Establishment of Multi-granularity Three-way Decision Model Based on the Minimization of Financial Risk

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Abstract. To reduce the decision risk from direct acceptance or rejection in the traditional two-way decision, the multi-granularity space of the problem decision is analyzed, and the multi-granularity three-way decision model based on the minimization of financial risk is studied in this paper. Based on the cost analysis of the three-way decision, to identify the optimal granularity space, the characteristics of different decision weights that various attributes have in the granularity space are combined to identify the decision action with the minimum risk from multiple different levels of granularity with the importance and decision weight of granulation as the heuristic information. Finally, to address some practical problems that require an urgent decision in the uncommitted options, the two-way decision transformation method based on risk control is provided and applied to the practical instance.

Keywords: Risk Minimization, Granulation, Multi-granularity Space, Optimal Decision

1. Introduction

With the rapid development of the Internet, communication technology, and cloud computing technology, the information society has entered the era of big data. As big data often presents the characteristics of large-scale, multimodal, and rapid growth, traditional data analysis theories, methods, and technologies face tremendous challenges in the effective mining, processing, and decision of massive information, such as computability [1], effectiveness, and timeliness. In the traditional two-tier decision, there are only two options: accept or reject, yes or no, but when solving many practical problems[2,3], they are forced to accept or reject decisions, which can incur unnecessary costs or lead to severe consequences. For example, when the effective information or evidence obtained is insufficient, it is not appropriate to judge whether a suspicious face image is a thief or a company employee in the surveillance video, that is, the risk of accepting or rejecting is greater than that of not deciding. To make a better and less risky decision, we introduced the three-way decision...
Theories are introduced into the decision information system. That is to say, when the decision cannot be made accurately, the uncommitted option will be chosen. The introduction and development of the three decision theories have attracted extensive attention in the field of intelligent information processing and decision. Currently, they have been widely used in medical diagnosis, oil exploration, face recognition, financial investment and other fields. In uncommitted decision, with the collection and update of decision information, the accurate decision is possible. The decision process is regarded as the transformation from coarse-grained to fine-grained. Multi-granularity decision rough set theory derives multiple granular spaces through multiple binary relations for modeling, from which useful knowledge can be mined and an effective decision can be formed. In recent years, multi-granularity rough set theory has been continuously improved and effectively applied. In this regard, the three-way decision methods of multi-granularity space analysis to minimize risk.

2. Three-way decision theories

When the traditional two-way decision faces some practical problems, such as being unable to make an accurate decision due to the influence of factors such as insufficient information and evidence, etc., forcing to accept or reject the decision will bring a certain risk of a wrong decision, and may also pay some unnecessary costs or consequences. The three-way decision is the introduction of the uncommitted option in the traditional two-way decision, i.e., when facing some problems that cannot be accurately decided, the decision can be postponed until sufficient decision information is collected, so as to reduce the risk or cost of a direct decision. In practical application, the three decision methods are more in line with the principle of minimum decision cost.

$\lambda_{pp}$, $\lambda_{BP}$, $\lambda_{NP}$ represent the value of risks corresponding to three decisions of $a_p, a_B, a_N$ when $x$ truly belongs to $X$; $\lambda_{PN}$, $\lambda_{BN}$, $\lambda_{NN}$ represent the value of risks corresponding to three decisions of $a_p, a_B, a_N$ when $x$ truly belongs to $-X$, and the corresponding decision cost matrix is as follows:

$$M_C = \begin{bmatrix} \lambda_{pp} & \lambda_{BP} & \lambda_{NP} \\ \lambda_{PN} & \lambda_{BN} & \lambda_{NN} \end{bmatrix}. \quad (1)$$

In the actual decision, the cost risk of correct decision $\lambda_{pp} = \lambda_{NN} = 0$. Hence, the simplified decision matrix can be obtained as follows:

$$M_C = \begin{bmatrix} 0 & \lambda_{BP} & \lambda_{NP} \\ \lambda_{PN} & \lambda_{BN} & 0 \end{bmatrix}. \quad (2)$$

According to the Bayes minimum risk decision theory and the simplified cost matrix, the Conduct $a_p, a_B, a_N$ the expected risk cost of three decision behaviors is $R\left(a_p, [x]_S\right)$:

$$R\left(a_p, [x]_S\right) = \lambda_{pp}P\left(X [x]_S\right) + \lambda_{PN}P\left(-X [x]_S\right) = \lambda_{PN}P\left(-X [x]_S\right) \quad (3)$$

3. Multi-granularity Three-wat Decision
Generally, when people analyze and make decisions on problems, they mainly start from the global and local aspects, that is, from different granularity levels, they decompose complex problems into several subproblems and simplify the solution of complex problems through the methods of subproblem analysis and solution, correlation analysis among subproblems, etc. In the process of problem analysis and solution, people can build a multi-granularity analysis model from different granularity or through the transformation of multi-granularity levels. In the three decision methods, when the decision information is insufficient, the complete information of accurate decision cannot be obtained. The decision-maker needs to further improve the decision information to make the next accurate decision possible, For example, in face recognition, it is found that the target image obtained by people gradually reduces with the distance between the lens and the image, making the information from the coarse-grained to the fine-grained, that is to say, the target can be distinguished clearly from the outline of an image, In the face of coarse-grained image, the decision of the image can be temporarily included in the decision ranks of the boundary domain, and the lens can be gradually turned to the boundary domain. In the process of collecting more fine-grained information, the face features are gradually clear until it is accurately recognized and the decision results are obtained.

Currently, in the research of multi-granularity space analysis, the number of granulation of different attribute characteristics to the universe is mainly considered, while the dominant weight of the decision is less considered by different granulation degrees. However, in the actual problem analysis and decision, the importance of different granularity or different feature attributes to the decision is not the same. For example, in medical diagnosis, According to the main characteristics of patients, such as sudden onset, fever, bleeding, bone, and joint diseases, doctors diagnose whether patients have leukemia. However, in the actual diagnosis, doctors often determine bleeding, hepatosplenomegaly, and other important decision weight in leukemia diagnosis according to clinical experience and disease incidence.

In the real world, the information system acquired by people often has the characteristics of uncertainty, incompleteness, and redundancy. Under different granularity spaces, the description of the information systems, the mining of valid data, or decision is usually different. Therefore, in the decision process, different granularity spaces can be analyzed and appropriate granularity levels can be selected to minimize the risk cost of decision actions.

According to the condition attribute set, starting from the multi-granularity space, increasing the granularity level until the granularity of N layers, the granularity matrix under the multi-layer granularity corresponding to Table 1 can be obtained, as shown in Table 2

| Table 1. Decision information under granular representation |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| U               | a1             | a2             | ...            | an             | d               |
| x1              | a1v11          | a2v21          | ...            | anvni          | Ci1d1          |
| x2              | a1v12          | a2v22          | ...            | anvni          | Ci2d2          |
| ...             | ...            | ...            | ...            | ...            | ...            |
| xi              | a1v1i          | a2v2i          | ...            | anvni          | Cid1          |
| ...             | ...            | ...            | ...            | ...            | ...            |
| xmn             | a1v1mn         | a2v2mn         | ...            | anvmn          | Cidm          |
Table 2. Granularity matrix

| granularity | Semantic representation of granular logic | Granularity representation |
|-------------|------------------------------------------|-----------------------------|
| 1           | \( a_1v_1 \)                              | \( m(a_1v_1) \)             |
| 2           | \( a_1v_1a_2v_2 \)                         | \( m(a_1v_1a_2v_2) \)       |
| \( i \)     | \( \vdots \)                              | \( \vdots \)               |
| \( j \)     | \( a_1v_1a_2v_2\ldots a_jv_j \)           | \( m(a_1v_1a_2v_2\ldots a_jv_j) \) |
| \( \vdots \) | \( \vdots \)                              | \( \vdots \)               |
| \( n \)     | \( a_1v_1a_2v_2\ldots a_nv_n \)           | \( m(a_1v_1a_2v_2\ldots a_nv_n) \) |

In multi-granularity and three branch decision, usually in the face of some urgent decision problems, delayed decision may also bring some risks. For example, in the case of acute disease diagnosis and treatment or stock decision selection, which needs immediate decision, delayed decision may need to bear the risk of not making decision processing temporarily, which will often affect the treatment of disease or miss good stock decision. In the above situation, it is necessary to analyze the risk of delayed decision.

4. Multi-granularity three-way decision based on the minimization of financial risk

Combined with the multi-granularity and three-way decision model based on the minimization of financial risk, the multi-granularity and three-way decision mainly include two stages: multi-granularity analysis and three-way decision. According to the decision problem, we start from a single knowledge granularity level, take the decision weight as heuristic information, seek the optimal granularity level to minimize the risk of decision activities, and the decision action mainly includes accepting decision, rejecting decision and not Commitment decision. However, in the real world, in the face of some urgent decision problems, if the decision is not committed, it may miss the best period of decision. Therefore, in the multi-granularity three-way decision based on the financial risk minimization processing, the decision transition stage is added. By analyzing the factors such as decision over time, decision granularity change, etc., the minimum risk is finally selected as the decision granularity.

Mr. Zhang and Mr. Wang plan to purchase one set of facade rooms in the downtown business district, with the unit price of 22000 yuan / m² and the area of 50m². They plan to lease the facade room they are expected to purchase. Currently, their available capital is 400000 yuan, and their total monthly economic income is 1000 yuan. Please give specific investment decisions according to their purchasing ability and economic income.

According to the current purchasing capacity and the total amount of houses, the current purchase details are calculated according to the equal principal and interest repayment method (240 months) in the form of housing commercial loans as shown in Table 3

Table 3. House purchase details

| Purchase list     | Price / 10000 yuan |
|-------------------|--------------------|
| Total housing     | 110                |
| Existing funds    | 40                 |
| Total interest    | 39.9466            |
| Total repayment   | 109.9466           |
| Monthly amount    | 0.4581             |
The attribute set \( s \) involved in house purchase includes total loan amount (characteristic a), repayment situation (characteristic B), house service life (characteristic C), expected lease price fluctuation (characteristic d), lease life (characteristic E) and change of lease market (characteristic f).

This paper analyzes the risk cost of multi-granularity decision, in which \( X \) refers to the house purchase event of Mr. Zhang and Mr. Wang, DC = \{buy, not buy, delay decision\}. Combined with the market situation of the business district, determine the minimum risk cost threshold pair \((α = 0.6, β = 0.2)\). If the decision to buy a house has a small impact on economic life, the expected income can be obtained. If the risk cost threshold, the decision to buy a house has an enormous effect on economic growth, the income may be temporarily not visible or the income is tiny, The choice is between buying and not buying, waiting for further decision.

However, due to the uncertain factors such as market situation, rental price and customer's purchasing power of the commercial street, if the house is not purchased temporarily, the house may have been sold when it is ready for acceptance or decision, and the rental price or house price of the house has an upward trend, then the suspension decision of Mr. Wang and Mr. Zhang may miss the opportunity of investment income, To minimize the risk cost of decision, it is analyzed that the main factors that affect the risk cost in the delayed decision state are: the expected rental price is 100 yuan/m\(^2\), the lease life is more than 3 years each time, the commercial street rental market meets the non-decreasing trend, the bank interest rate may decline, there is a certain repayment pressure, and the house price may rise.

5. Conclusions

The uncommitted options are introduced into the traditional two-way decision to avoid the cost or consequence of forced decision when an accurate decision cannot be made. Given that different granularity has various decision leading information, the granulation of knowledge is analyzed based on the decision information table. The number and weight of granulation decisions are taken as the main indexes, and conversion among different granularity levels is performed to identify the optimal granularity space. To minimize the cost of decision risk, the risk control and multi-granularity three-way decision method are discussed, which has provided a new research perspective for the decision of practical problems and the handling of risks.

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