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A Conversational Model for the Reminiscence Therapy of Patients with Early Stage of Alzheimer

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Abstract. Reminiscence therapy is a treatment that helps mitigate unstable psychological states in patients with Alzheimer's disease, where past experiences are evoked through conversations between the patient and their caregiver, stimulating autobiographical episodic memory. It is highly recommended that people with Alzheimer's receive this type of therapy constantly. This article describes the initial work in the development and implementation of a conversational model that can support caregivers of patients with this type of dementia to provide therapy periodically and enhance the benefits it offers. It is intended that the model allows generating personalized conversations between a prototype of the conversational system and patients. The proposed model collects patient information related to their preferences, history and lifestyle to personalize the conversation according to the profile of them. The modules that integrate this architecture are the following: Automatic Speech Recognition (ASR), Natural Language Understanding (NLU), Dialog Management (DM), Dialog Model, Natural Language Generation (NLG) y Text-to-Speech (TTS).

Keywords. Alzheimer, conversational model, dialog model, reminiscence therapy.

1 Introduction

Dementia is a neurodegenerative and progressive condition that is characterized by the alteration of cognitive processes, behavior, emotional state and the limitation in the ability to develop activities of daily living [1]. The most common type of dementia is Alzheimer's, covering up to 80% of cases worldwide. It is also one of the main reasons for disability in elderly people over 65, generating dependence on those who suffer from it. In 2010, there were 35.5 million people with dementia worldwide, and it is estimated that by 2030 this rate will increase up to 65.7 million, while by 2050 the worrying amount of 115.4 million is anticipated [2].

According to this trend, an accelerated growth in the population of older adults is expected in Mexico within the next 20 years. Some estimates indicate that during the period from 2000 to 2030 the population between 0 and 14 years will present a decrease of 14%, the population from 15 to 64 years will have a growth of 47%, while the population over 64 years will increase 300% [3]. The analysis of these data is relevant as it shows a need in the development and implementation of the necessary care for this population group. Almost a third part of this population will be older adults with various levels of dependence, and as mentioned above, the main cause of dependence in the elderly is precisely dementia.

Although dementia is currently not curable, it is necessary that people suffering from some type of dementia can preserve a good quality of life as long as possible. In this sense, there are both pharmacological and non-pharmacological treatments focused on mitigating the psychological, behavioral and cognitive impairment symptoms. It is preferable that the treatment of a patient with Alzheimer's disease begins with a non-pharmacological intervention, since this type of treatment promotes the use of different methods and techniques to provide emotional and physical stability to patients without the side effects of pharmacological treatments [4]. Through the implementation of appropriate environments, stimulating tasks and a diverse kind of therapies according to the needs of each patient, the benefits of this type of interventions can be maximized [5].

Reminiscence therapy is among these types of interventions; therapy is based on conversations between the patient and his caregiver, which are guided by the caregiver and focus on activities and experiences of the past, where the patient is chronologically guided through his life story [6]. This type of therapy focuses on the long-term memory of the patient using information that is familiar to the patient, and relatively easy to remember, since during the early stage of Alzheimer's the short-term memory is mainly affected. The benefits of subjecting Alzheimer's patients to reminiscence therapy have been analyzed in several studies and it has been observed that carrying it out constantly supports improving unstable psychological and emotional states in patients, as well as increasing their sociability and trust [6-8].

However, it is difficult for most patients with Alzheimer's to consult a specialist or therapist periodically. Similarly, due to the overburden in Alzheimer’s patient caregivers, they are quite limited in the time they can use to provide therapy constantly. In this sense, the objective of this work is focused on the creation of a conversational model capable of generating personalized conversations in order to support caregivers and therapists to provide reminiscence therapy in a constant way.

2 Related Work

It is relevant to mention that a large number of proposes focus on the diagnosis of dementia through the classification of symptoms and identification of distinctive characteristics for early detection. Thus, in [9] they propose a virtual avatar with spoken dialogue functionalities that conducts an interview to patients, which is based on the MMSE (Mini-Mental State Examination), Wechsler's memory scale and other related neuropsychological tests. Authors record the interaction between the avatar and the patient, extract diverse audiovisual characteristics and subsequently implement classification algorithms, achieving an accuracy of 0.93 in the detection. In the approach proposed by [10], they analyze three main linguistic characteristics that are considered as verbal indicators of confusion in people with Alzheimer's disease, which are: the richness in the vocabulary, the structure of the syntactic trees of the sentences and acoustic signals. Finally, they apply various machine learning algorithms to identify confusion within the dialogue reaching 82% accuracy.

On the other hand, there are proposals that focus on the development of assistive technology to help people with dementia to carry out their daily life activities [4, 11-13], as well as to support different types of therapy for the management of psychological symptoms, emotional and behavioral [14-16].

In [13] a system that provides occasional reminders and reminiscence conversations remotely is implemented. Through video calls they aim improving psychological stability and being able to assist people with dementia to perform simple tasks. They observed that after the intervention, the psychological stability of a patient persisted for up to three hours after the conversation and the success rate when completing a task was increased to 80%. This type of proposal is compared in more detail against other instruction monitoring strategies in [17]. [11] describes the development of a mobile robot, called ED, which supports Alzheimer's patients in the performance of tasks through visual monitoring and verbal reminders. They analyze the voice interactions between ED and each of the Alzheimer's patients involved in the study (n = 10). Their analysis reveals that for patients who have high levels of confusion, it is very likely that they ignore the robot at the time it provides assistance to perform a task, which represented 40% of the behavior of the group under study.

In the work described in [12] they analyzed the interaction between people with Alzheimer and a simulated intelligent cognitive assistant to support patients to develop their daily activities. The assistant is able to detect when there is a problem to perform the task on the part of the patient and then offers assistance based on the context of the moment of confusion. The authors performed the evaluation of the system in three focus groups: Alzheimer's patients, their caregivers and people without Alzheimer's. Finally, the analysis of the data obtained from each of these groups showed that the interaction style and the type of voice have a greater relevance for Alzheimer's patients. It is desirable that there may be a personalization in the interaction that exists between the cognitive assistant and the patient.

Similarly, in [4] an assisted cognition system was designed and the results on the use and adoption of the system are analyzed to support in providing occupational therapy and assess the effectiveness of the system to mitigate behavioral changes in Alzheimer's patients. They carry out an evaluation of the system with two couples (patient-caregiver) and observe that the personalization of the intervention and the tactile interface for interaction facilitate the adoption of the system. They also mention that implementing this type of systems in the treatment of Alzheimer's patients reduces the workload of their caregivers.

Alternatively, in [14] a study is conducted which describes how people with Alzheimer's disease can help develop a companion robot. In their work, they identify elements of importance for patients, which make a company robot have a higher level of acceptance. They mention that a relevant aspect is the need for the robot to know

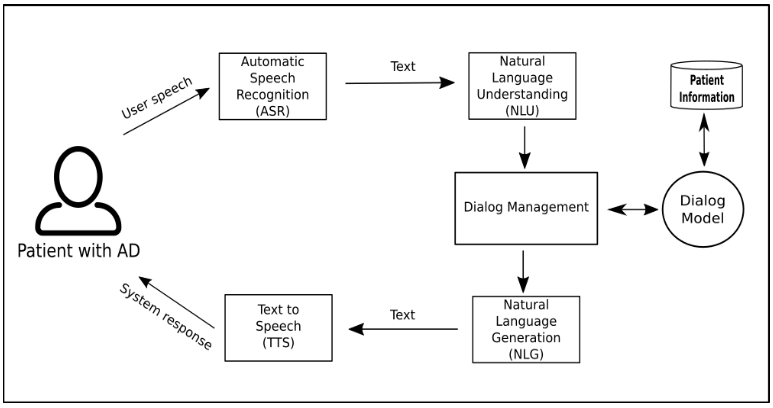

Fig. 1. Conversational model architecture.

interests, preferences and the patient's life history and use this information to motivate the conversation and reminiscent about events that patients can still remember. Similarly, in [15] they design a semi-autonomous agent (Eva), which is capable of engaging in simple conversations by controlling a human operator to be perceived as an autonomous agent.

Eva implements direct interventions with Alzheimer's patients, through simple conversations and music therapy. After conducting a preliminary evaluation with a group of caregivers of patients with Alzheimer's disease (n = 8), they obtain quantitative and qualitative results that were used to evaluate the robot's interaction skills.

Because the production and understanding of language is relatively well preserved in the early stage of Alzheimer’s, proposals that use spoken dialogue systems to support early diagnosis and the development of non-pharmacological treatments have shown be well adopted by patients and caregivers, so they can be a valuable tool in the treatment of this condition.

Most of the proposals analyzed implement generic dialogues, that is, the same conversation takes place for all patients and therefore they do not provide the benefits that have been observed in conversations where the dialogue is personalized to each patient as established by the Reminiscence therapy Therefore, this paper proposes a model to generate a personalized dialogue focused on reminiscence therapy, such as the one described in section 3.

3 Proposed Conversational Model

In this section, the proposed architecture of the conversational model is presented. The modules of this architecture are shown in Figure 1 and they are as follows: Automatic Speech Recognition (ASR), Natural Language Understanding (NLU), Dialog Management (DM), Dialog Model, Natural Language Generation (NLG) and Text-to-Speech (TTS).

3.1 Automatic Speech Recognition (ASR)

The ASR module is responsible for recognizing the user's (Alzheimer's patient) utterances and transcribing them in written sentences (plain text). Because the purpose of the work is focused on the development of the conversational model and not on a method for automatic speech recognition, at this initial stage the Google Cloud Speech-to-Text[1] web service is used, since it shows a good performance when recognizing speech in the Spanish language.

In general, the ASR module recognizes and transcribes emissions in real time. Subsequently, the transcribed emissions are processed by the NLU module using various techniques in order to obtain the semantic attributes present in the emissions.

3.2 Natural Language Understanding (NLU)

Once the user's broadcasts have been transcribed, it is necessary to analyze the text to obtain the semantic interpretation of the information contained in the received message, so that it can be processed by the conversational model. This process will be carried out in the NLU module by implementing various language processing techniques to perform this task. Some of these techniques involve: syntactic analysis, recognition of named entities, and classification of speech acts, to name a few. Currently we are working on the development of a method for the identification and classification of speech acts, which are described below.

Speech acts classification. The purpose of the identification and classification of speech acts is to determine the intention of an utterance. A speech act is an utterance that serves as a function in communication and this function could be a greeting, request, complaint, invitation, compliment or statement. The process for creating a model for classifying speech acts is the one shown in Figure 2.

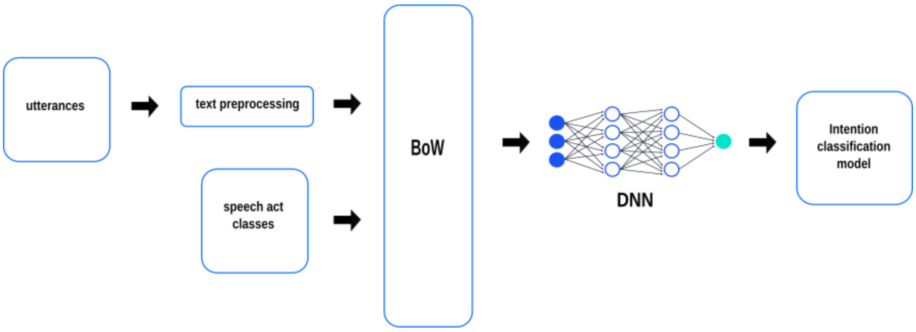

Fig. 2. Creation of the intention classification model.

[1] https://cloud.google.com/speech-to-text/

Table 1. Types of speech acts.

Speech act	Function
Assertives	The speaker affirms or denies something (affirming, suggesting, informing, concluding, etc.)
Directives	The sender tries to get the receiver to perform some action (inviting, ordering, asking)
Commissives	The issuer agrees to varying degrees to perform an action or to do something in the future (swearing, promising, bet)
Expressives	The speaker expresses an affective state, which can be emotional or physical (greeting, congratulating, complaining)
Declarations	Its execution produces a change in some state of affairs, so the issuer is usually an authority (marrying, baptizing, etc.)

Initially, a corpus of 130 phrases was created, which is considered to be likely emissions by users when interacting with the system. Subsequently, five types (classes) of speech acts were established that the system could recognize and classify which are shown in Table 1.

In this way, each phrase within the created corpus is associated with a type of speech act, but it is also associated with a specific act, which could be understood as a subclassification.

For example, the phrases ("Hello", "Good morning", "How are you"), are labeled as expressive_gretting, that is, they are the type of expressive speech act, but specifically is an act of greeting; the phrases ("What is your name?", "What are you like?") are labeled as directive_quetion_personal, which in this case is considered a directive speech act, but specifically they are an act of question and in this case they can be specified further as a personal question. Until now the labeling process was carried out manually.

Once each phrase is associated with a type (class) of speech act, a vector (Bag of Words) of all the phrases in the corpus is created. The created BoW representation is then used as input data in a neural network to obtain a speech act classification model or intention classification model (ICM). The neural network used follows a simple (feed-forward) scheme with two hidden layers. The goal of the neural network is to assign a class label for each phrase represented by BoW.

Until now, the model created offers an accuracy of 0.89, however, it is contemplated to increase the number of phrases, as well as experiment with other classification algorithms to try to obtain a better precision. It is also important to mention that although, with the current classification model, it is intended to know the intention of the emission, it is still necessary to extract the semantic attributes that will allow the system to understand not only the type of intention (speech act) detected, but the purpose of the intention.

A chatbot was created to implement the speech act classification model. It uses the model to identify the type of speech act of a new sentence and select a possible response from a set of candidate responses. The tasks performed by the chatbot are the following:

1. Initially, the chatbot receives a written sentence, which is preprocessed.
2. A vector (BoW) is created by comparing the words of the input sentence with the patterns that have been used to train the classification model. If the word is within the established patterns, then it is setting in the vector.
3. Using the BoW representation, the model is implemented to predict the speech act in the entry sentence. That is, the model determines which pattern the sentence is associated with.
4. Finally, the model returns the set of classes along with the probability of the sentence to belong to each class. In this case, to establish if the sentence belongs to a class is determined by setting a probability threshold $\mu = 0.75$ to determine if the sentence can belong to one of the classes or not, this process is carried out as follows:

   a. From the set of classes C and probabilities P, the one with the highest probability value $P(c)$ is selected. If the probability of the selected class is greater than the established threshold, that is, $P(c) > \mu$, then the sentence is classified with the speech act denoted by the class. Subsequently, a response is selected from the set of response templates associated with that class.
   b. On the other hand, if the probability value of the selected class is less than the threshold $P(c) < \mu$, then the sentence cannot be associated to any class and the chatbot displays the message *"Sorry, I did not understand"*.

An example of a chatbot dialogue is shown in Table 2.

Table 2. Example of a dialog context with the chatbot.

Dialog between the user (U) and the system (S)
S: Hola, buenos días.
U: Hola, ¿quién eres? (*expresivo_saludo, directivo_pregunta_personal*)
S: Soy María y me gusta platicar con las personas.
U: ¿de qué te gusta platicar? (*directivo_pregunta_gustos*)
S: …*
Candidate response templates for the speech act: *directivo_pregunta_gustos*
* Puedo platicar de diversos temas como música, películas y varias cosas más.
* Me gusta mucho platicar sobre la familia. ¿Te gustaría que platicar sobre tu familia?
* Me agradaría platicar sobre qué tipo de música te gusta. ¿Te gustaría?

As can be observed, the set of templates are currently static, therefore, during the development of this work these response templates there will be modified, so that they will be dynamic responses in order to customize the response according to the user

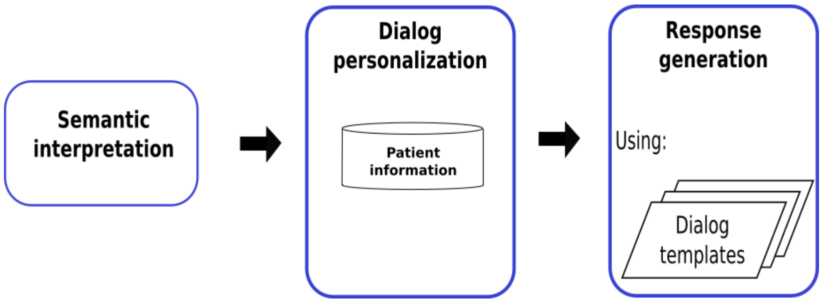

Fig. 3. Development of the dialog model.

information. In addition, it is important to mention that although at the moment a response is selected randomly according to the type of intention detected in the sentence, it is subsequently proposed that the response will be selected based on the conversation history.

3.3 Dialog Management (DM)

The DM module will be in charge of controlling the conversation shifts between the user and the system, determining the actions to carry out a performance during the interaction according to the current state of the dialogue, but will also analyze the history of the dialogue to determine which will be the most appropriate response. This module will interact directly with the Dialogue Model module to provide it with the semantic information that can be used to select relevant patient information and personalize the conversation.

This module will implement a dialog manager to determine which of the potential moves will be optimal in each state, to meet the goals or interests of the user. The dialog manager consists of two sub-components: the dialogue strategy and the adaptation strategy. The dialog manager is based on a state machine. Each state specifies a transition state from the current state and the condition to validate that transition, as well as a syntax for what the user can use as response in that state (for example, single-choice option or an open-answer option in the case when a question is posed to the user). State definitions also include the specification of agent schemes as templates with variables that are instantiated each time the state is entered. Schemes are a type of protocols, which directs a specific type of dialogue and its completion. The implementation of the DM is contemplated to be developed in a future version of this work.

3.4 Dialog Model

During the construction of the dialogue model, a set of stages have been considered according to the particular tasks that need to be developed in each one. Figure 3 shows the general process for the construction of the dialogue model.

Initially, it is necessary for the dialogue model to obtain a semantic interpretation of the user's utterances. This interpretation as mentioned above is done in the NLU module. The information collected from the patient is then used as it is intended that the created model be able to generate a personalized dialogue for each patient.

The collection of patient information is carried out through a set of forms proposed in [18, 19], which focus on collecting data on family relationships, history and lifestyle of patients with Alzheimer's. The information is provided by the patient's caregiver, who is usually a close relative. Then, once the patient information is available, the dialogue model can use this information to generate a response according to the patient's information and the context of the dialogue to personalize the conversation.

3.5 Natural Language Generation (NLG)

The response has to be appropriate to the context of the dialog, this means that it is necessary include the information provided by the Dialog Management module and this information will be formatted using lexical elements and an adequate syntactic structure to be understood by the user. That is, it has to be given in natural language and in this particular case in the Spanish language.

In this case, the use of predefined templates to generate the response is considered. Each template will have pre-established words and phrases and empty fields that will be filled with information provided by the Dialogue Management module as mentioned above. Because Alzheimer's patients usually prefer the use of simple and short sentences to communicate, the templates will be developed according to these characteristics.

3.6 Text-to-Speech (TTS)

Finally, the response generated will be synthesized through the TTS module using the IBM Watson Text-to-Speech[2] web service that provides a more natural voice generation. However, like the ASR module, it is not possible to make a comparison with different tools that allow this task to be carried out.

At this moment, the architecture of the conversational system and the objective of each of the modules that integrate it have been described in a general way. In this sense, the model is currently being developed to recognize and classify speech acts used by the user (person with Alzheimer's) when interacting with the system.

4 Conclusions and Future Work

Due to the cognitive impairment that affects people with some type of dementia, in this case specifically with Alzheimer's dementia, in early stages the patients present various types of symptoms, where one of the most common is short-term memory loss.

[2] https://www.ibm.com/watson/services/text-to-speech/

This situation significantly affects their behavior towards the people around them and generates unstable psychological states such as anxiety and depression. However, it has been observed that providing patients with non-pharmacological treatments such as reminiscence therapy helps to mitigate this type of symptoms and improve their quality of life. Therefore, it is not strange that there is a great effort from the computational approach in order to develop tools that support the different types of therapies that seek to mitigate the psychological, emotional and behavioral symptoms generated by dementia. Nevertheless, in the case of conversational models or systems focused on providing therapy to Alzheimer's patients, most of these proposals are based on an interaction with the patient through generic dialogues without taking into account the life history and preference of the patients; this means that a personalization during the intervention is not achieved.

This document presents the proposal for the creation of a conversational model that serves as a support tool in providing reminiscence therapy to patients with Alzheimer's disease, through the generation of personalized conversations according to life history and interests of each patient. This would allow us to take advantage of the benefits of providing the therapy constantly.

Because the proposed proposal is in an initial development, as future work it is contemplated to continue with the development and improvement of the method of classification of speech acts and to implement compression techniques of natural language that allow to extract semantic attributes of the emissions, as well as to develop each one of the methods described in the architecture of the conversational model. Finally, it is considered to carry out an initial experimentation of the system to evaluate the adoption of the system by patients with early stage Alzheimer's.

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