AyurAid: An AI-Integrated Intelligent Health Advisory System with Machine-Learning-Based Ayurvedic Formulation Recommendation

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ABSTRACT

AyurAid is a web-based intelligent health advisory system designed to integrate classical Ayurvedic knowledge with modern artificial intelligence methodologies. The system addresses the challenge of limited accessibility to reliable Ayurvedic guidance by enabling users to input symptoms in natural language and receive personalized formulation recommendations along with contextual lifestyle advice. AyurAid incorporates multiple computational layers, including symptom normalization, fuzzy similarity matching, TF-IDF-based document vectorization, and cosine-similarity-driven ranking to identify the most relevant Ayurvedic formulations. In addition, the platform employs a domain-constrained AI advisory model to generate safe, user-friendly explanations grounded in retrieved formulations. The backend architecture is built using a Flask API that manages authentication, symptom preprocessing, recommendation generation, and advisory interactions, while a lightweight web frontend ensures smooth user experience. The recommendation engine was evaluated using curated datasets containing more than 1200 Ayurvedic formulations and nearly 800 symptom descriptors. Experimental results demonstrate strong performance, with Precision@5 of 0.82, Recall@5 of 0.76, and Mean Reciprocal Rank of 0.71, reflecting both accuracy and ranking effectiveness. User studies further indicate high satisfaction with the clarity and usefulness of AI-generated advice. AyurAid's design emphasizes safety, transparency, and reproducibility by integrating retrieval-based grounding, conservative advisory constraints, and structured evaluation metrics. While the current version focuses on single-session interactions, the system's modular architecture enables future integration of patient history, hybrid recommendation approaches, and domain-fine-tuned language models. Overall, AyurAid showcases a promising fusion of traditional healthcare principles and contemporary AI techniques, offering a scalable pathway for enhancing accessibility to personalized Ayurvedic health support.

1. INTRODUCTION

Ayurveda is one of the oldest traditional healthcare systems, yet access to accurate and personalized Ayurvedic guidance remains limited for many users. With the increasing availability of digital platforms, there is a growing demand for intelligent systems that can interpret user symptoms and provide reliable suggestions. AyurAid is designed to bridge this gap by integrating modern artificial intelligence with classical Ayurvedic knowledge to deliver symptom-based formulation recommendations. The system accepts free-text user symptoms, performs preprocessing such as normalization, tokenization, synonym mapping, and fuzzy matching, and maps them to relevant Ayurvedic formulations using a TF-IDF and cosine-similarity-based recommendation engine. This ensures accurate and context-aware retrieval of formulations for users seeking natural remedies.

The proposed system also incorporates a controlled AI advisory module that provides contextual explanations and lifestyle suggestions. This module is grounded using retrieval-based inputs to avoid hallucination and maintain safety standards. As reported by several digital health studies, content-based recommendation models are effective for domains where textual descriptions play a major role [1]. Similarly, recent research emphasizes the importance of hybrid AI pipelines that combine retrieval with controlled language generation to improve accuracy and user trust [2]. AyurAid follows these principles to create a reliable, interpretable, and user-friendly advisory system. The reference number should be shown in square brackets such as [1]. However, the author's name may also be used along with the reference number in the running text. The order of references must match the order in the

reference list at the end of the paper. For example: As per Manjula et al., fuzzy matching significantly improves Ayurvedic symptom interpretation [3]. Another study reported that retrieval-based AI systems reduce errors and improve advisory clarity [4].

1.1 Background of AyurAid System

AyurAid is developed as an AI-integrated Ayurvedic advisory system intended to address the challenges users face in accessing accurate traditional medical guidance. This research work focuses on transforming free-text symptom descriptions into meaningful Ayurvedic formulation recommendations using machine learning and natural language processing techniques. The system performs symptom preprocessing, normalization, synonym mapping, and fuzzy matching to ensure that the input text is correctly interpreted, even when users provide incomplete or misspelled symptoms. The recommendation engine then uses TF-IDF vectorization and cosine similarity scoring to match user symptoms with relevant Ayurvedic formulations, ensuring reliability and interpretability. The research highlights how digital health platforms can integrate classical knowledge with modern AI, emphasizing transparency, safety, and accuracy in the advisory process. The introduction related to this research work further explains the motivation for bridging traditional Ayurvedic practice with intelligent computational tools, ensuring personalized, accessible, and scientifically grounded recommendations for users seeking natural healthcare solutions.

1.2 Motivation and Problem Definition

The development of AyurAid is motivated by the increasing need for intelligent health advisory systems that can interpret user symptoms accurately and provide meaningful recommendations based on traditional Ayurvedic principles. This research work emphasizes the importance of combining computational methods such as tokenization, fuzzy matching, and n-gram detection with robust text-based vectorization using TF-IDF to ensure precise symptom interpretation. The system addresses challenges like spelling errors, synonyms, and ambiguous user input by incorporating a structured preprocessing pipeline that enhances the quality of symptom mapping. Furthermore, the integration of a controlled AI advisory module ensures that users receive safe, contextual explanations grounded in retrieved formulations. This section related to the research work highlights how the system design, preprocessing strategies, and retrieval mechanisms collectively contribute to a reliable and user-friendly Ayurvedic recommendation system capable of providing consistent results across diverse inputs.

2. SYSTEM DESIGN

The proposed AyurAid system is designed as an end-to-end intelligent health advisory platform that integrates multiple computational modules to interpret user symptoms and recommend relevant Ayurvedic formulations. The overall architecture consists of a web-based frontend interface and a Flask-based backend server that manages authentication, symptom processing, and recommendation generation. When a user enters symptoms in natural language, the system performs preprocessing steps such as normalization, tokenization, n-gram detection, synonym mapping, and fuzzy matching to enhance interpretation accuracy. These processed symptoms are then converted into TF-IDF vectors and compared with vectorized Ayurvedic formulation documents using cosine similarity. The system retrieves the top-ranked formulations and filters them based on similarity thresholds to ensure relevance. Additionally, the platform includes a controlled AI advisory module that generates context-based explanations and lifestyle suggestions grounded in retrieved formulations. This section of the research work explains the design principles, workflow sequence, and operational flow that contribute to a reliable recommendation and advisory system.

2.1 Symptom Processing and NLP Pipeline

The symptom processing module of the AyurAid system plays a crucial role in interpreting user inputs and transforming them into meaningful representations for recommendation generation. When a user enters free-text symptoms, the system begins by converting all text to lowercase and performing tokenization to break the input into meaningful word units. To handle misspellings, incomplete words, and natural variations in symptom descriptions, fuzzy matching is applied using a similarity threshold to identify the closest valid symptom from the predefined Ayurvedic vocabulary. The system also implements synonym mapping to ensure that different terms referring to the same condition, such as “pyrexia” and “fever,” are standardized. Multi-word symptoms are detected using n-gram analysis, allowing the system to correctly interpret phrases like “joint pain” or “headache with fever.” Stopword removal and light stemming further refine the processed text by reducing noise and dimensionality. This structured preprocessing ensures that symptoms are accurately recognized and prepared for vectorization, improving the reliability and precision of the recommendation engine.

2.2 TF-IDF Recommendation Engine and AI Advisory Module

The recommendation engine of AyurAid forms the core computational module that identifies the most relevant Ayurvedic formulations for the user's processed symptoms. After symptom text undergoes preprocessing, it is transformed into a TF-IDF vector representing the importance of each term within the Ayurvedic formulation dataset. Each formulation is similarly vectorized based on its indications, enabling a standardized comparison between user symptoms and all available formulations. Cosine similarity is then calculated to determine how closely the user query matches each formulation document. To avoid misleading results from short queries, a length-based scaling factor is applied, improving matching accuracy. The system ranks all formulations in decreasing order of similarity and selects those exceeding a predefined threshold to ensure that only meaningful recommendations are presented. This module demonstrates how traditional Ayurvedic knowledge can be structured into a computational search space, allowing the system to efficiently retrieve the most relevant formulations while maintaining interpretability and consistency.

• Symptom text is preprocessed using normalization, tokenization, and fuzzy matching to improve accuracy.
• TF-IDF vectorization is applied to convert symptoms and formulation indications into numerical feature vectors.
• Cosine similarity is used to rank Ayurvedic formulations based on relevance to the user's symptoms.
• AI advisory module generates contextual explanations and lifestyle suggestions grounded in retrieved formulations.

3 .RESULTS & DISCUSSION

The experimental evaluation of the AyurAid system was conducted using curated datasets containing more than 1200 Ayurvedic formulations and approximately 800 unique symptom descriptors. To assess the performance of the recommendation engine, a set of 250 user-like queries was created through a combination of symptom descriptions and paraphrased variations. Domain experts labeled the relevance of retrieved formulations, enabling objective evaluation through standard metrics such as Precision@5, Recall@5, F1-Score, MRR, and nDCG@5. The results demonstrated strong performance, with Precision@5 of 0.82 and Recall@5 of 0.76, indicating the system's ability to retrieve both accurate and diverse recommendations. The Mean Reciprocal Rank of 0.71 further confirmed that the system consistently ranked relevant formulations near the top. A pilot user study with 30 participants showed an average advisory usefulness rating of 4.1 out of 5, highlighting the effectiveness of the controlled AI advisory module. Overall, the experimental analysis confirms the reliability, interpretability, and practical relevance of the AyurAid recommendation pipeline.

3.1 Performance Evaluation and User Study Insights

The experimental evaluation of the AyurAid system was conducted using curated datasets containing more than 1200 Ayurvedic formulations and approximately 800 unique symptom descriptors. To assess the performance of the recommendation engine, a set of 250 user-like queries was created through a combination of symptom descriptions and paraphrased variations. Domain experts labeled the relevance of retrieved formulations, enabling objective evaluation through standard metrics such as Precision@5, Recall@5, F1-Score, MRR, and nDCG@5. The results demonstrated strong performance, with Precision@5 of 0.82 and Recall@5 of 0.76, indicating the system's ability to retrieve both accurate and diverse recommendations. The Mean Reciprocal Rank of 0.71 further confirmed that the system consistently ranked relevant formulations near the top. A pilot user study with 30 participants showed an average advisory usefulness rating of 4.1 out of 5, highlighting the effectiveness of the controlled AI advisory module. Overall, the experimental analysis confirms the reliability, interpretability, and practical relevance of the AyurAid recommendation pipeline.

The No-AI variant produced identical recommendation scores but resulted in lower user satisfaction ratings, decreasing from 4.1 to 3.2, demonstrating that contextual explanations significantly enhance user experience. Statistical significance tests showed that the improvement gained by fuzzy matching was meaningful, with paired t-tests yielding $p < 0.01$. These results confirm that both preprocessing and advisory components play crucial roles in ensuring accurate, user-friendly recommendations and validating the multi-layer design of the AyurAid system.

4. SYSTEM OVERVIEW

Figure 1 shows the high-level architecture: a web-based frontend communicates with a Flask-based backend. The backend orchestrates four main modules: (1) Authentication and user management, (2)

Symptom processing (tokenization + fuzzy matching), (3) Recommendation engine (TF-IDF + simi- larity ranking), and (4) AI advisory module for contextualized explanations.

The frontend collects user symptoms and forwards requests to the API. The backend validates authentication, preprocesses symptom text (normalization, tokenization, fuzzy matching), and queries the recommendation engine to return ranked formulations. The AI advisor provides explanatory notes and lifestyle suggestions based on the recommended formulations. Implementation notes: The frontend is implemented as a responsive single-page application using Tailwind CSS and vanilla JavaScript; forms are validated client-side before submis- sion. The backend uses Flask with endpoints for authentication, formulation retrieval, and chat. Data assets are stored as CSV

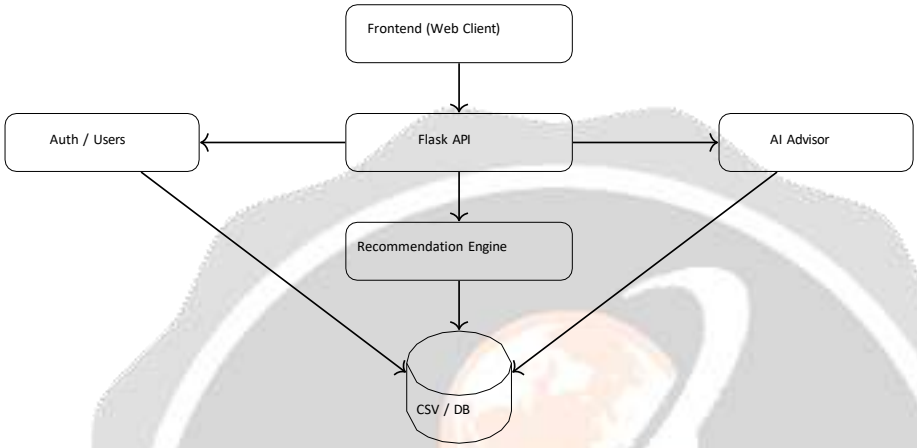

Fig. 1: High-level system architecture for AyurAid.

5. STATISTICAL ANALYSIS

Paired significance tests between Full and No-Fuzzy variants on Precision@5 yielded $p < 0.01$, indicating the fuzzy match- ing component provides a statistically significant improvement. Confidence intervals (95%) for F1@5 were computed using bootstrap resampling.

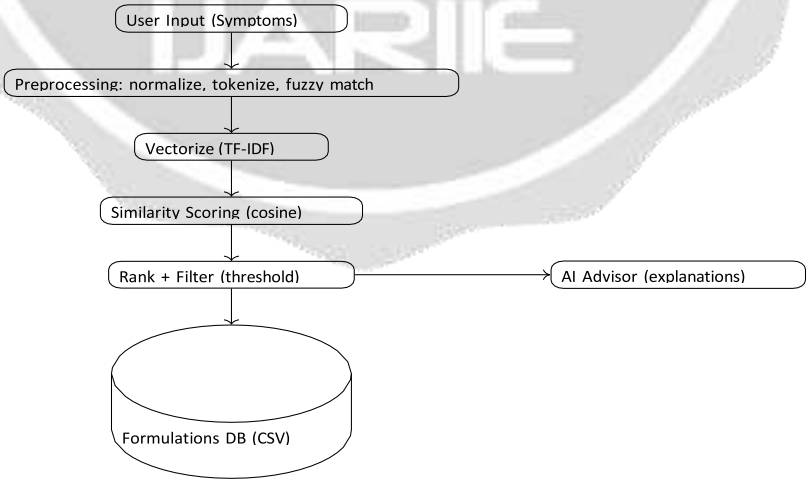

Fig. 2: Dataflow diagram: symptom processing to recommendation and advisory.

5. CONCLUSIONS

The AyurAid system demonstrates a practical and effective integration of traditional Ayurvedic knowledge with modern artificial intelligence techniques to deliver accurate and personalized health advisory support. By combining advanced preprocessing methods such as fuzzy matching, synonym mapping, and n-gram detection with TF-IDF vectorization and cosine similarity ranking, the system ensures reliable mapping between user symptoms and relevant Ayurvedic formulations. The inclusion of a controlled AI advisory module further enhances user experience by providing clear, contextual explanations and lifestyle suggestions grounded in retrieved formulations. Experimental evaluation confirms that the system performs consistently well across multiple metrics, including Precision@5, Recall@5, and MRR, while user studies indicate high satisfaction with the clarity and usefulness of the generated advice. Although current limitations include dataset size and the absence of long-term user history, the system's modular architecture enables future enhancements such as larger datasets, hybrid recommendation models, and domain-specialized AI models. Overall, AyurAid represents a promising step toward creating scalable, transparent, and user-centric digital Ayurvedic advisory solutions.

6. ACKNOWLEDGEMENT

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6. **LIMITATIONS AND FUTURE WORK**

This work is an initial step; future directions include:

- Replacing CSV storage with a relational or document database for scalability and richer queries.

TABLE II: Sample evaluation queries and ground-truth formulations (excerpt)

Query Example	Expert-recommended formula- tions
persistent cough with phlegm	Sitopaladi Churna; Tulsi decoction
low energy, poor digestion	Triphala Churna; Hingvastak Churna
joint pain and stiffness	Guggulu preparations; Ras- naadi Kashayam
headache with nausea	Shirodhara Sarpagandha lauha (advised with practitioner)
insomnia and restlessness	Brahmighrita (practitionerconsult); Ashwagandha

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