Application of Fuzzy Neural Network for Real Estate Prediction

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Abstract. A FNN prediction model based on hedonic price theory to estimate the appropriate price level for a new real estate is proposed. The model includes a database storing hedonic characteristics and coefficients affecting the real estate price level from recently sold projects that are representative in the local environment. The experimental result shows that the fuzzy neural network prediction model has strong function approximation ability and is suitable for real estate price prediction depending on the quality of the available data.

1 Introduction

The profession of real estate valuers arises because each real estate asset is different from all other real estates. Real estate assets are heterogeneous, that is, their characteristics vary. Recently, hedonic pricing models have also been used to complete the sales comparison approach. This grounds real estate prediction more firmly in modern economics and finance theory and artificial intelligence methods [1]. Fuzzy Neural Network (FNN) is a connecting link between fuzzy logic and neural computing. They are generally applied in electrical engineering and automatic control area to simulate the problem solving process of human brain and assist people in making decisions under complex situations [2]. So fuzzy neural network prediction model based on hedonic price theory was highly appropriate to the tasks of real estate prediction and decision-making. Moreover, adaptive neuro-fuzzy inference systems (ANFIS) provided the means by which the judgments could be formalized without application of an artificial process to make the judgments precise [3]. The main objectives of this paper are to develop a fuzzy neural network price prediction model, which can learn from historical data on the correlations between various factors that influence the prices of real estates and the actual selling prices, so that the model can be used to estimate the appropriate price level for a real estate. This chapter attempts to present fuzzy neural network concepts and issues that are associated with application to prediction of market prices of real estate. The paper is organized as follows. In Section 2, the survey of fuzzy neural network is discussed. Hedonic Price Model is proposed in Section 3. In Section 5, the model of predicting market prices of real estate, it includes data collection and analysis, model construction, conceptual model and error analysis. Section 6 concludes the paper.

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2 Fuzzy Neural Networks

Fuzzy neural network is a concept that integrates some features of the fuzzy logic and the Artificial Neural Networks (ANN) theory. It based on the integration of two complementary theories. Purpose of the integration is to compensate weaknesses of one theory with advantages of the other [4]. Fuzzy logic and neural networks are complementary technologies. ANN extracts information from systems to be learned or controlled, while fuzzy logic techniques most often use verbal and linguistic information from experts. A promising approach to obtain the benefits of both fuzzy systems and ANN and solve their respective problems is to combine them into an integrated system. FNN techniques have several features that make them well suited to a wide range of knowledge engineering applications. These strengths include fast and accurate learning, good generalization capabilities, excellent explanation facilities in the form of semantically meaningful fuzzy rules, and the ability to accommodate both data and existing expert knowledge about the problem under consideration.

3 Hedonic Price Model

Real estate assets are heterogeneous, that is, their characteristics vary. Researchers and practitioners have found that hundreds of factors might affect prices in various situations. Interaction effects and non-linear relationships between prices and hedonic variables complicate the issues. So people interested in prices of particular real estate assets consult valuers who collect and interpret recent sales evidence in order to arrive at a price estimate based on interpretation of differences between real estates [5].

The hedonic price models where price as a function of hedonic characteristics is estimated by multivariate regression represent the insight that people buy a bundle of characteristics of real estates, not a simple, one-dimensional source of utility. Many factors influence the prices people pay for real estate. These models are written as:

Price=coefficients*characteristics +differences.

The coefficients are weights, dollars per unit of characteristic. The characteristics are features of the real estate that have an effect on utility to buyers. Differences mean the price implications, positive or negative, of the differences in hedonic characteristics between the real estates [6]. Usually a large but not very homogeneous sample of sales prices is used to estimate best fitting coefficients in a hedonic price model. The equation is $Ps=\sum b_i X_i$ where X_i are real estate characteristics like size, age, etc. And b_i are coefficients or weights. Normally these coefficients would differ because price is not a linear function of most real estate characteristics.

4 The Application of Fuzzy Neural Network Prediction Model

4.1 Data Collection and Analysis

The main objective of this section is to find out any correlation between various factors and real estate prices for given project characteristics in the local environment. A database storing hedonic characteristics and coefficients was established from recently sold projects that are representative in the local environment, and A knowledge base in the form of fuzzy rules, neural networks, or regression models that relate factors affecting real estate prices to recommended pricing structures was constructed. The methodology was based on a questionnaire survey to establish the correlations among the variables, supplemented by case study of selected projects using interviews. The following explains types of data needed for the proposed research.

The data to be collected consists of a sample of recently completed building projects of various categories. Hedonic characteristics and coefficients of each case project are grouped into four areas of five factors: Location, Design and appeal, Quality of construction, Above-grade room count/gross living area, and surrounding conditions. The definitions of the above variables and the exact form and manner in which the data items are solicited, e.g. quantitative or qualitative, range and levels, direct or deduced, will be tailored in the design of the questionnaire. Follow-up interviews are used to supplement and clarify information.

4.2 Model Construction

For FNN prediction model, the structure adapted consists of four layers. The function of each layer is discussed below. Layer 1 reads real number input variables xi (i=1, 2, … 5). In the FNN prediction model of this study, layer l reads the evaluated value of each identified influencing factor for markup estimation. Layer 2 fuzzifies the input variables according to the membership functions. Every input value x_i x_i has 2 membership degree $\mu_{A_i^j}(x_i)$ (j=1, 2), which represent the characteristic of the influencing factor. Gaussian functions [7] is applied for all the membership functions, where

$$\mu_{A_i^j} = \exp\left(-\left(\frac{x_i^j - a_i^j}{\sqrt{2}b_i^j}\right)^2\right) \tag{1}$$

$\mu_{A_i^j}$ is the membership degree of x_i, a_i^j is the parameter determining the center value, b_i^j is the parameter determining the width of the membership function. The reason for using Gaussian membership function is because of the good characteristics of this function. The following calculation and training process adapted the Gaussian membership function, the denominator of the training functions will not be zero and fewer parameters need to be adjusted. Layer 3 calculates μ_k (k =1,2…32), the active degree of the *k*th rule according to the relevant fuzzy inference rules collected for markup estimation.

$$\mu_k = \mu_{A_1^j}(x_1)\mu_{A_2^j}(x_2)....\mu_{A_n^j}(x_5) \tag{2}$$

Where μ_k is the active degree of the *k*th rule and $\mu_{A_1^j}(x_i)$ is the membership degree of the *i*th input factor's *j*th characteristics. Layer 4 defuzzifies the final output M of such a neural fuzzy system with centroid defuzzification equation as follows:

$$M = \frac{\sum_{k=1}^{32} \mu_k w_k}{\sum_{k=1}^{32} \mu_k} \quad (3)$$

Where w_k is the markup percentage from the *k*th rule and M is the final estimated markup percentage.

4.3 Conceptual Model

The FNN prediction model has been implemented under Fuzzy Logic Toolbox in MATLAB. We've applied fuzzy inference to modeling systems whose rule structure is essentially predetermined by my interpretation of the characteristics of the variables in the model [8]. Upon user interaction, using a given training data set that contains desired input/output data pairs of the target system to be modeled, the fuzzy system was trained by adjusting the membership function parameters that best model this data. Then the toolbox function anfis constructs a fuzzy inference system (FIS) whose membership function parameters are adjusted using a backpropagation algorithm. The training will stop after the training data error remains within this tolerance. Model validation is the process by which the input vectors from input/output data sets are presented to the trained FIS model, to see how well the FIS model predicts the corresponding data set output values. When checking data is presented to anfis as well as training data, the FIS model is selected to have parameters associated with the minimum checking data model error.

4.4 Error Analysis

The trained FIS model was verified with new real estate data. The experiment indicates favorable prediction results with the actual real estate prices of detached houses. As the table 1 shows, random Minimum and maximum errors are 1% and 11% respectively, while median error is 5% and 6%.

Table 1. Results of FNN predictive model

No.	FNN Model Output	Actual Prices	Value Difference	Error
1	1947	2100	-153	7.86
2	2193	2030	163	7.43
3	2538	2480	58	2.29
4	2071	2000	71	3.43
5	1776	1750	18	1.02
6	2205	2300	-95	4.31
7	1788	1680	108	6.04
8	2895	1100	-206	10.87
9	2334	2180	154	6.59
10	1807	1900	-93	5.15

While these kinds of calculations may seem tedious and overly time consuming they improve the prediction product by allowing the valuer to make representations supported by evidence regarding the accuracy of the value estimate provided.

Moreover, further automation could allow valuers to test empirically the validity of their price adjustment models. Different coefficients could be used to see which would minimize prediction errors. Optimum sample sizes could also be explored.

Therefore, from this perspective, FNN prediction model in this study gave a reasonable and acceptable value of real estate.

5 Conclusion

We developed a FNN prediction model to estimate the appropriate price level for a new real estate. The experimental result demonstrated that applications of artificial intelligence methods to real estate prediction and decision support allow getting significantly improved predicting results and outperforms the classic prediction methods. Although the results from this study seem appealing in enhancing prediction technique, the fuzzy rules could be fine-tuned in order to produce more accurate results. For instance, the FNN model can be improved for other application domain and can be enhanced to meet current market and user needs. Hence the future study will try to identify more variables to be added in FNN prediction model, i.e. economy and socio-economic factors.

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