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# THE DEVELOPMENT OF A CASE-BASED REASONING SYSTEM AS A TOOL FOR RESIDENTIAL VALUATION IN BANGKOK

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**Abstract:** The academic profession has shown considerable interest of case-based reasoning systems. A number of systems have already been developed for law, medical, and engineering applications. However, few systems are currently available for residential valuation. This study describes the development of a case-based reasoning system for valuers. Especially, the study examines the usefulness of the system for the valuation of townhouses in Bangkok, Thailand.

## 1 Introduction

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, Jensen 1990, McClusky et al. 1996, Rossini 1997, Tay and Ho 1994, Worzala 1995) can be used to implement expert systems. These systems enhance judgmental processing by providing to novice users, the knowledge and the problem-solving strategies of experts (Leidner et al. 1995 and Murphy 1990). Such systems can also be used by experts in the decision making process and as an effective and efficient decision making aid. Rossini (1999) suggests that in some circumstances, such systems may produce more accurate valuations (on average) than standard manual valuations. Further more, many younger inexperienced valuers would welcome the introduction of such systems as they tend develop a deeper understanding of their decision making process as well as assisting them to achieve more consistent results.

Because many researchers believe that rules form a large part of human information processing, rule-based reasoning has been used to implement many expert systems in the past (Bonissone et al. 1992, Denna et al. 1991, Smith et al. 1993, Sutton 1990, Winston 1992). This is equally true for residential valuation systems. To operate a rule-based residential valuation system, it is necessary to determine the optimal weights for individual property attributes that will be incorporated within the rules. These attribute weights can be derived from a variety of sources, but the most typical is by using standardized regression coefficients or other inferential methods. The problem with a typical rule based system is that these weights must be assessed for each residential submarket and then updated regularly to keep the system up to date. Because the regression is not generalized, the rules and weights must be changed often and this is tedious work (Churbuck, 1992).

Alternatives to the rule based systems are those based on data mining. 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). These methods are generally data hungry and for most residential valuation situations means the use of a large property transaction database.

However, in some locations such data is either not readily available or is unreliable and in these situations valuers normally use previous experiences or cases in evaluating the property market. These previous cases can be used to implement a case-based reasoning system. In addition, the system can emulate the problem-solving processes of domain experts by using past experiences to solve new problems (Gupta, 1994). Case-based reasoning matches the valuers' use of previous experiences in judging property valuation and can be used not only as decision aids by professionals but also as training tools by novices (Garfinkel, 1995). The purpose of this study is to consider a case-based reasoning system for residential property in Bangkok, Thailand. This system should be useful as an aid for experienced valuers and a guide to assist inexperienced valuers to learn proper judgment and methodology.

The remainder of this paper has the following sections. The first section presents the background of case-based reasoning system. The second section explains the process for constructing the case-based reasoning system for residential property in Bangkok. The third section discusses the evaluation of this case-based reasoning system. The last section provides conclusions and examines limitations of the study.

## 2 Background of case-based reasoning

Case-based reasoning represents knowledge in the form of cases. The contents of the cases are stored directly in a case base (Zeleznikow and Hunter, 1995). To find solutions, case-based reasoning uses analogical reasoning. The analogical reasoning is the process of determining the outcome of a current problem by comparing input problems to similar past experiences (Zeleznikow and Hunter, 1995). This analogical reasoning results in finding previous cases similar to the present problem and then adapting the previous solutions to fit the current problem.

The quality of case-based reasoning's solutions depends on three fundamental factors (Kolodner, 1993; Gupta, 1994): (a) the number of well-defined cases stored in the system; (b) the ability of the system to recall experiences by using an index and to interpret the new situation in terms of those experiences; and (c) the adaptation of an old solution to meet the demands of a new situation. Some case-based reasoning systems also possess the ability to evaluate and adapt experiences to avoid repeating past mistakes (Kolodner, 1993).

The explanation and dialogue structures of case-based reasoning play an important role in developing users' problem-solving skills. The case-based reasoning explanation facilities allow the system to explain why the current problem is similar to or different from a set of cases drawn from its database. These explanations are important for building users' confidence and for helping novices learn from past experiences (Gupta, 1994). Case-based reasoning explanations cite actual cases in providing the explanation. This makes the explanation more useful (Kolodner, 1993; Gupta, 1994; Zeleznikow and Hunter, 1995; Kesh; 1995). Because case-based reasoning uses analogical reasoning, the system has to comply with a form-based or free-text dialogue. A form based is presented on the screen with a position marked by parameter names (Eklundh et al., 1985). The values, number or alphabet are entered in the fixed position. Free text dialogue is any alphabet that describes a current problem.

The free-text dialogue provides flexibility for users to input problems into the system. However, users must know relevant keywords or problems, otherwise, they cannot get started. Some case-based reasoning systems do, however, allow users to start with a free-text dialogue. After the systems find the closely matching cases, the systems will allow users to answer additional questions in any order. Some case-based reasoning systems provide users with a form-based dialogue to enter data. The form-based dialogue is often better than the free-text dialogue because it provides more guidance for entering information within given parameters.

Little research has been conducted on the impact of form-based dialogue on novice users. Nonetheless, numerous design issues, such as the sequence of questions, need to be considered in building effective dialogue interfaces (Schneiderman, 1997). For example, the effective form-based dialogue emerges when the order of questions in a form-based dialogue is consistent with the cognitive order held by the user (Norman, 1991). The incongruent order of questions with the users' cognitive order will disrupt the users' cognitive processing. "Incongruity creates dissonance between the users' knowledge base and the system's knowledge base" (Norman, 1991, p. 133). As a result, if the ordering of questions in a form-based dialogue is not carefully designed, some novice users will find that the dialogue of case-based reasoning will impede their problem-solving ability.

Case-based reasoning also has advantages and disadvantages. According to researchers (Kolodner, 1993; Gupta, 1994; Zeleznikow and Hunter, 1995; Kesh; 1995), the advantages of case-based reasoning are as follows. First, case-based reasoning is an efficient reasoner.

It solves problems by adapting old solutions without any need to derive answers from scratch each time. Second, the system can re-use the solutions without going into the sequence of tedious questions for new problems as rule-based reasoning does. Third, case-based reasoning is competent over time. It captures and indexes its past mistakes. Moreover, it provides a warning to the reasoner so that he/she can avoid those past failures. Fourth, case-based reasoning cites actual cases in making the explanation. Citing actual cases make the explanation more useful.

A disadvantage of case-based reasoning is that users might rely on previous experience without validating it in the new situation (Kolodner, 1993). Users might allow cases to bias new problem solutions. This is clearly a problem in changing property markets where past cases may not reflect current market trends. In addition, when users, especially novices, are reasoning, they might not recall all appropriate sets of cases for solving problems.

## 3 Developing the case-based reasoning systems

This section reports the processes for constructing a prototype case-based reasoning system for residential property in Bangkok. First, the factors of residential valuation were selected. Second, the cases and case-based reasoning systems were developed.

### 3.1 Selection of the factors

Whipple (1995) suggests that price inference is the most appropriate method to value residential property. This requires the valuer to find comparable properties (or cases) to enable an inference to be made. To make this inference the valuer must then identify factors that cause major price variations and make appropriate adjustments. Many researchers in Thailand (i.e., Kongchan, 1998; Rodchakpai et al., 1998) suggest that there are six main factors that should be used in Bangkok for an artificial intelligence residential valuation system. These are number of bedroom, building size, building age, land size, distance from main road, and quality of building material. In addition to these six key factors, the road type, location of the building, garage or car parking facilities, number of floors in the building and number of bathrooms can also be served as a useful variables in property valuations.

### 3.2 Development of cases and weights

The residential valuation cases for the prototype case-based reasoning system were extracted from the database used by Rodchakpai et al. (1998). The database comprised of 236 residential property cases within Bangkok. The system is designed to match a subject property to the three nearest cases, provide matching scores, then report the basis for the prediction of the expected selling price from the matching weights. The matching weights are parameters that define the relative contribution of each attribute to a case's score. It tells the system how much weight to give this attribute compared to the other attributes that make up the case. To find matching weight of each attribute, the system uses standardized regression coefficients. This matching weight is easier to change in case-based reasoning system than in rule-based reasoning systems (Churbuck, 1992). This is because in a rule base system, each change results in changes to both the variables and the rules. In a case-based reasoning system, the variables is changed only one time in the question panel of the CBR program.

### 3.3 Development of case-based reasoning systems

A commercially available case-based reasoning shell was used to build a residential valuation system. The shell selected has the ability to

i) run on Microsoft Windows
ii) interface with other programming languages
iii) create customised user interfaces
iv) provide explanations of cases after reaching a solution.

The system provides three windows on one screen: the problem-description window, the question-answer window, and the matching-case window. Users enter problems such as residential area in the form of free-text dialogue on the problem-description window. The user then answers a list of questions on the question-answer window. As the users answer questions, the system presents the most appropriate matches from the available cases (and the matching score) on the matching-case window. Users can read the details of the case and the system's reasoning used to derive its solution by selecting matching cases. Appendix A, shows example screens of the case-based reasoning systems. Appendix B shows examples screens of explanations.

## 4 An evaluation of the case-based reasoning systems

Twenty valuers from the Government Housing Bank in Thailand were used to evaluate the prototype system in terms of ease of use, usefulness and confidence of the conclusion. Each valuer participated in three sections of approximately one hour. First, the supervisor gave details of the experimental procedures, the experimental times, and the task requirements. Second, the valuers followed instruction to use the case-based reasoning systems to answer two example residential valuation cases. Finally, the valuers filled in an evaluation questionnaire. Each question in the questionnaire was measured on a 7-point Likert scale. Rating of 1 indicated 'strongly agree' while 7 indicated 'strongly disagree'.

The questionnaire (provided in the appendix C) measured, among other things, *perceptions of the quality of the system*, and *confidence in conclusion provided by the system*. The research focuses on users' perceptions of ease of use of the artificial intelligence systems and perceptions of usefulness of the artificial intelligence systems. The measures for each variable are explained in the following paragraphs.

### 4.1 Users' perceptions of the quality of the artificial intelligence systems

Users' perceptions are the opinions that users have formed as a result of interacting with the artificial intelligence system. This research measures users' perceptions of the quality of the artificial intelligence systems as their perceptions of usefulness and ease of use of the systems. Usefulness relates to how much a particular system will enhance the user's performance (Davis, 1989). Ease of use relates to the effort required to use a system (Davis, 1989). Davis (1989) found that his instrument has a Cronbach alpha of 0.97 for the usefulness and 0.91 for the ease of use. Meanwhile, the reliability alphas of ease of use and confidence are 0.91 and 0.84 respectively from Olaniran (1996).

### 4.2 Users' confidence in the conclusions provided by the artificial intelligence systems

Confidence is defined as the degree of trust in the accuracy of the artificial intelligence's conclusions. Confidence in the conclusions provided by the artificial intelligence systems reflects attitudes that users can have towards the system after using it in training or for problem solving (Gregor, 1996). The level of confidence is affected by the type of explanations provided by an artificial intelligence system (Lamberti and Wallace, 1990; Ye, 1995; Ye and Johnson, 1995; Yoon et al., 1995). Gregor (1996) found that her instrument has a Cronbach alpha of 0.88.

## 5 Analysis of the results

Twenty responses were used to analyse the perception of the quality of the system and confidence in the conclusions provided by the system. As the number of responses was too small to be assessed using factor analysis, descriptive statistics for the variables will be analysed. Information regarding years of experience in residential valuation was used to group respondents into 3 levels. This grouping follows current valuation standards and practices in Malaysia (Fernandez, 1996). Level one of valuation practice ranged from 3 to 5 valuation practicing years, level 2 ranged from 6 to 10 years of experience, while level 3 started from 15 years. Table 1 presents descriptive data for valuers who participated in the experiment.

**Table 1 - Descriptive Statistics of Variables**

| Items | Valuer Experts | | |
|---|---|---|---|
| | **Level 1 (3-5 years)** | **Level 2 (6-10 years)** | **Level 3 (15 years up)** |
| Gender: | | | |
| Male | 7 | 7 | 3 |
| Female | 2 | 1 | 0 |
| Ease of use - Mean score (Std. Dev.) | 2.37 (1.04) | 2.22 (1.37) | 1.96 (1.02) |
| Usefulness - Mean score (Std. Dev.) | 3.04 (1.16) | 2.71 (1.29) | 2.54 (0.66) |
| Confidence in conclusion – Mean score (Std. Dev.) | 1.89 (1.05) | 1.78 (0.87) | 2.44 (1.13) |

Many valuers found that the systems helped them to attain experience in predicted selling price. Some examples of the comments are stated below:

> *If this is what valuers actually do or it is as close as you can get to it. Why don't we use it? I found it very comprehensive and I learnt definitions as well as valuation techniques.*
>
> *It helped me to understand the topic of valuation. Before I used the program, I was confused about this topic but now I am a bit more confident about property valuation and what it is and how to identify relevant problem factors.*
>
> *The system helps me to focus on problems.*
>
> *A very succinct and useful program.*
>
> *I found the system helpful in understanding how professional valuers are performed.*

Furthermore, the participants found the systems very useful for understanding valuation. Future research will involve methods to implement the system as a training tool for novice valuers to enhanced valuers' judgment.

## 5 Conclusion

This study has described the construction of a case-based reasoning system as a method for residential valuation in Bangkok. The case-based reasoning system seems to enhance valuers' understanding of the valuation process, there is confidence in the conclusion provided by the system and valuers' have positive perceptions of usefulness and ease of use of the system. In addition, the systems can be used as a decision aid to valuers.

As this is the first stage in the development of a prototype model, there are a number of limitations to this study. The most significant is that cases in the systems do not include all factors needed to value residential property in Bangkok. Covering all aspects of residential valuation in the study would make the system too complicated to use at this early stage. However, the system has covered the most important factors and produced useful results. A second major limitation is that the twenty responses from the questionnaires may not be a representative of all expert valuers. A larger sample of valuers needs to be investigated when the system is developed further. The research so far does show that the system has potential to become a viable commercial tool for the valuation of residential property in Bangkok.

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## Appendix A: Example screens of case-based reasoning systems for residential valuation

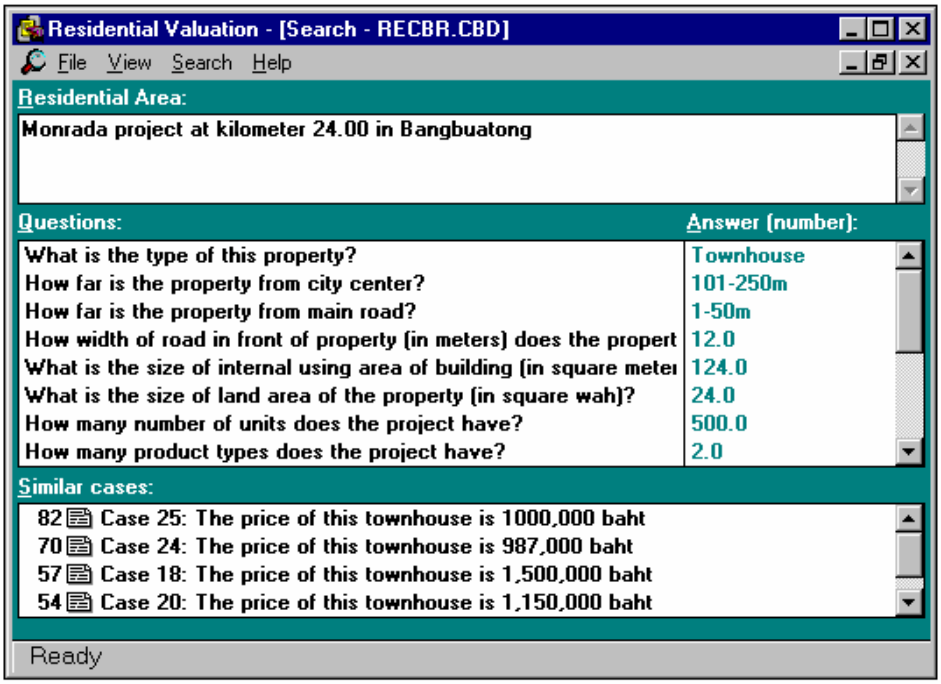


**Fig. 1.** The screen for residential valuation

## Appendix B: Example screens of explanation from case-based reasoning systems

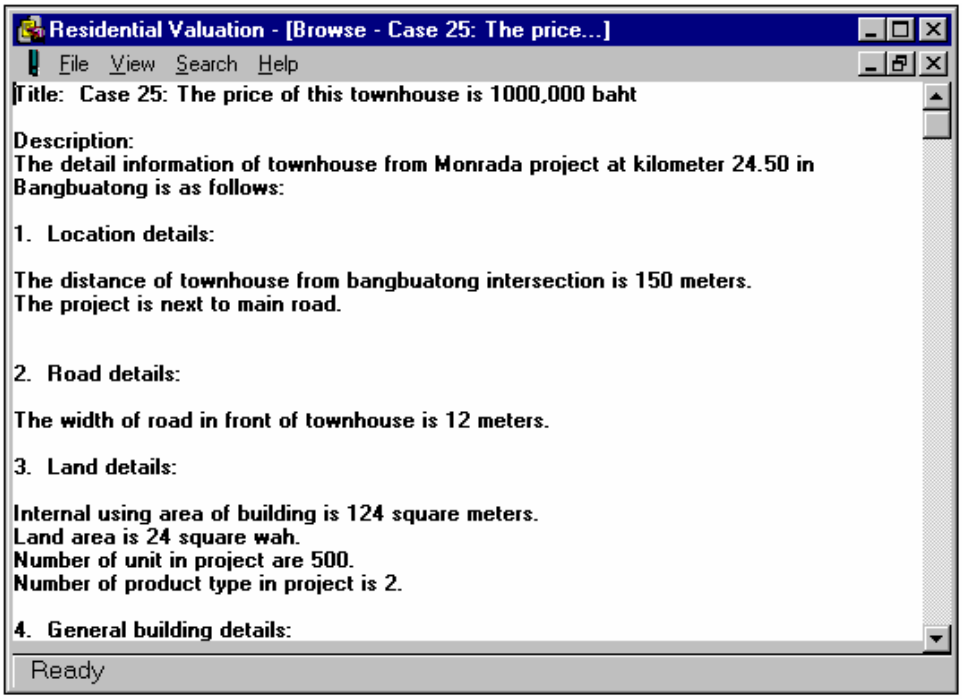


**Fig. 2.** The system's explanation for residential valuation

## Appendix C: Questionnaire

Please complete all the following questions by encircling the response which best represents **YOUR FEELINGS** to that statement.

**Part 1: Ease of use**

1.1 I find the system easy to use.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Strongly Agree | | | | | | Strongly Disagree |

1.2 Learning to operate the system is easy for me.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Strongly Agree | | | | | | Strongly Disagree |

1.3 It is easy for me to become skillful in using the system.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Strongly Agree | | | | | | Strongly Disagree |

**Part 2: Usefulness**

2.1 I find the system useful as a training device.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Strongly Agree | | | | | | Strongly Disagree |

2.2 I find the system useful as a decision aid.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Strongly Agree | | | | | | Strongly Disagree |

2.3 Using the system makes it easier to learn how to evaluate property.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Strongly Agree | | | | | | Strongly Disagree |

2.4 Using the system enhances my effectiveness on evaluating property.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Strongly Agree | | | | | | Strongly Disagree |

2.5 I would not recommend anyone to use the system as a training device.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Strongly Agree | | | | | | Strongly Disagree |

2.6 Using the system enables me to understand how to evaluate property more quickly.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Strongly Agree | | | | | | Strongly Disagree |

2.7 I do not find the system useful in learning how to evaluate property.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Strongly Agree | | | | | | Strongly Disagree |

**Part 3: Confidence in conclusion**

3.1 The cases' conclusions are reasonable.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Strongly Agree | | | | | | Strongly Disagree |

3.2 The system is reliable.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Strongly Agree | | | | | | Strongly Disagree |

3.3 The system helps me to find accurate answers to problems.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Strongly Agree | | | | | | Strongly Disagree |

**Part 4: Other comments**

Please write down any comments that you have in the space below.

_____
_____
_____
_____
_____
_____
_____
_____
_____

Thank you for your participation