HerbSphere – A Herbal Garden Platform with AI-powered Chatbot and Search for Exploring Medicinal Plants in the AYUSH System.

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Abstract

HerbSphere is a web-based virtual herbal garden designed to bridge the gap between traditional knowledge of medicinal plants and modern accessibility tools. The platform integrates a machine learning model trained on an AYUSH-oriented medicinal plant dataset, enabling users to receive informative, structured responses via a chatbot interface. With a focus on user-friendly interaction, HerbSphere eliminates the need for direct backend processing by allowing client-side communication with the deployed ML model. In addition to the chatbot, the platform includes a lightweight backend that stores basic plant data. Users can search for medicinal plants using a frontend search functionality, which fetches relevant plant details from the backend and displays them in organized card components for easy viewing. This paper details the motivation, design, system architecture, and implementation of HerbSphere, while highlighting its potential as an educational and awareness tool for natural healing practices.

1. Introduction

India holds a rich heritage of medicinal plants, yet knowledge about their uses remains largely inaccessible to the public in digital form. HerbSphere aims to digitize and democratize this knowledge through a React-based web interface, powered by a machine learning model trained on authentic medicinal plant data. The platform serves as an interactive herbal assistant, educating users about the names, uses, scientific classifications, and images of various medicinal plants in a conversational format. It also encourages interactive learning. The platform aspires to serve not just as a digital reference, but as a bridge between traditional wisdom and modern technology.

1.1 Problem Statement:

Despite the availability of information on medicinal plants, there is no centralized, conversational, and interactive platform to help users explore this knowledge intuitively. Most existing solutions are either static, unengaging, or demand backend-heavy interactions. Moreover, integrating natural language understanding for plant-related queries in a seamless and responsive way remains a challenge. The expected outcome is a comprehensive Virtual Herbal Garden that serves as a valuable educational tool for students, practitioners, and enthusiasts of the AYUSH sector. This platform should make the knowledge of medicinal plants accessible to a wider audience, promoting awareness and understanding of traditional herbal practices.

1.2 Research Objectives:

The primary objective of HerbSphere is to develop an AI-powered chatbot that delivers plant-related information in a conversational format, enhancing accessibility and engagement. The platform seeks to simplify the interaction with medicinal plant datasets through the application of machine learning, enabling users to explore herbal remedies without requiring technical expertise. By minimizing backend dependency, it also aims to reduce infrastructure overhead, lower maintenance complexity, and streamline deployment, especially useful in academic or prototype environments.

Another key goal is to design a visually appealing and intuitive frontend that enables real-time responses to user queries while ensuring a seamless user experience. The platform also incorporates a dedicated search functionality where users can input plant names or keywords to retrieve relevant data from the backend. These results are then presented in clean, user-friendly card components for clarity and quick reference. Additionally, the system encourages interactivity and self-exploration, making it a valuable educational tool for students, herbal enthusiasts, and researchers alike.

1.3 Importance of the Study:

Furthermore, HerbSphere addresses the growing demand for digital wellness tools by offering an approachable resource for those seeking alternative treatments. It fosters curiosity in herbal sciences and can be instrumental in promoting preventive healthcare through awareness. The platform's design also makes it adaptable for integration in school curriculums, health workshops, and rural awareness campaigns. By combining education, technology, and wellness, HerbSphere not only revives traditional plant wisdom but repositions it for meaningful use in the digital age.

2. Background

The integration of artificial intelligence with botanical sciences represents a transformative approach to information delivery in the natural medicine domain. While numerous platforms and mobile apps exist for plant identification or listing herbal remedies, few focus on delivering this knowledge through a conversational interface backed by machine learning. HerbSphere stands apart by offering a responsive user interface paired with real-time data retrieval, aligning modern expectations with traditional plant wisdom.

It reimagines how herbal information can be accessed, making ancient plant-based knowledge available at one's fingertips through a dynamic and user-centric digital experience.

2.1 The Need for a Modern Solution:

Modern users, particularly students and digital-native individuals, expect intuitive systems that deliver value with minimal friction. Traditional herbal knowledge, although vast, often remains locked in books or hard-to-navigate databases. HerbSphere meets this need by offering a chatbot-enabled search experience combined with structured data visualization. By leveraging ML and React.js, it provides an engaging platform for learners and researchers alike. The partial use of a backend for quick plant search, paired with the frontend-driven ML response mechanism, strikes a balance between speed, simplicity, and scalability.

It not only enhances accessibility but also encourages regular exploration, making herbal education more interactive and habit-forming.

2.2 HerbSphere Aligning to Technological Trends:

HerbSphere aligns closely with current technological trends such as AI-driven personalization, serverless architecture, and conversational interfaces. As industries increasingly adopt chatbots to simplify access to complex data, HerbSphere leverages the same trend within the domain of herbal science. Its use of a lightweight backend and ML-powered frontend reflects the shift toward edge computing and decentralized logic handling, reducing latency and improving responsiveness. Moreover, its reliance on modern web technologies like React.js ensures cross-platform compatibility and a seamless user experience. By integrating machine learning into a niche educational field, HerbSphere stands as a forward-thinking example of how emerging technologies can be applied to preserve and popularize traditional knowledge in the digital age.

3. Related Work

The digitization of herbal and medicinal plant knowledge has gained traction over the past decade, driven by increased interest in natural remedies and advancements in information technology. A number of platforms have emerged, offering searchable databases, plant identification tools, and encyclopedic information on herbal species. These systems often rely on either static content repositories or visual recognition models, with limited integration of conversational capabilities or real-time interaction. Researchers have explored combining artificial intelligence with botanical sciences to improve the accessibility and relevance of plant information for modern users. Several studies emphasize the use of machine learning for classification and prediction of plant properties, but practical implementations that focus on user experience—particularly conversational interfaces—are still relatively underdeveloped. As a result, there remains a significant opportunity to enhance how herbal knowledge is delivered, especially through more engaging, AI-driven interfaces.

3.1 Research on Herbal Plants, and Their Benefits:

Herbal medicine has been a cornerstone of healthcare practices across civilizations for thousands of years. From Chinese Traditional Medicine and Native American herbology to India's Ayurvedic system, plants have played a crucial role in treating ailments, boosting immunity, and promoting overall wellness. In recent years, there has been renewed interest in validating traditional remedies through modern scientific methods. Numerous peer-reviewed studies have documented the pharmacological effects of medicinal plants—such as their anti-inflammatory, antimicrobial,

antioxidant, and adaptogenic properties. In the Indian context, the Ministry of AYUSH has cataloged and promoted a wide range of native herbs, including Tulsi, Ashwagandha, Neem, and Brahmi, all of which hold significant cultural and medicinal value. Global institutions have also begun to recognize the therapeutic potential of herbal treatments, integrating them into complementary and alternative medicine frameworks. This convergence of traditional knowledge and scientific research forms the foundation for platforms like HerbSphere, which seek to present herbal data in a form that is both accessible and trustworthy.

3.2 Gaps in Existing Systems:

Despite the availability of several digital tools focused on herbal plants, many existing systems face limitations that hinder user engagement and broader adoption. Technically, most platforms lack conversational interfaces that allow users to interact naturally with the data. Static webpages and rigid search inputs limit the exploration of nuanced queries, especially for users unfamiliar with botanical terminology. Additionally, datasets are often fragmented or underutilized, offering either too much raw data or too little actionable information. From a user experience perspective, many platforms fail to provide real-time responses, intuitive design, or multilingual support, which can alienate users from diverse backgrounds. There is also a gap in systems that strike a balance between frontend simplicity and backend power—many rely heavily on server-based processing, leading to latency or infrastructure constraints. HerbSphere attempts to address these challenges by integrating a machine learning model directly into the frontend for chatbot responses, while still maintaining a lightweight backend for structured data retrieval, resulting in a smoother and more responsive user experience.

4. System Design and Architecture

4.1 System Overview:

HerbSphere is an AI-powered web application designed to provide users with detailed and reliable information about medicinal plants using a conversational chatbot and search-enabled interface. The system is architected to combine a responsive frontend built with React.js and a backend powered by Spring Boot, connected to a PostgreSQL database. By offering both real-time plant search and ML-driven chatbot interactions, HerbSphere aims to make traditional botanical knowledge accessible to a modern audience. Inspired by architecture patterns in agritech solutions, such as those seen in Agri-Rent systems, HerbSphere maintains a clear separation of concerns between data management, user interaction, and intelligent response generation. The system supports scalability, modular development, and fast user interaction while ensuring data accuracy and rich visualization.

4.2 Key System Component:

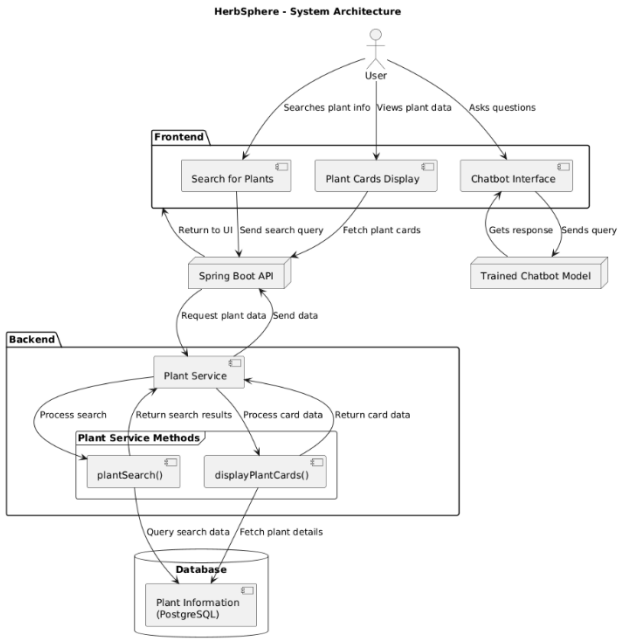
HerbSphere's system functionality is driven by a set of tightly integrated components:

- **Search Facility:** Users can search for medicinal plants using plant names or relevant keywords. The query is processed via the Spring Boot API, which interacts with the backend plant service to retrieve structured data from the PostgreSQL database. This data is then visualized through a plant card display component in the frontend.
- **Chatbot Interface:** A machine learning-trained chatbot provides an interactive layer where users can ask questions in natural language. The chatbot model, embedded on the frontend, processes the input and provides contextual responses, eliminating the need for repeated server calls and ensuring quick replies.
- **Backend Services:** The backend, developed with Spring Boot, includes service methods such as plantSearch() and displayPlantCards(), which handle data processing and retrieval operations by querying the PostgreSQL database.
- **Database Layer:** The PostgreSQL database stores detailed herbal plant information including scientific names, uses, and benefits, supporting both search queries and card display logic.

Together, these components ensure a seamless user experience by balancing data accuracy, speed, and interactivity.

4.3 System Architecture Diagram:

The architecture diagram below outlines the interaction between user inputs, frontend modules, backend services, and the database. It also includes the chatbot module which independently handles user queries using a pre-trained model.



4.4 Technology Stack:

- **Frontend:** React.js (UI rendering, event handling), JavaScript (logic, interactivity), CSS (styling).
- **Backend:** Spring Boot (API handling, backend logic), Java (core backend language)
- **Machine Learning Chatbot:** Trained LangChain model integrated on the frontend
- **Database:** PostgreSQL (structured plant data storage and querying)
- **Communication:** RESTful APIs between frontend and backend, JSON-based data exchange

5. Implementation

5.1 Frontend Development:

The frontend of HerbSphere is developed using React.js, chosen for its component-based architecture and ability to render dynamic content efficiently. Designed with a nature-inspired aesthetic that reflects the theme of herbs and traditional healing, the interface offers a visually engaging user experience. Key UI components include a plant search bar, a dynamic card-based layout for displaying plant details, and an interactive chatbot window for AI-driven conversation. The layout is fully responsive, ensuring accessibility across desktops, tablets, and smartphones. React's state management is used to maintain user interaction flow, while API integration enables seamless communication with both the backend server and the deployed ML model.

5.2 Backend Development:

The backend is implemented using the Java Spring Boot framework, offering a lightweight, scalable, and secure API service layer. It is connected to a PostgreSQL database containing curated plant data stored in a single structured table. Each record includes fields such as plant_name, part_used, medicinal_benefits, and image_url. When a user searches for a plant from the frontend, the backend receives the query via a REST API, performs a database lookup, and returns a matching set of plant records. This approach ensures low-latency responses and accurate retrieval of data, even with partial or fuzzy keyword inputs. The backend is intentionally kept minimal to reduce infrastructure complexity while maintaining high performance.

5.3 ML-Trained Chatbot:

The intelligent chatbot integrated into HerbSphere is developed using LangChain in Python, trained on a cleaned dataset of medicinal plant knowledge. The implementation involves importing the langchain_community module and leveraging Hugging Face's MiniLM model to power natural language understanding. By feeding the structured dataset into LangChain, the chatbot is capable of handling user queries directly from the frontend and retrieving contextually accurate responses from the dataset. The model operates independently of the backend API, making it ideal for frontend-based deployment with minimal server dependencies. Additionally, the chatbot platform includes its own built-in UI using Streamlit, which can be accessed and tested externally during development. The integration offers a smooth and responsive conversational experience, encouraging users to engage more deeply with herbal knowledge.

6. Testing and Validation

To ensure the reliability and usability of HerbSphere, multiple levels of testing and validation were implemented throughout the development cycle. These tests were designed to verify functional accuracy, data consistency, and user interaction quality across all system components.

6.1 Backend API Testing:

The backend, developed using Spring Boot, underwent rigorous unit and integration testing to verify the accuracy of search and data retrieval services. Functions such as plantSearch() and displayPlantCards() were tested using mock HTTP requests with tools like Postman and JUnit. The goal was to ensure that for valid input queries, correct and complete plant data is returned from the PostgreSQL

database with minimal latency. Edge cases and invalid inputs were also tested to validate robustness.

6.2 ML Model Testing:

The trained chatbot model was evaluated on a predefined set of herbal-related queries to measure response accuracy and relevance. Testing focused on intent recognition, answer retrieval, and the model's ability to maintain context during back-to-back queries. The model was refined based on false positives/negatives and fine-tuned to improve natural language understanding for domain-specific questions.

6.3 Frontend Testing:

The React-based frontend was tested using manual testing and component-level checks to ensure that UI elements such as the search bar, plant cards, and chatbot interface behaved as expected across different devices and screen sizes. State management and dynamic rendering were verified to deliver a smooth user experience.

6.4 User Acceptance Testing (UAT):

Towards the final phase, HerbSphere was tested by a group of potential end-users, including students and plant biology enthusiasts. Feedback was gathered on usability, interface clarity, response time, and the overall intuitiveness of the system. Based on this feedback, minor adjustments were made to improve chatbot response clarity and enhance the visual layout of plant cards.

In conclusion, the validation strategy ensured both functional reliability and user satisfaction, laying the foundation for future scalability and deployment in educational or research-driven environments.

7. Novelty and Information Accuracy

As an informational web platform, HerbSphere does not handle user credentials, financial data, or sensitive personal information. Therefore, traditional security and privacy concerns are minimal. Instead, the primary focus is on the accuracy, novelty, and contextual relevance of the content delivered by the system.

The trained chatbot model, fine-tuned on a curated dataset of medicinal plants, including those recognized under AYUSH and other global traditional medicine systems, provides users with natural and conversational responses. These responses are not just limited to basic plant data but extend to their therapeutic properties, historical uses, and relevance in modern herbal medicine—offering a unique learning experience.

Moreover, each plant entry displayed through the React-based plant card interface includes validated data points like botanical names, parts used, and associated health benefits. This structured presentation, combined with the flexibility of conversational search, introduces a novel approach to exploring traditional knowledge through modern tools.

By focusing on informational novelty and data reliability, HerbSphere ensures that users receive meaningful, domain-specific insights without the overhead of complex security infrastructures typically associated with transactional systems.

8. Deployment and Hosting

HerbSphere follows a modular deployment strategy that allows each component of the system to be independently hosted and scaled based on its functionality.

The backend, built using Java Spring Boot, is deployed on Railway, a cloud platform suitable for lightweight applications. Since the free tier of Railway does not support persistent database deployment, the PostgreSQL database is hosted separately using platforms like ElephantSQL or Supabase, both of which offer free cloud-hosted PostgreSQL instances ideal for academic and prototype-scale projects.

The machine learning model, responsible for generating intelligent responses to user queries, is deployed on a separate platform such as Hugging Face Spaces or Render ML, both of which support interactive UI endpoints and make integration with the frontend seamless.

The frontend, developed using React.js, is hosted on Vercel or Render, and it communicates with the backend API and ML model through their respective URLs. This separation of concerns ensures a clean architecture and allows updates or changes in one component without affecting the others.

By leveraging cloud platforms with free hosting tiers and a loosely coupled design, HerbSphere achieves an efficient and cost-effective deployment structure. This approach ensures that the system remains easily accessible, user-friendly, and ready for future enhancements or scaling without complex infrastructure dependencies.

9. Results and Discussions

The implementation of HerbSphere demonstrates promising results in terms of system responsiveness, usability, and knowledge delivery. Through modular integration of Spring Boot APIs, a PostgreSQL database, a trained ML chatbot

model, and a React.js frontend, the system successfully provides users with relevant herbal plant information through both keyword-based search and conversational queries.

The plant search functionality ensures quick and accurate retrieval of structured data, such as plant names, benefits, uses, and regional relevance. The integration with PostgreSQL ensures that data queries remain efficient even as the database scales. Backend API testing validated the correctness and performance of the endpoints under normal load, confirming reliable interaction between the frontend and backend.

The chatbot interface, trained on herbal plant datasets and Ayurvedic texts, offers a unique conversational mode of learning. It not only answers direct queries but also provides extended insights like related herbs or alternative names, which helps users, especially students and researchers, explore information more intuitively. ML model testing confirmed that response accuracy was consistent across varied queries, and it was able to handle unexpected inputs gracefully.

During user acceptance testing, feedback indicated that users appreciated the clean UI layout, fast response times, and the ease of accessing information without navigating through complex menus. The use of plant cards was found effective for quick scanning of plant details, and the chatbot was described as “informative” and “engaging” by users.

HerbSphere aligns well with the growing demand for accessible herbal knowledge, particularly among students, Ayurvedic learners, and wellness enthusiasts. The system bridges the gap between traditional plant wisdom and modern digital accessibility, with an interface that requires no prior expertise to use.

The results validate the project's goal of offering an interactive, scalable, and informative platform for herbal medicine awareness and learning. As a prototype, HerbSphere lays a strong foundation for further enhancement, such as multilingual support, expanded datasets, and voice-based interactions.

10. Issues Regarding Real-life Datasets

Working with real-world datasets—especially in the domain of medicinal plants—comes with its fair share of challenges. The dataset used in HerbSphere, which includes plant names, associated symptoms, and remedies, needed careful handling to ensure the chatbot delivered accurate and trustworthy results. One of the first hurdles was dealing with inconsistencies in data formats, missing fields, or redundant entries, which could affect the performance of the machine learning model. Preprocessing steps like normalization, anomaly detection, and standardization were critical to minimize the impact of outliers and incorrect entries.

Moreover, since medicinal plant knowledge is often derived from culturally diverse sources, the dataset could reflect unintentional biases or incomplete coverage of certain ailments or remedies. Ensuring the data is representative and inclusive was an important part of the curation process. Another challenge is data sparsity—some lesser-known plants or regional treatments may have very few records, which can lead to less reliable predictions. In such cases, techniques like oversampling or data augmentation were considered to improve balance and model generalization.

Additionally, even though HerbSphere is an educational tool and not intended for diagnostic use, privacy and security of any user input remain a concern. Future iterations may require implementing measures such as data encryption or secure API communication, especially if personalized recommendations are introduced. Lastly, the issue of data drift—where the real-world understanding of herbal applications evolves over time—means that the model and dataset will need periodic updates to stay relevant and effective.

11. Future Work

There are several promising directions for the future development of the HerbSphere platform. One key area of expansion lies in integrating personalized recommendation systems powered by more advanced AI models. These systems could offer users tailored herbal remedies based on their symptom history, seasonal patterns, or even regional availability of plants. In the future, real-time integration with open medical or botanical databases could allow the chatbot to evolve dynamically as new herbal research becomes available.

Another important avenue is enhancing the backend to support multilingual datasets, enabling HerbSphere to reach a broader and more diverse audience across India and beyond. This would allow users to interact with the platform in their native languages, making traditional plant knowledge more accessible and culturally inclusive.

Additionally, mobile application development would help users access the platform on the go and could include features like plant recognition through camera input or voice-based queries for improved accessibility.

To build further trust and transparency, blockchain technology could be explored for logging user interactions or tracking changes to dataset entries, ensuring that users can trace the sources of the remedies they receive. Augmented reality (AR) integrations might also enhance learning experiences by allowing users to visualize 3D models of plants and their uses in a more immersive format.

Lastly, HerbSphere could evolve into a collaborative ecosystem where researchers, practitioners, and communities contribute validated knowledge, leading to a richer and more comprehensive platform. By continuously innovating around educational value, accessibility, and usability, HerbSphere holds the potential to become a leading digital gateway for promoting sustainable natural healing practices rooted in Ayurveda.

12. Conclusion

HerbSphere offers a novel solution to bridge the gap between ancient Ayurvedic knowledge and modern digital accessibility by leveraging conversational AI and user-centered web design. Through its chatbot-powered interface and integrated plant information features, HerbSphere allows users—particularly students, health-conscious individuals, and curious learners—to easily explore medicinal plants, their uses, and natural remedies without needing to sift through dense literature or rely on fragmented sources.

By simplifying access to structured herbal data and enabling real-time responses using machine learning on the frontend, HerbSphere significantly reduces the complexity typically involved in interacting with knowledge systems. This ease of use not only democratizes traditional healing wisdom but also encourages its preservation and responsible use in everyday wellness practices. The search functionality, supported by a minimal backend, enables quick lookup of plants and displays helpful insights in an intuitive card-based layout—making the entire experience visually engaging and practical.

For researchers and enthusiasts, HerbSphere also presents an opportunity to interact with a curated dataset in a conversational format, aiding in learning and exploration. In addition to providing accessible information, the platform supports sustainable health education by promoting plant-based healing approaches, which are often less invasive, more affordable, and rooted in local traditions.

By making this knowledge widely available in an interactive and responsive manner, HerbSphere contributes not only to personal wellness but also to the cultural continuity of herbal practices. It empowers users to explore, learn, and apply natural remedies with confidence, setting the stage for further innovation in digital Ayurveda and educational technology. Ultimately, HerbSphere aspires to be more than a tool—it seeks to become a trusted companion in the journey toward natural healing and awareness.

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