2021 International Young Scholars' Conference

ARTIFICIALLY INTELLIGENT CONVERSATIONAL CHATBOTS: MAIN TYPES, PROGRAMMING ISSUES, AND POSSIBLE SOLUTIONS

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Abstract

In recent years, artificially intelligent (AI) conversational chatbots have become widely used and proved to be a practical and effective support tool in many areas. Advances in machine learning and neural networks have made such proliferation of AI chatbots possible, yet there are still many programming issues and challenges in developing chatbots for various specific domains of human activity. This paper reviews types of artificially intelligent conversational chatbots and programming issues associated with each type. The following main types of chatbots are discussed: 1) script-based chatbots, 2) database-based chatbots, and 3) natural language processing-based chatbots. Key programming challenges in creating chatbots and existing solutions are reviewed.

Keywords: chatbot, conversational AI, natural language processing

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PROGRAMMING ISSUES, AND POSSIBLE SOLUTIONS

Artificially intelligent (AI) chatbots are software designed for communication and help users obtain information or advice via text or voice messages. Advances in the field of artificial intelligence have contributed to the wide adoption of chatbots. In particular, recent developments in machine learning, neural networks, and natural language processing (NLP) made chatbots smarter and more useful in many ways (Ali, 2020). Thanks to these computer science advances, modern chatbots allow businesses to improve customer experiences at a relatively low cost. They serve users and reduce human employees' workload by effectively dealing with repetitive and frequently asked user questions or requests. Even when chatbots send user queries to human employees, human employee's time and energy are used more efficiently as they only deal with a few cases where their direct involvement is necessary. In other words, AI chatbots have become popular because they allow businesses to serve their clients well while also reducing costs. Ai chatbots are used in areas like education (Chocarro et al., 2021), medicine (Miner et al., 2020), banking (Trivedi, 2019), and many others.

Despite such progress in making chatbots useful and the wide adoption of chatbots, there are still programming issues associated with chatbot development. This paper reviews recent literature in the field of chatbot programming and development and summarizes the key programming issues as well as ways to address them.

The rest of the paper is structured as follows: the second section discusses the main types of chatbots, the third section summarizes the chatbot programming issues and potential solutions, and the last section concludes.

Main types of chatbots

Overall, chatbots have different degrees of complexity and can be classified by different criteria and architecture (Cahn, 2017). One way to group chatbots is into three main types based on their historical evolution as follows: 1. script-based chatbots, 2. database-based chatbots, and 3. natural language processing-based chatbots.

First, script-based chatbots (also referred to as button-based chatbots) are designed to function in a predefined linear way. They have the simplest type of dialog system because developers create a rigid tree-like structure where users choose between options. When interacting with such chatbots, users mostly don't type anything, they just press the provided buttons to get what they need or want. Such chatbots are often used in various kinds of online booking or delivery services. This type of chatbot is easy to create and use.

The second type of chatbots is database-based chatbots (also referred to as rule-based chatbots). They rely on specific keywords from the user messages. Depending on what keyword is identified by the chatbot, it moves to the next stage of the conversation by using a response from the database connected to that specific keyword. The design and complexity of such chatbots might be very simple or more cumbersome, however, the basic idea is that the chatbot retrieves the keyword from the user's message and with an "if-then" statement matches it with some response from the database or moves to another condition connected to the keyword. Such chatbots are efficient when a simple form of a dialog system is needed, for example for answering frequently asked questions or other similar services.

The third type of chatbots is natural language processing-based chatbots (also referred to as AI-based chatbots). These are more complex and more human-like dialog systems that involve NLP, machine learning, and deep learning models for different purposes. This type of chatbots

generally consists of three parts which is the natural language understanding part, the dialog management part, and the response generation part (Ali, 2020).

AI chatbots: Programming issues and possible solutions

Based on the review of the literature on chatbot development, the three major issues challenging programmers were identified.

1. Accounting for linguistic complexity. Human communication is a highly complex process. Users' messages to chatbots come in various accents, linguistic varieties, grammatical forms, with various lexical or grammatical nuances (and even errors). Even when using a chatbot for a specific purpose, for example, for getting information about banking services, users interact with the chatbot in highly nonlinear ways often using language in creative ways. In addition, users have their unique backgrounds, circumstances, needs, language capabilities, and demands.

Solution: Natural language processing algorithms. One promising (though not magical) solution is to use natural language processing algorithms to account for linguistic complexity (McTear et al., 2016). By extracting meaning from spoken or written messages, natural language processing algorithms can handle identity-specific encodings (pitch, tone, etc.), grammatical mistakes, self-corrections, and other aspects of speech that altogether create the context (Gruhn et al., 2013; Tur and Mori, 2011).

Particularly promising for chatbot developers are advances in natural language understanding (NLU). NLU developer tools have become standard parts of complex AI solutions. For example, NLU components are part of such developer frameworks as IBM-Watson, Google-Dialogflow, Microsoft-LUIS, and the open-source Rasa NLU.

2. Adapting to evolving conditions. Classification accuracy or recognition accuracy remains a challenge for chatbots. Further, even after a chatbot has been built and piloted, there are

things that change in the world or in the things users expect from the chatbot. New types of dialogs may need to be added into the dialog management part or new responses may have to be added in the response generation part. In some cases, the entire architecture or ML model sequences may need to be redesigned.

Solution: Machine learning algorithms and human support. The potential solution here is the utilization of machine learning and deep learning algorithms. Machine learning algorithms can be used to adapt the chatbot to evolving conditions via improved intent classification, entity recognition, and response probability prediction. To make the chatbots even more adaptive, ML models can be improved by feeding on the responses generated by human employees in response to complex user requests. Specifically, if an unexpected question was received by the chatbot and the chatbot couldn't respond, it could send the question to the human employee's email. Later, when the human employee responds to the question, that email enters into the chatbot's response generation part and the dialog management part gets enhanced too. In sum, a knowledge database, a dialogue history corpus, and an external data source providing the chatbot with "intelligence" supported by machine learning algorithms address this programming issue (Abdul-Kader and Woods, 2015). Human-annotated corpora, discussion forums, and email conversations are commonly used for these purposes (Nass and Brave, 2007). Open-source conversational AI frameworks like Deep Pavlov hold much promise in tackling this issue in the future generations of chatbots.

Conclusion

This paper discussed artificially intelligent chatbots, their main types, programming issues, and promising solutions for those issues. The following main types of chatbots are discussed: 1) script-based chatbots, 2) database-based chatbots, and 3) natural language processing-based

chatbots. Two key programming challenges in creating chatbots such as accounting for linguistic complexity and adapting to evolving conditions were discussed. Existing solutions for these programming issues, such as the use of NLP and ML algorithms were reviewed.

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