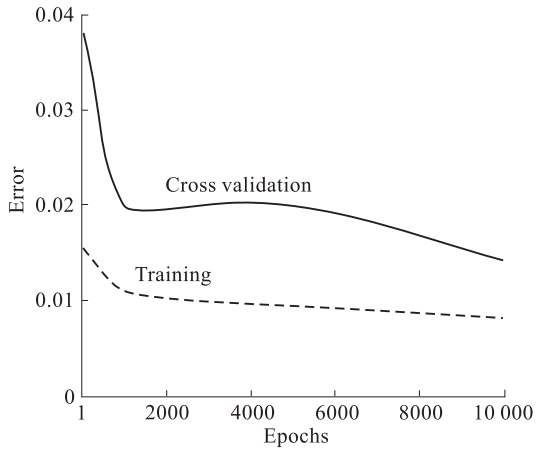

Fig. 4 Model 3 (1 hidden layer, 5 neurons) training and cross validation error

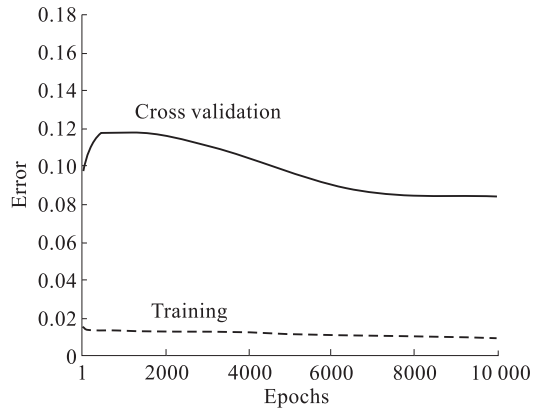

Fig. 5 Model 4 (2 hidden layer, 6-4 neurons) training and cross validation error

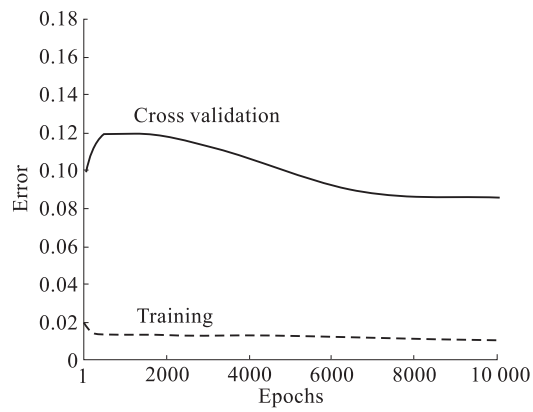

Fig. 6 Model 5 (2 hidden layer, 5-3 neurons) training and cross validation error

Based on the forecasted ratio between the asking and selling prices, the investor would have the necessary information to make the decision to sell a house or to wait. If the forecasted ratio is very low, this signifies an expected near drop in the average house selling

price over the short-term. In this case, the investor may reduce the asking price slightly to sell a house quickly in order to avoid an expected future big drop.

The main limitation of the developed model is that it is not expected to forecast the behavior of the housing market on the long-term. The future work will include training the ANN models to forecast the performance for periods of 6 and 12 months. However, this will entail utilizing larger sets of data spanning several decades in order to capture the cycles of housing market behavior.

4 Conclusions

This paper presented the development of an artificial neural network-based model that is designed to support real estate investors and home developers in predicting the behavior of the housing market on the short-term. The model utilizes artificial neural networks which are trained using historical market performance data sets in order to predict unforeseen future performance. An application example is analyzed to illustrate the use of the model and demonstrate its capabilities of effectively analyzing and predicting the housing market performance. The model testing and validation showed that the error in prediction is in the range between –2% and +2%.

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