Lecture Notes in Networks and Systems 1041

Marcelo Zambrano Vizuete · Miguel Botto-Tobar · Sonia Casillas · Carina Gonzalez · Carlos Sánchez · Gabriel Gomes · Benjamin Durakovic *Editors*

Innovation and Research – Smart Technologies & Systems

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Preface

The 4th edition of the International Research and Innovation Congress – Smart Technologies and Systems, CI3 2023, took place from August 30 to September 1, 2023, at the facilities of the Instituto Tecnológico Universitario Rumiñahui, located in the city of SangolquÍ, Pichincha, Ecuador.

The conference was organized by the Red de Investigación, Innovación y Transferencia de Tecnología RIT2, made up of the most relevant university institutes in Ecuador, among which are ITCA, BOLIVARIANO, ARGOS, VIDA NUEVA, ESPÍRITU SANTO, SUDAMERICANO, ISMAC, SAN ISIDRO, ARTES GRÁFICAS, ORIENTE, HUMANE, SUCRE, CENTRAL TÉCNICO, POLICÍA NACIONAL and RUMIÑAHUI.

Additionally, the event is sponsored by the Secretaría de Educación Superior, Ciencia, Tecnología e Innovación SENESCYT, Labortorio de Comunicación Visual de la Universidad Estatal de Campinas—Brazil, Universidad Ana G. Méndez—Puerto Rico, Centro de Investigaciones Psicopedagógicas y Sociológicas—Cuba, Instituto Superior de Diseño de la Universidad de La Habana—Cuba, GDEON and the Corporación Ecuatoriana para el Desarrollo de la Investigación y la Academia—CEDIA.

The main objective of CI3 2023 is to generate a space for dissemination and collaboration, where academia, industry and government can share their ideas, experiences and results of their projects and research.

"Research as a pillar of higher education and business improvement" is the motto of the Conference and suggests how research, innovation and academia must coincide with the productive sector to leverage social and economic development.

CI3 2023 had 145 papers submitted, of which 52 were accepted for publication and presentation. To guarantee the quality of the publications, the event has a staff of more than 70 experts, from different countries such as Spain, Argentina, Chile, Mexico, Peru, Brazil, Ecuador, among others, who carry out an exhaustive review of each proposal sent.

Likewise, during the event a series of keynote conferences were held, given by both national and international experts, allowing attendees to get in touch with the latest trends and technological advances around the world. Keynote speakers included: Ph.D. Carina González, University of La Laguna, Spain; Ph.D. Gabriel Gómez, State University of Campinas, Brazil; Ph.D. Carlos Sanchez, University of Zaragoza, Spain; Ph.D. Juan Minango, Instituto Tecnológico Superior Rumiñahui; Dr. Iván Cherrez, Universidad Espíritu Santo, Ecuador; and Ph.D. Nela Paustizaca, Escuela Politécnica del Litoral, Ecuador.

The content of this proceeding is related to the following topics:

- Smart Cities
- Innovation and Development
- Applied Technologies
- Economics and Management
- ICT for Educations.

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Applied Technologies

Building a WhatsApp Chatbot with Node.js: File Processing and AI Response Generation

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Abstract. This paper presents the development and implementation of an AI-powered chatbot system tailored for educational institutions. The system utilizes a diverse dataset of conversations specific to the educational domain, enabling accurate understanding and response generation for frequently asked questions, inquiries, and specific queries related to the institute's programs, admissions, courses, and facilities. The dataset is pre-processed to ensure clean and formatted text, incorporating techniques such as tokenization, stemming, and stop-word removal. The underlying model of the chatbot is based on the GPT-2 transformer model, known for its exceptional language generation capabilities and contextual understanding. Additionally, the Logic Learning Machine (LLM) algorithm is employed to generate intelligible rules, enhancing the chatbot's decision-making process. The implementation involves the integration of various libraries and technologies, including 'whatsapp-web.js' for establishing a WhatsApp session, 'openai' for AI-driven completions, and 'twilio' for response delivery via messaging service. The system demonstrates its effectiveness in accurately understanding and responding to user queries, contributing to improved communication and information dissemination within the educational domain. Overall, the chatbot system presents a valuable tool for educational institutions, enhancing user experience, and streamlining communication processes.

Keywords: Chatbot · Educational institutions · AI-powered · Logic Learning Machine (LLM)

1 Introduction

In recent years, chatbots have emerged as a popular tool for providing efficient and personalized assistance in various domains. With the advancement of artificial intelligence (AI) technologies, chatbots have become increasingly sophisticated, enabling organizations to automate customer interactions and streamline

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their operations. In the field of education, chatbots have proven to be valuable assets, providing information and support to students, parents, and staff [1,2].

The concept of chatbots can be traced back to the 1960s when ELIZA, a natural language processing program, was developed. Since then, chatbot technology has evolved significantly, leveraging AI techniques to understand and respond to user queries in a conversational manner [3]. AI plays a crucial role in enabling chatbots to interpret user inputs, extract relevant information, and generate appropriate responses.

One of the key components of AI that powers chatbots is neural networks. In particular, recurrent neural networks (RNNs) and transformer-based models like GPT (Generative Pre-trained Transformer) have gained prominence for their ability to capture context and generate human-like responses [4]. These models leverage deep learning techniques to process and understand natural language, allowing chatbots to handle complex conversations.

Neural networks are a fundamental component of AI that enables chatbots to understand and respond to user queries. In the context of chatbots, recurrent neural networks (RNNs) and transformer-based models like GPT have emerged as powerful tools for natural language processing [5].

RNNs are particularly effective in handling sequential data, making them well-suited for processing conversational text. They have a feedback mechanism that allows them to maintain an internal state, enabling them to capture context and dependencies across different parts of a conversation. This makes RNNs capable of generating responses that consider the entire conversation history, leading to more coherent and contextually appropriate answers [6,7].

On the other hand, transformer-based models, such as GPT, have revolutionized the field of natural language processing. GPT is a state-of-the-art language model that uses a transformer architecture to process and generate text [8]. Transformers rely on self-attention mechanisms, which allow them to capture long-range dependencies and understand the context of a sentence or a document more effectively. This enables chatbots powered by transformer-based models to generate highly accurate and contextually relevant responses.

Both RNNs and transformer-based models leverage deep learning techniques, such as training on large datasets and fine-tuning with specific objectives, to improve their language understanding capabilities [9]. These models can be trained on vast amounts of text data to learn patterns, semantics, and linguistic nuances, enabling them to handle complex conversations and generate human-like responses [10].

By utilizing neural networks like RNNs and transformer-based models, chatbots can provide more intelligent and context-aware interactions, enhancing the overall user experience and making them valuable tools for various applications, including customer support, information retrieval, and educational assistance [11].

In this paper, we present the development of a custom chatbot designed to assist in providing information about Instituto Tecnologico Universitario Rumiñahui (ISTER). Our chatbot incorporates AI techniques, including nat-

ural language processing and neural networks, to offer a seamless and interactive experience for users. We explore the capabilities of AI-powered chatbots in enhancing the information dissemination process and improving user engagement. By leveraging the advancements in AI technology, our chatbot aims to provide accurate and relevant information, streamline communication, and enhance the overall experience for users.

The remainder of this paper is organized as follows. Section 2 provides an overview of the methodology employed for developing the custom chatbot. Section 3 discusses the implementation details, highlighting the AI techniques and neural networks utilized. Section 4 presents the evaluation results and performance metrics of the chatbot. Section 5 discusses the implications and potential future enhancements. Finally, Sect. 6 concludes the paper and summarizes the key findings and contributions.

2 Methodoly

In this section, we provide an overview of the methodology employed for developing our custom chatbot. The development process involved several key steps, including data collection, pre-processing, model selection, training, and evaluation [12]. The methodology aimed to create a robust and efficient chatbot that effectively assists users in obtaining information about our educational institute.

2.1 Data Collection

To develop a chatbot that accurately understands and responds to user queries in the educational domain, we collected a dataset from ISTER's web page as it is shown in Fig. 1. The dataset includes frequently asked questions, common inquiries, and specific queries about ISTER, its programs, admissions, courses, and facilities. This data collection process ensures that the chatbot will have a broad understanding of user intents and variations in queries related to the ISTER.

The collected dataset will be used to train a language model, specifically a chatbot, using techniques such as natural language processing and machine learning. By training the chatbot on this dataset, it will be able to learn patterns, understand user intents, and provide accurate responses to queries about ISTER and related topics.

Training a language model involves processing the dataset, extracting relevant features, and training the model to understand the context, intent, and nuances of user queries [13]. This process helps the chatbot generate appropriate and informative responses based on the input it receives.

2.2 Data Pre-processing

In the process of developing the chatbot, the collected dataset underwent thorough pre-processing to clean and format the text. This pre-processing stage is

Fig. 1. Ister's web page.

crucial for ensuring the quality and effectiveness of the trained language model. Here are the steps involved:

1. Removal of Irrelevant Information: Irrelevant information such as HTML tags, special characters, or noisy data was removed from the text. This step helps in eliminating unnecessary noise and improving the quality of the dataset.
2. Text Normalization: Text normalization techniques were applied to achieve consistent representation of words. This involved converting all text to lowercase, handling contractions (e.g., "can't" to "cannot"), and removing punctuation marks.
3. Tokenization: Sentences were split into individual words or tokens. This step helps the model understand the structure of the text and process it at a granular level.
4. Stemming or Lemmatization: Stemming or lemmatization techniques were used to reduce words to their base form. This helps in reducing the dimensionality of the vocabulary and capturing the essence of the words.
5. Stop-word Removal: Stop words, such as "the", "and", or "is", which do not carry significant meaning, were removed from the text. This improves the efficiency of language processing by focusing on more informative words.

In addition to these pre-processing steps, VectorStore was utilized in the development process. VectorStore played a role in managing and working with the vector embeddings derived from the pre-processed text [14]. It allowed for efficient storage, retrieval, and manipulation of the vector embeddings, enabling tasks such as semantic search and similarity matching.

By incorporating VectorStore into the development pipeline, it enhanced the capabilities of the chatbot by providing efficient indexing and retrieval of relevant information based on semantic similarities captured in the vector embeddings.

2.3 Model Selection

For the chatbot's underlying model, we explored different options based on the requirements of our educational institute. After careful consideration, we selected a transformer-based model, specifically the GPT-2 model, known for its exceptional language generation capabilities and context understanding.

2.4 Training

The selected model was trained on the pre-processed dataset using supervised learning techniques. We employed transfer learning to leverage the pre-trained GPT-2 model's language understanding abilities and fine-tuned it on our specific educational dataset [15]. The training process involved optimizing model parameters, such as learning rates and batch sizes, to improve performance and generate high-quality responses.

2.5 Evaluation

To assess the effectiveness of our custom chatbot, we conducted rigorous evaluations using various metrics, including response accuracy, contextual coherence, and user satisfaction. We performed both manual evaluation, where human evaluators assessed the quality of responses, and automated evaluation, where we compared the generated responses against ground truth answers from domain experts.

The methodology outlined in this section ensured the development of a custom chatbot that leverages neural network models and AI techniques to provide accurate and contextually appropriate responses to user queries. The subsequent sections of this paper will delve into the implementation details, challenges faced, and the achieved performance of our custom chatbot.

3 Implementation Details and AI Techniques

In this section, we provide a comprehensive overview of the implementation details of our custom chatbot, focusing on the AI techniques and neural networks utilized. We discuss the key components, architecture, and algorithms employed to create an intelligent and interactive chatbot for our educational institute.

3.1 Chatbot Architecture

The chatbot architecture comprises several modules that work together to facilitate smooth communication between the user and the chatbot. These modules include natural language understanding (NLU), dialogue management, and natural language generation (NLG). The NLU module processes user input, extracting intents and entities, while the dialogue management module maintains the conversation flow. The NLG module generates coherent and contextually appropriate responses based on the input and system state.

3.2 AI Techniques for Natural Language Processing

To enhance the chatbot's language processing capabilities, we employed various AI techniques, including named entity recognition (NER), part-of-speech (POS) tagging, and sentiment analysis. NER identifies and categorizes named entities such as names, locations, and organizations. POS tagging assigns grammatical tags to words in a sentence, enabling the chatbot to understand the syntactic structure. Sentiment analysis determines the sentiment expressed in user queries, allowing the chatbot to respond accordingly.

3.3 Neural Networks for Chatbot Development

To enable the chatbot to understand and generate human-like responses, we utilized advanced neural network models. Recurrent Neural Networks (RNNs) see Fig. 2 and Long Short-Term Memory (LSTM) see Fig. 3 networks were employed for sequence modeling and capturing context dependencies. These models excel in understanding and generating text sequences, ensuring the chatbot's ability to provide coherent and meaningful responses.

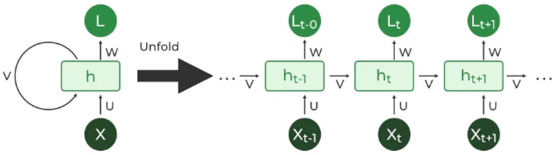

Fig. 2. RNN Network Implemented.

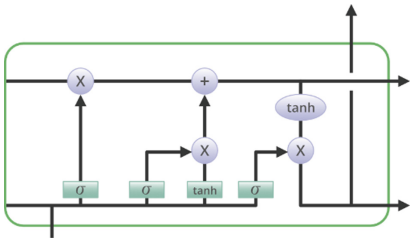

Fig. 3. LSTM Network Implemented.

3.4 GPT-2 for Language Generation

For the language generation component of the chatbot, we leveraged the power of the GPT-2 (Generative Pre-trained Transformer 2) model. GPT-2 is a transformer-based language model that utilizes the attention mechanism to capture dependencies and generate high-quality text. By fine-tuning GPT-2 on our educational dataset, we achieved more accurate and contextually appropriate responses.

4 Implications and Results

In this section, we present the implementation details of a chatbot designed to provide accurate and efficient responses to user queries in the educational domain. The chatbot leverages the capabilities of the WhatsApp Business API, Twilio messaging service, and the OpenAI API for natural language processing. Additionally, the implementation incorporates the use of the VectorStore library for data preprocessing and the Logic Learning Machine (LLM) model for rule-based machine learning. The primary goal of the chatbot is to enhance the user experience by delivering comprehensive and context-aware information about our educational institute's programs, admissions, courses, and facilities.

4.1 Model Selection

After careful consideration of various options, a transformer-based model called GPT-2 (Generative Pre-trained Transformer 2) was chosen as the underlying model for the chatbot. GPT-2 is renowned for its exceptional language generation capabilities and its ability to comprehend and generate contextually relevant responses. Additionally, the Logic Learning Machine (LLM) model, which is based on the Switching Neural Network (SNN) paradigm, was incorporated into the implementation. The LLM model, developed by Marco Muselli, a Senior Researcher at the Italian National Research Council CNR-IEIIT in Genoa, offers an efficient approach to generating intelligible rules, making it a valuable addition to our chatbot's functionality.

4.2 Integration with WhatsApp and Twilio

The implementation integrates the WhatsApp Business API and Twilio messaging service to facilitate seamless communication with users. The 'whatsapp-web.js' library is utilized to interact with the WhatsApp API, while the 'twilio' library enables message sending through the Twilio platform. Upon receiving a user query, the chatbot processes the request using the OpenAI API and generates a response based on the GPT-2 model and LLM rules. The response is then sent back to the user via both WhatsApp and Twilio SMS services. In Fig. 4 is shown its logo.

Fig. 4. Twilio.

4.3 File Processing and Response Generation

To handle user requests involving file uploads, the implementation includes functionality to read and process text files and PDF files. The 'pdfjs-dist' library is employed to extract text from PDF documents, while the 'fs' module enables reading of text files. The extracted text is preprocessed using the VectorStore library, and subsequently, the OpenAI API is utilized to generate a response based on the processed data. The response is sent back to the user via both WhatsApp and Twilio, ensuring a seamless and consistent user experience.

In the development of the chatbot the following steps where followed:

Importing Required Modules. The necessary modules and libraries are imported, including 'whatsapp-web.js' for interacting with the WhatsApp API, 'qrcode-terminal' for generating QR codes, 'fs' for file system operations, 'openai' for accessing the OpenAI API, 'twilio' for sending messages via Twilio, and 'pdfjs-dist' for PDF processing. The 'dotenv' library is used to load environment variables from a '.env' file.

Configuration and Initialization. The WhatsApp client and Twilio client are created using the provided credentials from the environment variables. A WhatsApp QR code is generated and displayed for authentication.

File Reading and Processing. Utility functions are defined to read text files and PDF files asynchronously. The 'readTextFile' function reads the content of a text file and returns it as a string. The 'readPDF' function reads the content of a PDF file and extracts the text from each page, concatenating them into a single string. The 'runCompletion' function determines the file type based on the file extension. If it's a PDF file, it uses 'readPDF' to extract the text; otherwise, it uses 'readTextFile'. The extracted text is then passed to the OpenAI API for language processing and completion. The response is limited to a maximum of 200 tokens.

Sending Response via Twilio. The 'sendResponseViaTwilio' function is responsible for sending the response to the user's phone number via Twilio. It uses the Twilio client to create a new message with the response text and sends it to the specified phone number. This code provides the foundation for

a chatbot that can process user requests, generate responses based on the provided data files, and send the responses back to the user via both WhatsApp and Twilio SMS.

In Fig. 5 shows the established session with WhatsApp by generating a QR code. This QR code acts as a gateway for users to authenticate the chatbot with their WhatsApp accounts. Users simply need to scan the QR code using the WhatsApp mobile app, enabling the chatbot to send and receive messages on their behalf.

Fig. 5. QR code.

Once the session is established, the Node.js server initializes the WhatsApp client using the 'whatsapp-web.js' library. The client is responsible for managing incoming and outgoing messages. Upon successful initialization, the server logs a message indicating that the client is ready to send and receive messages.

The chatbot continuously listens for incoming messages from WhatsApp users. Using event listeners, it captures incoming messages and performs appropriate actions based on their content. One such action is triggered when a user sends a message starting with '#' as is shown in Fig. 6.

When a '#' request is detected, the chatbot extracts the file path from the received message and prepares to process the dataset. The code supports both PDF and text file formats. For PDF files, it utilizes the 'pdfjs-dist' library to extract the text content from each page and concatenate them into a single string. For text files, it reads the content directly.

With the file content extracted, the chatbot proceeds to generate an AI-driven completion response using the OpenAI API. The 'text-davinci-003' model, a variant of the GPT-3 model, is employed for this purpose. The extracted text

Fig. 6. Message starting with '#'.

is used as the prompt for generating the completion response. The generated response is limited to a maximum of 200 tokens to ensure concise and relevant replies as is shown in Fig. 7.

```
async function runCompletion () {
  const fileContent = fs.readFileSync('./file.txt', 'utf8');
  const completion = await openai.createCompletion({
      model: "text-davinci-003",
      prompt: fileContent,
      max_tokens: 200,
  });
  return completion.data.choices[0].text;
```

Fig. 7. Generating AI-driven Completion from File Content.

Once the completion response is generated, the chatbot sends it back to the user as a reply via WhatsApp. Additionally, it leverages the Twilio API to send the response to the user's phone number. This multi-channel approach ensures that the user receives the completion response through WhatsApp as we can observe in Fig. 8.

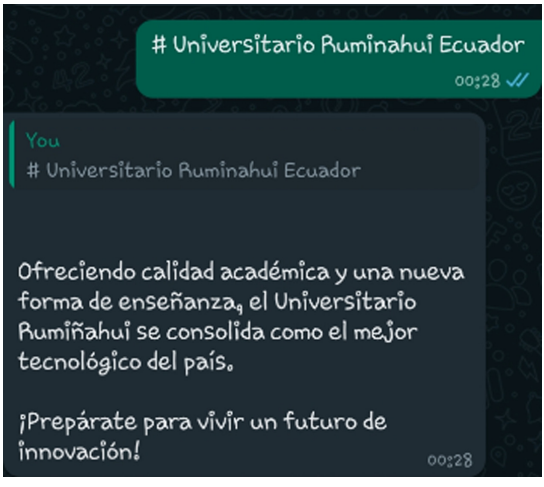

Fig. 8. Message response via Whatsapp.

5 Conclusion

In this paper, we have presented the development and implementation of an AI-powered chatbot system for educational institutions. The system utilizes a diverse dataset of conversations related to the educational domain, which includes frequently asked questions, inquiries, and specific queries about the institute's programs, admissions, courses, and facilities. The collected dataset was thoroughly pre-processed, involving cleaning, text formatting, tokenization, and other techniques to ensure accurate understanding and processing of user queries.

For the underlying model of the chatbot, we selected the GPT-2 model, a transformer-based model known for its exceptional language generation capabilities and context understanding. Additionally, we incorporated the Logic Learning Machine (LLM) algorithm, which generates intelligible rules and enhances the chatbot's decision-making process.

The implementation of the chatbot system involves a combination of technologies and libraries. We utilized the whatsapp-web.js library to establish a session with WhatsApp and handle incoming messages. The code includes functionality for displaying a QR code for session establishment and a "Client is ready" message upon successful initialization.

Furthermore, we integrated the openai library to leverage the OpenAI API for generating AI-driven completions based on user queries. The code includes functions for reading text files and PDF files, extracting their content, and passing it to the OpenAI API for completion generation. The generated completions are then sent as responses to user queries.

Additionally, we incorporated the twilio library to enable sending responses via Twilio's messaging service. The code includes a function that sends the generated completion response to the user's phone number using Twilio.

Through this implementation, we have demonstrated the capabilities of the developed chatbot system in accurately understanding and responding to user queries in the educational domain. The combination of a diverse dataset, advanced language models, and intelligible rule generation has contributed to the chatbot's effectiveness and efficiency in providing relevant and informative responses.

Overall, the implemented chatbot system serves as a valuable tool for educational institutions to enhance their communication with students, address their inquiries, and provide them with timely and accurate information about programs, admissions, courses, and facilities. The system's effectiveness and adaptability make it a promising solution for improving the overall user experience and streamlining communication processes in the educational sector.

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