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AI-Powered Health Chatbots: Toward a general architecture

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Abstract

A Chatbot is a conversational agent that simulate human conversation, through text or voice messages. One of the first goals of a Chatbot is to interact with the user just like a human. When it comes to Health Chatbots, another main goal is to be able to get the correct answer to the user request.

In this paper we propose a general Architecture of an AI-Powered Health Chatbot with Four components to reach the two goals, which integrates dialogue and communication part in natural language understanding (NLU) and natural language generation (NLG), and the expert part based on deep learning whose function is to give appropriate response from pre-formatted data.

Keywords: Health Chatbot, AI-Powered Health Chatbot, Artificial Intelligence, Architecture, NLP, Deep Learning, Conversational Agent, NLU, NLG;

1. Introduction

A Chatbot is a conversational agent that simulate human conversation, through text or voice messages. The first conceptualization of the chatbot is attributed to Alan Turing, who asked "Can machines think?" in 1950 [1]. One of the first goals of a Chatbot is to interact with the user just like a human. When it comes to Health Chatbots, another main goal is to be able to get the correct answer to the user request.

Artificial intelligence can now provide more solutions for different problems, especially in the medical field. In

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order to perform the above goals, an AI-Powered Health Chatbot is what we need. We'll distinguish between human-like conversation part with the NLP Algorithms and the expert part with other Deep Learning algorithms. As a result of this study, a general architecture for AI-Powered Health Chatbot is proposed in this paper.

The rest of this paper is organized as follows. Section 2 is a literature review of AI-Powered Health Chatbots. Section 3 describes AI Approaches for Health Chatbots and how they work. Section 4 extracts the different essential components of the Health Chatbot. Section 5 proposes our general architecture for the Health Chatbot. Then Section 6 presents the conclusion and enumerates the future work.

2. Literature review

The first conceptualization of the chatbot is attributed to Alan Turing, who asked "Can machines think?" in 1950 [1]. Turing put a test called Turing Test, in which a person blindly asks questions to a machine and to a human. The Chatbot passes the test if the interrogator can't identify the machine. Many chatbots did pass the test like Mitsuku, ELIZA and Alice [2]. The ultimate goal then of each Chatbot is to simulate human conversation, to provide the function of presence, give the impression of an embodied agent. [3]

Many chatbots have a "general use" as a virtual assistant; it can wake you up, start your musique, do a google search for you, etc. Other Chatbots were developed to do specific tasks, like consumer services chatbots, travel and airlines chatbots, gaming chatbots and our concern in this paper; Health Chatbots.

2.1. AI-Powered Health Chatbots

In order the understand the user and give a meaningful response, just like a human, the chatbot in general and health chatbot in particular, uses artificial intelligence. In this section we'll study some of the best AI-Powered Health Chatbots [4]:

- Baidu Melody: Application Chatbot developed for, developed and distributed in October 2016 by the Baidu research laboratories. Understand English and Chinese languages.
- Dr. Ai: Application and Facebook-Messenger-Based, developed by Health Tap. It's a general symptom checker. Only understands English.
- Babylon Health: Application that combines different illness symptoms and compare it with a database of similar symptoms. Only understands English
- Sensely Molly: Developed by Sensely to be an AI-powered Virtual Nurse to help patient. Molly is one of the few chatbots "speaking" many languages including English, Arabic and French. It also

2.2. Baidu Melody

Melody is the Chatbot application developed by the Chinese search engine Baidu, it facilitates communication between patients and doctors. It's an AI-powered conversational bot. Melody collects medical information from patients and transmit it to real-life doctors.

The patient can open the application and ask his medical question, Melody will then ask context-relevant questions to clarify information and with Deep Learning and Natural Language Process technologies ask about additional, not mentioned symptoms. This conversation with the application provides the full picture to the Doctor so he can make his diagnosis. [5] [6]

Andrew Ng, chief scientist, Baidu, said: "Melody is designed to help both doctors and patients. By focusing on the medical assistant space, we've built a conversational bot that can give highly-customized and situation-appropriate responses to a patient's query." [7]

2.3. Dr. Ai

Developed by the startup HealthTap. Beside the application, Dr. Ai is also a Facebook-Messenger-Based chatbot, which gives lot of information about the patient (age, gender, etc.). Based on Artificial Intelligence and Natural Language Process technologies, Dr. Ai is a general symptom checker; when the patient asks a question or give a

symptom, the chatbot gives potential causes from a database that contains similar questions [5][8]. Figure 2 shows the Dr. Ai service with an example of a question/answer. At any time, the patient can contact a real-life doctor for texting or video consultation as we can see on the figure.

HealthTap CTO Sastry Nanduri said: "… advanced smart NLP (natural language processing) algorithms, can translate a patient's concerns into structured, mapped, and contextualized data that our artificial intelligence can process into actionable explanations based on who you are, and your symptoms and medical history." [9]

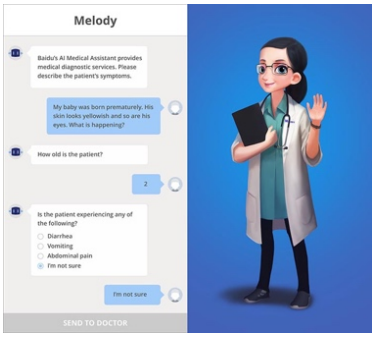

Fig. 1. Melody user interface

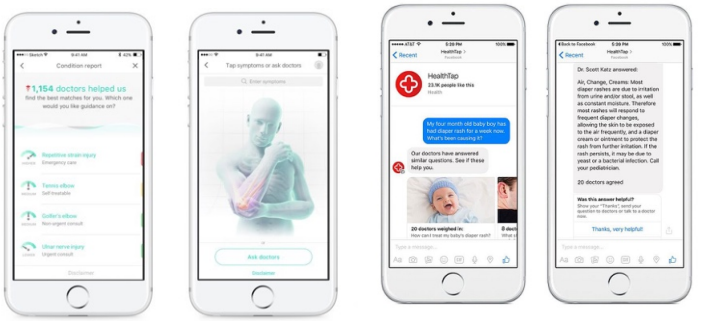

Fig. 2. Dr. Ai Application and Facebook-Messenger Interface

2.4. Babylon Health

The name of Babylon Health was inspired from the ancient city of Babylon, almost 2500 years ago, citizens needing medical advice often gathered in the town square to share thoughts on treatments for common illnesses. This is one of the earliest examples of democratizing healthcare that inspire the 21st century services [10]. Babylon Health provides a quick, on-demand service for patients without important health problems, using Artificial Intelligence technologies, it combines different illness symptoms and can also read and learn from patient health records, including the consultation notes made by doctors, and compare it with a database of similar symptoms. When needed, the user can contact a real-life doctor for episodic and well-defined needs. [11]

Since 2017, Babylon Health is proposed by UK National Health Service (NHS) to patients near London and Birmingham for online consultations with doctors.

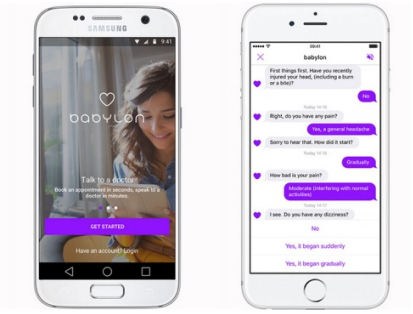

Fig. 3. Babylon user interface

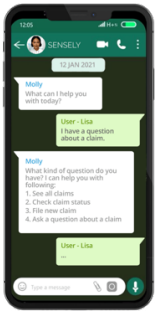

Fig. 4. Molly user interface

2.5. Sensely Molly

Molly was developed by Sensely to be a sort of AI-powered Virtual Nurse to help patient. Molly is an avatar so the patient can feel just like he's talking to a real human. Molly interact with patients, ask them questions about their health, symptoms, using speech, text, images and videos. Them redirect them to the appropriate care setting. Molly, like a human nurse, doesn't give a diagnosis or a prescription. Her main objective is to reduce the time spend by the patient with the wrong. [12]

3. Health Chatbots and AI approaches

3.1. How Chatbots work

From all studied AI-Powered health chatbots, we can distinguish two main parts:

Communication part: If the user interacts with the chatbot through voice, the chatbot should implement voice recognition algorithms, if on the other side, he interacts with the chatbot through text, the chatbot should implement text recognition algorithms. In both cases, selecting the right technology for natural language processing looks to be the biggest challenge here. Babylon Health chatbot for example uses speech recognition algorithms

Expert part: once the chatbot understands the user's request, the new challenge is to get him the appropriate response. Chatbots are implementing here other Artificial Intelligence Algorithms such as Machine Learning, Deep Learning, Transfer Learning, Etc.

The table below, describes the algorithms used for those two parts.

Then while comparing the different health chatbots we can see that they are using different **client interfaces**. As shown in the table, Baidu melody for example is only represented in a separate application, while molly can be used, with the appropriate **API**, in a separate application, as an SDK in a client web site or on a social media messenger like WhatsApp or Facebook-Messenger.

Table 1. AI-Powered Health Chatbot Parts

AI-Powered Health Chatbot	Communication Part	Expert Part	Client service
Melody	Natural Language Processing (NLP): Natural language understanding (NLU) and Natural language generating (NLG) [13]	Machine Learning: Deep Learning, CNN + BLSTM [14]	Application
Dr. Ai	Natural Language Processing (NLP): Natural language understanding (NLU) and Natural language generating (NLG) [15]	Machine Learning: deep learning, RNN [16]	Application + Facebook-Messenger
Babylon Health	Natural Language Processing (NLP): Natural language understanding (NLU) and Natural language generating (NLG) [15]	Machine Learning: Deep Learning and Transfer Learning [17]	Application
Molly	Natural Language Processing (NLP): Natural language understanding (NLU)	Machine Learning: Deep Learning, CNN	Application + integrable SDK + Messenger + Whatsapp + …

3.2. Artificial Intelligence Approaches

From our study we can clearly identify two artificial intelligences approaches: First approach is the Natural Language Processing for the communication part. It depends on the chatbot structure. If it communicates through text message or voice, if it's oriented structured or unstructured conversations. The second approach is the Machine Learning Algorithms for the responding part and it requires a huge amount of data to give acceptable results. The data have different origins, it can be the interaction history; The more user interacts with the bot, the better precision he gets. It could be from a knowledge base.

4. Components of a Chatbot

4.1. Client platform

For the user, the first difference between health chatbots is the client platform holding the chatbot. From the studied chatbots, we distinguished three types of client platform:

Autonomous client platform: the chatbot is a separate application that can be downloaded and used independently from any other client platform. It can however get inputs from other application/devices, g.e, heart rate from a smartwatch or age and gender from google account.

Integrated SDK: the chatbot is used as a service on the website of a third party, like insurance company to

receive client instant questions for example.

Messaging platform based: the chatbot is a persona the client is chatting with, on his usual messaging platform as Facebook-Messenger, Telegram or WhatsApp. The client in this case has the exact same user experience as he uses to. No training or adaptation period are needed in this case. For our upcoming work, we're taking this client platform type and we'll justify this choice.

4.2. NLP Engine

As discussed before, the chatbot has to understand the user request first. And since the user is messaging or recording voice on his everyday language, one of the biggest challenges is to communicate with the user. The role of the NLP Engine is to: Understand the user and get understanded by the user. We're are talking here about two different functionalities even if both of them are using Natural Language Processing (NLP) technologies. The NLP Engine is the "social" part of the chatbot, it communicates with the user through two subtopics of NLP:

Natural Language Understanding (NLU): is responsible for handling and converting formless data, it allows the machine to understand users and run the necessary parameters for processing requests. [18]

Natural Language Generation (NLG): is responsible to produce a natural language containing the desired information given a semantic representation. [19]

We're giving details on our NLP Engine in future paper.

4.3. Core Engine

Core Engine can be qualified by the rational brain of the chatbot, the expert. It gets as input, pre-processed data from NLP Engine and depending on the chatbot, it compares the request with similar requests on his database or calculate the response. Either way, in all AI-Powered chatbots, core Engine is using Machine Learning Algorithms to get the user response. In the studied chatbots, the used algorithms are:

Convolutional neural networks (CNN): adjusted to seek for the influential text patterns (sequences of words, word n-grams) the most relevant to the intent. [20]

Recurrent neural network (RNN): Easy to set up but the simple RNN is suffering from the short memory problem (due to a vanishing gradient), this is why both LSTM and BiLSTM are adjusted to process the sequential data and to overcome limitations. [20]

Transfer learning (TL): provides a pre-trained model with large number of data, based on attention mechanism, it uses self-attention to find the relations within sequence found dependency among words in one sequence. [21]

We're giving details on our Core Engine in future paper.

4.4. API's

Since an API is an interface that defines interactions between the user interface and the NLP Engine, it depends on those two components. We're mentioning it here as a part of the global architecture, but we're not giving any more details about in this paper.

5. General Architecture

As we can see in figure. 5 this is the proposed architecture for our AI-Powered Health Chatbot, and we will give further explain for every component in the next upcoming papers.

First of all, the end user interacts with the chatbot through a client platform. It's important to be user friendly and give an excellent UX. Each time, the user is having a request, it's routed to the NLP Engine using the appropriate API's, in the NLP Engine, and with NLU, the chatbot understands the request and format the data into understandable form that can be understanded by the Core Engine.

Once the Core Engine receives the formatted data, it searches using Deep Learning Algorithms, the appropriate response and send it back to the NLP Engine.

The NLP Engine receives the request response in formatted format, which cannot be understanded by the end user, this is why, and using NLG, the NLP Engine rephrase it the way the user can understand it.

And once again it's transmitted to the user using the appropriate API's.

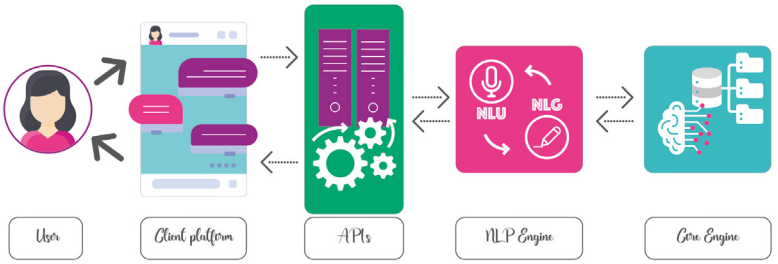

Fig. 5. General Architecture for AI-Powered Health Chatbot

6. Conclusion and Future Work

In this paper we presented four AI-Powered Health Chatbots. The four of them share the use NLP (both NLU and NLG) to communicate with the user, and the use of deep learning to get an answer to the user request. From this observation we defined in this paper the four components of our AI-Powered Health Chatbot: the client platform, the API's, the NLP Engine and the Core Engine. Based on those components we propose the general architecture of our AI-Powered Health Chatbot.

As future work, we will focus our next papers on the choice of deep learning algorithms that will best meet the needs of our chatbot, the construction of our dataset and how the exert Core Engine extracts the appropriate information. Then we plan to describe our NLP approach and present our AI-Powered Health Chatbot prototype.

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