A Review of Expert System Applied in Real Estate Valuation

Justine Prita Kusuma Ahmad Borhannuddin[1]*, Abdul Hadi Haji Nawawi[1], Edie Ezwan Mohd Safian[2]

[1]*School of Architecture, Planning and Surveying, Universiti Teknologi MARA, 40450 Selangor, Malaysia*
[2]*School of Technology, Management and Business, Universiti Tun Hussein Onn Malaysia, 86400 Johor, Malaysia*
*Corresponding author E-mail:abdul274@salam.uitm.edu.my

Abstract

Expert system application is found in various industries, especially in real estate, medical, law, engineering and social science. The complexity of the real estate environment demands a technology like expert system that able to automating a process for valuing a property and produces an estimated value to the real estate market participants. However, the expert system is not a common in property valuation practice in Malaysia as compared to in developed countries such as the United State America and the United Kingdom. The purpose of this paper is to explore the expert system and its implementation in real estate valuation. By exploring the expert system, the limitation and benefits of the expert system in real estate valuation are also identified. Expert system has ability to solve complex problems of property valuation. Thus, expert system shall be practicable by real estate valuers in Malaysia to ensure the reliable valuation is delivered.

Keywords: *Artificial Intelligence; Expert System; Real Estate; Valuation*

1. Introduction

The real estate industry has moved into the era of technology and innovation. Since the 1980's, real estate valuers have begun to endeavour computerization to carry out the valuation task [18]. Technological power has changed the real estate valuer's perform their work, the growth of property development and the complexity of property environment. However, the traditional valuation methods are still widely practice by real estate valuers, even though many criticized the approach to be of subjective judgment [11], inaccurate [5, 11], static [12] and have failed to capture price volatility [13]. In one case, a property housing price collapse took place in the United Kingdom due to the valuation approach exercised by the real estate valuers did not adequately determine the risk [13, 17]. Therefore, the real estate valuers expectation on orthodox valuation practice has rise and the profession is shifting into automated manner in carrying out valuation task.

The aim of this paper is to explore about expert system to improve orthodox valuation practice and solve valuation problem in an automated manner. Study on expert system has been motivated due to no real estate organization and valuers apply ES to carry out valuation task in Malaysia unlike other developed countries. This is because, the traditional valuation practice and manual calculation is still accepted by the professional in the real estate industry [5]. Findings from this study should be a useful aid to inexperience real estate valuers in determining property value and real estate market participants in making a decision for property investment.

2. Artificial Intelligence

The artificial intelligence (AI) refers to the ability to perform and replicate the intelligent functions of the human brain [26]. The AI techniques have been applied in the form of expert system (ES) which helps to solve various complex problems. Therefore, studies on the application of the artificial intelligence and the expert system in real estate valuation have been increasing [2].

Several studies have been carried out a comparison between the AI with the traditional Multiple Regression Analysis (MRA) model. Overall result showed a higher degree of precision in the AI with 5% to 10% average error rate, while the MRA average error rate is between 10% and 15% [19]. Hence, the AI technique has the capability to outperform traditional statistical in the decision making process [2, 6]. This is important for real estate market participants to make a precise and reliable decision, especially for the purpose of property investment.

Generally, the creation of the expert system needs certain technical concepts of AI. Notable studies focusing on expert system and AI technique in real estate valuation are shown in Table 1 [25, 19, 9, 33, 20, 7, 18, 3, 2, 23, 6]. Based on Table 1, the AI technique has obtained acceptance among real estate academician in most of the developed countries to have a paradigm shift in the valuation practice so that accurate valuation is attained. The AI approach has been applied to support the real estate valuer's works.

Table 1: Authors Contributed to Artificial Intelligence in Real Estate Valuation

Author	AI Technique	Real Property Valuation	Case Study
Rossini, P. (2000)	Rule-based Expert System	Forecasting Residential Valuation	Southern Australia
Gallego, J. (2004)	Artificial Neural Network	Housing Valuation	Madrid
Krol et al. (2007)	Rule-based Reasoning & Fuzzy System	Mortgage Valuation	Poland
Lasota et al. (2008)	Rule-based TSK Fuzzy Model	Residential Real Estate Appraisal	Polish, Poland
Lam et al.	Artificial Neural	Residential	Hong Kong

(2008)	Network	Property Forecasting	
Larraz, B. (2011)	Expert System	Mortgage Residential Valuation	Spain
Kilpatrick, J. (2011)	Artificial Neural Network & Genetic Algorithm	Residential Property Valuation	U.S.A.
Amir et al. (2013)	Rule-based Reasoning & Fuzzy Expert System	Investment Portfolio	Tehran, Iran
Adebola et al. (2013)	Artificial Neural Network & Case-based Reasoning	Residential Property Valuation	South Africa
Morano et al. (2015)	Artificial Neural Network	Housing Valuation	Bari, Italy
Utomo et al. (2017)	Rule-based Reasoning	Housing Property	Indonesia

3. Expert System

The expert system (ES) is derived from a branch of AI and has become a popular topic to be discussed in various industries and profession. The expert system is defined as "an interactive computer-based decision tool that uses facts and heuristics to solve difficult decision problems based on knowledge acquired from an expert" [30]. The basic idea of the expert system is simply to transfer human expertise to a computer program where knowledge is stored and users can utilize the computer system for information and advice [28]. The expert system is the most feasible approach and commercially successful forms of AI [21].

On another note, the expert system can be described as an elicitation of knowledge from experts, followed by the representation and validation in the form of a computer program. The system has the ability to make inferences and provide a specific conclusion to the user [29]. This process is similar to a real estate valuer that gives explanation and advices to real estate market participants.

Subsequently, the expert system attempts to understand the way humans solve typical problems where the computer is used to predict their behavior [25]. The expert systems also provide flexibility in obtaining a solution to multiple problems that cannot be dealt by orthodox approach [29]. Thus, the use of the expert system is growing in real estate valuation and proved to be an analyst in problem solving and decision making.

3.1. Expert System in Real Estate Valuation

The application of expert system (ES) has been studies by academician from various points of view. The expert system replicates human expertise, the knowledge must rely upon a nature and then representation of that expertise [16]. In the property valuation context, an expert system relies crucially on the true nature and judgement of the real estate valuer. This is because real estate valuers are the vast body of specific knowledge in property valuation. The real estate valuers knowledge is count on both modelling process and data adjustment phase in order to increase the degree of accuracy and reliability in the expert system [18].

Early research on the application of expert system in the valuation of residential property has changed significantly in the nature of valuation practice. However, Boyle's model was developed using statistical analysis of past sales rather than modelling the human expertise then, applying the model to comparable evidence in order to value in the same manner as real estate valuers [27]. Whereas, the expert system that modelling the real estate valuer expertise has been developed by Scott and Gronow to produce a residential property valuation and follow-up study by Nawawi research on commercial property [4, 18].

Besides that, the expert system also applies to mass appraisal. In the McCluskey and Anand model, a comparative factors and weights are determined by the valuation expert. The model then

coupled with hybrid system of artificial neural network and genetic algorithm [18].

Recently, expert system software was developed to solve residential valuation problem in an online manner named as the 'Residential Properties Valuation Report (RPVR)'. The RPVR expert system provides a description of the property, legal information, economic value, neighbourhood location and market price using the spatial estimation methods in order to analyze data from the property sales advertisement [7].

Also, prototype expert system software called "PROFIT" has been developed to forecast residential values by using case-based reasoning with fuzzy predictors [24]. The expert system was suggested as an ideal method dealing with qualitative forecasting of real estate property [10]. This is because the expert system allows modelling complex non linear and qualitative relationship which exists in property valuation.

For over a decade, the application of expert system for residential valuation has been suggested in the literature. The matrix table on the application of the expert system in property valuation is listed in Table 2 [15, 27, 4, 8, 25, 14, 7, 18, 6]. It shows that most of the researchers highlighted and recommended the application of the expert system in residential valuation in their study. There is a very limited study on the application of expert system for commercial property valuation. Nevertheless, the expert system can be usefully employed to various types of property and areas within real estate.

Table 2: The Matrix of Expert System Application in Real Estate Valuation

Authors	Residential Property	Commercial Property
Scott & Gronow (1990)	√	
Czernkowski (1996)	√	
Nawawi, A. H., D. Jenkins, & S. Gronow (1997)		√
O'Roarty et al. (1997)		√
Rossini (2000)	√	
Wilson et al. (2002)	√	
Larraz (2011)	√	
Kilpatrick (2011)	√	
Utomo et al. (2017)	√	

Moreover, expert system is suitable to be used in property valuation due to its ability to assume logically, uses the general rules of the thumb and gives advice even though there is incomplete information. The use of the expert system in property valuation can increase the accuracy, reliability, consistency and speed operations of the valuation nature and process [16, 25]. In such, the expert system will acts as a second opinion and learning aids to support the novice valuers in solving valuation problems and market participants to choose the right property for investment [25, 32].

3.2. Expert System Architecture

The expert system integrates knowledge, facts, reasoning in producing a conclusion or decision. In order to develop a decision for property valuation, an expert system fundamental architecture is required, as shown in Figure 1:

3.2.1. Knowledge Base

The knowledge base is the heart of the ES which includes all the knowledge needed to solve a specific problem in a domain area [30]. The knowledge can be factual and heuristics [21]. The factual knowledge is information gathered from scholars in the task domain. The heuristics knowledge can be obtain from experiences, opinions, rules of thumb, expert's evaluation or judgment.

The power of the expert system exists in its knowledge. Thus, the quality, accuracy and completeness of the information stored in

the knowledge base will crucially determine the success of the expert system [16]. This is because a successful expert system is one that is capable in combining the facts and heuristics that merge with computer power in problem solving.

3.2.2. Inference Engine

The inference engine is considered as the brain of the expert system that acts as a control structure which allows the expert to use search strategies to test different hypothesis to arrive to conclusion [30]. A common inference engine is representing knowledge in a rule based which is "if-then" rules in deducing a correct solution. The inference engine is the problem processing part of the expert system.

3.2.3. User Interface

The user interface of the expert system allows the user to have communicates with the expert system [21]. This component explains the particular conclusion suggested by the expert system. The expert system with efficient user interface should help users to accomplish their goals in the shortest way, designed to work for desired work practices, efficient use of input and a technology adaptable to user's requirement.
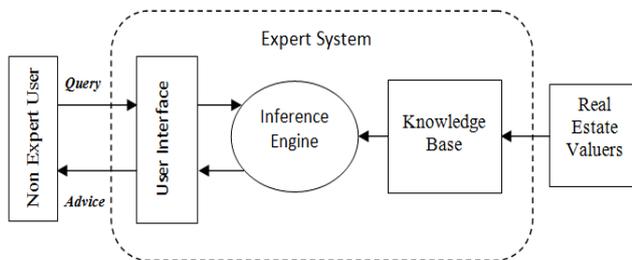

Fig. 1: Integration of expert system components.

3.3. Rule-Based Expert System

The expert systems that leverage machine learning concepts like rule-based reasoning, case-based reasoning, and artificial neural networks have been used in the real estate valuation. However, various authors believe that rules form a large part of human information processing [24]. Generally, the rule-based reasoning is most commonly used in many expert systems in the past.

The rule-based expert system is representing the real estate valuer's knowledge when undertaking valuation tasks in the form of series of rules and relationship. The rules for real estate valuation has been suggested in the literature. However, most of the real estate valuers have difficulty in formalizing the rules [27]. There is underlying rationality by combining the knowledge of local market with experience and awareness of national trends, the real estate valuers can utilize the powerful of computers to come up with the fair market value. Bikakis and Antoniou [1] mentioned that rules are simple, flexible, formal, and expressive. Each rule is of the form IF-THEN:

$$if\ X\ then\ Y \qquad (1)$$

The statement after the word IF represents some conditions which real estate valuer may observe. The statement after the word THEN represents some conclusion or action that real estate valuer should be executed. These can be demonstrated by considering the following sample set of rules, extraction from valuers in South Australia [27]. For example:

Rule 1
IF   sold at arms' length
AND   no extenuating circumstances exist
THEN   (80% certain that) market-price=fair

On another note, the rule-based expert system is the simplest method that mimics the reasoning procedure of a real estate valuer applied to a complex real estate environment. It is also enhancing judgement process in property valuation by providing users the expert's opinion of value. Therefore, rule-based reasoning is the most acknowledge and suitable approach to represent the expert valuers knowledge in the expert system.

3.4. Benefits of Expert System in Property Valuation

There are various potential benefits of expert system mentioned in the literatures. The benefits received by end user when using expert system [31]:-
1. Less time to complete tasks
2. Learning without supervision of experts
3. Diagnosis in short period
4. Effective uses of data
5. Making consistence and accurate decision
6. Training tool for trainees

For the real estate industry, the application of the expert system is able to reduce the costs of public and private organization in carrying out property valuation [25]. Expert systems also help to preserve and eliminate scarcity of expertise throughout the real estate industry. Real estate valuers are not experts in the overall real estate sectors. For example, commercial property and residential property are two different types of property. Thus, the need of an expert system is crucial to support the less skilled real estate valuer to solve the valuation problems.

The development of the expert system in real estate valuation is to provide a platform of expert's advice which acts as a learning tool for property practitioners [24]. The main motivation of using the expert system for property valuation is to achieve precise and reliable valuation. The expert system for property valuation is worthwhile for several reasons:-
1. The expert system will assist the valuers by giving a second opinion [6, 27].
2. The speed of decision can be very significant in a mortgage purpose because the financial institutions need a fast quotation of property value [15]
3. The expert systems also ensure compliance with the correct procedures and real estate valuers can expect an improvement in valuation practice by using the expert system [16].
4. The facts that the expert system valuation is using computerize tion helps to eliminate professional negligence due to the presence of hard evidence [13]
5. The expert system is applying similar rules, it provides an identical value from the same data. Therefore, consistency in property valuation is a guarantee [24, 30]

Furthermore, the expert system should be able to increase the accuracy of making a good decision in property valuation [25]. The expert system should be embraced due to its ability to extract expert knowledge, and to distribute human expertise to non experts. In general, the exposure of the expert system is important for real estate practitioners and educators.

3.5. Challenges to Applied Expert System for Real Estate Valuation in Malaysia

The expert system is not common and less exposed in real estate organizations and real estate valuers in Malaysia due to traditional valuation and manual calculation is still accepted by the real estate industry [5]. However, Malaysia is driving towards a developed nation and the government's Valuation and Property Services Department (JPPH) are putting an effort to improve the valuation practice [5]. There are countless research that have been conducted and successful prototype of the Computer Aided Mass Appraisal (CAMA) is applied and practice in rating valuation by local authorities in Malaysia.

This study intends to improve the valuation practice through the use of expert system. In practice, the expert system is closely similar to heuristic sales adjustment grids but added advantage of the ability for statistical characterization. However, to develop the expert system is a real challenge and time consuming when need to actually adaptable in real life for solving actual property valuation problems [18].

Moreover, the property development is growing in Malaysia which leads to a complex property environment. Thus, the real estate valuers cannot depend wholly on the orthodox valuation approach to carry out property valuation [5]. It required an automated valuation system to improve the valuation process in Malaysia.

4. Conceptual Framework

The development of expert system requires a well-planned task leads to a final deliverable and work on them orderly. Figure 2 illustrates the conceptual framework of the expert system for real estate valuation in Malaysia. This framework is used for the purpose of developing a comprehensive expert system for property valuation.
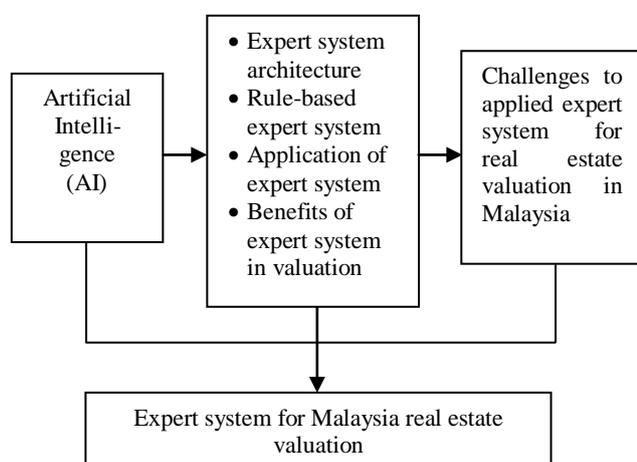
Fig. 2: Conceptual Research Framework

5. Conclusion

The expert systems have a potential to assist an industry that deals with complex and scarce expertise. The expert system technology will continue to expand the application and usage in the real estate industry worldwide. The technology transfers need to be considered earlier in the expert system development to achieve a success of the expert system in real estate valuation. In the coming years, the expert system valuation will be implemented in Malaysia and experience an increase in demand from real estate practitioners.

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