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Using Expert Systems and Artificial Intelligence For Real Estate Forecasting

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Abstract: This paper examines the use of expert systems and artificial intelligence, (in particular the application of neural networks) to real estate forecasting. While there is a great deal of literature about the use of artificial intelligence for mass appraisal, there is relatively little work on how it can be applied in real estate forecasting. This paper examines the current uses of artificial intelligence, particularly neural networks, in the business-forecasting field and considers suitable applications in real estate. The paper also considers the broader issue of expert systems and how a better system can lead to better results. Some real estate data are used as simple case studies to demonstrate their use.

Introduction:

Over the last few decades there have been significant changes to the methods of forecasting available to analysts and practitioners. Complex methods have become available for routine use and complex econometric models are often suggested as the solution to forecasting problems. However some researchers suggest that the use of better systems rather than better forecasting techniques would lead to better overall forecasts. This idea was strongly supported by the work of Makridakis et al. (1982). This research involved forecasting 1001 different time series using 24 different methods. They concluded that more sophisticated methods may produce no better results from simple ones. These are highlighted in the following quote from their conclusions.

> *"If the forecasting user can discriminate in his choice of methods depending upon the type of data (yearly, quarterly, monthly), the type of series (macro, micro, etc.) and the time horizon of forecasting, then he or she could do considerably better than using a single method across all situations - assuming, of course, that the results of the present study can be generalized.... Even though further research will be necessary to provide us with more specific reasons as to why this is happening, a hypothesis may be advanced at this point stating that statistically sophisticated methods do not do better than simple methods (such as deseasonalized exponential smoothing) when there is considerable randomness in the data.... Finally, it seems that seasonal patterns can be predicted equally well by both simple and statistically sophisticated methods."*

One implication of this is that forecasting systems with simple artificial intelligence (AI) and expert systems (ES) may produce better outcomes and be more efficient than those use a single, (and often more complex and sophisticated) model (DeLurgio, 1998). This paper examines some of the uses of expert systems and artificial intelligence within business and how they are being applied to real estate problems.

One particular aspect that is considered is the advantages of these systems as a learning tool for inexperienced real estate practitioners. An example is used to show how an expert system for residential valuations might work.

What are expert systems and artificial intelligence?

The field of artificial intelligence (AI) has developed rapidly as computing power has increased. Artificial intelligence refers to the ability to perform the intelligent functions of the human brain. In particular some forms of reasoning, some learning and general improvement over time. The uses of AI are varied with the major uses so far being in the computing and robotics area. They form an integral part in modern optical character and speech recognition software, are broadly used in robotics and have very wide spread applications through the military. The use of AI is now extending into the social sciences including business studies. The use of artificial neural networks (ANN) and genetic algorithms are becoming more wide spread particularly in the fields of market research and forecasting.

Expert systems may be considered to be a subset of AI. DeLurgio (1998) makes a clear distinction between conventional program systems (CPS) and expert systems (ES). He maintains that CPS involves the researcher wanting to create a system that deals with interesting and difficult tasks without regard to whether these are similar to those used by humans i.e. it does not matter how the job gets done, as long as it does. The ES tries to gain an understanding of how humans solve problems and then uses the computer to explain and predict their behavior. In practice many systems contain elements of both. So that many systems have some aspects of expert systems but often rely on some of the basic number crunching abilities of a CPS. This will increasingly become the trend in real estate applications where hybrid techniques will become more prominent (McCluskey, 1999). The emergence of expert or partly expert systems is important for educators in nearly all fields. The advantages of ES include the ability to provide expert advice to non-experts, assist experts to solve problems and to act as a teaching tool for non-experts (DeLurgio, 1998). For educators the final issue is very beneficial. A well-constructed ES can form a valuable teaching and training tool.

The use of artificial intelligence for forecasting

The most used AI technique is probably artificial neural networks (ANN). The concept of the ANN is that of a learning algorithm similar to the function of the human brain. They work by a series of interconnected neurons in a similar manner to the working of the brain. However even with the largest modern computers it is estimated that an ANN with 10 million interconnections would have a neuron structure somewhat smaller than a cockroach. (De Lurgio, 1998). The process of using the ANN for forecasting is largely the same as for other forecasting methods such as multiple regression. As a results these two techniques are very often compared. In each case there is input data which is used to model output data. They each use a series of coefficients in the modeling process and each attempt to minimize error terms in a similar manner. The standard methods of hold out samples are also commonly used in both as a measure of the forecasting ability. The internal process of the ANN is however more complex and less easy to reproduce and explain. It functions as a “black box” to a much larger extent than for traditional statistical methods. On the other hand, people with no background in the method seem to be able to make better predictions using ANN’s. This sets a dangerous precedent and it is probable the use of ANN’s will be over-sold and they will be used in situations where more conventional methods are probably superior. As a result, dangerous conclusions and recommendations will be made by people who use ANN’s badly. Notwithstanding this ANN’s have been well researched in business fields in recent years. For a basic time series situation Kuo et al. (1996) found that neural networks produced lower errors than Box-Jenkins and regression procedures. Denton (1995) found ANN to be superior for causal forecasting to regression. There are numerous examples of where ANN’s have been used for business forecasting. These include forecasting of electricity consumption (Nizami et al., 1995), airline passengers (Man et al 1995), company audits (Lanard et al (1995), bank failures (Tam, 1992), bankruptcies (Fletcher, 1993), stocks and bonds (Desai, 1998, Li, 1994), futures and financial markets (Meade, 1995, Kaastra et al, 1995, Mangasarian, 1995, Kuan et al, 1995, Grudnitski et al, 1993). In most cases researchers have found that ANN’s can produce forecasts with lower overall errors than with conventional methods such as regression.

The use of artificial intelligence for real estate forecasting

Forecasting is a major issue in most aspects of real estate practice. Valuation and appraisal are forecasting. Property development relies on forecasting of expected costs and returns. Property and facilities managers use forecasts of supply and demand as well as of costs and returns. Funds and investment managers rely on forecasts of value now and in the future through forecasts of growth and economic activity. With all this forecasting being relied upon it is somewhat surprising that the uses of AI and ES are primarily restricted to mass appraisal, however this is less surprising when an analysis of the use suggests that most of this would fit better into the description of conventional program systems. Early attempts at "automating" or "computer assisting" valuation go back as far as the late 1970's when sufficient computing power became available (Eckert, 1993, Jensen, 1984). The use of expert systems and artificial intelligence techniques for residential valuation has been suggested in the literature for over a decade. Methods such as rule-based reasoning (Scott et al. 1989, Nawawi et al. 1997), case-based reasoning (O'Roarty et al. 1997), and neural network (Borst 1995, Do et al. 1992, Evans et al. 1993, James, 1996, Jensen 1990, Lenk et al., McClusky et al. 1996, Rayburn, 1995, Rossini 1997, Tay and Ho 1994, Worzala 1995) have all been suggested as means of approaching mass appraisal and to some extent valuation generally. In general the emphasis has been on data mining from a large property transaction database. There are a wide variety of methods that can be used for data mining but these can be classified into nine groups; classification, regression, discovery of associations, discovery of sequential patterns, temporal modeling, deviation detection, dependency modeling, clustering and characteristic rule discovery (McCluskey and Anand, 1999).

The use of AI through neural networks is not well researched in other aspects of property. Kershaw et al (1999) compared the results of neural networks to those using regression to develop time series indices for residential data. Neural networks were found to be useful (but no better) for estimating a hedonic price index based on cross sectional transaction data but were found to be quite useful when dealing with time series data e.g. median prices. Other examples of the use of neural networks have been in the property development/ building fields including models for the demand for residential construction (Hua, 1996) and cost estimation. (De la Garza,1995).

Using of artificial intelligence and expert systems in real estate practice

The discussion so far has focused around neural networks and data mining techniques for forecasting. Forecasting is primarily a quantitative process using numerical data from the past to forecast the future. Expert systems are an ideal method for dealing with many other problems as well. One of these is qualitative forecasting. This is typically used for new products and in situations where there is no long-term series that might assist in giving a forecast. Expert systems can assist in the use of methods such as sales-force composites, surveys of customers and populations, jury of executive opinion and the Delphi method (Wilson et al, 1998). There are numerous other areas within real estate practice where expert systems could be usefully employed. Some examples are

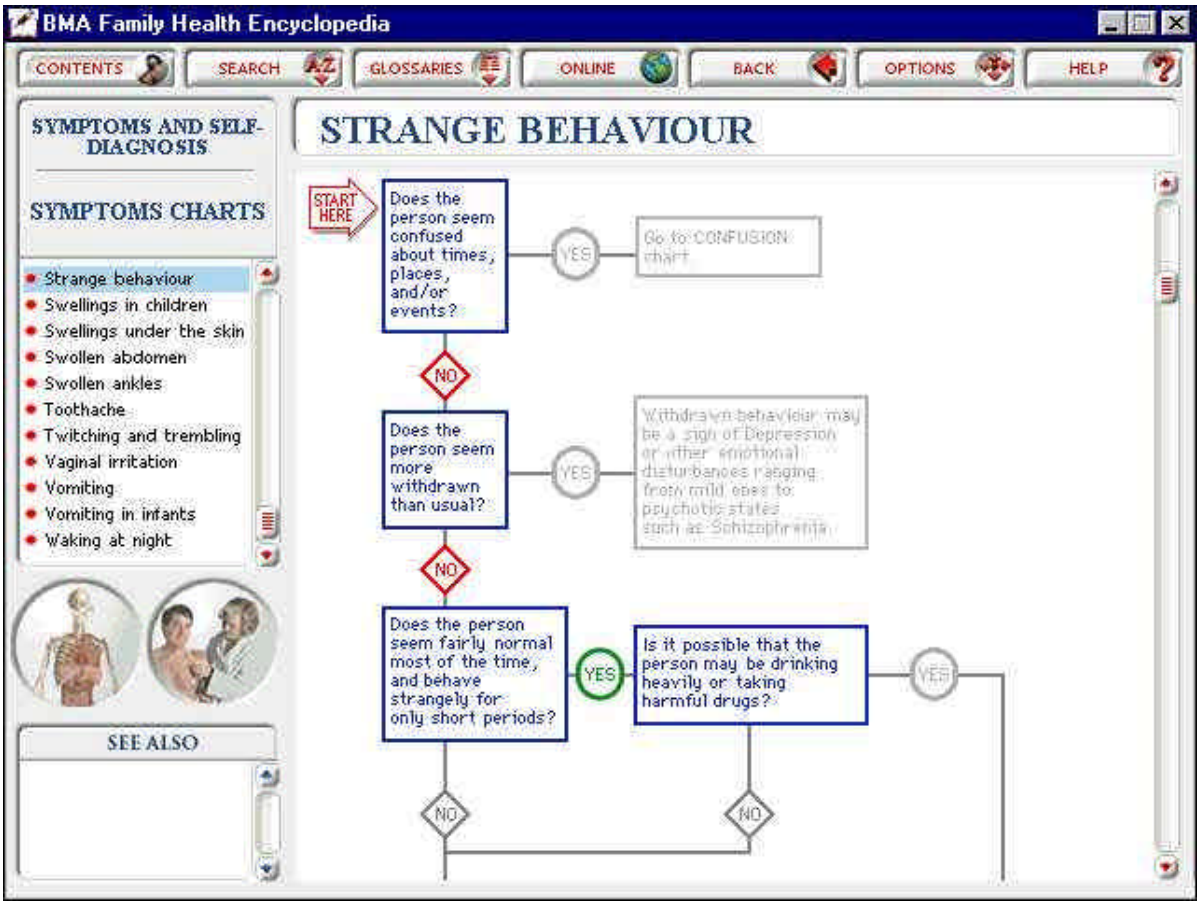
- the preparation of real estate documentation such as leases, contracts and forms. Expert systems can help the user prepare better documents by guiding them through the process and brining attention to issues that might other wise have been missed, as well as improving phrasing and structure.
- the costing of buildings and development projects. This requires a combination of data mining and rule based methods (or case based reasoning) to bring together the expert knowledge of quantity surveying, engineering and construction with current cost estimates.
- computing assistance with specialised as well as general computer software.
- preparation of reports and property descriptions
- property and facilities management problems where the ES can be used by both clients and property managers to streamline the solution to some problems

One of the obvious issues with each of these is that they are useful for the novice and can therefore assist in the teaching and training process until the user becomes and expert themselves.

Example of a common rule based expert system

Many useful expert systems use a rule-based approach where a set of rules are established and the user effectively moves from a starting point to some answer or output by answering a set of questions. Each next question is dependent upon the last answer or series of answers. There are many thousands of examples of such systems, and they are now widely used. shows a simple rule based system from the British Medial Association Family Health Encyclopedia (1997). Listed as interactive diagnostic charts, the program used a flow chart metaphor to assist the user to self-diagnose problems. The example in shows only the first of a large number of rule-based questions that eventually lead the user to a simple home remedy or advice to seek further expert help. More complex versions of this type of program are routinely used by the medical profession for education and training and as a continuous and updated reference.

Figure 1 - Example of a simple expert system (British Medial Association Family Health Encyclopedia)



An example of a residential valuation system

Valuation systems that are being proposed are usually more in the CPS rather than the ES mould. Most are probably better termed as automated or computer assisted valuation tools. The simplest use purely rule-based systems, sometimes implementing cost based methodologies. Future expert systems that utilise artificial intelligence, are likely to use hybrid techniques (McCluskey, 1999). The example discussed here had its foundation in 1992 (Rossini et al., 1992) with the design of a basic computer assisted appraisal system using Microsoft Windows. Since then it has progressed but is still clearly a "half way system" between CPS and ES, with future developments being in the ES area. The system uses a series of steps that the developers believe to automate a sound residential valuation practice with expert inputs and advice but with the option to override the system at any stage. Preliminary research using the (somewhat awkward) prototype system suggest that the accuracy of such a system would more than match the industry standards for **normal individual residential valuations**. (Rossini, 1999).

The system uses a seven-step process

Step 1. Collect and input details of the subject property.

Step 2. Find **"appropriate"** sales from the market place - using search and filter systems from the monthly updated sales database.

Step 3. Model the market using sales from Step 2. Test for any relationships and find the coefficients.

Step 4. Establish major value determinants and adjustments from the model in Step 3.

Step 5. Find **"appropriate"** number of the most comparable sales - using expert knowledge and value determinants from Step 4.

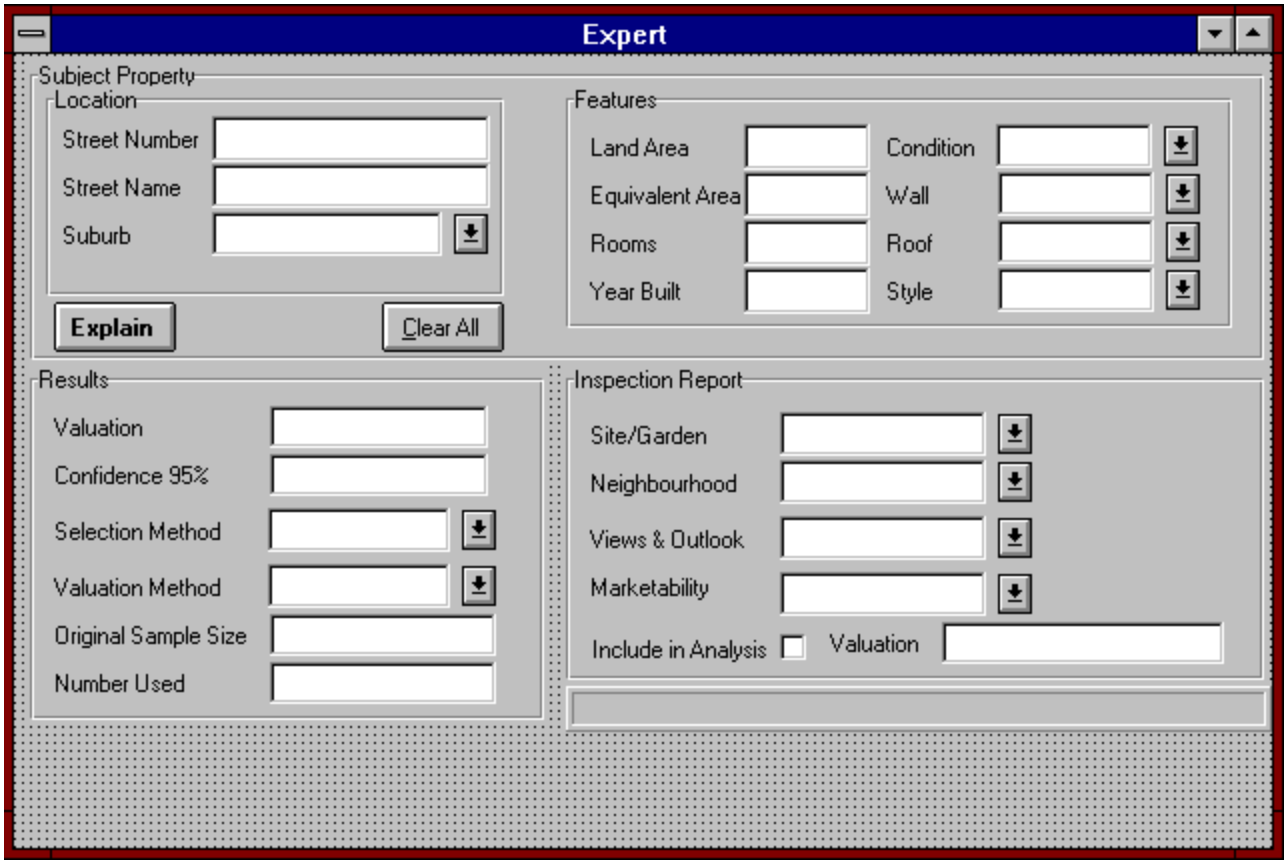
Step 6. Make adjustments to the most comparable sales to allow for differences between the subject and sale properties.

Step 7. Estimate value based on adjusted prices and relative comparability of each sale - using a weighted mean approach.

Step 1

The first step is to collect data about the subject property. For advanced or experienced users this data can be input directly. For the novice user or trainees, there is a rule-based system to allow for the user to be guided to the inputs. The prototype-input screen is shown as Figure 2. In the basic prototype this screen is used to input data, select methods and output the answer. The system will work with or without the data listed in the inspection report. This enable a valuation based on the "features" which are listed on the state valuation list however the result is less accurate in many locations.

Figure 2 - Step 1 of the Valuation System - inputting the data



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