HOUSE SELECTION VIA INTERNET BY CONSIDERING HOMEBUYERS’ RISK ATTITUDES

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Abstract

The widespread use of the Internet has significantly changed the behavior of homebuyers. Using information technology, homebuyers can rapidly find an appropriate house that meets their needs. Although online real estate agents can screen out first based on homebuyers’ requirements, however, most of current online housing systems are of limited abilities, particularly without considering homebuyers’ housing goals and risk attitudes. To increase effectiveness, online real estate agents should provide an efficient matching mechanism, personalized service and house ranking with the aim of increasing both buyers’ satisfaction and ideal rate. An efficient matching mechanism should provide an easy way for homebuyers to find a suitable house with consideration of their different housing philosophies and risk attitudes. In order to comprehend these ambiguous housing goals and risk attitudes, it is also indispensable to determine a satisfaction level for each fuzzy goal and constraint.

In this study, we propose fuzzy goal programming with an S-shaped utility function as a decision aid to help homebuyers choosing the preferred house via Internet. Homebuyers can specify their housing constraints with different priority levels and the thresholds for fuzzy search that can translate into standard query language for a regular relational database.

Keyword: Fuzzy Goal Programming, Utility Functions, Risk Attitude
1 INTRODUCTION

Many buyers’ experiences of using search tools through the Internet to find an appropriate house may be overwhelming (Apgar, 2009). This is due to the difficulty of evaluating the multitude of many factors, such as emotional priorities, financial situations and arbitrary preferences at the same time. To provide a successful “real estate” search, an efficient tool should provide different choices for homebuyers with different age, housing consideration and risk attitudes. Usually, risk tolerance increases with age when other variables are controlled (Wang and Hanna, 1997). Young buyers, who have less money, may be less risky by selecting an apartment. Middle-aged are risk lovers, with more money and more experience. Thus, they may choose bigger houses. With decreasing income, elders who are usually risk averters will choose houses with less risk such as countryside houses.

Most of online real estate agents, such as Yahoo Real Estate, provide a search tool with basic constraints that lists all candidate houses exactly matching buyers’ requirements from the database. Some potential candidates may have slight deviations from the target constraints but more preferred by homebuyers; however, the search tool excludes these houses. Because of multiple housing goals with different priorities for individual, it is a very complicate work for agents to comparing similar houses. In summary, we list some important concerns for online agents and homebuyers as follows: (1) Online real estate agents should provide a tool for homebuyers to prioritize the housing constraints. (2) Personalized service is an essential factor in increasing the competitiveness of online real estate agents (Hamilton and Selen, 2004). (3) Online real estate agents should match housing alternatives for buyers according to their housing philosophies and risk attitudes.

To the best of our knowledge, there is no single tool provided by real estate agents to handle all the above-mentioned problems. Therefore, in this paper, we try to develop a decision support aid to quantify ambiguous search criteria and rank the houses for buyers by considering these factors. Such a system also allows customers to specify the housing constraints with thresholds for fuzzy queries. All the constraints and fuzzy queries can be translated into a series of precise queries for a regular relational database.

2 HOUSING APPROACHES CLASSIFICATION

Bond et al. (2000) stated that the types of online property information provided by most online real estate agents include geographic region, asked price, neighborhood, structural features and a picture of the house. Real-time listings and virtual home tours make real estate websites rich in content and help homebuyers to be better informed throughout the search and purchase process (Kummerow and Lun, 2005). Because Internet can increase search intensity, prescreening capability allows homebuyers to discover and visit more appropriate properties in a short period (Zumpano et al., 2003). The current searching functions provided by the online real estate agents seem too simple to meet buyers’ preferences. In order to provide sufficient considerations for customers, this study collects important housing attributes from previous studies and interviews with ten house buyers and ten senior real estate agents in Taiwan. Some duplicate or irrelevant attributes are eliminated and the final selected list is depicted in Table 1.

<table>
<thead>
<tr>
<th>Housing attributes</th>
<th>Sub items of housing attributes</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housing Value</td>
<td>Price</td>
<td>Linberg et al., 1989; Michaelides, 2011</td>
</tr>
<tr>
<td></td>
<td>Owner’s estimate of annual housing value</td>
<td>Arimah, 1992</td>
</tr>
<tr>
<td>Structure Attributes</td>
<td>Lot size</td>
<td>Stull, 1970; King, 1976; Linberg et al., 1989</td>
</tr>
<tr>
<td></td>
<td>Prorated ground floor size</td>
<td>Arimah, 1992</td>
</tr>
<tr>
<td></td>
<td>Age of the house</td>
<td>Stull, 1970</td>
</tr>
<tr>
<td></td>
<td>Number of floors</td>
<td>Arimah, 1992</td>
</tr>
</tbody>
</table>
In order to elicit the important housing attributes for buyers, this study also constructs an analytical hierarchy process (AHP) (Saaty, 1980). The use of AHP is to provide solutions for decision problem in a multi-criteria environment (Forman and Gass, 2001). We invite twenty homebuyers to evaluate these housing attributes using an AHP questionnaire. The overall relative weights of attributes and sub-attributes, as shown in Table 2. As seen in this table, price is the most important consideration. The second important consideration is the lot size. In addition, distance to children’s schools and safety in the neighborhood are also important sub-attributes for housing choices.

### Table 1. Housing attributes

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Local weights</th>
<th>Sub-attributes</th>
<th>Local weights</th>
<th>Global weights</th>
<th>Priority order</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housing Value</td>
<td>0.23</td>
<td>Price</td>
<td>0.70</td>
<td>0.161</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Owner's estimate of annual housing value</td>
<td>0.30</td>
<td>0.069</td>
<td>8</td>
</tr>
<tr>
<td>Structure Attributes</td>
<td>0.22</td>
<td>Lot size</td>
<td>0.50</td>
<td>0.110</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of floors</td>
<td>0.10</td>
<td>0.022</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of rooms</td>
<td>0.40</td>
<td>0.088</td>
<td>5</td>
</tr>
<tr>
<td>Neighborhood Attributes</td>
<td>0.28</td>
<td>Pollution level</td>
<td>0.30</td>
<td>0.084</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Safety</td>
<td>0.32</td>
<td>0.090</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Landscaping</td>
<td>0.23</td>
<td>0.064</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recreational facilities in the neighborhood</td>
<td>0.15</td>
<td>0.042</td>
<td>11</td>
</tr>
<tr>
<td>Location Attributes</td>
<td>Distance to downtown</td>
<td>Distance to workplace</td>
<td>Average distance to children’s school</td>
<td>Public transportation</td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td>---------------------</td>
<td>----------------------</td>
<td>--------------------------------------</td>
<td>----------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.27</td>
<td>0.16</td>
<td>0.40</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.043</td>
<td>0.108</td>
<td>0.032</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>6</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Composite priority weights for attributes and sub-attributes

3 METHODOLOGY

In this paper, we propose a decision support system using fuzzy goal programming (FGP) method with an S-shaped utility function to help homebuyers searching house on Internet with consideration of their housing risk attitudes and satisfaction levels.

3.1 Goal programming (GP) and fuzzy goal programming (FGP)

The housing choice, which involves homebuyers’ heterogeneous preferences, is a typical multi-criteria and multi-objective decision-making problem. Buyers usually have different satisfaction levels for various housing criteria and often expect some conflicting housing goals, such as minimizing house price while maximizing lot size utility. In order to pursue aspirations-maximization, Charnes and Cooper (1961) proposed GP to model real world problems and it is especially useful for multi-criteria and multi-objective decisions. The mathematical formulation of GP is introduced as follows:

\[
\text{Minimize } \sum_{k=1}^{n} | f_k(X) - g_k |
\]

Subject to \( X \in F \), (\( F \) is a feasible set).

where \( f_k(X) \) is the function of the \( k \) th goal, and \( g_k \) is the aspiration level of the \( k \) th goal.

In order to solve the DM’s imprecise aspiration of goals, Narasinh (1980) utilized the fuzzy weights approach to describe linguistic priorities in the utility functions. The conventional form of FGP can be expressed as follows:

\[
\text{Minimize } \sum_{k=1}^{n} \max \{0, \min \{f_k(X) - g_k, 0\}\}
\]

Subject to \( X \in F \), (\( F \) is a feasible set)

where \( f_k(X) \) is the function of the \( k \) th fuzzy goal approximately greater or equal to (approximately less or equal to) the aspiration level \( g_k \); other variables are defined as in GP.

Fuzzy goals and fuzzy constraints can be defined as fuzzy sets in the space of alternatives (Bellman and Zadeh, 1970). For simplicity but without losing generality, the preference-based utility functions are expressed as follows:

\[
\mu_k(f_k(X)) = \begin{cases} 
1, & \text{if } f_k(X) \geq g_k, \\
\frac{(f_k(X) - l_k)}{g_k - l_k}, & \text{if } l_k < f_k(X) < g_k \quad \text{for } f_k(X) \geq g_k, \\
0, & \text{if } f_k(X) \leq l_k
\end{cases}
\]

where \( l_k \) and \( u_k \) are, respectively, lower and upper limits for the \( k \) th goal; \( f_k(X) \) and \( g_k \) are defined as in GP.

Other solutions include the weighted additive model, provided by Tiwari et al (1987), and the weighted max-min model, provided by Lin (2004). However, with a preemptive priority setting, unless a particular goal is achieved, the other goals should not be considered. The inexperienced
setting of weights in the formulation of GP can lead to incorrect results (Tamiz et al., 1998).


In order to handle DM’s fuzzy preferences, Fan et al. (2002) proposed a method to solve multiple attribute decision making (MADM) problems by considering the fuzzy relations of alternatives. Rasmy et al. (2002) established a fuzzy expert system based on DM’s linguistic preferences for multiple objective decision making (MODM) problems. Cheng et al. (2006) derived a fuzzy inference system as a negotiation agent to search for a mutually acceptable contract in e-market.

Chang (2010) presented an approach to formulate a S-shaped utility function without adding extra binary variables. The utility function describes the risk attitude of decision makers, including risk aversion and risk seeking. In order to comprehend the ambiguous housing goals and risk attitudes from conflicting preferences, it is indispensable to determine the satisfaction level for each fuzzy goal and constraint.

### 3.2 The proposed method

With the prospect theory (Kahneman and Tversky, 1979), we can find the varying risk attitudes of DMs in different situations. Homebuyers will exhibit more risk aversion in gain situations as a concave function. On the other hand, homebuyers will prefer to be risk lovers in loss situations as a convex function. Therefore, each homebuyer should have his/her own S-shape utility function for risk attitude. The combination of above discussion may lead to a more effective approach with many advantages. The proposed method can solve some or all shortcomings of each individual approach. Therefore, we integrate FGP with S-shaped utility function as a decision aid to help Internet housing choice as follows.

There are $K$ goals. For each goal with attributes $A_i$, $(A_i, \mu_{A_i})$, where $A_i$ represents the $j$th attribute of the $i$th house alternative, and $\mu_{A_i}$ is the utility function of the $j$th attribute for the $i$th house alternative. The average satisfaction level for the attribute $j$ is given as

$$
\mu_{\text{attribute}}(A V_j) = \frac{1}{K} \sum_{i=1}^{K} \mu_{A_i}(x)
$$

and the utility function of DM’s satisfaction level $\mu_{A_i}(x)$ is defined as in FGP method. This study formulates the buyer’s housing preference among house alternatives with Eq. (1).

This study constructs the aspiration-maximization of buyer’s housing goals with consideration of their risk attitude (Eqs. (2)-(6)), while meeting the buyer’s constraints in Eq. (7). To describe the risk attitudes of DMs, we use the approach of Chang (2010) to formulate the S-shaped utility function in Eqs. (2)-(6). There are two housing goals, the maximization of the expected gain and the minimization of the expected loss. With the slope increase/decrease, Eqs. (2)-(6) can formulate these two goals as a concave/convex function with homebuyers’ risk attributes (risk averter/lover) in different situations. Eq. (7) reflects homebuyers’ constraints, such as price, expected lot size and so on. Sometimes, a homebuyer cannot find a suitable house when too many constraints are requested. With Eqs. (7)-(8), a buyer can set preemptive priority for each constraint to obtain the best available housing options. This modified FGP will determine the most appropriate constraints and recommend a suitable ranking list. This leads to the following formulation:

**Minimize**

$$
\sum_{i=1}^{n} w_i p_i + w_i^2 p_i + w_i^3 p_i + \alpha_i (e_i^+ + e_i^-)
$$

**Subject to**
\begin{align}
\lambda_i &= [\mu_j(b_{i2}) - \mu_j(b_{i1})] \frac{p_{i1}}{b_{i2} - b_{i1}} + [\mu_j(b_{i3}) - \mu_j(b_{i2})] \frac{p_{i2}}{b_{i3} - b_{i2}} + [\mu_j(b_{i4}) - \mu_j(b_{i3})] \frac{p_{i3}}{b_{i4} - b_{i3}}, \\
\lambda_i - e_i^1 + e_i^2 &= 1, \\
Z_i(x) - p_{i1} - p_{i2} - p_{i3} &\leq b_{i1}, \\
w_i < w_i < w_i, \\
0 \leq p_{i1} \leq b_{i2} - b_{i1}, 0 \leq p_{i2} \leq b_{i3} - b_{i2}, 0 \leq p_{i3} \leq b_{i4} - b_{i3}, \\
\mu_{ij} x &\geq \mu_{attribute}(AV_j) P_r, r = 1,2,...m \\
\sum_{i=1}^{m} P_i &\geq B, \\
x &\in F \ (F \text{ is a feasible set}) \ i = 1,2,...n
\end{align}

In the proposed model, a DM can choose different weights \( w_{ij} \) on each deviation to determine the priority of deviations \( p_{ij} \). The risk attitudes of can be described as risk averse (a concave utility function) and risk seeking (a convex utility function). In this study, we formulate these two housing risk attitudes in gain and loss situation in Figures 1-6.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure1}
\caption{A concave utility function as a risk averter in gain situation}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure2}
\caption{A convex utility function as a risk lover in gain situation}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure3}
\caption{A concave utility function as a risk averter in loss situation}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure4}
\caption{A convex utility function as a risk lover in loss situation}
\end{figure}
Figures 1 and 3 present the concave utility function of a risk averter in gain and loss situations, respectively. As shown in Figures 1 and 3, the slope decreases from $S_{i1}, S_{i2}$ to $S_{i3}$. This means that with the increased risk of expected gain/loss $z_i(x)$, the average accumulated satisfaction level $\mu_y(z_i(x))$ of the decision maker decreases. The slope $S_{i1} > S_{i2} > S_{i3}$ indicates that the decision maker is a risk averter. Figures 2 and 4 show a convex utility function of a risk lover in gain and loss situations, respectively. From Figures 2 and 4, the slope increases from $[S_{i1}] < [S_{i2}] < [S_{i3}]$. This means that with the increased risk of expected gain/loss $z_i(x)$, the average accumulated satisfaction level $\mu_y(z_i(x))$ of the decision maker increases. The slope $[S_{i1}] < [S_{i2}] < [S_{i3}]$ shows that the decision maker is a risk lover.

This study formulates homebuyers’ risk attitudes in gain situations with a S-shaped utility function as shown in Figure 5. Where the average accumulated satisfaction level $\mu_y(z_i(x))$ is a convex function (risk lover) for $0 \leq z_i(x) \leq \beta_i$ and is a concave function (risk averter) for $z_i(x) \geq \beta_i$. Similarly, the homebuyer’s two risk attitudes in loss situations are formulated with the S-shaped utility function as shown in Figure 6. Where the average accumulated satisfaction level $\mu_y(z_i(x))$ is a concave function (risk averter) for $0 \leq z_i(x) \leq \beta_i$ and is a convex function (risk lover) for $z_i(x) \geq \beta_i$.

DMs can determine the housing constraints with different thresholds for fuzzy queries, and then these fuzzy queries will be translated into precise SQL for regular relational database as follows.

```
SELECT housing alternative
FROM housing table
WHERE Attribute at least /most WITH matching rate (fuzzy query)  (9)
Fuzzy query Eq.(9) can be substituted by precise query Eq.(10) while implementing in relational database.
WHERE A ≥ a  AND  A ≤ b  (precise query)  (10)
```

In short, the main contributions of proposed method are as follows.

1. Homebuyers can easily describe and quantify ambiguous housing preferences with fuzzy satisfaction levels. Moreover, online real estate agents can even convert this approach into a utility function.

2. DMs can decide suitable weights for their risk attitudes in different situations. To express the risk attitudes in different situations, they assign different expected gains or losses on individual house
alternatives. The proposed approach can transform these risk attitudes into weights for each target and present different housing ranks.

3. DMs can set preemptive priorities for each constraint in different situations.

4. The proposed approach can deal with fuzzy searches in related databases on Internet for buyers. In order to meet their constraints with linguistic quantifiers, this model evaluates the available houses by giving preferential weights according to these fuzzy satisfaction levels.

The approach starts from inputting the homebuyer’s preferences, goals and criteria, and developing a modified FGP model to obtain individual solution for each objective function as the following six steps: Step 1: Identify homebuyer’s housing goals with suitable risk attitude and roughly determine his/her housing criteria. Step 2: Define homebuyer’s satisfaction level for each housing goal and criterion. This process allows a homebuyer to develop the utility function for the fuzzy goals and ambiguous criteria. Step 3: Search for possible alternatives in database on Internet using the linguistic quantifiers such as “at least,” “at most,” or “about.” Step 4: Establish the FGP model with an S-shaped utility function, and aggregate all the homebuyer’s fuzzy goals and criteria. Step 5: Solve the FGP model with the S-shaped utility function, which evaluates each alternative according to homebuyers’ risk attitude and scoring attribute set by the fuzzy preferences. Step 6: Rank the house alternatives based on obtained scores, with which the customer can make the final choice of the utility-maximizing house.

4 CONCLUSIONS

A user-friendly interface of online search tool for house is the key to win consumers’ trust and preference. This study presents an integrated approach to support homebuyers on their online evaluation process. The proposed approach helps homebuyers in the following ways:

1. It screens available houses according to homebuyers’ risk attitudes in loss or gain situations. In this way, the proposed approach will maximize the sum of satisfaction levels with weighted goals.

2. It transforms homebuyers’ fuzzy satisfaction levels into a fixed form.

3. DMs can determine the appropriate constraints with different thresholds for fuzzy queries. This method evaluates the available houses by translating DM’s queries into precise queries of SQL.

4. Personalized ranking is provided by the proposed system. Homebuyers can adjust their fuzzy goals or set different preemptive priorities on each constraint with ease to derive the different ranking lists.

5. Available houses with some important advantages but slight deviations from the search specifications will not be retrieved by current systems, but can be found in the proposed system.

In the competitive market of real estate, it is important to provide a user-friendly interface for customers to input fuzzy criteria and then a ranking list based on buyers’ preferences and risk attitudes. In order to investigate customer satisfaction of the proposed decision aid system, a laboratory quasi-experiment will be implemented using Active Server Pages and an Access database to demonstrate the effectiveness of the proposed approach. The proposed approach can not only solve housing problem, but also can be implemented in many practical decision making problem.

References


