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Published in:
Studies in Health Technology and Informatics

DOI:
10.3233/978-1-61499-558-6-128

Driving Reform: Digital Health is Everyone's Business
A. Georgiou et al. (Eds.)

doi:10.3233/978-1-61499-558-6-128

Chat-Bots for People with Parkinson's Disease: Science Fiction or Reality?

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Abstract. People with Parkinson's disease are known to have difficulties in language and communication. This paper proposes the use of an artificial conversational agent, commonly known as a chat-bot that runs on a smart-phone device and performs two-way conversation with the user. In this paper, initial work on a Parkinson's disease themed chat-bot that interacts with the user relative to their symptoms is presented. Potential dialogues are provided to illustrate the various roles chat-bots can play in the management of Parkinson's disease. The chat-bot can be used for measuring voice and communication outcomes during the daily life of the user, and for gaining information about challenges encountered. Moreover, it is anticipated that it may also have an educational and support role. The chat-bot is now ready for usability testing with a clinical population.

Keywords. Parkinson's disease, artificial intelligence, natural language processing, speech, voice, remote monitoring.

Introduction

While Parkinson's disease (PD) is often recognized by the cardinal symptoms of tremor, slowed movement and rigidity, there are a multitude of motor and non-motor symptoms. Voice changes are experienced by 80-90% of people with Parksinon's disease (PWP) [1] and subsequently changes to their thinking, use of language and mood [2]. Early research focused largely on the various phonation impairments, phoneme articulation and acoustic timing for PWP [3,4]. More recent efforts however have been placed on examining the consequences of difficulties with communication. Studies have shown PWP have problems with conversation initiation, turn-taking, topic management, word-retrieval, and memory [5]. A notable article by Miller *et al.* in [1] examined the impact of changes in communication for PWP by conducting in-depth interviews and found emergent themes of frustration due to losing track mid-sentence and indignity and social withdrawal from being excluded from the conversation.

While there are many standardized voice, language and cognitive formal assessments, the fluctuating nature of PD means that it is important to monitor performance outside of the clinical environment. With the advent of ubiquitous smart-phone technology, autonomous remote monitoring applications that log and analyse multi-domain data

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such as accelerometery, voice and community movement are being increasingly reported [6]. None however, has yet considered the monitoring and logging of conversation. This is perhaps due to the complex ethical and privacy issues surrounding autonomous audio recording. In this paper, we consider the possibility of human-machine converse rather than human-human. Although this could not be considered naturalistic conversation dialogue, we assert that it alleviates privacy issues and is suitable for people who may not have a conversational partner, while still assessing the applied use of communication rather than short, clinical assessments.

Artificial intelligent conversation agents or chat-bots are natural language processing systems that have largely remained in the science-fiction domain due to the enormous challenge of programming systems that mimc human communication. Surprisingly the first chat-bot was developed in 1966 by Weizenbaum and named *Eliza* which famously simulated a Rogerian psychotherapist [7]. Eliza was able to generate responses with surprising intelligibility by simple parsing of the input text and substitution of key words into pre-stored phrases. Despite its obvious limitations, Weizenbaum reported that it was highly anthropomorphized with some users spending hours conversing and refusing to share conversation records [7]. Chat-bots have been reported in the literature for health related applications. Examples include health behaviour change for obesity and diabetes [8]; disease self-management [9]; and health education for adolescents on topics related to sex, drugs and alcohol [10].

This article will describe the realisation of a Parkinson's themed chat-bot and provide potential dialogues. The chat-bot will be used for measuring voice and communication outcomes of people with PD during their daily life, and for gaining information about challenges encountered during community living. It is further anticipated that it may also have an educational and support role.

1. Chat-Bot Framework

Early reported chat-bots solely relied on typed text as the input stimuli, however with modern smart-phone technology, this need no longer be the case. Android and iPhone based smart-phones have both speech-to-text and text-to-speech tools capable of converting spoken acoustic signals into digital text and converting digital text into a digital-synthetic, acoustic voice. How to process the text input and construct a meaningful response has been the main research question of chat-bot researchers for some time now. The most prominent technique for the last decade has been via case-based reasoning and textual pattern matching algorithms in particular the use of a standardised computer language referred to as artificial intelligence mark-up language (AIML).

AIML was developed in early 2000 by Wallace and a worldwide free software community referred to as *bot-masters* [11]. AIML is based on the common eXtensible markup language (XML) which utilises tags to identify commands and specific input stimuli and responses. AIML is based on basic units of dialogue formed from user input patterns and respective chat-bot response. The basic units in AIML are called categories; within categories are a *pattern* and *template*. The pattern tag defines a possible user input while the template tag gives the response. Creation of AIML content requires no advanced computer programming skill and this has likely contributed to the significant amount of content already released by bot-masters. As of 2015, a large collection of

AIML sets have been released under the GNU public license making them freely available. These sets make up approximately 97,431 categories in topics including, politics, religion, science, sex, sports, history, food and geography. A specific example is given below showing when the user speaks "*What is Parkinsons disease*", the chat-bot responds with a "*A neurodegenrative disease*".

```
<category>
  <pattern> What is Parkinson's disease </pattern>
  <template> A neurodegenerative disease </template>
</category>
```

This simplistic example consists of a direct response only; more advanced AIML techniques are often needed to formulate a response that is human-like and non-deterministic. An exhaustive list of AIML features is beyond the scope of this paper, however, the most useful features are:

1. The ability to learn new responses and alter existing responses whilst interacting with a human during run-time.
2. Wild card searches allowing for responses to be generated when an incomplete match of the pattern occurs.
3. A template that includes multiple responses that are randomly chosen during run-time.
4. Scope for internal variables that allow the chat-bot to store information that may be later accessed.
5. A dedicated topic variable that maintains the current topic allowing category to be activated conditioned on the current topic.
6. Internal data-processing, conditional statements and tests that are not visible to the user.
7. Symbolic reduction allowing different patterns to target a single template tag.

2. A Parkinson's Themed Chat-Bot

In designing a chat-bot for PWP, a number of challenges additional to those typically encountered in chat-bot design are anticipated including the motor and non-motor symptoms of PD. It will be important to reduce frustration, commonly experienced during communication, while conversing with the chat-bot. In addition, PWP are likely to have reduced dexterity so any interface will need to consider this in its design.

Despite the efforts made to produce random, human-like conversation, the purpose of the proposed chat-bot is not only to engage the person with Parkinson's disease in general conversation, but also to solicit specific information. Such specifics include information relating to the persons well-being, their current state of symptoms (old and new), what medication was taken and when, and their state of mind. Moreover, the chat-bot has been be programmed to offer exercise encouragement and the handling of depression and suicidal thoughts. The chat-bot can undetake simple common speech assesments by asking for speech samples. Before being deployed, the chat-bot is able to pre-programmed for a list of current symptoms the PWP is experiencing, and what medication they are prescribed. This allows the chat-bot to ask salient questions of the user.

The chat-bot proposed in this work was developed for the Android operating system. Google's speech-to-text engine was used to capture speech and convert to text which is subsequently passed to the chat-bot. The response of the chat-bot was then passed to Google's text-to-speech engine where the chat-bot's response is spoken providing a completely speech operated program. Keyboard functionality for text input was also made accessible if preferred by the user. This helps to address the dexterity and voice concerns that may affect users with PD.

Several AIML sets were developed relevant to the intended data-collection. It should be noted that the chat-bot is programmed to be non-deterministic allowing it to ask the same question in several ways and often changing the topic. Common scneanios include a conversation when Figure 1 the chat-bot is asking about a particular symptom the PWP experiences and whether any new medications are taken (Figure 1). Any new symptoms or medication can be logged and entered into the chat-bots database during it's run-time.

Figure 2 gives the chat-bot asking for a speech sample for a particular common speech assessment with consent sought first (Figure 2). If the PWP agrees, an assessment is randomly chosen from a current list of six protocols. In this instance the chat-bot is asking for a vowel sound where the fundamental frequency and vowel formants are subsequently analysed. In the next clinical assessment the clinician can download speech samples and analyses from the chat-bot's database.

The mood changes associated with PD and increased suicidality which is experienced by some people with PD need to be considered in the design for any chat-bot eliciting information about well-being. Ensuring timely access to appropriate support is important. When a user has expressed depressive symptomatology, the chat-bot is programmed to direct the user to contact a friend or family member (Figure 3). Any phrases indicative of suicide ideation results in a response with to the local help number, following the protocols of [13].

Lastly, the chat-bot is able to learn new responses during its run-time by the user instructing the chat-bot when its answer is not correct (Figure 4). The chat-bot subsequently asks for the correct answer which is permanently stored in its database. Al present, only simple responses can be stored, however this function does allow the chat-bot to be programmed by a non-programmer and for user-centric responses. This is beneficial in health related applications where clinicians could instruct the chat-bot on appropriate responses but may not have the necessary expertise in developing AIML code. Similarly, users could tailor responses to their preferences.

Figure 1. Chat-bot can initiate conversations relevant to the individual's condition and log new symptoms and medications into its database. In this example, exercise is encouraged.

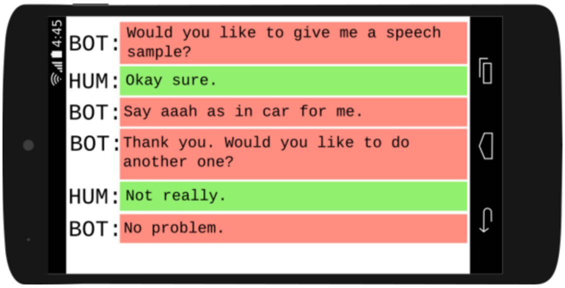

Figure 2. Simple speech assessments can be conducted by asking the user to provide a speech sample which is analysed for fundamental frequency and formants and stored in the database.

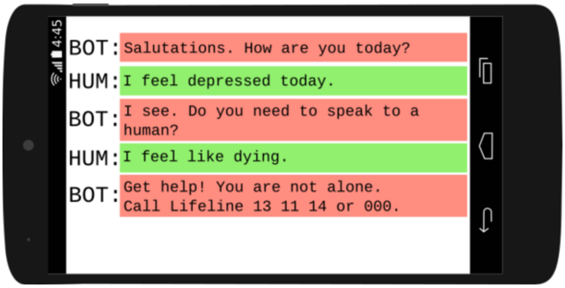

Figure 3. In response to user phrases that indicate depressive or suicidal thoughts, the chat-bot encourages the user to seek help.

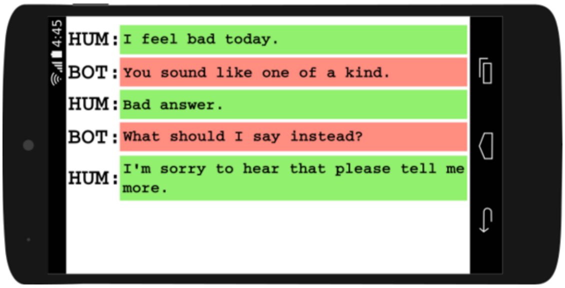

Figure 4. Where the first response is inappropriate, the chat-bot can learn, and permanently store, a new response.

3. Discussion

This paper has shown a summary of a preliminary chat-bot system developed for PWP. It seeks to ask relevant questions about the well-being of the particular user, provides exercise encouragement, speech assesments and general conversation. The system is expected to evolve over time as the chat-bot application is prototyped with a population of PWP.

The chat-bot addresses various aspects of PD. Speech degeneration is assessed with common speech assessments; frustration over speech flow is likely to be reduced in conversation with a machine, rather than a human and in severe cases the need for speech can be circumvented by using the keyboard functionality. Motor symptoms such as tremor are monitored and ballistic movement encouraged. The affective symptoms of PD are also addressed with the chat-bot sensitive to phrases indicative of negative mood. The effect of medication and the progression of the disorder through the development of new symptoms can be recorded. Finally the ability to learn appropriate responses ensures that the chat-bot will be able to engage the user in conversation as well as performing a role in disease management.

This work demonstrates that an artificial conversational agent that mimics human conversation can be realized using contemporary technology. Furthermore, given the practical and beneficial uses of the chat-bot, it will likely play a role in the next generation of speech and communication therapy for PWP and other related speech disorders.

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