The System Parameter Fusion Principle and its Application to Evaluating the Level of Real Estate Enterprise Informatization

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Abstract: In this paper, the meaning of real estate enterprises informatization is discussed according to the current situation of evaluating real estate enterprises informatization in China. It puts forward the index system of real estate enterprise informatization, and presents a way to evaluate the level of real estate enterprises using the system parameter fusion principle.

Keywords: Data fusion, real estate enterprise, informatization, index system, evaluation

1. INTRODUCTION

Modern technology provides a great amount of information. It appears in various forms such as texts, graphics, images, and even sounds. This great amount of information in various forms will submerge useful data, which must be easy to process and present to human supervisors. In computer monitoring systems, especially real-time expert systems, we need one or two parameters to express the quality and/or security of the whole system. This paper presents a principle called System Parameter Fusion Principle for synthesizing system parameters from sensor or transducer data into a single parameter and shows its applications.

2. PRINCIPLE

Let \( M_i \) be the measurement value of the \( i \)th variable (\( i = 1, 2, ..., n \)), \( O_i \) the optimum of the \( i \)th variable, \( H_i \) the upper limit of the \( i \)th variable, \( L_i \) the lower limit of the \( i \)th variable, \( W_i \) the weight of the \( i \)th variable. \( W_i \) indicates the importance of this variable in the system,

\[
\sum_{i=1}^{n} W_i = 1. 
\]

The more important the variable in the system is, the greater value we ascribe to the \( W_i \).

There are two synthesized parameters, \( G \), which indicates the quality of the system, and \( S \), which indicates the security of the system.

\[
G = \sum_{i=1}^{n} W_i \cdot f(M_i) \quad (2)
\]

\[
S = \prod_{i=1}^{n} f(M_i)^{w_i} \quad (3a)
\]

i.e., \( \ln S = \sum_{i=1}^{n} W_i \cdot \ln f(M_i) \quad (3b)\)

In which, \( f(M_i) \) is the quality function, the value limits are from 0 to 1. \( f(M_i) \) can be the linear function of \( M_i \), or other quadratic function of \( M_i \). First this paper gives two simple forms:

(1) \( f(M_i) \) can be the simplest linear function of \( M_i \)

\[
f(M_i) = \begin{cases} 
\frac{M_i - L_i}{O_i - L_i} & \text{(if } L_i < M_i < O_i) \\
\frac{M_i - H_i}{O_i - H_i} & \text{(if } O_i < M_i < H_i) \\
0 & \text{(otherwise)} 
\end{cases} \quad (4)
\]

Figure 1 \( f(M_i) \) can be the simplest linear function of \( M_i \).
(2) \( f(M_i) \) can be the semicircular function of \( M_i \),

\[
f(M_i) = \begin{cases} 
1 & \text{if } L_i < M_i < O_i \\
1 - \left( \frac{M_i - O_i}{O_i - L_i} \right)^2 & \text{if } O_i < M_i < H_i \\
0 & \text{otherwise}
\end{cases}
\]  
(5)

If \( O_i - L_i = H_i - O_i \), then

\[
f(M_i) = \begin{cases} 
1 & \text{if } L_i < M_i < O_i \\
1 - \left( \frac{M_i - O_i}{O_i - L_i} \right)^2 & \text{if } O_i < M_i < H_i \\
0 & \text{otherwise}
\end{cases}
\]  
(6)

Figure 2 \( f(M_i) \) can be the semicircular function of \( M_i \)

The user may choose any kind of \( f(M_i) \), such as the S-curve quality function[1]. No matter what kind of functions \( f(M_i) \) is, when all the measurement values reach their optima, the quality of the system will be 1. If any of the measurement values exceeds its limits, the security of the system will be 0; the system should set an alarm and show which sensor is out of limits or in failure. The nearer the quality of the system reaches 1, the better the system. The nearer the security of the system reaches 0, the more dangerous the system. Some system should set an alarm when the security of the system approaches 0.

The idea of this principle was successfully applied in monitoring of an ultra-energy efficient house at Noble-Kirk farm in Canada[2] and other applications[3]. This paper presents its application to evaluating the level of real estate enterprise informatization.

3. APPLICATION TO EVALUATING THE LEVEL OF REAL ESTATE ENTERPRISE

3.1 Constitution of the Real Estate Enterprise

Informatization Index System

Enterprise informatization has become the basis of national economy informatization. The real estate industry, as one of the key industries of the national economy, has also become the key point of national economic development. The real estate enterprise informatization is the inevitable trend of its development. The degree of informatization of an enterprise will exert an extremely profound influence on aspects of the enterprise’s production, operation and management, etc. However, how to measure an enterprise’s degree of informatization cannot solely rely on subjective inference. It is necessary to have corresponding quantitative measurement and calculation, analysis and estimation. On the basis of these quantitative results, we judge and determine this enterprise’s degree of development of informatization, and establish the modes suitable for this enterprise’s informatization development.

Accurately and objectively evaluating the real estate informatization is one of the important tasks of informatization construction. Therefore, this must rely on the quantitative evaluation index system. As the informatization process involves many aspects, so it is necessary to establish a set of index system according to the enterprise’s characteristics, and from different planes and levels, to conduct objective and quantitative evaluation of informatization development and to quickly discover problems and adopt appropriate strategies and approaches, so as to ensure the realization of the informatization goal.

The key to making the results obtained from the real estate enterprise informatization level evaluation as close as possible to the actual situation lies in establishing a set of scientific, comprehensive and practical evaluation index systems. On the premise of guaranteeing the realization of the purpose and requirement of the combined evaluation, it is necessary to consider the following few aspects. First, the evaluation index system must be the aggregation able to reflect the evaluation subject’s characteristic factors, the
implication of each index should be clear, and no repetition between the indexes is allowed; Secondly, the index system should be able to comprehensively reflect the characteristics of the real estate company, with nothing left out; Thirdly, the evaluation index system should, on the scientific and reasonable premises, select suitable and not too complex levels and index quantities. Figure 3 shows an evaluation index system for the level of real estate enterprise informatization.

Figure 3 shows an evaluation index system for the level of real estate enterprise informatization

A detailed description of the indexes is as follows:

Index C₁ Computer Hardware Level: refers to the proportion of the number of computers of all types that the enterprise possesses to the total number of its staff, the quality of the equipment, and the utility situation embodying the enterprise’s informatization equipment. This index may be divided into three grades: 3 points for grade 1; 2 points for grade 2, 0 points for grade 3.

Index C₂ Computer Software Level: The quantity and utilization of software of all kinds used for real estate development, management and marketing aspects that the enterprise purchases or develops on its own. This index can be divided into three grades: 3 points for grade 1; 2 points for grade 2; 0 points for grade 3.

Index C₃ Enterprise Network Scale: The proportion of the total number of computers on the intranet established by the enterprise to its total number of computers. This index may be divided into three grades: 2 points for grade 1, 1 point for grade 2, 0 points for grade 3.

Index C₄ Enterprise Network Performance: Combined evaluation of this index should be conducted based on indexes of the intranet’s bandwidth, server capacity, speed and safety, etc. This index can be divided into three grades: 2 points for grade 1, 1 point for grade 2, 0 points for grade 3.

Index C₅ Enterprise Website Construction Level: Evaluation of this index should be conducted based on the browse quantity and content of the websites established by the real estate enterprise on its own. Its content should include the real estate enterprise’s self-image publicity, the enterprise’s latest developments and news, sales inquiry, intermediary information and information about real estate management, etc. This index can be divided into three grades: 4 points for grade 1, having plenty of all types of real estate information, strong prestige, quick updating speed, and good interface; 2 points for grade 2, having a certain amount of real estate information, ordinary prestige, a certain time lag in updating; 0 points for grade 3, at this grade, the amount of information is small, the web page construction is simple, and web sites lack necessary maintenance.

Index C₆ Development Process Utility Level: refers to the utilization of the automatic equipment in the course of real estate development. This index can be divided into three grades: 3 points for grade 1, 2 points for grade 2, 0 points for grade 3.
Index C7 Transaction Process Utility Level: refers to the utilization of computers in the course of transaction. For instance, conduct combined evaluation of the enterprise’s on-line transaction, on-line intermediary service, transfer and the enterprise’s electronic business development. This index can be divided into three grades: 3 points for grade 1, 2 points for grade 2, 0 points for grade 3.

Index C8 The Level of Contribution of Information Technology to Economic Results: This index indicates the proportion of the increased economic results that the enterprise is able to achieve by making use of information technology in the enterprise’s overall profit. The increased economic results can be obtained by adopting Formula (7):

\[ E_i = [(I_x - I_0) + (C_o - C_x)]S - KR \] (7)

where: \( E_i \) is the economic results after adopting information technology, \( I_x \) is the income after adopting unit information technology.

\( I_0 \) is the income before adopting unit information technology, \( C_o \) is the cost of the original technical mode.

\( C_x \) is the cost of unit information technical mode, \( S \) is the cumulative amount for extension of information technology.

\( R \) is the research and development costs, \( K \) is the standard scientific and technological results coefficient (Take 0.15)

For example, a certain real estate company develops the intelligent housing. Its price of each m² is 200 yuan higher than the selling price of ordinary housing, its corresponding combined cost also increases by 50 yuan. If 10,000 m² of this intelligent housing is sold, and the research and development fund is 1,000,000 yuan, then there will be:

\[
(200-50) \times 10000-0.15 \times 1000000=1350000 \text{ yuan.}
\]

This index can be divided into five grades: 5 points for grade 1, accounting for over 40% of the overall profit; 3 points for grade 2, accounting for over 25% of the overall profit; 2 points for grade 3, accounting for over 10% of the overall profit; 1 point for grade 4, accounting for less than 10% of the overall profit; 0 points for grade 5, having no contribution.

Index C9 Management Informatization Level: To be divided into four grades based on the actual situation. 7 points for grade 1, on the basis of realizing ERP, comprehensively realizing the enterprise supply chain management, client relationship management, completely realizing the intelligent management; 5 points for grade 2, realizing the enterprise network-based comprehensive management; 3 points for grade 3, initially realizing the enterprise office work automation system and financial affairs management system; 0 points for grade 4, not adopting information technology.

Index C10 Management Control Level: This index mainly reflects the degrees of network and integration in the enterprise’s operation process. It can be divided into four grades: 5 points for grade 1, the management control is highly integrated, the enterprise is internally integrated and the enterprise’s internal groups are integrated with external enterprises. 3 points for grade 2, the management and control information realize the process integration, data integration and network integration; 2 points for grade 3, the management and control information realize the information integration; 0 points for grade 4, the enterprise management information and control information do not have any integration.

Index C11 Enterprise Leadership and Information Persons in Charge (CIO) Level: refers to the degree to which the enterprise leadership attaches importance to informatization. This index can be divided into four grades: 3 points for grade 1, attaching the greatest importance to informatization, staffing a full-time information department and persons in charge; 2 points for grade 2, attaching fairly great importance to informatization, having an information department and concurrent person in charge; 1 point for grade 3, attaching insufficient importance to informatization, but having a department concurrently in charge of the functions of the information department; 0 points for grade 4, attaching no importance, not having an information department.
3.2 Evaluation Method of Real Estate Enterprise Informatization

3.2.1 Determination of the weights

The index weight refers to the numerical indication of the relative importance of each index in the whole system. Whether the weight determination is reasonable or not will exert a decisive influence on the combined evaluation results and evaluation quality. Since the index system of real estate enterprise informatization evaluation is comparatively large, so the level analysis method (AHP) is often adopted to determine the weight of each index.

(1) Determination of the guideline level

The weight of the sub-target level is determined by adopting the expert opinion method, i.e. inviting a few experts to complete the weight survey form independently. After the forms are collected, overall sorting is made, and the statistical results are returned to the individual experts, asking them to state reasons and give corresponding weights. After three rounds of investigations are made of the fifteen experts, the weights obtained are 0.2, 0.3, 0.3, and 0.2.

(2) Determination of the index level

The index level weight adopts the improved AHP method, i.e. first, establish the judgment matrix, compare each pair of the indexes in the sub-target level and give the judgment value based on the three scales of 0, 1, 2 according to the degree of relative importance, thus obtaining the initial judgment matrix. Calculate the collating index of all the index importance degrees.

Translate the three scales’ initial judgment matrixes into formal judgment matrixes, then use the root method to conduct computation and pass the consistency check, it is possible to obtain the weights of C1-C5: 0.15, 0.16, 0.25, 0.21, 0.23, the weights of the corresponding C6-C8 are: 0.2, 0.4, 0.4, the weights of C9-C10 are 0.5, 0.5, the weights of C11-C13 are: 0.25, 0.35, 0.4.

3.2.2 Method of the combined evaluation

Based on the System Parameter Fusion Principle, we can consider 13 indexes in the system as 13 parameters. First, we calculate the weight W_i. W_i are the product of the weight of the guideline level and its weight of the correspondent index level. We use the S-curve quality function as f(M) shown as figure 4 [1].

\[ f(M) = \begin{cases} 
0 & \text{for } M < a \\
\frac{2}{(c-a)} \left( M - a \right)^2 & \text{for } a \leq M \leq b \\
1 - \frac{2}{(c-a)} \left( M - c \right)^2 & \text{for } b \leq M \leq c \\
1 & \text{for } M > c 
\end{cases} \]

Figure 4  \( f(M) \) can be the S-curve function of \( M \).

Here, when \( M \geq c \), the \( i^{th} \) variable reaches the optimum,
$a = L_i$, the lower limit of the $i^{th}$ variable. $b$ is between $a$ and $c$, $b = (a + c)/2$.

If $n$ experts take part in the evaluation, every expert gives a $M$. For every $M$, we can use equation (8) to calculate $f(M)$.

$$f(M_i) = \frac{\sum_{j=1}^{n} f(M_{ij})}{n} \quad (i=1,2,\ldots,n) \quad (9)$$

Then

$$S = \sum_{i=1}^{m} W_i \cdot f(M_i) \quad (i=1,2,\ldots,m) \quad (10)$$

Here, $S$ is the enterprise informatization overall level, $W_i$ is the weight, $n$ is the number of experts and $m$ is the number of indexes.

### 3.3 Real Example Research

#### 3.3.1 Evaluation of the informatization level of a certain real estate development enterprise

We now conduct a combined evaluation by taking as example the Suzhou XG Construction Group Co., Ltd. This company is a state-owned real estate development grade 1 qualification enterprise with 248,500,000 yuan of registered capital, and has passed the ISO 9002 International Quality System Certification. It has been rated as a municipal level and provincial level civilized unit for four consecutive years, and has been given the titles of the commodity housing combined quality trustworthy unit and the advanced unit of Construction Ministry’s national construction management project, meanwhile it has been rated on the enterprise financial standing grade as AAA grade by Jiangsu Province International Counseling and Evaluation Company.

By the end of 2001, it has developed and constructed a total of 2,400,000 $m^2$ of houses of various types, with the project compliance rate at 100%, the excellence rate at 60%. The real estate area under its management amounts to 2,000,000 $m^2$.

Early in 2001, an expert team (consisting of 15 persons) was set up to conduct the combined evaluation of this company. The results are collected, and having undergone statistical sorting, are as shown in Table 1.

<table>
<thead>
<tr>
<th>index</th>
<th>$C_1$</th>
<th>$C_2$</th>
<th>$C_3$</th>
<th>$C_4$</th>
<th>$C_5$</th>
<th>$C_6$</th>
<th>$C_7$</th>
</tr>
</thead>
<tbody>
<tr>
<td>average</td>
<td>0.94</td>
<td>0.77</td>
<td>1</td>
<td>0.87</td>
<td>0.37</td>
<td>0.84</td>
<td>0.84</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>index</th>
<th>$C_8$</th>
<th>$C_9$</th>
<th>$C_{10}$</th>
<th>$C_{11}$</th>
<th>$C_{12}$</th>
<th>$C_{13}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>average</td>
<td>0.32</td>
<td>0.37</td>
<td>0.56</td>
<td>0.79</td>
<td>0.81</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 1 Itemized Results of Experts Evaluation

Based on equation (10), we can get the overall level of enterprise informatization overall level for Suzhou XG Construction Group Co., Ltd. is 0.66, i.e. 66 points.

#### 3.3.2 Supplementary explanation

This real research example only shows one state of this enterprise’s level of informatization. If it is intended to show the position the enterprise has in the overall informatization level of the local enterprises, it is necessary to conduct combined testing of the informatization level of all the local enterprises. According to the combined testing of the informatization level of twenty real estate enterprises in Suzhou, Jiangsu, China conducted by this expert team, the informatization level standard score of real estate enterprises in Suzhou is 52 points on the average. It can be seen that Suzhou XG Construction Group Co., Ltd. is at a fairly high level against the local informatization level.

### REFERENCES

