Chatbots Technology and its Challenges: An Overview

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Abstract. A chatbot is a conversational agent that uses Artificial Intelligence (AI) to interpret the text of the chat using Natural Language Processing (NLP) in particular, instead of making direct contact with a live person, users can make conversation via text or voice. Chatbots are a fast-growing AI trend that involves the use of applications communicating with users in a conversational style and imitating human conversation using human language. Many industries are attempting to include solutions based on artificial intelligence like chatbots to improve their customer service in order to deliver better service to their customers with faster and less expensive support. This paper is a survey of the published chatbots to discover knowledge gaps and indicate areas that require additional investigation and study, starting from history and how it evolves during the past, then chatbots architectures to understand how it works, and to identify application of chatbots in many domains, and finish by chatbots limitations that shorten its lifespan and how can future work improve the chatbot for best performance.

Keywords: Chatbots · Artificial Intelligence · Natural Language Processing · Deep Learning

1 Introduction

Interactive Agent, Artificial Conversational Entity, talk bot, chatterbot, human-computer dialogue system, digital assistants, those expressions mean the same term called chatbot. The recent is composed of two words ''chat" and ''bot" to refer to a bot for messaging that provides a human computer interaction (HCI) [1] which can perform three types of communication's forms: speech [2], text and image. Over the past decade, AI has transformed the world subtly, machines now can learn and think through without the intervention of humans. Moreover, the number of chatbots has grown especially in the last two years as shown in Fig. 1 the development of research in this field according to Google Scholar.

Thanks to AI that can solve the most serious issue that chatbots face today is their inability to understand and produce natural expression. The AI-Chatbots

J. Kacprzyk et al. (Eds.): AI2SD 2022, LNNS 637, pp. 56–64, 2023.
https://doi.org/10.1007/978-3-031-26384-2_6

Period	Number of papers of chatbots in Google Scholar
2014-2016	539 results
2016-2017	2,680 results
2018-2019	11,800 results
2020-2021	21,000 results

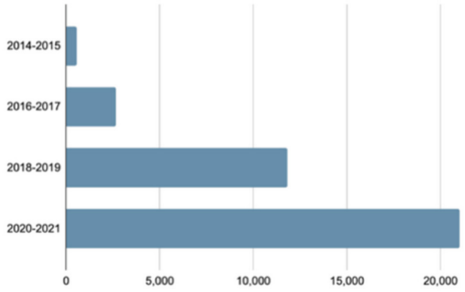

Fig. 1. Development of research in chatbots over the time by counting the number of papers according to Google Scholar.

overcomes the limitations of rule based chatbots using NLP, Machine Translation (MT), Image Recognition (IR), Neural Networks (NNs)...and many branches of AI to reach the best user experience [3].

According to industry analysts, the worldwide chatbot market will be worth USD 2485.7 million by 2028 and chatbot adoption will save businesses $11 billion a year in the healthcare, banking, and retail sectors by 2023 [4]. Nowadays many industries are in the race to develop their chatbots of customer services that offer rapid and smart development in many domains such as businesses, education, healthcare and governance... It allows users to receive answers to their questions in a timely manner without having to wait in phone lines or send several emails or search online for responses. Hence there are a variety of areas that a chatbot can serve, and they are often regarded as the key to a company's long-term success and competitiveness.

This paper covers a survey of chatbot design, architecture types and suggests steps to choose suitable architecture. This paper is structured as follows:

2 History

Back to 1950, "can machines think?" was a question posed by Alan Turing [5] that reveal the rise of chatbot concept, 16 years later especially in psychology domain first chatbot named ELIZA [6] permit to encourage the patient to talk but the chatbot's capability is too inflexible, hereafter in 1970 [7] PARRY was created to imitate a paranoid patient [8], Later in 1988, this chatbot named JABBERWACKY, its objective was to switch from a text-based system to a completely voice-operated or verbal chatbot, this chatbot has so far achieved only second place in the annual Loebner Prize [9].

The human-computer communication system's development process is shifting from "adapting people to computers" to "adapting computers to people"

[10], In 1990 the prototype of chatbot JULIA was created [11] by the creator of the term 'chatterbot' Michael Mauldin [12], and it was a famous once upon time, thenceforward in 1992 an AI speech synthesis called DR. SBAITSO in psychotherapy [13], then ALICE the name is acronym of Artificial Linguistic Internet Computer Entity, this chatbot is inspired from ELIZE and designed with pattern matching or rule based which we are going to talk in following section; this chatbot is implemented in Artificial Intelligence Markup Language (AIML) created in 1995 [14]. This language is used to specify the pattern-matching rules that connect words and phrases submitted by users to associated subject areas [15].

In 2001 a chatbot named SmarterChild [16], which ran on MSN Messenger, used for entertainment [17], later in 2007 IBM launched his question-answering (QA) system named Waston [18] it still alive for now, designed for businesses, automating responses to customer inquiries [19], That revolution push big tech companies like Google, Apple and Microsoft to launch their chatbots named virtual personal assistants [20], in 2010 SIRI chatbot was created by Apple [21], then Google developed GOOGLE NOW in 2012 [22], then ALEXA in 2015 by Amazon [23], one year later Microsoft crafted CORTANA [24]. The Fig. 2 shows a brief chronological sequence of previous chatbots.

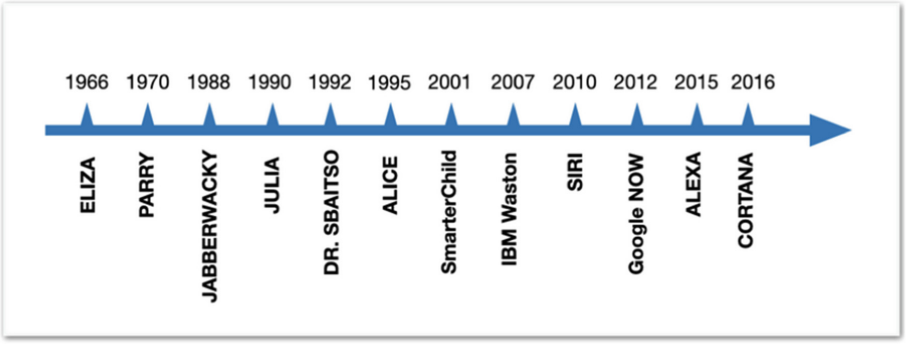

Fig. 2. Chronological sequences of chatbots.

3 Architectures and Types of Chatbots

3.1 Architectures

A chatbot also known as a conversational agent or an artificial dialogue system [25]. It is a computer system that acts as an interface between human users and software applications, communicating mostly through natural language (spoken or written). Chatbots are frequently portrayed, conceived, and developed as a flow of communication between multiple components as shown in Fig. 3 However, it also has all of the necessary details:

User Interface Component: the chatbot's service starts when it receives a request from a user via text or speech-based application [26], such as Facebook Messenger, Slack, WhatsApp, WeChat, Viber, or Skype.

User Message Analysis Component: The User Interface Controller sends the user's request to the User Message Analysis Component, which analyzes it to detect the user's intent and extracts entities using machine learning techniques or pattern matching [26].

Dialog Management Component: this Component manages the conversation background and keeps it up to date. It saves the current purpose as well as the specified individuals until the conversation reaches that stage. If the chatbot is unable to gather the requisite context information, it will ask the user for additional context information to fill in the gaps [26].

Backend: when rule-based chatbots are used, a Knowledge Base is developed (KB). It also contains a list of handwritten answers to the user's inputs [26].

Response Generation Component: uses one or more of the three possible models to produce responses: Rule-based, Retrieval-based, or Generative-based [26].

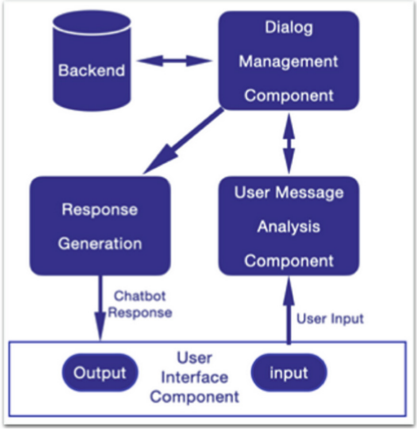

Fig. 3. General Chatbot Architecture [26].

In [27], the authors proposed an architecture composed of layers, and they added a security layer, elseways another work [28] attempt a complete syntactical and semantic study of user inputs as part of the system design, [29] works on architecture too, but no architectural design is provided. Depending on the type of chatbot, the developer may choose the components to implement [26].

3.2 Type of Chatbots

Chatbots are classified depending on knowledge: particular knowledge domain or more than one Knowledge Domain (KD), Generic chatbots (G) can answer any user query from any domain, while Domain-Specific (DS) chatbots can only respond to questions about a specific information domain, and chatbots that work through multiple domains are known as Cross or Open-Domain (OD) chatbots, also there is a classification based on response generation: Rule based (RLB), Retrieval based (RB) and Generative based (GB) Chatbot, and Hybrid based (see Fig. 4) Though Generative-based chatbots are useful for engaging an individual in informal open-domain conversations, based on the previous and preceding inputs, they use NLG to answer in a natural language that resembles humans. Without creating new text responses, RLB chatbots select an answer from a collection of rules; this type is better for closed-domain communications. The RB model is more adaptable because it chooses the best solution based on a review and examination of available resources. If none of the rules fit [26], hybrid chatbots that weigh the retrieved information against the created response to determine which is better [26]. When the chatbot has completed an answer, it displays it to the user and waits for feedback.

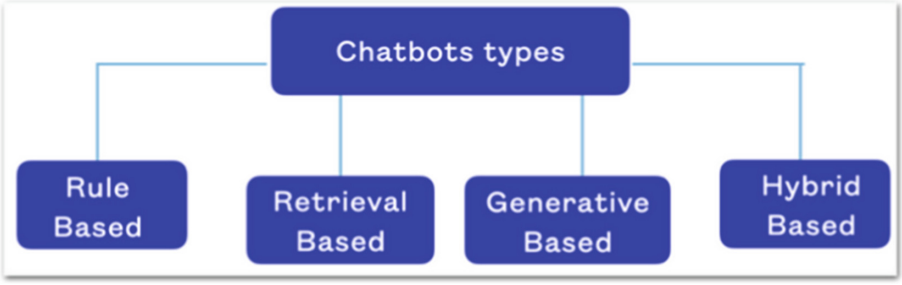

Fig. 4. Different types of chatbots.

A chatbot's operation can be combined with human interaction in certain cases where more flexibility is needed. Human computation is used in at least one aspect of a human-mediated (HM) chatbot. Staff working to incorporate their intelligence into fully Autonomous (A) chatbots will be able to resolve their flaws, chatbots may be classified as Open-source (OS) or Commercial (C), depending on the Permissions granted by the development platform, furthermore another classification is based on the type of Communication Channel (CC) used by chatbots, which can be text, speech, image, or all three.

Intrapersonal chatbots (RA) (Fig. 5) are close friends who live in the user's domain and are aware of his requirements, they are often connected to messaging apps such as Slack and WhatsApp. Interpersonal chatbots (ER) are those that provide services such as restaurant reservations, airline reservations, or FAQ searches without being a friendly companion. Finally, Inter-agent chatbots allow

bots to communicate with one another like Alexa and Cortana are two chatbots that have been linked together to converse [26].

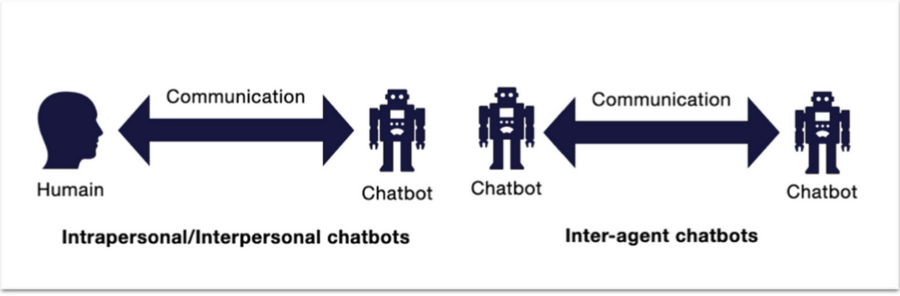

Fig. 5. Difference between Intrapersonal/ Interpersonal/Inter-agent chatbots.

4 Discussion

Every paper customizes its features and numbers of layers needed for a good architecture of the chatbot that responds to all user's needs. The choice of suitable chatbot approach, types, languages, and platforms follows the intelligence level of the chatbot and tasks of this chatbot, as shown in Fig. 6 Chatbot owner can answer the following questions to check satisfaction:

1- Will the Chatbot Respond to New Questions or Not? This question will help to choose the suitable approach, as mentioned in Fig. 7. Pattern matching for rule based chatbots and the other approach for chatbots which needs to learn from old conversations.

2-What are the Tasks Chatbot Can Do? The answer of this question will classify the chatbot type: KD, Service Provided (SP), Response Generation Method (RGM), Human Aid (HA) and Goals as detailed in examples of available chatbots in Table 1.

3-Which Language Will the Chatbot Speak and How Many? This question will reveal the needs of translation and to check the availability of corpus, datasets and models in this language.

4-Will the Chatbot be Connected to Many Platforms Like Facebook, WhatsApp, Skype...? This question helps to know which CC must be integrated (speech, text, image); the benefit of those platforms is that the user is already familiar with the messaging applications, and it has a big population.

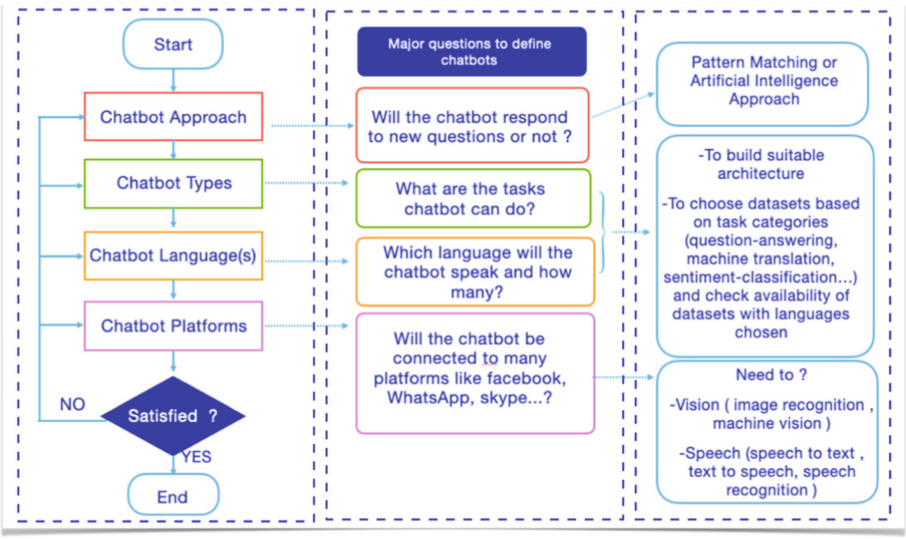

Fig. 6. Flowchart to build suitable architecture for chatbot.

The Table 1 and Table 2 presents a list of chatbots in different domains using a set of metrics: KD, SP, RGM, HA, P, CC, Goals (if chatbot is Informative (IF), Task Based (TB) or Chat Based (CB)), Languages used and links of project.

There has been a major increase in the production and usage of chatbots in recent years, with significant benefits in a variety of domains. They work 24 h a day, 7/7 in customer service centers, handling many clients at the same time, lowering pay-roll costs significantly. In education, they also serve a growing num-

Table 1. Goals and Languages of existing Chatbots in different domains.

References	Chatbot's name	Domain	Languages	Goals
[30]	Suve: Covid-19 symptom checker	Health	English /Estonia	IF+TB
[28]	English practice (CSIEC)	Education	English	CB+TB
[31]	Chatbot platform for B2B services	Business	English	CB+TB
[32]	the LvivCityHelper bot	Governance	Ukrainian	IF+TB

Table 2. Type of existing chatbots in different domains.

References	KD	SP	RGM	HA	P	CC	Link
[30]	DS	RA	RLB+GB	A	OS	Text	https://eebot.ee/en/
[28]	G	RA	RLB	None	OS	Text/voice	http://www.csiec.com
[31]	OD	RA	None	A	C	Text/voice/image	https://itsalive.io
[32]	OD	RA	None	A	OS	Text	https://city-helper.com

ber of students by providing educational material and personal assistance. They also outperform human teachers in some situations, such as when they reduce language anxiety in foreign language students. They offer a variety of services to patients in the area of healthcare, but there is a risk when patients receive a less precise answer, that is why it is necessary to measure the effectiveness of chatbots especially in the health domain.

5 Conclusion

This survey aims to present a comprehensive view of chatbots to reduce time of researchers to understand chatbots and its architectures and types, help developers to choose which approach is best and show examples of available chatbots in different domains with languages used and link of project. Future work will concentrate on challenges and good practices of chatbots, also its performance indicators in terms of customer relations, how can we be sure that a bot is working at full capacity? and how to improve the performance of a chatbot over time?

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