Development of a Chatbot as an Intelligent Personal Assistant for Teaching and Learning Data Structures

Desarrollo de un Chatbot como Asistente Personal Inteligente para la Enseñanza y el Aprendizaje de Estructuras de Datos

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ABSTRACT

The realm of education is witnessing a burgeoning array of AI applications, with one noteworthy addition being Chatbot technology. This innovation has been harnessed to streamline both teaching and administrative functions. This paper introduces HexBot, a Chatbot meticulously crafted to enhance the learning journey of students enrolled in a data structures course at an esteemed educational institution. The development of HexBot entailed an exhaustive exploration of cutting-edge practices, methodologies, and apt tools. Additionally, a comprehensive user survey was conducted to ascertain preferences and requirements pertaining to the Chatbot's utilization for this specific purpose. HexBot was successfully implemented on the SnatchBot platform and seamlessly integrated into a dedicated Telegram channel. Encouragingly, the outcomes underscore its efficacy in empowering college students to independently access precise information about data structures within the realm of computer science, thereby obviating the necessity for human intervention.

Keywords: *Chatbot; Data Structures; Intelligent Personal Assistant; Artificial Intelligence; Educational Assistant*

RESUMEN

El ámbito de la educación está presenciando una creciente variedad de aplicaciones de inteligencia artificial, y una adición notable es la tecnología de Chatbot. Esta innovación se ha aprovechado para optimizar tanto las funciones de enseñanza como las administrativas. Este artículo presenta HexBot, un Chatbot meticulosamente diseñado para mejorar el proceso de aprendizaje de los estudiantes matriculados en un curso de estructuras de datos en una prestigiosa institución educativa. El desarrollo de HexBot implicó una exploración exhaustiva de prácticas vanguardistas, metodologías y herramientas apropiadas. Además, se llevó a cabo una encuesta integral de usuarios para determinar las preferencias y requisitos relacionados con la utilización del Chatbot con este propósito específico. HexBot se implementó con éxito en la plataforma SnatchBot e integró de manera fluida en un canal dedicado en Telegram. De manera alentadora, los resultados destacan su eficacia al capacitar a los estudiantes universitarios para acceder de manera independiente a información precisa sobre estructuras de datos dentro del ámbito de la ciencia de la computación, eliminando así la necesidad de intervención humana.

Palabras clave: *Chatbot; Estructuras de Datos; Asistente Personal Inteligente; Inteligencia Artificial; Asistente Educativo*

1. INTRODUCTION

Currently, the effectiveness of a customer service system relies on the quality of information it provides, as well as the services and channels available to ensure high satisfaction [1]. In the educational context, the student is the primary customer, and it is crucial to offer support for both administrative and educational needs. Cutting-edge technologies enable the assistance of students at various levels through the creation of artifacts capable of performing processes and tasks automatically. These innovations trace their origins to the field of Artificial Intelligence, enabling the development of machines with abilities to simulate intelligence, process images and videos, predict events, and comprehend human language [2].

Artificial Intelligence, as a broad concept, has been a subject of study for many years, giving rise to specialized disciplines to tackle various intelligent tasks. A notable example is the field of Natural Language Processing, which focuses on facilitating the development of applications that understand human mechanisms related to language [3]. Within this discipline, we find a branch dedicated to creating intelligent programs with the ability to interact with humans through text or voice, providing swift responses based on the provided information. This branch deals with Chatbots, computer systems capable of autonomously generating text in a way that is comprehensible to humans when read [4].

Despite the advancements in Chatbot technology over time, there remains a need to investigate how to effectively integrate this technology into various applications to optimize problem-solving [5]. Currently, Chatbots are predominantly used in areas such as customer service, online shopping, payment processing, information delivery, personal assistance, entertainment, and e-commerce [6][7][8]. The most common Chatbot model is a system capable of emulating a conversation with a person and carrying out a series of tasks autonomously, without the need for human intervention; examples of such tasks include making restaurant reservations, scheduling appointments in calendars, or collecting and presenting information to users [9].

A Chatbot, or conversational agent, is a software tool designed to interact with users in a natural and conversational manner, whether through text or voice, on a specific topic or domain [10]. Its main goal is to emulate a human conversation, and to achieve this, the Chatbot incorporates a language model and computational algorithms that enable it to simulate informal interactions similar to those that occur in a chat conversation between a human and a computer [11] . The cornerstone of a Chatbot is Natural Language Understanding (NLU), which is responsible for interpreting the context and meanings of user inputs in natural language, even when they are formulated in an unstructured manner. Based on this understanding, the Chatbot can respond appropriately according to the user's intent. Identifying this intent is crucial and is complemented by the extraction of specific entities from the relevant domain. More precisely, an intent represents a mapping between what a user expresses and the action the Chatbot should take in response. These actions are the steps that the Chatbot will execute when specific intents are triggered by user interactions. Additionally, these actions may include parameters that provide detailed information to carry out the action effectively [12].

Especially in the realm of education, the implementation of Chatbots has proven to be invaluable as an innovative pedagogical tool. They have been utilized in various capacities, such as a strategy to enhance the learning experience through gamification[13] , facilitate the teaching of the English language, and function as intelligent assistants in advanced academic settings [14][15], improve the educational process for higher-level students [16] or To support teaching-learning processes in educational environments, especially in areas that are difficult to understand, such as [17].It is within this latter application that the proposition of this article is situated, aiming to equip educational institutions with the capability to address academic inquiries from students without the need for dedicated personnel solely for this task.

The aim of this article is to outline the design and implementation process of a Chatbot named Hex-Bot, tailored to assist university students in the teaching and learning process of a data structures course within an educational institution. Moreover, this proposal can offer round-the-clock service through other channels, which in turn reduce labor costs and introduce novel innovative services. The objective of this endeavor is to discern the kind of information and services that are best accessed through a Chatbot, as well as how the assistant's personality impacts user experience and interaction.

This article represents the culmination of an undergraduate project titled 'Development Of A Chatbot As An Intelligent Personal Assistant For Teaching And Learning Data Structures' Section 2 elucidates the methodology employed for the study's development, followed by the presentation of our Bot's implementation and results in Section 3. Finally, we present our conclusions.

2. METHODOLOGY

This study primarily focuses on the teaching and learning process of data structures through a virtual chat bot assistant. Figure 1 shows the phases that were followed for the development of the bots.

Figure 1- Chatbot Development Phases
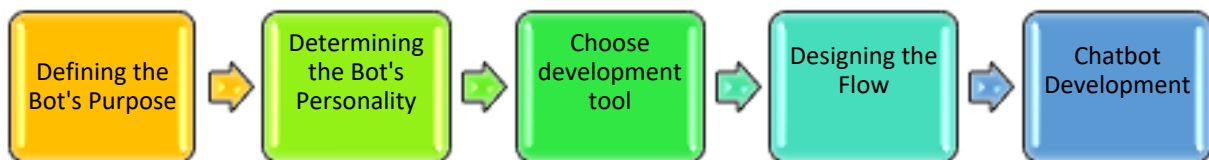
Phase 1: Defining the Bot's Purpose.
In this phase, the Bot's purpose is defined. In this study, it has been established that the Bot will serve as a support tool for the teaching-learning process of a specialized course in Computer Science, specifically focusing on the area of data structures.

Phase 2: Determining the Bot's Personality.
During this phase, it is crucial for the Chatbot under development to cater to potential users in the educational environment. Its language should be clear and friendly, with a cheerful tone. A Bot that exhibits human-like traits tends to provide users with a greater sense of comfort, especially when coupled with computational functionalities.

Phase 3: Choose development tool.
In this stage, it is crucial to choose the development approach for the Chatbot, which should be aligned with its purpose and personality. Development can be undertaken from scratch using programming languages, supported by design tools. Alternatively, one may opt for an existing platform that streamlines the construction process by providing pre-defined designs, and in some cases, robust natural language models. Additionally, it is essential to decide whether the Chatbot will incorporate learning capabilities, utilizing language models, machine learning, and deployment platforms.

Phase 4: Designing the Flow
It is crucial to establish a well-defined interaction flow for the bot, enabling it to provide guidance to users to sustain their interest while efficiently addressing their inquiries. The main challenge lies in anticipating potential conversation scenarios and determining the best approach to respond to questions that may be less clear or slightly deviate from the central topic. This aspect holds relevance within the context of a Chatbot design methodology.

Phase 5: Chatbot Development

During this stage, the implementation of the Chatbot takes place, building upon the previously defined design, its personality, and its purpose. At this phase, relevant topics within the scope will have been selected, along with welcome messages, positive feedback responses, and those for occasions when the Bot may not fully comprehend. Additionally, comprehensive testing with end-users and deployment trials will be conducted to ensure its effectiveness and functionality.

3. RESULTS

HexBot is introduced, a chatbot designed to enhance the learning environment for students enrolled in a data structures course within a computer science-related program. The development of HexBot involved a thorough exploration of appropriate cutting-edge practices, methodologies, and tools. Furthermore, a comprehensive user survey was conducted to ascertain preferences and requirements associated with the utilization of the chatbot.

In this study, we utilize SnatchBot for the creation of the Chatbot, wherein all components are constructed through a series of "interactions" in Figure 2. Interactions serve as the conduits of communication between the user and the Bot, offering a diverse array of types to imbue the Bot with functionality.

Figure 2- SnatchBot Interactions
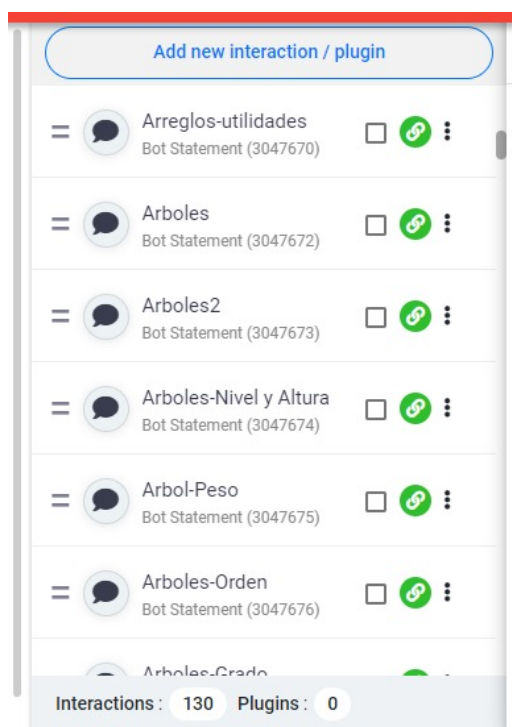
The initial interaction established is the "presentation", as depicted in Figure 3. Here, the application extends a welcoming message to the user, introduces itself, poses an initial open-ended question, and provides a concise menu of options to facilitate expedited navigation.

Figure 3- Initial Interaction

Each interaction involves diverse components, such as the Bot Message, Cards (similar to quick-access buttons), and Connections (encompassing fixed or NLP-based connections). The Bot Message comprises training phrases or terms guiding the interaction towards other components, while NLP connections empower the creator to utilize their customized NLP model or leverage pre-existing, reusable models. See in Figure 4.

Figure 4- Components Interaction

The provided NLP models empower the creator to train the model with novel intentions or entities. In this scenario, an intention within a sentence encapsulates the statement's purpose or objective, exemplified by phrases like "I intend to purchase a book." Conversely, an entity denotes a tangible real-world object explicitly named in the sentence, spanning individuals, locations, organizations, temporal references, and beyond. For instance, in the sentence "My Mother traveled to Spain," the entities encompass "Mother" (person) and "Spain" (country).

The introductory engagement, as depicted in Figure 3, sets off a sequence of Bot operations based on the user's response. These operations involve interacting with another dialogue, exploring further into the presented information, or adjusting the phrasing of a question if the Bot encounters challenges in understanding the user's input. For example, you can select from the provided menu, where you will find the entire topic of Data Structures, or you can ask any question such as "What is a graph?" as illustrated in Figure 5.

Figure 5- Dialogue with a user
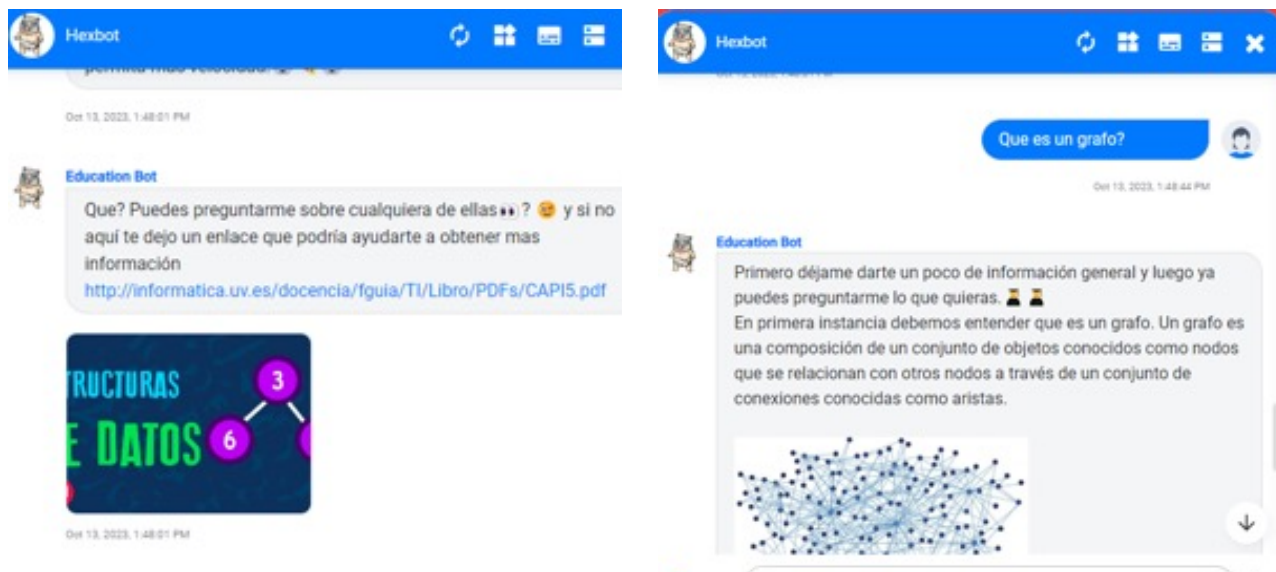
The Bot can respond based on previously loaded interactions related to important topics to reinforce. In the response, it will display text accompanied by images, as shown in Figure 6. Additionally, it will present various sources such as web links or videos related to the topic. It is important to emphasize that these sources can be interchangeable based on the Bot's configuration.

Figure 6- Interaction with text and images

In Snapchat, you can observe the deployment of various bots in different ways. For instance, the 'HexBot' has been deployed on the Telegram social network, as shown in Figure 7.

Figure 7- HexBot deployed on Telegram.
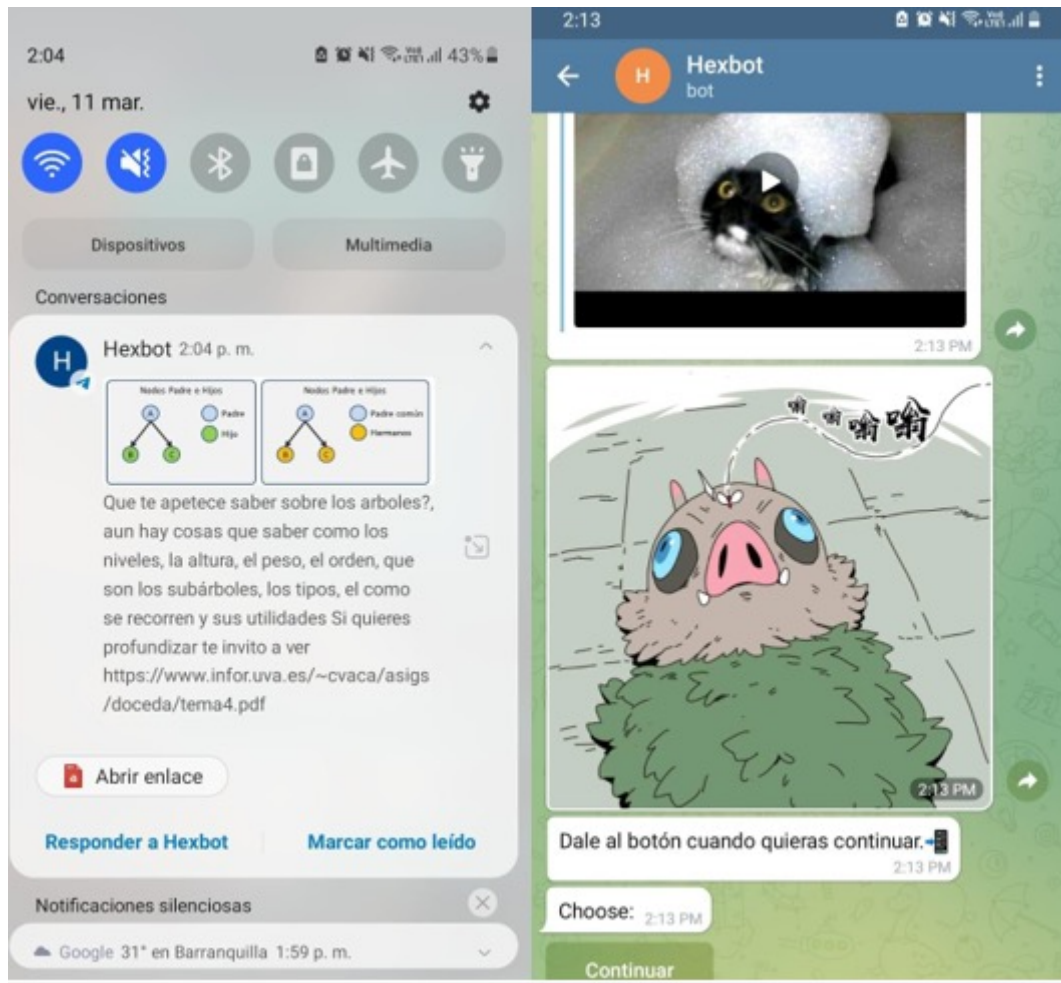
Finally, after each interaction is fully executed, it undergoes meticulous testing with the same tool before integration into the Bot. Additionally, offline testing is conducted to ensure seamless interaction with users. This comprehensive testing protocol ensures a robust and effective chatbot experience.

4. CONCLUSION

This article introduces Hex-Bot, a Chatbot system designed to assist university students in accessing information related to a Data Structures course at an academic institution. Developed using the SnatchBot platform and integrated into the Telegram social network, Hex-Bot underwent a meticulous five-phase methodology. These phases included defining the Bot's purpose, determining its personality, selecting a development tool, designing the flow, and executing the Chatbot's development. The result is a finely tuned Chatbot, optimized to cater to the identified target audience, with a primary emphasis on the efficient delivery of essential information.

Based on valuable user feedback, we've identified key areas for improvement in our data structures chatbot. These enhancements involve expanding the scope of information coverage, refining visual aesthetics, integrating multimedia elements, and extending deployment across multiple social platforms. Our future plans include enhancing the natural language processing (NLP) models to enable the bot to learn from user interactions. As we move forward, our commitment to utilizing this technology in university education remains steadfast, with a specific focus on enriching both teaching and learning experiences.

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