International Conference on Sciences, Engineering & Environmental Technology (ICONSEET), 16(16): 01-09, 2024
ISSN 0749-9650

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Design and Implementation of a Web-Based Informational Chatbot: A Case Study of Computer Science Department Federal Polytechnic Ede (*CS infoBot*)

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ABSTRACT: *This study aims to design and implement a web-based chatbot for the Computer Science Department at Federal Polytechnic Ede, Osun State, by providing users with accurate and timely access to departmental information. The study addresses the inefficiencies of traditional administrative methods, which are often slow and prone to delays, especially during peak periods like admissions and exams. It developed a hybrid system using a JSON-based knowledge base for static information and Google Gemini API for dynamic, context-aware responses. The frontend was developed with HTML, CSS, and JavaScript for a user-friendly interface, while Python and Flask powered the backend to ensure seamless query processing. Testing included user feedbacks and iterative adjustments to enhance functionality. The resulting chatbot successfully provides real-time responses, significantly reducing delays in information access. This system demonstrates the potential of chatbots to streamline communication and support in academic settings.*

Keywords*: AI in Education, Natural Language Processing, Educational Chatbots, Automated Information Systems, Federal Polytechnic Ede, AI-driven Chatbot*

1.0 INTRODUCTION

The rapid growth of technology has reshaped many sectors, including education, where institutions now use digital tools to enhance learning, streamline administration, and improve communication. One key development is the rise of chatbots—AI-powered systems that mimic human conversations to provide automatic responses. Initially rule-based, chatbots have advanced with AI and NLP, becoming more accurate and capable. Research, such as by Adamopoulou & Moussiades (2020), shows chatbots are effective across various fields, including education, where they enhance accessibility and efficiency.

Studies (e.g., Okonkwo & Ade-Ibijola, 2021; Dutta et al., 2019) highlight that chatbots in higher education reduce the workload on administrative staff by answering common questions on admissions, courses, and schedules, leading to greater student satisfaction. At Federal Polytechnic Ede, the Computer Science Department faces challenges with traditional methods of handling high volumes of queries. The delays frustrate users seeking quick information, underscoring the need for a chatbot to handle routine inquiries.

This research aims to implement a web-based chatbot for the department, using AI and NLP to instantly respond to frequently asked questions, alleviating the administrative load and enhancing user experience. Such a chatbot aligns with the broader trend of digital transformation in education, creating a more responsive and engaging environment and positioning the department as a digital leader.

1.1 AIMS & OBJECTIVES

Aim:

The primary aim of this study is to design and implement a web-based chatbot for the Computer Science Department at Federal Polytechnic Ede, Osun State, which will grant users access to accurate and timely information.

Objectives:

1. Create an interactive, user-friendly chatbot interface.
2. Build a knowledge base of FAQs and departmental information.
3. Enable real-time responses about courses, faculty, and events.

1.2 SCOPE OF THE STUDY

The scope of this study is limited to the development and implementation of a web-based chatbot for the Computer Science Department at Federal Polytechnic Ede in Osun State. The chatbot will be developed to handle queries such as:

i. Course options and timetables.
ii. Faculty and staff contact information
iii. Departmental events and news
iv. Admission requirements and procedures
v. General administrative processes

1.3 SIGNIFICANCE OF THE STUDY

1. **Enhanced Information Accessibility:** Provides 24/7 access to information for students, faculty, and applicants, removing delays caused by manual responses.
2. **Reduced Administrative Workload**: Automates common queries, allowing administrative staff to focus on more complex tasks.
3. **Improved User Experience:** Delivers instant, accurate responses, increasing satisfaction among users.
4. **Efficient Communication:** Ensures quick and effective dissemination of important information within the department.

2.0 LITERATURE REVIEW

The integration of chatbots in education has surged recently, driven by advancements in AI and NLP, making these tools essential for round-the-clock support in administrative tasks, student inquiries, and learning assistance. This chapter reviews existing literature on educational chatbots, covering their applications, benefits, challenges, and trends, to support the design of a chatbot for the Computer Science Department at Federal Polytechnic Ede.

2.1 Evolution of Chatbot Technology in Education

Chatbots have evolved significantly since the 1960s, with early systems like Joseph Weizenbaum's ELIZA offering basic pattern-matching responses. Modern chatbots, powered by AI advances and deep learning techniques such as RNNs and transformers, now provide sophisticated, context-aware interactions. They offer personalized responses, assist in problem-solving, and integrate with educational management systems, delivering real-time, up-to-date information to students and staff (Smutny & Schreiberova, 2020; Winkler & Söllner, 2018).

Natural language understanding (NLU) and generation (NLG) advancements have also enhanced chatbots' ability to accurately interpret complex queries and provide coherent, contextually relevant responses. This evolution has positioned chatbots as valuable tools for improving engagement, operational efficiency, and personalized support in educational settings.

2.2 REVIEW OF RELATED WORKS

The adoption of chatbots in education has gained considerable momentum, with numerous studies highlighting their transformative role in improving administrative efficiency and enhancing student engagement. This section provides an in-depth review of recent research projects and implementations of chatbots in educational settings, offering insights into their effectiveness, challenges, and potential for future development.

Winkler and Söllner (2018), in their study presented at the Australasian Conference on Information Systems, examined the potential of chatbots to improve student success in higher education. They proposed a chatbot designed to provide personalized learning support and found that such systems could significantly enhance the learning experience by offering immediate, tailored assistance to students. The authors emphasized the importance of integrating chatbots with existing learning management systems to provide a seamless experience for users.

Building on this work, Smutny and Schreiberova (2020) conducted a comprehensive review published in Computers & Education, analyzing chatbots used for educational purposes across various fields. Their findings indicated that chatbots were particularly effective in language learning, programming education, and providing administrative support. The authors

emphasized the potential of chatbots to offer personalized learning experiences and reduce educators' workload. They also highlighted the need for more sophisticated natural language processing capabilities to handle complex student queries effectively.

In a related study, Pérez et al. (2020) investigated the use of chatbots in higher education for improving student engagement. Their work, published in the International Journal of Interactive Multimedia and Artificial Intelligence, demonstrated how chatbots could effectively handle student queries about course content, schedules, and administrative procedures, leading to increased student satisfaction and reduced workload for staff. The researchers noted that chatbots were particularly effective in providing instant responses to common questions, allowing human staff to focus on more complex issues that required personal attention.

Adamopoulou and Moussiades (2020), in their work Chatbots: Hisory, Technology, and Applications, analyzed the evolution of chatbots and their applications in various industries, including education. The authors discussed how advances in natural language processing (NLP) have enabled chatbots to better understand user queries and deliver more accurate responses. Their research highlights the technological advancements that have made chatbots an efficient solution for automating student services and improving information accessibility.

Hien et al. (2018), in their study published in the Journal of Telecommunications and Information Technology, explored the use of chatbots in university information systems. They proposed a model for integrating chatbots with existing university databases to provide students with quick access to information about courses, schedules, and academic procedures. The researchers emphasized the importance of data security and privacy when implementing such systems, particularly given the sensitive nature of student information.

Extending the scope of chatbot applications, Ondáš et al. (2019) published a study in the IEEE Access journal, focusing on the use of conversational AI in e-learning environments. Their work demonstrated how chatbots could be used to create interactive learning experiences, particularly in the context of language education. The authors highlighted the potential of voice-enabled chatbots to improve students' speaking and listening skills, suggesting a new frontier in educational technology.

In a similar vein, Okonkwo and Ade-Ibijola (2021) presented their findings in the International Journal of Artificial Intelligence in Education, showcasing a chatbot designed to assist computer science students with programming concepts. Their system used natural language processing to interpret student queries and provide explanations, code examples, and debugging assistance. The authors noted significant improvements in student understanding and engagement, particularly for complex programming topics.

Addressing the challenge of scalability in educational support, Cunningham-Nelson et al. (2019) published their work in the Australasian Journal of Educational Technology. They developed a chatbot capable of handling a high volume of student queries during peak periods, such as exam times or course registration. The system demonstrated the ability to significantly reduce response times and improve overall student satisfaction with support services.

Focusing on the personalization aspect of educational chatbots, Hobert (2019) presented a study in the Proceedings of the 52nd Hawaii International Conference on System Sciences. The author explored the use of adaptive learning techniques in chatbot design, allowing the system to tailor its responses based on individual student profiles and learning progress. This approach showed promise in providing more effective and engaging learning experiences for students with diverse needs and learning styles.

Lastly, Molnár and Szüts (2018) published their findings in the Journal of Applied Technical and Educational Sciences, examining the ethical considerations of using AI-powered chatbots in educational settings. Their work highlighted the importance of transparency in chatbot interactions, ensuring that students are aware when they are communicating with an AI system. The authors also discussed the potential biases that could be introduced through chatbot algorithms and the need for careful design and monitoring to ensure equitable support for all students.

3.0 METHODOLOGY - SYSTEM OVERVIEW

3.1 Introduction

The chatbot is designed to provide instant, automated responses to department-related queries for the Computer Science Department. The system uses a hybrid approach: a JSON-based knowledge base for static information and a language model API (Google Gemini) for dynamic responses, allowing the chatbot to handle both routine questions and more complex inquiries.

3.2 SYSTEM ARCHITECTURE SUMMARY

The system's architecture enables it to balance quick, static responses with the flexibility of real-time, dynamic answers. This hybrid structure is crucial for handling a wide range of queries efficiently while reducing the load on department staff.

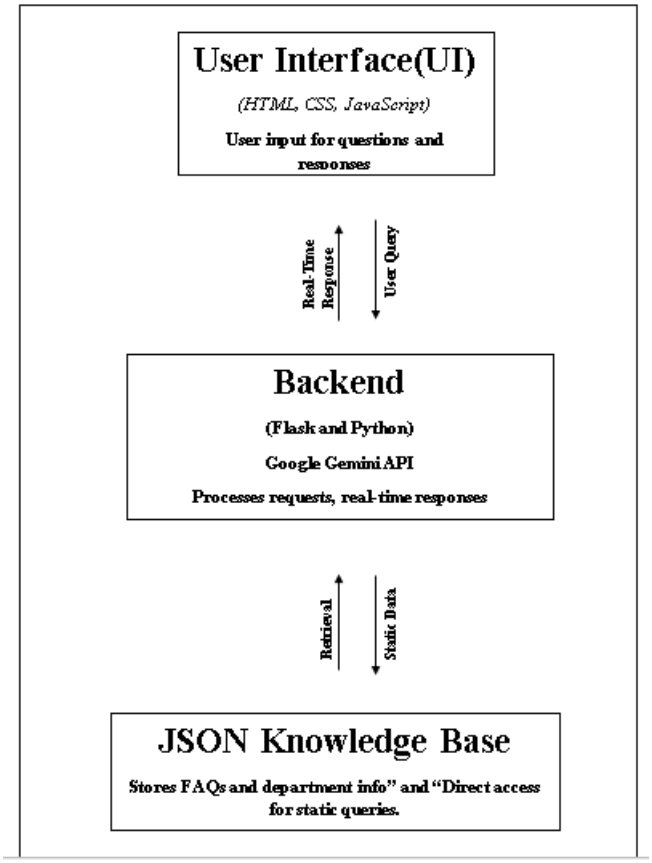

Fig 1.0 System Architecture Diagram

3.3 DEVELOPMENT PROCESS

1. **Requirement Analysis**: Surveys and interviews with students, staff, and faculty helped define frequently asked questions and common information needs, informing the JSON content.
2. **Frontend Development:** Built with user experience in mind, emphasizing clarity, simplicity, and responsiveness.
3. **Backend and API Integration:** The backend was set up to interact seamlessly with the frontend and to handle JSON and API responses efficiently.
4. **Testing and Iteration:** The system underwent unit and user testing, ensuring all components worked together smoothly and adjustments were made based on user feedback.

3.4 SYSTEM COMPONENTS

1. **Frontend (User Interface):** Developed using HTML, CSS, and JavaScript, the frontend provides a clean, intuitive interface for users to input queries and view responses. The responsive design ensures usability across various devices.
2. **Backend:** Built with Python and the Flask framework, the backend processes requests and manages the logic for both static and dynamic responses.
3. **JSON Knowledge Base:** Stores frequently asked questions, course information, and faculty details, allowing the chatbot to quickly respond to common queries without querying the API.
4. **Google Gemini API Integration:** For questions that require nuanced responses, the backend routes the query to the Google Gemini API, which generates context-aware answers based on natural language processing.

3.5 HOW THE SYSTEM WORKS

Step 1: User Query Input

A user inputs a question via the frontend interface. This question could range from basic (e.g., "Who teaches a particular course?") to complex (e.g., "Can you explain how it rains?").

```
58    <!-- Chatbot Interface Preview -->
59
60  <section class="chatbot-preview" id="chatbot-preview">
61      <h2>Chat Now!</h2>
62      <div class="chatbot-demo">
63        <div class="chat-window" id="chatWindow">
64          <div id="chat-log">
65            <!--Chat logs will appear here -->
66          </div>
67          <input
68            type="text"
69            id="user-input"
70            placeholder="Type your message..."
71          />
72          <button onclick="sendMessage()" id="sendButton">Send</button>
73        </div>
74      </div>
75    </section>
```

Fig 2.0 HTML code displaying the chat interface section for users to input and receive feedback on their queries.

Step 2: Query Handling in Backend

The backend receives the query and determines whether it can be answered with predefined information from the JSON knowledge base or requires a dynamic response via the API.

Simple Queries: If the query matches an entry in the JSON knowledge base (e.g., course details, faculty contact information), the backend retrieves the relevant information directly from JSON and returns it to the user.

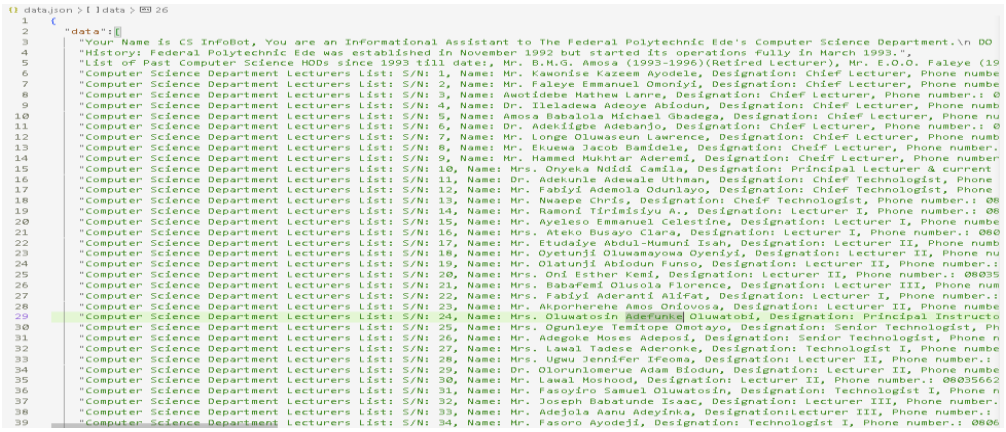

Fig 2.1Pre-defined information loaded in the JSON Knowledge base

Complex Queries: If the query requires a more nuanced response, the backend forwards it to the Google Gemini API. This API processes the query using advanced NLP, generating a suitable response based on its understanding of context and language.

```python
# Load system instruction from JSON file
def load_instructions():
    with open('data.json', 'r') as file:
        data = json.load(file)
        return "\n".join(data.get("data", ["Default instruction if not found."]))


# Configure the Google API
genai.configure(api_key="AIzaSyCGD_6pbYbONo6I6Bfl6w13tJyLrduxFWU")

generation_config = {
    "temperature": 1,
    "top_p": 0.95,
    "top_k": 64,
    "max_output_tokens": 8192,
    "response_mime_type": "text/plain",
}

# Load the system instruction from the JSON file
system_instruction = load_instructions()

# Initialize the generative model with the system instruction
model = genai.GenerativeModel(
    model_name="gemini-1.5-flash",
    generation_config=generation_config,
    system_instruction=system_instruction,
)
```

Fig 2.2 -Python code initializing the Google Gemini API with JSON instructions and generation parameters for handling complex queries.

Step 3: Response Delivery

The backend sends the response (either from JSON or the API) back to the frontend, which displays it to the user in the chat interface. The response delivery time is optimized to occur within seconds.

```python
# Route to handle chat messages
@app.route('/chat', methods=['POST'])
def chat():
    try:
        user_input = request.json.get('message')

        # Retrieve previous context from the session, if any
        history = session.get('chat_history', [])

        # Add the new user message to the history
        history.append({"role": "user", "parts": [user_input]})

        # Start a chat session with the existing history
        chat_session = model.start_chat(history=history)

        # Get model response
        response = chat_session.send_message(user_input)
        response_text = response.text

        # Add the model's response to the history
        history.append({"role": "model", "parts": [response_text]})

        # Update the session with the new history
        session['chat_history'] = history

        # Send back the model response as JSON
        return jsonify({"response": response_text})

    except Exception as e:
        # Handle any errors that occur during the process
        return jsonify({"error": str("An error occurred. Try again later.")}), 500

```

Fig 2.3 Python code that managing chat requests by processing user input, generating model responses, giving feedbacks and maintaining session history.

4.0 RESULTS AND DISCUSSION

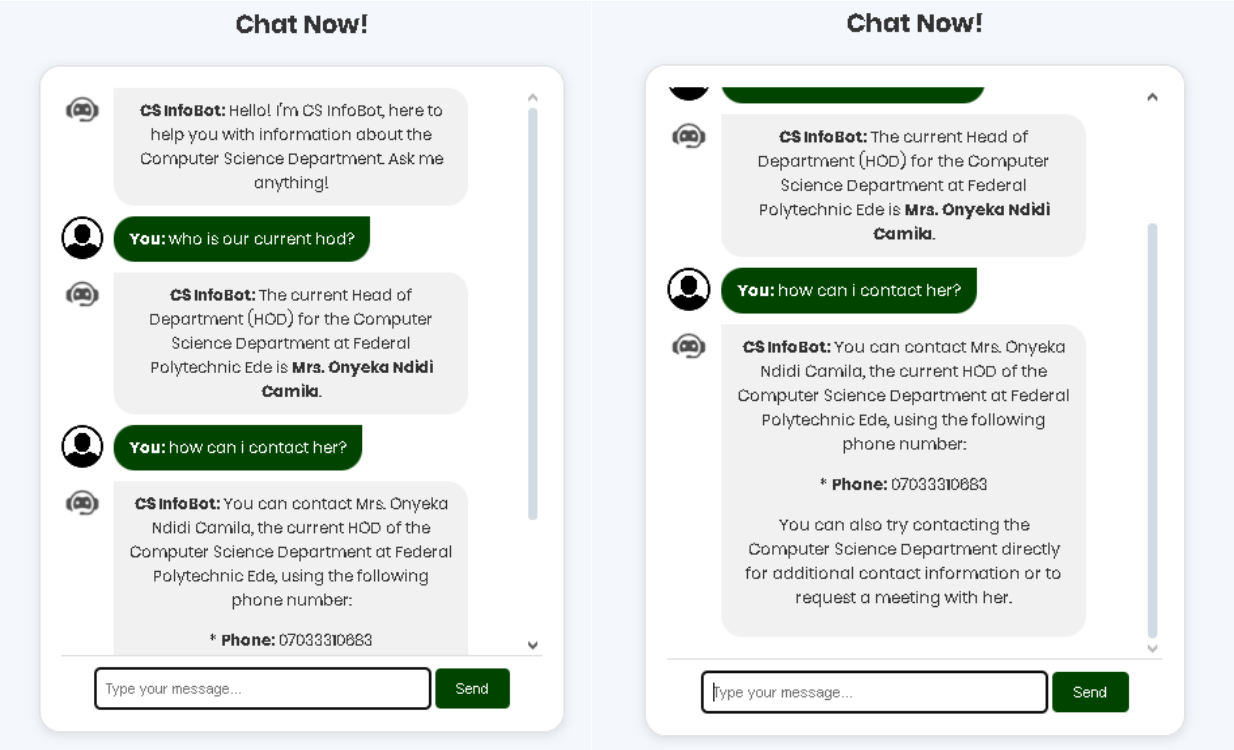

*Fig 3.0 and Fig 3.1: sample questions and responses from the **CS Infobot***

Figure 3.0 and 3.1 shows the chatbot interface, from which an enquiry was made about the current HOD of Computer Science Department. It is seen above that the chatbot was able to give correct information about the current HOD which is Mrs Onyeka N.C as well as her contact information.

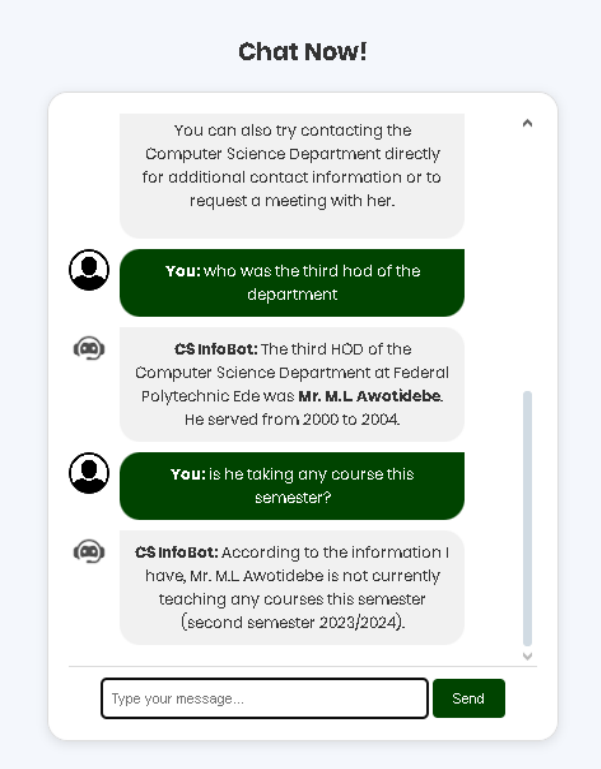

Fig 3.2: question on who was the third HOD of the department and the response

Figure 3.2 shows that the chatbot was asked a question about the third person who headed the Computer Science Department (HOD) elected in computer science department. It is seen that the chatbot provided a correct information which is Mr M.L Awotidebe, who served from 2000 -2004. It is also seen that the chatbot was further asked whether he still teaches any course in the institution, also which it reported negative.

5.0 CONCLUSION

This study successfully designed and implemented a web-based chatbot for the Computer Science Department at Federal Polytechnic Ede. By leveraging AI and NLP technologies, the chatbot addresses the inefficiencies of traditional administrative methods, providing instant and accurate responses to frequently asked questions. The integration of a JSON-based knowledge base and Google Gemini API ensures a balance of static and dynamic query handling, enhancing user satisfaction and operational efficiency. The chatbot significantly reduces the workload on administrative staff, offers 24/7 access to departmental information, and improves communication within the department. This scalable solution aligns with modern educational trends, setting a benchmark for digital transformation in academic institutions.

However, the study faced certain limitations. The chatbot's performance is dependent on the quality and comprehensiveness of the preloaded knowledge base, which may limit its ability to handle complex or unanticipated queries. Additionally, the reliance on the Google Gemini API introduces dependency on third-party services, which may pose challenges related to costs and service interruptions. Future improvements could include expanding the knowledge base, enhancing NLP capabilities for greater accuracy and user engagement, and exploring more robust and independent AI models to mitigate third-party dependencies.

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