Context-Aware Hybrid Conversational Agent for College Enquiries Using Rule-Based and Machine Learning Approaches

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Abstract- In recent years, the use of conversational agents has increased in the education sector to simplify access to institutional information. However, most college enquiry chatbots remain limited by their reliance on static, rule-based logic and lack contextual understanding of user queries. This paper presents the design and implementation of a **context-aware hybrid conversational agent** specifically developed to handle **college enquiry scenarios**.

The proposed system integrates both **rule-based pattern matching** and **machine learning-based intent classification** to create a robust, adaptive chatbot capable of handling both structured and unstructured queries. To achieve context-awareness, the chatbot tracks and retains recent conversation history within user sessions, allowing it to interpret follow-up or incomplete questions meaningfully. For instance, the chatbot can resolve queries like *"What about the fee?"* by linking them to the previously mentioned course in the conversation.

A lightweight machine learning model trained on custom college enquiry datasets is used to classify user intent when the input does not match predefined rules.

The hybrid approach ensures high accuracy for frequent questions while maintaining flexibility for varied or ambiguous queries. The system is deployed as a web-based application using Flask and can be easily adapted for other educational institutions.

Through practical evaluation and test cases, the chatbot demonstrates improved response accuracy and a more natural user experience compared to traditional rule- based bots. This work contributes toward intelligent automation in educational support systems and highlights the importance of combining multiple AI techniques for effective conversational interfaces.

Keywords:

Chatbot, Conversational Agent, College Enquiry System, Context Awareness, Intent Classification, Hybrid NLP, Rule-Based System, Machine Learning, Educational Automation, Flask

1. INTRODUCTION

In the digital era, the demand for intelligent and responsive systems to automate information dissemination has significantly increased, particularly in the field of education. Colleges and universities often

receive a high volume of repetitive queries from students and parents regarding admissions, course offerings, fee structures, hostel facilities, and other institutional details. Traditional communication channels, such as phone calls, emails, or static websites, are often inadequate to handle these queries efficiently and in real-time. This gap has given rise to the development of conversational agents, commonly known as chatbots, that can provide instant, round-the-clock support.

While several chatbot systems exist, many of them rely solely on rule- based mechanisms or static keyword matching, which limits their ability to

understand natural language or adapt to dynamic user inputs. These bots typically fail when faced with vague or context- dependent queries, leading to a poor user experience. For instance, a user might ask a follow-up question such as "What about the second one?" after inquiring about available courses. A traditional chatbot, unaware of the previous message, would be unable to respond meaningfully.

To address these limitations, this project presents the design and implementation of a **Context-Aware Hybrid Conversational Agent for College Enquiries**. The proposed system integrates both **rule-based logic** and **machine learning (ML)** techniques to improve the bot's flexibility and accuracy. It uses predefined rules for common questions while employing a lightweight intent classification model for handling unstructured inputs. Furthermore, the system incorporates **context-awareness** by storing and referencing recent user interactions, allowing it to respond intelligently to follow-up questions or incomplete statements.

The chatbot is developed using Python and Flask, with a simple and responsive web interface. The integration of hybrid natural language processing (NLP) approaches ensures that the chatbot can not only provide accurate information but also maintain a coherent conversational flow. The system can be customized for various educational institutions and extended to support multilingual communication and voice-based interaction in future iterations.

This project contributes to the growing field of educational automation and showcases how hybrid AI techniques can be effectively combined to build smarter, more conversational systems.

2. PROPOSED SYSTEM

The proposed system introduces a **Context-Aware Hybrid Conversational Agent** designed to streamline college enquiry processes by intelligently responding to user queries through a combination of rule-based logic and machine learning techniques. The chatbot is capable of handling both structured and unstructured inputs by first attempting to match user queries with predefined patterns for common questions, and when such rules do not apply, it leverages a trained machine learning model to classify the user's intent based on natural language input. To enhance the quality of interaction, the system incorporates **context-awareness** by storing recent conversation history using session memory, enabling it to respond meaningfully to follow-up questions or vague references, such as "What about the second one?" or "How much does it cost?" when the preceding topic was, for example, a specific course. The model is trained on a custom dataset using TF-IDF for text vectorization and a lightweight classifier like Naive Bayes or Logistic Regression. The application is built using Python and Flask for the backend, while the user interface is delivered via a web- based frontend using HTML, CSS, and JavaScript. This architecture allows for fast and responsive interactions while maintaining adaptability. The system is modular and scalable, with potential for enhancements such as multilingual support, voice-based interaction, and real- time database connectivity. By combining natural language understanding with session-level context handling, the proposed chatbot offers a more intelligent, flexible, and user-friendly solution for automating college-related enquiries.

2.2 PROPOSED TECHNIQUE WORKS

1. Intent Classification using TF- IDF

TF-IDF (Term Frequency–Inverse Document Frequency)

Used to convert user input into feature vectors that represent how important a word is to a document in a corpus.

Equation:

$$\text{TF-IDF}(t, d) = \text{TF}(t, d) \times \text{IDF}(t)$$

Where:

- TF (t, d) Frequency of term t in document d

- IDF(t) = log (N / 1+DF(t)), N = total number of documents, DF(t) = number of documents containing term t.
- Example:

If "admission" appears 2 times in a query of 10 words and in 5 out of 100 documents: TF = 2/10 = 0.2, IDF = log(100/1+5) ≈1.22
⇒ TF – IDF = 0.2 × 1.22 = 0.244

2. Naive Bayes Classifier for Intent Prediction

A probabilistic classifier used after vectorization to determine the most likely intent.

Equation (Bayes' Theorem):

P (c | x) = P (x | c). P(c) / P(x)

Where:

- P (c | x) = posterior probability of class c given feature x
- P (x | c) = likelihood of feature x given class c
- P(c) = prior probability of class c
- P(x) = prior probability of feature vector x

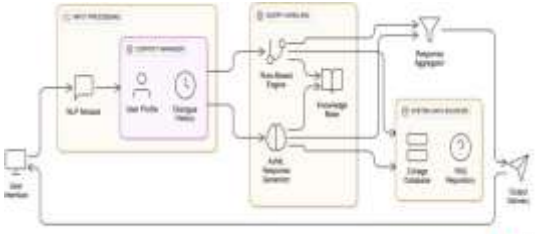
Simplified for classification:

$$\hat{y} = \arg\max_{c \in C} P(c) \prod_{i=1}^{n} P(x_i \mid c)$$

Example:

Input query: "how much is the tuition?" Assuming:
P("fees")=0.5
P("tuition"|"fees")=0.6
P("tuition"|"admission")=0.1 Then:
P("fees"|"tuition")=0.5·0.6=0.3>P("admissi on"|"tuition")=0.5·0.1=0.05⇒Predicted inte nt: "fees"

3. System Architecture of Context- Aware Hybrid Conversational Agent Integrating Rule-Based and AI/ML Approaches



4. CONCLUSION

2.3 ADVANTAGE OF THE PROPOSED SYSTEM

The proposed system offers several notable advantages that make it highly suitable for modern educational environments. By combining rule-based logic with machine learning models, the chatbot ensures both high accuracy and flexibility in responding to a wide range of user queries. Its ability to maintain conversational context allows for natural, multi-turn interactions, creating a human- like user experience. Operating 24/7, the chatbot provides instant responses to students, parents, and other stakeholders, significantly reducing the administrative burden on staff. Designed with scalability in mind, it can be easily updated with new intents, responses, and language support as institutional needs evolve. The chatbot is optimized specifically for educational domains, ensuring accurate handling of inquiries related to admissions, courses, fees, and campus facilities. Its web-based accessibility makes it available across various devices without requiring extra installations. Additionally, the system supports an admin interface for real-time content management, and its structure allows future enhancements such as sentiment analysis, voice integration, and multilingual support. Together, these features contribute to a smart, efficient, and user-friendly solution for The proposed hybrid chatbot system for college enquiry successfully integrates rule- based logic with machine learning intent classification to provide intelligent, accurate, and context-aware responses to user queries. By leveraging both predefined rules for common questions and ML models trained on domain-specific data, the system ensures that even varied or indirect queries can be interpreted meaningfully. The inclusion of a context manager allows the chatbot to remember previous interactions within a session, enhancing conversational flow and user satisfaction. This system serves as a reliable virtual assistant for prospective students and stakeholders by offering instant support on topics like courses,

fees, admission procedures, and campus facilities, all via a user-friendly web interface. The modular, extensible design ensures the system remains scalable and adaptable to institutional needs.

5. FUTURE ENHANCEMENTS

Multilingual Support: Expand the chatbot's language capabilities to support regional and international languages using Natural Language Toolkit (NLTK), spaCy, or integration with Google Translate API to enhance accessibility for a diverse user base.

Voice Assistant Integration: Incorporate speech-to-text and text-to-speech

capabilities using tools like Google Speech API or Amazon Polly, allowing users to interact with the chatbot via voice.

Feedback System: Introduce a feedback mechanism to collect user ratings and suggestions on chatbot responses, helping fine-tune performance and identify knowledge gaps.

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