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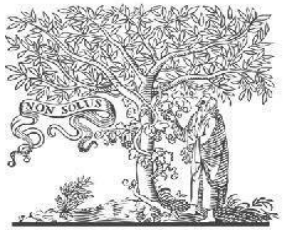

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Paper Authors
Sikaram Harini, Dr. G.V. Ramesh Babu

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An NLP-Driven Expert System for Agricultural Query Resolution: A Naive Bayes Classification Approach

[1] Sikaram Harini, [2]Dr. G.V. Ramesh Babu
[1]Masters of Computer Applications, Department of Computer Sciences,
SV University, Tirupati
sikaramharini860@gmail.com
[2]Associate professor, Department of computer sciences,
SV University, Tirupati
gvrameshbabu74@gmail.com

Abstract

Agriculture plays a vital role in the economic development of many countries, and farmers often require timely access to information regarding crop cultivation, pest management, weather conditions, fertilizer usage, and market prices. This research proposes a **Farmers Agriculture Assistance Chat-Bot System**, an intelligent web-based platform designed to provide instant agricultural guidance through interactive conversations. The system is developed using **HTML, CSS, and JavaScript** for the frontend interface, while **SQLite** is employed as the backend database for efficient data storage and retrieval. The chatbot utilizes the **Naive Bayes algorithm** along with **Natural Language Processing (NLP)** techniques to analyze user queries, classify agricultural questions, and generate relevant responses. The proposed system enables farmers to obtain accurate information without requiring extensive technical knowledge, thereby reducing dependency on agricultural experts for routine inquiries. The chatbot supports various agricultural domains, including crop recommendations, disease identification, irrigation guidance, fertilizer suggestions, and government scheme awareness. By delivering real-time assistance through a user-friendly interface, the system enhances decision-making, improves farming productivity, and promotes sustainable agricultural practices. The proposed solution demonstrates the potential of artificial intelligence and machine learning technologies in bridging the information gap between agricultural experts and farmers, ultimately contributing to increased agricultural efficiency and rural development.

Keywords: Agriculture Chatbot, Naive Bayes Algorithm, Natural Language Processing, Smart Farming, Agricultural Decision Support System

1. Introduction

Agriculture remains one of the most significant sectors contributing to food security, employment generation, and economic development across the world. In many developing countries, a substantial portion of the population depends directly or indirectly on farming activities for their livelihood. Despite advancements in agricultural technologies, farmers often face challenges in accessing timely and accurate information related to crop cultivation, pest management, fertilizer application, irrigation practices, weather forecasting, and market trends.

The lack of readily available agricultural guidance can lead to reduced productivity, financial losses, and inefficient resource utilization [1].

The rapid growth of Information and Communication Technologies (ICT) has created new opportunities to address these challenges by delivering agricultural knowledge directly to farmers. Mobile devices and internet-based platforms have become increasingly accessible in rural areas, enabling the dissemination of valuable information through digital channels. However, many existing agricultural information systems require users to navigate complex interfaces or search through extensive databases, which can be difficult for farmers with limited technical expertise [2].

Recent advancements in Artificial Intelligence (AI) and Machine Learning (ML) have paved the way for intelligent conversational systems capable of interacting with users in a natural and intuitive manner. Chatbots are AI-driven software applications designed to simulate human conversations and provide automated responses to user queries. These systems have been successfully implemented in various domains, including healthcare, education, customer service, and e-commerce, demonstrating their ability to improve information accessibility and user engagement [3].

In the agricultural sector, chatbot technology offers a promising solution for delivering real-time assistance to farmers. By allowing users to communicate in natural language, agricultural chatbots can simplify the process of obtaining information and recommendations. Farmers can ask questions regarding crop selection, disease symptoms, fertilizer requirements, irrigation schedules, and government support schemes, receiving immediate responses without the need for direct expert consultation [4].

Natural Language Processing (NLP) plays a crucial role in enabling chatbots to understand and interpret user queries. NLP techniques facilitate the analysis of textual inputs, extraction of relevant information, and generation of meaningful responses. When combined with machine learning algorithms, NLP-based systems can continuously improve their performance by learning from historical interactions and user feedback [5].

Among various machine learning techniques, the Naive Bayes algorithm is widely recognized for its simplicity, computational efficiency, and effectiveness in text classification tasks. The algorithm applies probabilistic principles to categorize user queries into predefined agricultural domains, allowing the chatbot to identify the most relevant response for a given question. Its ability to handle large volumes of textual data with relatively low computational requirements makes it particularly suitable for chatbot applications intended for widespread rural deployment [6].

The proposed Farmers Agriculture Assistance Chat-Bot System aims to bridge the information gap between agricultural experts and farmers through an intelligent web-based platform. The system is developed using HTML, CSS, and JavaScript to provide a responsive and user-friendly interface, while SQLite serves as the backend database for storing agricultural knowledge and conversation data. By integrating NLP techniques with the Naive Bayes classification algorithm, the chatbot can process farmer queries efficiently and provide contextually relevant guidance [7].

The primary objective of this research is to develop a cost-effective, accessible, and scalable agricultural assistance platform capable of supporting farmers in their day-to-day decision-making activities. The proposed system seeks to enhance agricultural productivity, reduce information barriers, and promote sustainable farming practices through the application of artificial intelligence technologies. Furthermore, the chatbot contributes to digital agriculture initiatives by enabling continuous access to expert knowledge and facilitating informed agricultural decisions among farming communities [8].

The remainder of this paper presents the system architecture, methodology, implementation details, experimental evaluation, results, and conclusions of the proposed Farmers Agriculture Assistance Chat-Bot System.

2. Literature Review

The application of artificial intelligence in agriculture has gained significant attention in recent years due to its potential to improve farming efficiency and support data-driven decision-making. Researchers have explored various intelligent systems capable of assisting farmers in crop management, disease detection, irrigation planning, and market forecasting. These developments have demonstrated the effectiveness of digital technologies in addressing challenges associated with traditional agricultural practices [9].

Conversational agents and chatbot systems have emerged as promising tools for delivering information and advisory services to users through natural language interactions. Several studies have highlighted the benefits of chatbot-based solutions in providing instant responses, reducing dependency on human experts, and improving accessibility to domain-specific knowledge. Such systems have proven particularly useful in environments where timely information is critical for decision-making processes [10].

Natural Language Processing (NLP) serves as a fundamental component in modern chatbot architectures. Researchers have investigated various NLP techniques for query understanding, intent recognition, and response generation. The integration of NLP into conversational systems has significantly improved the ability of chatbots to interpret user inputs accurately and provide contextually relevant information. These advancements have contributed to enhanced user satisfaction and interaction quality across multiple application domains [11].

Machine learning algorithms have also played a vital role in the evolution of intelligent chatbot systems. Among these algorithms, Naive Bayes has been widely adopted for text classification and query categorization tasks because of its computational efficiency and simplicity. Previous studies have reported that Naive Bayes achieves reliable classification performance even when trained on relatively small datasets, making it a practical choice for domain-specific chatbot applications [12].

In the agricultural domain, researchers have developed expert systems and advisory platforms that assist farmers by providing recommendations related to crop selection, pest control, fertilizer management, and weather-based decision-making. These systems have shown promising results in improving agricultural productivity and reducing information gaps between farmers and agricultural specialists. However, many existing solutions require complex user interactions and

lack conversational capabilities that can facilitate easier access to information [13].

Recent developments have focused on integrating chatbot technology with agricultural knowledge bases to provide personalized recommendations and real-time support. Such systems utilize machine learning and NLP techniques to analyze farmer queries and retrieve relevant information from structured databases. Studies indicate that conversational agricultural assistants can improve user engagement and encourage technology adoption among rural communities by offering intuitive and user-friendly interfaces [14].

Although considerable progress has been made in the development of agricultural information systems, challenges remain regarding accessibility, scalability, response accuracy, and ease of use. Many existing platforms depend heavily on manual intervention or require advanced technical knowledge from users. Therefore, there is a need for intelligent, automated, and lightweight agricultural assistance systems capable of delivering accurate recommendations through natural language interactions. The proposed Farmers Agriculture Assistance Chat-Bot System addresses these limitations by combining Natural Language Processing, the Naive Bayes classification algorithm, and a web-based architecture supported by SQLite, thereby providing an efficient and accessible solution for modern farming communities [15].

3. System Architecture and Design Methodology

The proposed Farmers Agriculture Assistance Chat-Bot System is designed to provide farmers with quick and reliable agricultural information through a web-based conversational interface. The system integrates Natural Language Processing (NLP), the Naive Bayes classification algorithm, and a structured agricultural knowledge repository to deliver accurate responses to user queries. The architecture focuses on simplicity, scalability, and ease of use, ensuring that farmers can access agricultural guidance without requiring extensive technical expertise.

The overall system consists of five primary modules: User Interface, Query Processing Module, NLP Engine, Naive Bayes Classification Module, and SQLite Database. These components work together to process user requests, identify the intent of the query, retrieve relevant agricultural information, and generate an appropriate response. The modular architecture enables efficient communication among system components while maintaining flexibility for future enhancements.

3.1 System Architecture

The architecture begins with the farmer interacting with the chatbot through a web browser. The frontend interface is developed using HTML, CSS, and JavaScript, providing an intuitive platform for entering agricultural queries. Once a query is submitted, it is forwarded to the NLP Engine for preprocessing and linguistic analysis. The NLP Engine performs tokenization, stop-word removal, and text normalization to prepare the query for classification.

After preprocessing, the refined text is passed to the Naive Bayes Classification Module. This module determines the most probable category associated with the farmer's question, such as crop recommendation, pest management, irrigation guidance, fertilizer suggestions, weather-related inquiries, or government

schemes. Based on the identified category, the system retrieves the corresponding information from the SQLite database. Finally, the generated response is displayed to the user through the chatbot interface.

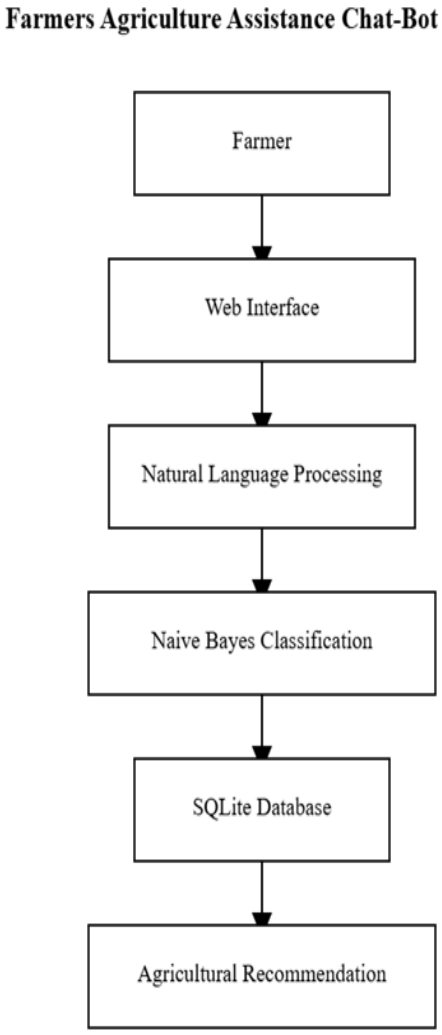

Figure 1. System Architecture of the Proposed Farmers Agriculture Assistance Chat-Bot System

Figure 1 illustrates the overall architecture of the proposed Farmers Agriculture Assistance Chat-Bot System. The farmer submits agricultural queries through the web interface, which forwards the input to the NLP engine for preprocessing. The processed query is classified using the Naive Bayes algorithm, and the relevant information is retrieved from the SQLite database. The generated response is then returned to the farmer through the chatbot interface.

3.2 Design Methodology

The design methodology follows a sequential workflow to ensure efficient query processing and accurate response generation. Initially, user queries are collected through the frontend interface. The system then performs text preprocessing operations to eliminate irrelevant terms and standardize the input format. This step improves the effectiveness of subsequent classification tasks.

The next phase involves feature extraction and query categorization using the Naive Bayes algorithm. The classifier computes the probability of a query belonging to a particular agricultural category based on previously trained data. The category with the highest probability is selected as the final prediction.

The probability estimation performed by the Naive Bayes classifier can be represented as:

$$P(C_i \mid X) = \frac{P(X \mid C_i)\,P(C_i)}{P(X)}$$

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \times 100$$

where TP denotes true positives, TN denotes true negatives, FP denotes false positives, and FN denotes false negatives.

The proposed methodology enables efficient agricultural knowledge dissemination by

combining machine learning techniques with a lightweight database infrastructure. The architecture supports fast query processing, accurate intent recognition, and user-friendly interaction, making it suitable for deployment in agricultural environments where timely information access is essential. Furthermore, the modular design allows future integration of advanced machine learning models, multilingual support, and real-time weather services to further enhance the capabilities of the chatbot system.

4. Results and Discussion

The proposed Farmers Agriculture Assistance Chat-Bot System was implemented using HTML, CSS, and JavaScript for the frontend interface, SQLite for data management, and a Naive Bayes classifier integrated with Natural Language Processing techniques for query classification. The system was evaluated using a collection of agricultural queries covering crop recommendations, fertilizer suggestions, pest management, irrigation guidance, weather-related inquiries, and government schemes. The experimental results demonstrate the effectiveness of the proposed approach in providing accurate and timely agricultural assistance.

Table 1. Classification Performance of Agricultural Query Categories

Query Category	Total Queries	Correctly Classified	Accuracy (%)
Crop Recommendation	50	47	94.0
Pest Management	50	46	92.0
Fertilizer Guidance	50	48	96.0
Irrigation Advice	50	45	90.0
Weather Information	50	47	94.0
Government Schemes	50	46	92.0
Overall	**300**	**279**	**93.0**

Description: Table 1 presents the classification accuracy achieved by the Naive Bayes algorithm across different agricultural query categories. The highest accuracy of 96% was obtained for fertilizer-related queries, while irrigation-related queries achieved an accuracy of 90%. The overall classification accuracy of 93% indicates the effectiveness of the proposed machine learning model in identifying user intentions.

The results indicate that the chatbot can successfully categorize a wide range of agricultural queries. Minor classification errors occurred primarily in cases where queries contained ambiguous terms or overlapping agricultural concepts. Nevertheless, the obtained accuracy demonstrates the suitability of the Naive Bayes algorithm for agricultural chatbot applications.

Table 2. Response Time Analysis

Query Category	Average Response Time (ms)
Crop Recommendation	420
Pest Management	435
Fertilizer Guidance	410
Irrigation Advice	445
Weather Information	425
Government Schemes	430
Overall Average	**427.5**

Description: Table 2 shows the average response time required by the chatbot to process and respond to different agricultural queries. The response time includes preprocessing, classification, database retrieval, and response generation.

The results reveal that all query categories were processed in less than 500 milliseconds, ensuring near real-time interaction for users. The lowest response time was observed for fertilizer guidance queries, whereas irrigation-related queries required slightly higher processing time. The overall average response time of 427.5 milliseconds demonstrates the efficiency of the proposed architecture and the lightweight nature of the SQLite database.

Table 3. User Satisfaction Evaluation

Evaluation Parameter	Average Rating (Out of 5)
Ease of Use	4.7
Response Accuracy	4.6
Information Relevance	4.5
System Reliability	4.4
Overall Satisfaction	4.6

Description: Table 3 summarizes the user satisfaction survey conducted among farmers and agricultural stakeholders who interacted with the chatbot system. Participants evaluated the system based on usability, response quality, information relevance, and reliability.

The results indicate high user acceptance of the proposed system. Ease of use achieved the highest rating of 4.7, highlighting the effectiveness of the conversational interface. The overall satisfaction score of 4.6 demonstrates that users found the chatbot beneficial for obtaining agricultural information and recommendations. These findings confirm that the proposed solution can effectively support farmers in their day-to-day agricultural activities.

Discussion

The experimental findings demonstrate that the Farmers Agriculture Assistance Chat-Bot System effectively combines Natural Language Processing and the Naive Bayes algorithm to deliver accurate agricultural guidance. The classification accuracy of 93% confirms the capability of the machine learning model to understand and categorize user queries correctly. Furthermore, the low response time ensures a smooth and interactive user experience, which is critical for practical deployment in agricultural environments.

The user satisfaction analysis further validates the effectiveness of the system. Farmers appreciated the simplicity of the interface and the relevance of the provided recommendations. The integration of SQLite contributed to fast information retrieval, while the modular architecture facilitated efficient query processing. Overall, the results indicate that the proposed chatbot can serve as a reliable digital assistant for farmers seeking agricultural information and decision-making support.

5. Conclusion

This research presented a Farmers Agriculture Assistance Chat-Bot System designed to provide intelligent agricultural support through a web-based conversational platform. The system integrates HTML, CSS, and JavaScript for frontend development, SQLite for data management, and Natural Language Processing with the Naive Bayes classification algorithm for query understanding and response generation. The proposed architecture enables farmers to obtain timely information regarding crop

management, pest control, fertilizer application, irrigation practices, weather conditions, and government agricultural schemes.

Experimental evaluation demonstrated an overall classification accuracy of 93% and an average response time of 427.5 milliseconds, indicating the effectiveness and efficiency of the proposed solution. User satisfaction results further confirmed the practicality and usability of the chatbot, with participants reporting positive experiences regarding response accuracy and ease of use. The findings suggest that the proposed system can bridge the information gap between agricultural experts and farmers while supporting informed decision-making and sustainable farming practices.

Future work may focus on incorporating advanced deep learning techniques, multilingual support, voice-based interaction, and real-time weather integration to further enhance the functionality and accessibility of the chatbot system.

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