ProjectNavigator: A Software Project Management Approach Selection Assistant

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***Abstract*—In software projects, project management approaches are crucial. Selecting a suitable management approach based on the specific project characteristics becomes the key to the success of the project. However, software projects are becoming more and more complex, and project managers tend to rely on subjective judgment to select the project management approaches. At present, project managers lack a systematic method or tool that can help them quickly and accurately select the most suitable project management approach to reduce project risks and improve the success rate. The objective of this research is to propose a tool to assist project managers in selecting the most suitable project management approach based on the specific project characteristics. This research will collect and analyze existing project management approaches and their applicable scenarios to extract relevant influencing factors. Then, a recommendation tool is developed to compare and recommend the most suitable project management approach. Finally, the usability and effectiveness of the tool will be validated through expert evaluation and usability testing. Through this tool, project managers can quickly analyze and compare the suitability of different management approaches and obtain specific guidance and suggestions, significantly improving the success rate of projects.**

Keywords*—Software projects; project management; recommendation tool; expert evaluation; usability testing

I. Introduction

With the rapid development of the software industry and rising project complexity, software projects are facing increasing challenges. Different project types and environmental characteristics make it particularly critical to select suitable project management approaches [1]. The most widely used project management approaches are waterfall, agile, and hybrid. Each approach has its unique advantages and limitations. The waterfall approach is known for its structured and phased process, which is suitable for projects with clear and stable requirements, but it has significant limitations in the rapidly changing software development environment [2]. In contrast, the agile approach performs well in projects with frequently changing requirements through iterative development and flexibility, but it may also lead to scope creep and insufficient resource management [3]. In recent years, the hybrid approach has gradually emerged. It combines the planning of waterfall and the flexibility of agile, providing potential solutions for complex projects, but also increasing the complexity of project management [4].

The main challenge for project managers is selecting a suitable management approach that matches project characteristics. Currently, they often rely on subjective judgment, which increases the risk of decision-making [5]. Therefore, they need a tool to assist them in selecting a suitable management approach. However, the existing studies mainly focus on the theoretical analysis of the three approaches and their scenarios or generate recommendation results through static tables [6]. These studies usually have limited analytical dimensions and lack user-friendly tool support, which makes it difficult to meet the needs of comprehensive evaluation for project management approaches.

To address the gap, this study aims to develop a decision-making tool combining comprehensive characteristic analysis and graphical results display. The tool provides intuitive, efficient, and practical support for project managers. It can capture the project characteristics provided by users and combine them with the weight calculation model to generate the recommendation result through a user-friendly interface.

This study focuses on the selection of management approaches for software development projects, specifically waterfall, agile, and hybrid. The target users are project managers and team leaders. To ensure the effectiveness and usability of the tool, this study will validate the tool through expert evaluation and usability testing.

The organization of the paper is as follows. A review of the literature on project management approaches and the key factors influencing approach selection is presented in Section II. Building on the review, Section III introduces the methodology. The results of the evaluation and discussion are given in Sections IV and V, respectively. Finally, Section VI concludes the study and outlines future work.

II. Literature Review

A. Approach and Methodology

In project management, approach and methodology there are two different concepts. The approach is a high-level guidance framework that defines the basic principles and directions of project management. In contrast, the methodology provides specific operational guidance, such as scrum and Kanban. According to Gemino et al. [7], the approach provides strategic guidance on “what to do”, while methodology focuses on the specific implementation of “how to do”. This distinction lays a theoretical foundation for the development of the project management tool in this research. The approach is the primary focus of this research, leaving the specific methodology outside its scope.

B. Waterfall, Agile, and Hybrid Approaches

The waterfall approach is linear and sequential, including five stages: requirements, design, implementation, testing, and maintenance. This approach is particularly suitable for projects with clear requirements and few changes during the project, as it emphasizes detailed planning and thorough documentation. By defining clear stages and verification processes, this approach reduces the project uncertainty. However, it lacks the flexibility to handle changing requirements effectively [8].

The agile approach emerged in the mid-1990s, aiming to solve flexibility and adaptability problems. This approach adopts the iterative development mode, delivering product increments in each iteration of the development process. This ensures timely feedback and rapid adaptation to changing requirements [9]. However, its low reliance on documentation increases the need for effective communication, while its high demand for team autonomy can lead to coordination challenges and scope creep [2].

The hybrid approach combines the advantages of waterfall and agile approaches, avoiding their limitations. The hybrid approach aims to balance flexibility and structure. It ensures stability in project planning while adapting to changes [10]. However, implementing a hybrid approach requires that the team has a comprehensive knowledge of multiple approaches. This understanding is essential to effectively integrate their strengths to achieve project objectives [11].

C. Factors Influencing Approach Selection

The selection of a suitable project management approach depends on multiple contextual factors. To understand which factors are most influential, this study conducted a literature review of 20 recent studies that analyzed or discussed the selection of agile, waterfall, or hybrid approaches. While all 20 studies were reviewed to extract key influencing factors, several representative works are highlighted here to illustrate how these factors affect approach selection.

Thesing et al. [6] proposed a decision model for project management methodology selection, categorizing and summarizing factors around project constraints, time and budget, organizational culture, and team characteristics. In terms of project constraints, projects with high requirement stability and high complexity are suitable for the waterfall approach. The project can be controlled through detailed document management and phasing. In time-sensitive projects, the agile approach performs well with rapid delivery of minimum viable products and a high frequency of customer feedback. Regarding budgeting, the waterfall approach emphasizes detailed cost estimation for projects with fixed costs. Regarding organizational culture, organizations with centralized decision-making and hierarchical management tend to adopt the waterfall approach. In addition, for team characteristics, small teams are easier to implement the agile approach, while large or distributed teams usually rely on the structured management of the waterfall approach.

Ly et al. [12] conducted a detailed analysis of the communication styles in the agile and waterfall approaches, identifying the differences in communication tools and communication channels. The waterfall approach relies on formal communication channels to complete task allocation and progress tracking through structured and standardized tools. For example, the team uses InSite system for task management and issue recording to ensure the traceability of project process and the controllability of plan. In contrast, the agile approach emphasizes more informal communication channels during execution-monitoring-control phase, where 90% of the communication is done through Microsoft Teams and only 10% relies on oral communication. The team can share dynamic information through real-time communication tools and promote task adjustment and feedback cycle. This effectively supports the applicability of the agile approach in the environment with frequently changing requirements and high levels of uncertainty.

The selection of a project management approach is influenced by multi-dimensional factors, including key business drivers, time and resource constraints, stakeholder needs and participation, project risk management, project complexity, and project size and cost [13]. These factors provide a decision-making framework for the evaluation and selection of project approaches. In addition, the hybrid approach shows high adaptability in projects with stable and dynamic requirements, especially for projects with high complexity. The hybrid approach can achieve a balance between structural management and dynamic adjustment, optimize resource allocation and risk management, and is particularly suitable for project environments that cannot be handled by a single approach. In practice, the successful application of the hybrid approach is directly related to the experience of project managers and requires that they dynamically customize and apply specific approaches and tools for each project [14].

Cruz et al. [15] conducted a systematic review of 80 studies comparing waterfall, agile, and lean project management approaches. The study highlighted that the waterfall approach is more suitable for well-defined projects with stable requirements, while agile approach is more adaptable to complexity, technological uncertainty, and frequent delivery. In addition, the study identified that factors such as stakeholder participation, team configuration, and organizational culture play important roles in determining approach suitability.

To provide an overview, Table I summarizes the key influencing factors and their frequency across the 20 studies.

TABLE I FACTORS INFLUENCING PROJECT MANAGEMENT APPROACH

Factors	References																				Frequency
	[7]	[8]	[9]	[2]	[11]	[6]	[12]	[17]	[13]	[14]	[18]	[19]	[20]	[16]	[21]	[15]	[22]	[23]	[24]	[25]	
Requirement Stability	√	√	√	√	√	√	√	√	√	√	√		√	√	√	√	√	√	√	√	19
Complexity	√		√	√	√	√	√	√	√	√	√	√		√	√	√		√	√		17
Time Constraints	√	√	√	√	√	√		√	√		√		√		√						11
Budget Constraints	√	√	√	√	√	√			√		√				√						9
Organizational Culture			√		√	√		√	√	√	√						√	√	√	√	11
Team Characteristics	√	√	√		√	√	√	√	√		√		√		√	√	√	√	√	√	16
Communication Tools							√														1
Stakeholder Participation	√		√	√		√		√	√		√			√	√	√	√	√			12
Business Drivers			√	√		√			√												4
Manager Experience										√	√										2
Contract Type		√									√										2
Innovation Level		√						√	√	√	√	√									6
Technological Uncertainty			√					√		√		√		√	√				√	√	8
Delivery Frequency		√		√	√	√		√		√	√		√		√	√	√	√		√	13
Regulatory Constraints			√	√					√	√	√									√	6

III. METHODOLOGY

A. *Identification of Key Factors*

To identify the key factors influencing project management approach selection, this study reviewed 20 recent studies. Based on their frequency in Table I, the top 12 most frequently mentioned factors are selected for further analysis and modeling.

B. *Construction of the Analytic Hierarchy Process (AHP) Model*

AHP is a method for making decisions with multiple criteria. It uses pairwise comparisons to assign weights to each criterion and builds a hierarchy to support decision-making. This makes it useful for selection in complex situations (Amponsah & Amponsah, 2020). In this study, a four-level AHP-based model is developed. It is based on multiple influencing factors and is structured into four levels, as illustrated in Fig. 1:

1) Goal level: Defines the decision objective, which is to select the most suitable project management approach.

2) Category level: Groups the influencing factors into three categories: project-related, organizational, and team-related.

3) Criteria level: Includes the top 12 key influencing factors identified from Table I.

4) Alternative level: Represents the three project management options: waterfall, agile, and hybrid approaches.

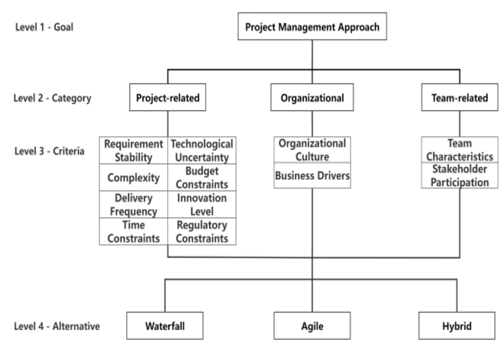

Fig. 1. AHP-based hierarchical model.

C. *Pairwise Comparison and Weight Assignment*

To quantify the relative importance of each criterion, pairwise comparisons are conducted using the Saaty scale from 1 to 9 [26], as shown in Table II.

TABLE II SAATY'S FUNDAMENTAL SCALE

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one activity over another
5	Strong importance	Experience and judgment strongly favor one activity over another
7	Very strong importance	One activity is strongly favored over another
9	Extreme importance	The evidence favoring one activity over another is of the highest order
2, 4, 6, 8	Intermediate values	Used for a compromise between two adjacent judgments

Within each group of related factors, every item is compared to the others to determine its priority. This process helps assign weights in a clear and structured manner. The comparison matrix for category level is shown in Table III.

TABLE III PAIRWISE COMPARISON MATRIX FOR CATEGORY LEVEL

Category	Project-related	Team-related	Organizational
Project-related	1	4	5
Team-related	1/4	1	2
Organizational	1/5	1/2	1

To ensure the consistency of the pairwise comparison matrix, the Consistency Index (CI) and Consistency Ratio (CR) are calculated. If the CR≤0.1, the matrix is considered consistent. The following formulas are used in the calculation:

$$\lambda_{max} = \sum (A\omega)_i / \omega_i \quad (1)$$

$$CI = (\lambda_{max} - n) / (n - 1) \quad (2)$$

$$CR = CI / RI \quad (3)$$

The value of Random Index (RI) [26] corresponding to the matrix size of n=3 can be obtained from Table IV.

TABLE IV RANDOM INDEX VALUE

N	1	2	3	4	5	6	7	8	9
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45

For the comparison matrix in Table III, the value of CR is 0.0078. It means that the matrix satisfies the consistency requirement. The weights were calculated using the Principal Eigenvector Method, and the normalized weights are presented in Table V.

TABLE V NORMALIZED WEIGHTS FOR CATEGORY LEVEL

Category	Weight
Project-related	68.3%
Team-related	20.0%
Organizational	11.7%

After determining the category-level weights, pairwise comparisons are conducted within each category to derive local weights for each factor. The global weights are then calculated by combining all the local weights with their corresponding category weights, as shown in Table VI.

D. Recommendation Logic

This study determines the recommendation result by evaluating the alignment between the project characteristics and three project management approaches, including agile, waterfall, and hybrid approaches.

The recommendation tool developed in this study collects project-specific information through a set of guiding questions. Each key factor is associated with 1 to 3 questions. Users are required to rate their project based on these questions using a scale from 1 to 5. The average of all scores under that factor is taken as the final score of this factor.

TABLE VI GLOBAL WEIGHTS OF ALL FACTORS

Category	Category Weigh	Factor	Local Weight	Global Weight
Project-related	68.3%	Requirement Stability	29.9%	20.4%
		Complexity	18.9%	12.9%
		Delivery Frequency	14.2%	9.7%
		Time Constraints	10.7%	7.3%
		Budget Constraints	10.7%	7.3%
		Technological Uncertainty	6.8%	4.6%
		Innovation Level	4.9%	3.3%
		Regulatory Constraints	3.9%	2.7%
Organizational	11.7%	Organizational Culture	75%	8.8%
		Business Drivers	25%	2.9%
Team-related	20.0%	Team Characteristics	66.7%	13.3%
		Stakeholder Participation	33.3%	6.7%

To ensure consistency in calculation, 1–5 scales are normalized to values between 0 and 1. The normalized score for each rating is calculated using the formula:

$$r_i = (s_i - 1) / 4 \quad (4)$$

where, s_i is the user's original rating and r_i is the normalized value between 0 and 1.

Next, each normalized score is compared with the ideal value for each project management approach. This study defines the ideal values based on the insight from the literature review. These values reflect the optimal project characteristics. The higher the value, the higher the alignment between this characteristic and the corresponding approach. Table VII presents the ideal values assigned to each factor for the three approaches.

TABLE VII IDEAL VALUES

Factor	Agile	Waterfall	Hybrid
Requirement Stability	0.1	1.0	0.6
Complexity	1.0	0.1	0.8
Delivery Frequency	0.9	0.1	0.6
Time Constraints	1.0	0.3	0.7
Technological Uncertainty	0.9	0.1	0.6
Budget Constraints	1.0	0.3	0.7
Innovation Level	0.9	0.1	0.6
Regulatory Constraints	0.1	1.0	0.8
Organizational Culture	0.9	0.1	0.7
Business Drivers	0.9	0.1	0.7
Team Characteristics	1.0	0.3	0.7
Stakeholder Participation	1.0	0.1	0.7

Following the normalization process, each normalized score is compared with the ideal value of each project management approach. The consistency between the project and a specific approach is quantified by the absolute difference between the user's normalized score and the ideal value. The following formula is used in the calculation:

$$Match_j = 1 - |r_j - p_j| \tag{5}$$

where, r_j is the normalized user rating for the factor, p_j is the ideal value of the corresponding approach and $Match_j$ is the matching score. Each matching score is then multiplied by the global weight of the corresponding factor to reflect its relative importance:

$$WeightedMatch_j = Match_j \times GobalWeight_j \tag{6}$$

The final score of each approach is the sum of the weighted matching values of all factors. For better understanding, the result is multiplied by 100 and presented on a scale from 0 to 100.

$$FinalScore = \sum WeightedMatch_j * 100 \tag{7}$$

The final recommendation result is determined by comparing the final scores across three approaches. The approach with the highest score is recommended as the most suitable approach. Fig. 2 presents a flowchart that summarizes the recommendation process.

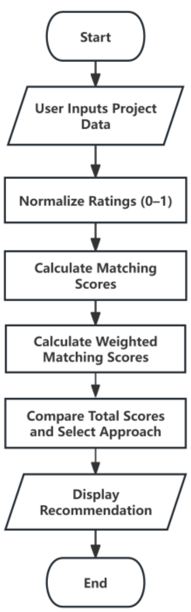

Fig. 2. Flowchart of the recommendation tool.

E. System Implementation

To implement the project management approach recommendation tool, this study develops a lightweight and user-friendly web-based system. The system is built using Spring Boot for backend logic, Thyme leaf for the interface layer, and Chart.js for visualization. It is deployed on the Render platform. This enables real-time user input processing and result display. The system architecture is illustrated in Fig. 3.

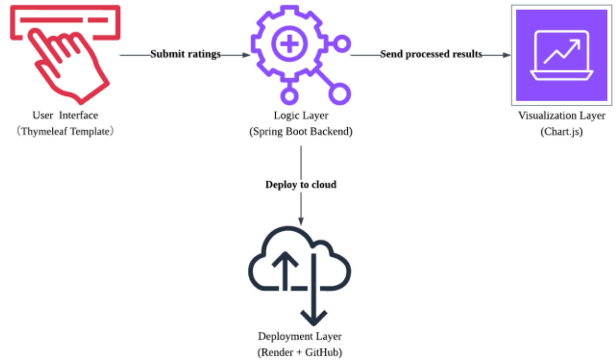

Fig. 3. System architecture of the recommendation tool.

The system provides a bilingual interface and an intuitive layout for users to input project characteristics and receive recommendations. Some snapshots of the interface are shown in Fig. 4 and 5.

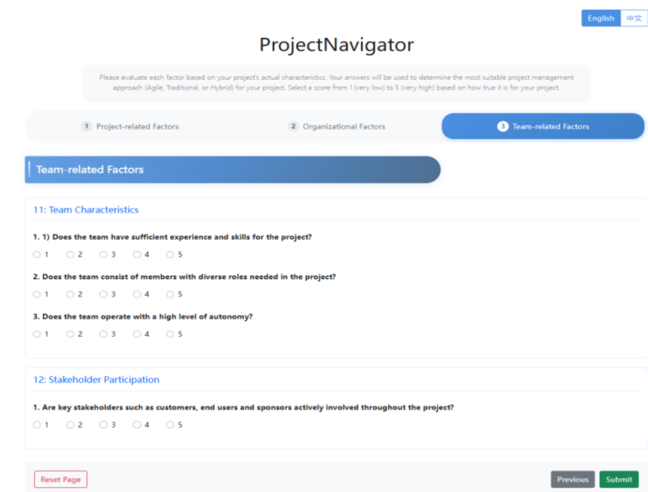

Fig. 4. Team-related questionnaire section.

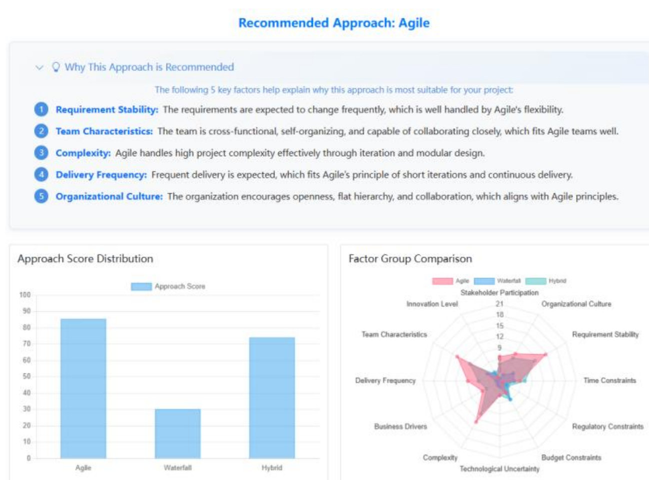

Fig. 5. Result display area.

F. System Validation

For effectiveness, the factor weights and the recommendation results are examined through expert evaluation. Furthermore, usability testing is carried out using the System Usability Scale (SUS). The results of both validations offer valuable insights for further optimization of the tool.

1) Expert evaluation: To validate the effectiveness of the tool, five experts are invited to complete evaluation questionnaires. These experts have over five years of experience in project management and are familiar with waterfall, agile, and hybrid approaches. Experts need to review the global weights of the 12 factors and evaluate whether each weight is reasonable through a questionnaire. The questionnaire presents the names, global weights, and brief definitions of each factor in a table, ensuring a consistent understanding among experts. For each factor, experts need to evaluate whether the weight is too high, reasonable, or too low based on their professional judgment. If a factor is too high or too low, the system will provide an input box for experts to enter a suggested weight. They were also invited to test the tool and evaluate the accuracy of its recommendation results. Their evaluation focused on whether the recommended approach was accurate and whether they would adopt it in real projects.

2) System usability evaluation: To evaluate the usability of the recommendation tool, five users with different project management experience ranging from one to seven years are invited to complete the SUS questionnaire. SUS is a standardized questionnaire tool consisting of 10 questions. In addition, each question has a Likert scale from strongly disagree to strongly agree and is calculated using standard methods [27]. For usability testing, five users can identify most usability issues [28].

IV. Results

A. Expert Evaluation Results on Factor Weights

Based on the expert evaluation, the global weights of the 12 factors were generally confirmed as reasonable. Only the requirement stability and business drivers were suggested for adjustment by more than three experts. The adjustment details are summarized in Table VIII.

TABLE VIII ADJUSTMENTS TO FACTOR WEIGHTS

Factor	Original Weight	Suggested Value	Average Value	Final Adjusted Weight
Requirement Stability	20.4%	10%,15%,18%,18%	15.25%	17%
Business Drivers	2.9%	5%,5%,7%,10%	6.75%	6%

After adjusting the weights of requirement stability and business drivers, the total weight of all factors is no longer 100%. To maintain consistency, the remaining 10 factors are scaled based on their original weights.

B. Expert Evaluation Results on Recommendation Accuracy

To evaluate the effectiveness of the recommendation results, experts were invited to use the system and provide feedback based on their professional judgment. After using the system, they were asked to evaluate whether the recommended approach was accurate and whether they would adopt it in actual projects. A 5-point Likert scale was used, ranging from strongly disagree to strongly agree. Four experts agreed that the recommended approach is accurate and could be adopted in actual projects. None of the experts chose disagree or strongly disagree.

C. System Usability Evaluation

The final SUS score was calculated as 84.5. According to Hyzy et al. (2022), this score exceeds the benchmark of 68, indicating an acceptable level of usability.

V. Discussion

A. Adjustment of Factor Weights

Based on the expert evaluation, two factors required adjustment: requirement stability and business drivers.

1) Requirement stability: The original weight of requirement stability is 20.4%. According to expert feedback, four experts considered that the value was too high and suggested a range of 10% to 18%. Although two experts suggested 18%, the lowest value of 10% significantly reduced the average to 15.25%. Considering the consensus among experts that this factor is overestimated, the final weight was adjusted to 17%. This adjustment reduces the weight while still maintaining its importance.

2) Business drivers: The original weight of business drivers is 2.9%. According to expert feedback, four experts considered that the value was too low and suggested a range of 5% to 10%. However, because the majority of expert suggestions were below 7%, the final weight was set at 6%. This value is closer to expert suggestions and avoids overadjustment.

B. Recommendation Accuracy

Expert evaluation results on recommendation accuracy indicate a high level of confidence in the effectiveness of the recommended results. This positive feedback validates that this tool can provide reliable and practical recommendation results based on project characteristics.

C. Usability of the System

The SUS score of 84.5 reflects a high level of usability, clearly above the benchmark of 68. This result shows that the tool is easy to learn and use for project managers. High usability also increases the likelihood of adoption in real projects.

D. Validation Significance and Related Work Comparison

These validation measures are essential to ensure that the tool is not only theoretically sound but also practically usable. Unlike many existing studies that only present theoretical models without a practical tool or systematic validation, this study develops the recommendation tool and validates it through expert evaluation and SUS testing. The results confirm its reliability, recommendation accuracy, and usability, indicating strong potential for adoption in real projects.

VI. Conclusion and Future Work

A. Conclusion

This study developed a web-based recommendation tool to assist project managers in selecting appropriate project management approaches. The tool enables users to input project characteristics through structured questions. Then the system recommends the most suitable project management approach from agile, waterfall, or hybrid approaches.

To ensure the effectiveness and usability of the tool, validation was conducted through expert evaluation and usability testing. Experts evaluated the global factor weights and recommendation results and provided adjustment suggestions for certain weights. Then, the model was optimized based on expert feedback to enhance its consistency with professional judgment. In addition, the system usability was evaluated through the SUS questionnaire, and the final score was 84.5, exceeding the acceptable threshold. The results indicate that the tool has good effectiveness and user experience in assisting the selection of a project management approach.

Overall, the recommendation tool developed in this study offers a clear and reliable way to help project managers select the most suitable project management approach and has strong potential for practical application.

B. Future Work

Although this study has successfully developed and validated the recommendation tool, there are still several areas that can be further improved. To enhance the effectiveness and usability of the tool, the following directions for future improvement are proposed:

- The current system uses the same global weight for all users. In the future, based on providing predefined weight templates, users can adjust these global weights within a limited range according to their own project characteristics. This can enhance the flexibility and personalization of the model while maintaining stability and consistency of recommendation logic.
- In the future, real-world software project data can be collected to further validate the effectiveness of these factors. This would help identify missing factors or weights that may require adjustment.
- A database would be integrated to store user input data and recommendation results. In addition, a feedback module can be added to allow users to evaluate the accuracy of the recommended approach after the project is completed. With sufficient historical data and user feedback, the system can adjust the model, improving the accuracy of the system.

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