

Hybrid Artificial Intelligence Using Decision Tree and Heuristic Optimization for Healthcare Facility Recommendation Systems

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ABSTRACT

This study proposes a healthcare facility recommendation system using a Hybrid Artificial Intelligence approach. The model integrates Decision Tree classification to identify user healthcare needs and heuristic-based optimization to rank healthcare facilities based on geographic distance and facility density. The study employed the Waterfall development model and used 150 simulated healthcare scenarios. Experimental results showed that the proposed model successfully classified user healthcare needs into Clinic, Hospital, and Emergency Unit categories, while the heuristic model effectively identified optimal healthcare facilities among multiple alternatives. Compared with conventional location-based approaches, the proposed model demonstrated more adaptive and efficient recommendation performance. These findings demonstrate the potential of hybrid artificial intelligence to support adaptive, accurate, and efficient healthcare decision-making.

INTRODUCTION

The rapid development of information technology and Artificial Intelligence has significantly transformed healthcare service systems (Alowais et al., 2023; Francisca Chibugo Udegbe et al., 2024; Rajpurkar et al., 2022). The availability of intelligent systems capable of providing fast and accurate information has become increasingly important, particularly in helping users identify healthcare facilities that match their medical needs and geographic locations (Jimma, 2023; Kundu & Ghosh, 2025; Rashid & Kausik, 2024).

Despite these developments, users still face difficulties in selecting appropriate healthcare facilities due to limited information integration and inefficient decision-making processes (Alsabah et al., 2025; Li et al., 2024). Conventional healthcare search systems generally provide location-based information without considering important user-specific factors such as medical urgency, symptom severity, accessibility, and healthcare service availability. As a result, healthcare recommendations may be less accurate and less adaptive to individual user conditions (Javaid et al., 2024; Kumar & Singh, 2025).

Several previous studies have attempted to address challenges in healthcare decision support and recommendation systems. Research on Decision Tree-based classification demonstrated its effectiveness in identifying user requirements and supporting healthcare decision-making (P et al., 2022). Other studies showed that artificial intelligence-based recommendation systems can improve service efficiency, recommendation accuracy, and decision quality in healthcare applications (Alowais et al., 2023; Rajpurkar et al., 2022). Meanwhile, heuristic optimization methods have been successfully applied to determine near-optimal solutions based on distance, accessibility, and travel-related parameters (Damasevicius, 2025; Salgotra et al., 2024). In addition, web-based healthcare information systems have shown promising results in improving healthcare accessibility and service integration (Xu et al., 2021). However, most previous studies employed single-method approaches and have not fully integrated classification and optimization techniques within a unified healthcare recommendation framework (Azevedo et al., 2024).

Based on this research gap, this study proposes a Hybrid Artificial Intelligence model by integrating Decision Tree classification and heuristic-based optimization in a web-based healthcare facility recommendation system. The main contribution of this research lies in combining user need classification and location optimization within a single intelligent framework. The proposed model was evaluated using 150 simulated healthcare scenarios to assess classification performance and recommendation effectiveness. Therefore, this study aims to design and evaluate an adaptive, accurate, and efficient healthcare facility recommendation model for digital healthcare applications.

LITERATURE REVIEW

Hybrid Artificial Intelligence

Hybrid Artificial Intelligence is an approach that combines multiple artificial intelligence techniques to improve decision-making performance, prediction accuracy, and system adaptability in complex environments (Alowais et al., 2023). By integrating classification, optimization, and recommendation algorithms, hybrid models are able to overcome the limitations of single-method approaches and generate more efficient solutions for healthcare applications (Mohammed & Hasan, 2023).

Decision Tree

Decision Tree is a supervised learning algorithm widely used in classification problems due to its ability to generate interpretable decision rules and efficient data categorization (P et al., 2022; Sarang, 2023). In healthcare systems, Decision Tree has been successfully applied to classify patient needs, medical priorities, and service requirements based on user input parameters, enabling transparent and accurate decision-making (Doelakeh et al., 2026).

Heuristic Optimization

Heuristic optimization is a computational approach designed to find near-optimal solutions within acceptable processing time, especially in problems involving multiple constraints and variables (Damasevicius, 2025; Salgotra et al., 2024). In healthcare facility recommendation systems, heuristic methods are commonly used to evaluate distance, service density, accessibility, and travel efficiency in determining the most appropriate facility (Figueroa-García et al., 2022).

Previous Studies

Previous studies have demonstrated that intelligent healthcare recommendation systems can improve service efficiency, decision accuracy, and user satisfaction in digital healthcare environments (Alowais et al., 2023; Rajpurkar et al., 2022). Studies involving machine learning classification have shown strong performance in identifying healthcare priorities, while optimization approaches have successfully improved location selection efficiency (Figueroa-García et al., 2022; P et al., 2022). However, most studies still focus on classification or optimization independently, and limited research has integrated both approaches into a unified healthcare recommendation framework (Azevedo et al., 2024).

Conceptual Framework

Based on the theoretical foundation and previous studies, this research proposes a conceptual framework consisting of four main stages: user input collection, healthcare need classification using Decision Tree, facility ranking using heuristic-based optimization, and recommendation output through a web-based healthcare system. This framework illustrates the integration between classification and optimization processes to generate adaptive, accurate, and efficient healthcare facility recommendations.

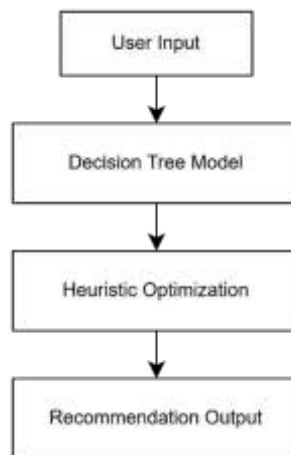


Figure 1. Conceptual Framework

Figure 1 illustrates the conceptual framework of the proposed healthcare facility recommendation system based on Hybrid Artificial Intelligence. The framework begins with user input, where healthcare-related parameters such as emergency level, symptom severity, geographic distance, and facility density are collected. These inputs are then processed by the Decision Tree model to classify user healthcare needs into appropriate service categories. The classification results are subsequently evaluated using heuristic-based optimization to calculate recommendation scores and rank available healthcare facilities. Finally, the system generates recommendation output by selecting the most suitable healthcare facility based on user conditions and location-related parameters.

METHODOLOGY

This study employed the Waterfall Model to develop a healthcare facility recommendation system using Hybrid Artificial Intelligence. The research process consisted of requirement analysis, system design, dataset preparation, model implementation, system testing, and performance evaluation. The proposed model integrated the Decision Tree algorithm for user healthcare need classification and heuristic-based optimization for healthcare facility ranking.

The study used 150 simulated healthcare scenarios developed during the system design phase in 2026. The dataset consisted of user healthcare conditions, geographic distance, and facility density parameters. Input variables included emergency level, symptom severity, age group, mobility condition, distance, and facility density, while the output variable was the healthcare service category consisting of Clinic, Hospital, and Emergency Unit.

The simulated dataset was generated based on healthcare service scenarios derived from previous healthcare studies and common patient service conditions. Each scenario represented a combination of healthcare-related parameters designed to simulate real-world healthcare decision-making situations. The Decision Tree model generated classification rules by recursively splitting the dataset based on informative attributes, including emergency level, symptom severity, age group, and mobility condition.

The classification results were subsequently processed using heuristic-based optimization to rank available healthcare facilities according to location-related parameters. Before scoring calculation, distance and facility density values were normalized into a range of 0 to 1 using min-max normalization to ensure consistent parameter scaling.

To evaluate healthcare facility recommendations, a scoring model was applied by combining distance and facility density parameters as shown in Equation (1).

$$Score = 0.6D + 0.4(1 - \rho) \dots \dots \dots (1)$$

In this model, D represents normalized distance, while ρ represents normalized facility density. The weighting values of 0.6 and 0.4 were assigned to emphasize distance as the primary factor in healthcare accessibility. A lower score indicates a more optimal healthcare facility recommendation.

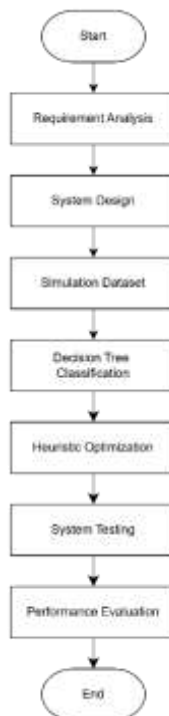


Figure 2. Research Methodology

Figure 2 illustrates the research methodology used in this study, beginning with requirement analysis and system design, followed by simulation dataset preparation consisting of 150 healthcare scenarios. The dataset was then processed using the Decision Tree model for healthcare need classification, followed by heuristic-based optimization for facility ranking. Finally, system testing and performance evaluation were conducted to assess recommendation effectiveness.

RESEARCH RESULT

The implementation of the proposed Hybrid Artificial Intelligence model was evaluated using 150 simulated healthcare scenarios. The evaluation consisted of healthcare need classification using the Decision Tree model and healthcare facility ranking using heuristic-based optimization.

The Decision Tree model successfully generated classification rules based on user healthcare conditions, including emergency level, symptom severity, age group, and mobility condition. The classification results produced three healthcare service categories: Clinic, Hospital, and Emergency Unit. Examples of classification results are presented in Table 1.

Table 1. Sample Results of Decision Tree Classification

Scenario	Emergency Level	Symptom Severity	Classification
S1	Low	Mild	Clinic
S2	Medium	Moderate	Hospital
S3	High	Severe	Emergency Unit

Following the classification stage, healthcare facilities were ranked using heuristic-based optimization based on distance and facility density parameters. The simulation results are presented in Table 2.

Table 2. Simulation Results of Healthcare Facility Recommendation

Facility	Distance (km)	Facility Density (%)	Score
A	2	50	1.40
B	3	20	1.88
C	1	80	0.92

Based on the simulation results, Facility C obtained the lowest score, indicating that it was selected as the most appropriate healthcare facility recommendation.

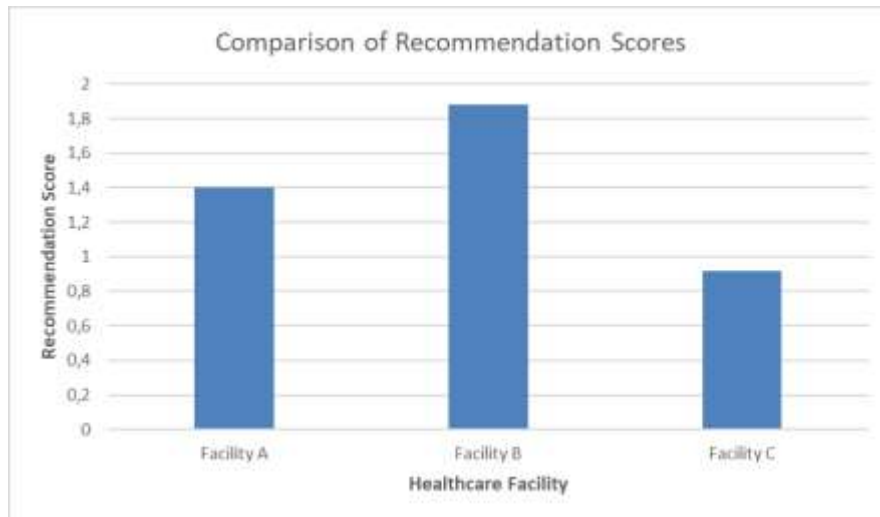


Figure 3. Comparison of Recommendation Scores

Figure 3 presents a comparison of recommendation scores generated by the heuristic-based optimization model. The results show that Facility C achieved the lowest score compared with other alternatives, indicating better accessibility and facility availability.

DISCUSSION

The experimental results demonstrated that the proposed Hybrid Artificial Intelligence model successfully integrated classification and optimization within a unified healthcare recommendation framework. The integration of the Decision Tree model enabled the system to classify user healthcare needs into Clinic, Hospital, and Emergency Unit categories based on healthcare-related input parameters. This classification process improved recommendation personalization by ensuring that healthcare services were selected according to individual user conditions rather than relying solely on geographic proximity.

Following the classification stage, heuristic-based optimization effectively ranked available healthcare facilities by considering both geographic distance and facility density. The simulation results showed that Facility C achieved the lowest recommendation score, indicating that shorter travel distance combined with higher facility density contributed to better healthcare accessibility and service availability. These findings demonstrate that multiple location-related parameters can significantly improve recommendation quality compared with single-parameter approaches.

Compared with conventional location-based search systems and previous single-method studies, the proposed model provided a more adaptive and comprehensive decision-making process by combining user need classification and location optimization within a single intelligent framework. These findings are consistent with previous studies on intelligent healthcare recommendation systems while extending their application through hybrid artificial intelligence integration.

CONCLUSIONS AND RECOMMENDATIONS

This study successfully developed a healthcare facility recommendation model using a Hybrid Artificial Intelligence approach by integrating the Decision Tree algorithm and heuristic-based optimization. The proposed model was evaluated using 150 simulated healthcare scenarios and successfully classified user healthcare needs into Clinic, Hospital, and Emergency Unit categories based on healthcare-related input parameters.

The heuristic-based optimization further ranked available healthcare facilities based on geographic distance and facility density, where Facility C achieved the lowest recommendation score of 0.92, indicating the most optimal recommendation. These results demonstrate that the proposed model is capable of generating adaptive, accurate, and efficient healthcare recommendations. Therefore, the proposed system has the potential to support digital healthcare decision-making and improve healthcare accessibility for users.

ADVANCED RESEARCH

This study was limited to simulation-based evaluation and did not involve real-time implementation, real patient data, or large-scale healthcare datasets. Future research is recommended to implement the proposed model in real-world healthcare environments, integrate real-time healthcare and geographic information, and evaluate system performance using larger, more diverse, and real-world datasets. In addition, future studies may explore the integration of other artificial intelligence techniques to further improve recommendation accuracy and system adaptability.

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