Design and Proof of Concept of Chatbot for People with Dementia

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***Abstract*—Dementia is a chronic, degenerative, incapacitating disease that affects millions of people yearly. People with dementia require constant supervision and assistance, unfortunately, most caregivers are unformal since professional healthcare can be unaffordable. We believe that this burden could be alleviated using a chatbot. Conversational agents are programs that simulate human conversation, a chatbot is a type of conversational agent that communicates through text. Chatbots have seen an increase in use in healthcare over the past decade and they have been proven especially effective dealing with mental health disorders and chronic conditions. However, there is still room for improvement regarding their intelligence when compared to other cutting edge conversational agents and there are barely any bots that support Spanish. Furthermore there are few chatbots specialized for people with any type of dementia. Alzheimer's being the most common one, this research's goal is to determine what features and characteristics a chatbot for people with Alzheimer's dementia should have. A comparative analysis of healthcare chatbots and development tools was conducted as groundwork for the design. An underdeveloped instance of said chatbot was implemented as a proof of concept, the architecture proposed allows for progress to be made on the chatbot without compromising its integrity. A list of Azure resources was used to achieve natural language processing, hosting, storage and other complementary functions such as text-to-speech and speech-to-text. All the development was done using Azure tools, namely the bot framework composer, which was sufficient for the intended purposes but it poses serious limitations. To implement some essential advanced features like an end-to-end skill bot for spontaneous conversation would require developing and training a neural network or using transfer learning to repurpose an existing one. There are many interesting additional applications for a chatbot for people with dementia such as reminiscence therapy, music therapy, cognitive monitoring and interfacing with office applications. A final iteration of the project should have a high emotional and intelligence quotient for companionship, a variety of automatable healthcare procedures like screening, therapy and self-management and useful documentation for caregivers.**

***Index Terms*—Alzheimer's disease; Alzheimer's dementia; Conversational Agent; Chatbot; Smart Health;**

I. Introduction

Alzheimer's disease (AD) is a chronic, degenerative and deadly condition that affects 800 million people around the globe. Older people are especially vulnerable, 96% of all cases are of individuals over 65 years of age, the risk of contracting the disease doubles every 5 years. The amount of cases is expected to double in the next 50 years [1], there is no known cure for it and no certain way to slow it down [2] making it a serious international public health threat. There is only one treatment that is said to attack the causes of the disease and some others that can alleviate the symptoms [3, 2]. AD is the leading cause of dementia, which is a condition that leaves the subject in the need of constant supervision causing memory loss, personality changes, disorientation, anxiety, decline of cognitive abilities and ultimately death [4].

There are many challenges left to face in order to overcome this epidemic. Since only the second stage of AD shows symptoms [5] and testing for it is complicated and expensive [6], treating the disease in time is almost never possible [2]. Often times, the best course of action is treating the symptoms with therapy which improves the overall quality of life of people with dementia [7]. There is a worldwide shortage of caregivers and most of the ones currently working are informal (unpaid and untrained) and in a financial struggle [8]. Technological solutions have been used successfully to better the healthcare of many patients, doctors and clinical personnel in general [9], but implementing these sort of information systems for people with dementia can pose more difficulties, many times requiring advanced features like artificial intelligence [10, 11].

II. Background

A conversational agent or "chatbot" is a system that uses natural language processing (NPL) to derive semantic meaning of text messages and then the intent of the message's transmitter [12]. Chatbots have seen a rise in popularity over the last years because of the increase in processing power and the

access to larger training databases. Customer service, digital personal assistants and healthcare have been some of the areas that have benefited from using chatbots as user interface or as a service [13, 14]. However, systems like those are still on their infancy, and the demand for personalized, high quality chatbots far surpasses what is in existence nowadays [15]. For example, no chatbot for people with AD that supported Spanish could be found during the research.

Conversational agents can be implemented in a variety of ways but for simplification purposes there can be divided into two groups: rule-based and intelligent. Rule-based chatbots use programming to define the way the dialog with the user flows, intelligent chatbots use machine learning instead [10]. Machine learning is useful in bots because there is no universal formula for human dialog and including each possible response to each possible question is impossible, nevertheless, NLP often requires a more advanced form of machine learning called deep learning [16]. The use case of a chatbot determines how intelligent it needs to be [17], task oriented chatbots such as bank answering machines can be ruled-based and fulfill its job. Intelligent assistants like Siri or Alexa have to be able to respond to almost any question and virtual companions like XiaoIce [18] need to be able to empathise with the user and be charismatic. The latter is likely the most complex form of chatbot, there does not appear to be any virtual companion for healthcare or customer service.

There is also much to say about the process of making an intelligent bot. One can make a Neural Network from scratch which involves implementation, data gathering and training or one can use transfer learning which consists on re-training an existing network [19]. A third option is using an bot building framework. These are services offered by software companies like Google, AWS and Microsoft that give developers tools and resources to build bots. On the topic of design there is an approach that was used on a smart house for people with dementia that was experience-centered. The users of the product, in this case patients and caregivers, are involved in deciding the features that it has. This prevents that the products are made to be used *on* people with AD rather to be used *by* them [20], a common occurrence on geriatrics.

III. State of the Art

A. Academic Research

There have been studies that approach healthcare using chatbots for AD patients and caregivers from multiple angles. Such as a diagnosing tool: using small questionnaires as cognitive tests to detect deficiencies [21]. Another one took it a step further and made the questions related to recent news to make it entertaining for the patients. The chatbot presents a news article found online and then asks questions about it, the test's goals was to measure the attention the subject could pay [22]. Conversational agents have also been used in a personal healthcare record manager, which keeps track of the patient's medical record, appointments and medicine as well as giving them access to clinical databases and online appointments. In these system the chatbot functions more as an intuitive user interface of a cloud-based application. It was also used to integrate multiple biometric sensors together [9, 23]. Other studies have even used chatbots for treatment. One through reminiscence therapy, which consists in encouraging the subject to remember their past through a conversation that is supplemented with visual and auditory artifacts [24]. The chatbot implemented, automatized a process that previously required a specialist and although the conversation produced was not very natural or human-like, the chatbot was able to come up with substantial questions about every image that was submitted to it [25]. Finally another study used reading comprehension and basic psychometric exercises to stimulate the patient's skills. This system was also the one mentioned as a diagnostic tool, the application was able to do both things. It was also multimodal, the user had different option to interact with the app: through voice, text or a touchscreen [21]. Each of these studies showcased conversational agents used not only to complete different tasks, but as different parts of o system. Since they are all useful and aren't mutually exclusive, an application combining all of their features would be of great value for the people with AD community.

B. Chatbots in Production

Currently the tools for making intelligent, context-aware, knowledgeable chatbots can be used by most developers and researchers [26, 27, 13, 28, 29, 30] thus, there are several chatbots available for the general public that can be potentially used by AD patients or caregivers. There are digital nurses that can schedule appointments or give rough diagnostics [31, 32, 33]. There are others for giving treatment [34] and for monitoring [35]. Nevertheless, they are all missing intelligence or real-world testing to make them fully effective and usable according to systematic reviews [10, 15, 11].

Satisfying this is no easy task, it requires multiple machine learning, deep learning and big data components but it isn't impossible [36, 16]. There is a special category called social chatbots [37] that are the closest ones to talk like humans. Examples of these bots are XiaoIce [18], GPT-3, [38] and Replika [39] which are either research projects or used for entertainment. There are no bots at this level in healthcare, or even customer service in general. This might be because they are systems too expensive and complicated to build and it will take time to use them for real world applications but it could also be because they are too unpredictable since social chatbots use machine learning for everything.

IV. Development

A. Objectives

The general objective of this project is to Design and develop a proof of concept of a conversational agent designed for people with dementia. Other specific objectives are determining the characteristics of and ideal conversational agent for people with dementia, generate a design specifying structure and technologies used and propose a course of action to build a fully functional prototype.

Characteristic	Classification		XiaoIce	GEN-DS	Replika	Cognitive Impairment Chatbot	Reminiscence Therapy Chatbot	Ideal Dementia Companion
Architecture	Rule Based			X				
	AI Chatbot	Standard (Deep learning)				X		
		Sequence-to-sequence					X	
		End-to-end	X		X			X
Conversational Focus	Virtual Companion		X		X			X
	Intelligent Assistant							
	Task-Oriented			X		X	X	
Features	NLU		X	X	X	X	X	X
	NLG		X		X			X
	Context Awareness		X	X	X	X		X
	Intent Recognition		X		X			X
	High Intelligence Quotient		X					X
	High Emotional Quotient		X		X			X
Technological Components	Conversation DataBase		X	X	X	X		X
	Domain Specific DataBase		X	X				
	Internet Access		X					X

TABLE I
COMPARATIVE ANALYSIS OF DIFFERENT CHATBOTS AND THEIR CHARACTERISTICS.

As a starting point for defining the ideal agent, 5 distinct and well documented chatbots were compared. Since no convention for classifying bot could be found, the most relevant properties for the research's particular objective were arbitrarily selected as comparison points. These features aren't independent or mutually exclusive, more than proposing a set of definitive qualities of a chatbot the goal of the Table 1 is to show the qualities an ideal chatbot would have. The architecture describes the components of the chatbot [12, 13], the conversational focus is goal of the chatbot [17], the features are the capabilities (NLU being Natural Language Understanding and NLG Natural Language Generation) [36, 18] and the external components are supplementary resources used [9].

Since the purpose of this project is a proof of concept, making a neural network from scratch was excessive. Transfer learning was a great option if there were a suitable dataset in Spanish which couldn't be found, leaving frameworks as the preferred option. Azure's bot framework composer was selected to undertake development since it had all the necessary functionality and it was accessible [40]. Figure 1 shows the different components of the chatbot and how they interact while Figure 2 is a flowchart of the steps taken during a conversation with a user. First, the utterance produced by the user is converted to text. This text is received by the chatbot and sent to LUIS to analyze it. LUIS sends back the extracted information and it is compared with the triggers, which are conditions that upon being true, initiate a new dialogue state. If no trigger is activated, the extracted information of the user input, the available context and the current state determines the next step in the dialogue. The next step could involve actions made by the chatbot such as waiting, responding, asking a question or fetching data. If a response is to be sent, the language generation module steps in and makes a custom response based on context and templates. The response is then sent to a text-to-speech converter and communicated to the user.

V. TOOL IMPLEMENTATION AND ANALYSIS

The following is a brief description of the resources offered in Azure that are relevant in the development of the bot.

- **Azure App Services:** A way of hosting a chatbot on the cloud so it can be connected to applications.
- **Language Understanding (LUIS):** Forms part of Azure Cognitive Services, it has the capability of recognizing the intent and language of a text and extracts entities and
- **Language Generation:** A set of tools that allow one to make templates that add variety to a conversational agent's possible responses. keywords.
- **QnA Maker:** Makes a query to a database based on a user's question and then answers it from the results.
- **Adaptive Dialogue:** The core mechanic of the Bot Framework, it allows the developer to define possible dialogue states and transitions. It is more sophisticated than a traditional rule-based system because it can use LUIS to determine the current state instead of only conditionals or regular expressions.

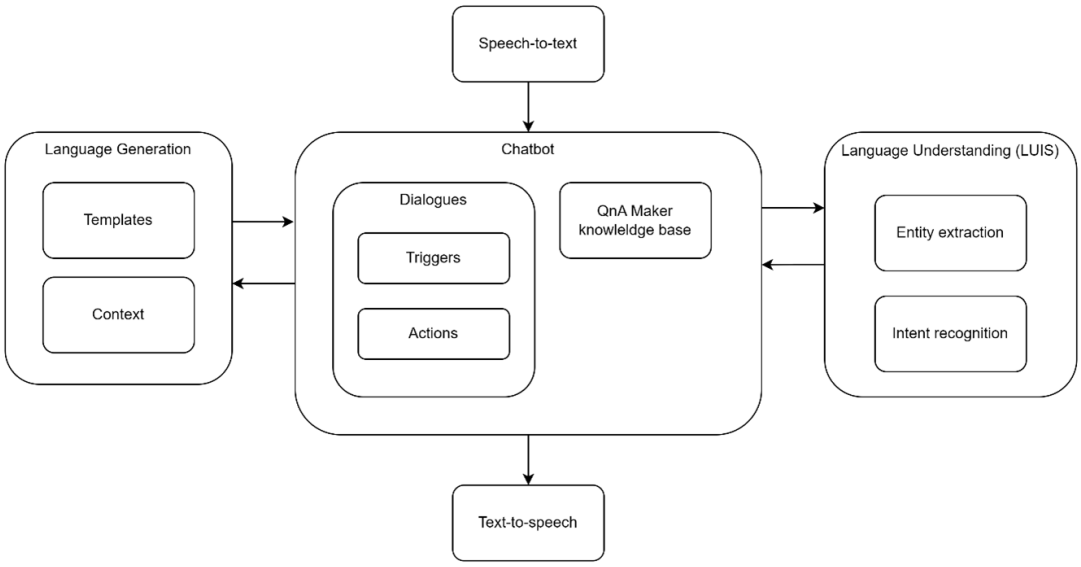

Fig. 1. Chatbot´s architecture diagram.

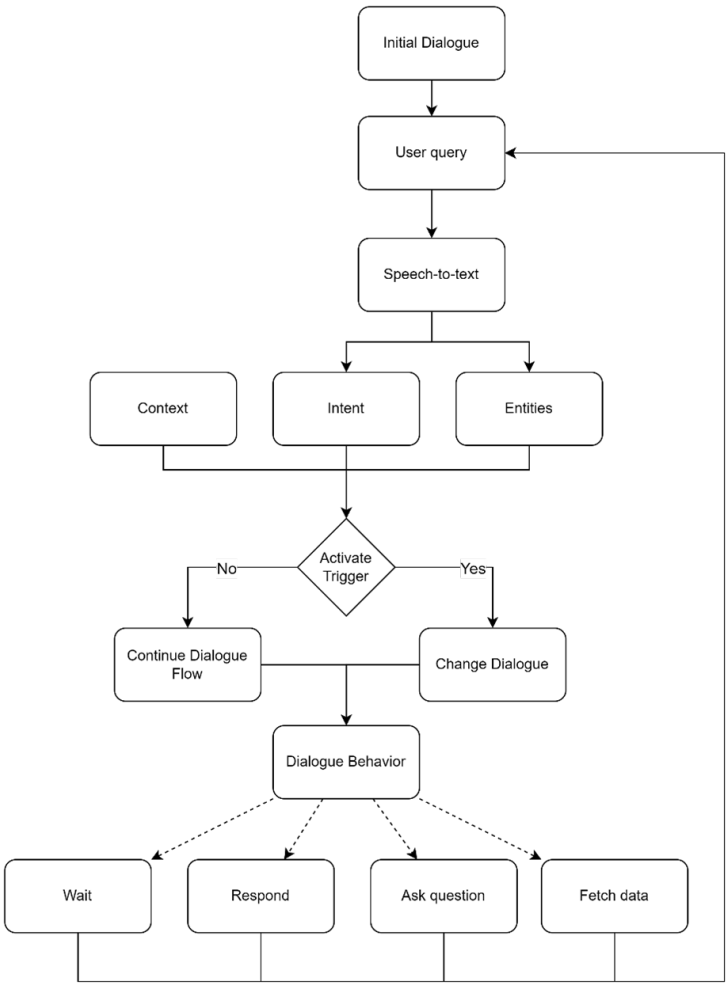

Fig. 2. Flow chart of the chatbot's behaviour.

- **State Management:** Manages internal storage, it has a user scope and a conversation scope. This can be used to gather user data or save account specific information.
- **Cosmos DB:** Storage on the cloud, useful when a single user communicates with the chatbot through multiple devices.
- **Bot Framework Emulator:** Replicates a connection to the chatbot and allows the developer to read the packages sent between client and application.

Additionally, Azure already has a healthcare focused power virtual agent available called Health Bot [41] which could be a useful point of reference.

VI. Results

Figures 3 is a high level representation of the functionality of the bot while Figure 4 are its triggers and dialogs. The opening dialog propts the user to a profile initialization and then to a potion menu of the bot's features. Information lookups includes the modules Consult Bot Options, Ask for Help and Caregiving Assistance. These modules offer relevant information about AD, caregiving, the chatbot itself and it can connect to the QnA resource to fetch information available on-line. Cognitive exercises prompts a series of mini-mental style questions and then stores the score for the caregiver to review afterwards [42]. Set up reminders adds, deletes and shows user-defined reminders. Admin bot ise made up of the modules Cancel Current Dialog, Reset Bot, Edit or View Profiles and Switch User. It includes all the thing unrelated to dementia that are useful for using the chatbot. Passive Monitoring is a trigger that goes off every time some discomfort, anxiety, anger or any negative feeling is detected from the user. It is not reliable since the language understanding works by using examples that are manually selected. Each time it goes off the event will be registered on the person with dementia's profile.

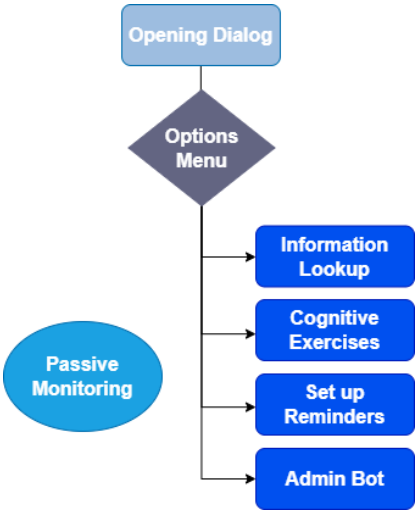

Fig. 3. Functionality diagram of chatbot for people with dementia proof of concept.

There is simplified version of the dialog flowchart of each module in the form of a diagram. Figure 5 is an example of

Main Dialog				
Triggers	Beginning Dialog	Cancel Current Dialog	Reset Bot	Consult Bot Options
	Ask for Help	Edit or View Profiles	Discontent Detection	Cognitive Monitoring
	Caregiving Assistance	Delete Reminder	View Reminders	Add Reminder
	Switch User	Menu		
Secondary Dialogs	Caregiving Assistance	Cognitive Function Monitoring	Bot Options	Caregiver Authentication
	Profile Settings			

Fig. 4. Dialogs of chatbot for people with dementia proof of concept.

one of those dialogs. The implementation in composer is more complex and allows for more flexible behavior. For example, if a user says "Anota algo", the add reminder dialog will trigger and the bot will ask the user what they want to write down but if the user says "Recuérdame comprar manzanas" the bot will skip the input prompt and will save the reminder immediately. This way if the user knows exactly what they want the bot to do, they can ask it and skip most of the conversation. Figure 6 shows the bot running on a web chat emulator. The bot can make response suggestions that are clickable, on top of sending the text. It is also possible to send audio or to have a live conversation using Direct Line Speech. The bot can store information provided by the user and to make messages based on it.

The bot framework composer turned out to be a very unreliable IDE. It lagged constantly, some of the files will become corrupted spontaneously, the copy and paste feature sometimes failed to work, the undo feature stored only one previous step, error messages were unhelpful and writing large functions or expressions was very cumbersome on the small input fields. It was an overall terrible coding experience. That being said, it saved a ton of time that would have been spent learning the SDK and reading the documentation, which was not that well made as well. The bot emulator did not supported LUIS in Spanish so the web chat emulator had to be used for debugging. It was enough for the intended purposes but it lacks the ability to read all the packages sent between client and bot which could be very useful when debugging for deployment. Direct Line Speech and QnA maker were unavailable from the institutional account that was used to work on the project, even though both services had free tier options.

The experience of people with dementia was a crucial aspect on the design of the bot but results would be much better if they themselves were included in the design process. This was mentioned on the background but unfortunately we didn't had the opportunity of working directly with people with dementia during this project.

VII. Conclusions and Contributions

The major struggle of the project was that the exploratory research determined that the missing part in chatbots was intelligence but the state of the art showed that making a social chatbot wasn't practical. The solution was to use a rule-based approach for language generation but some machine learning for the dialog state management. Even though it is

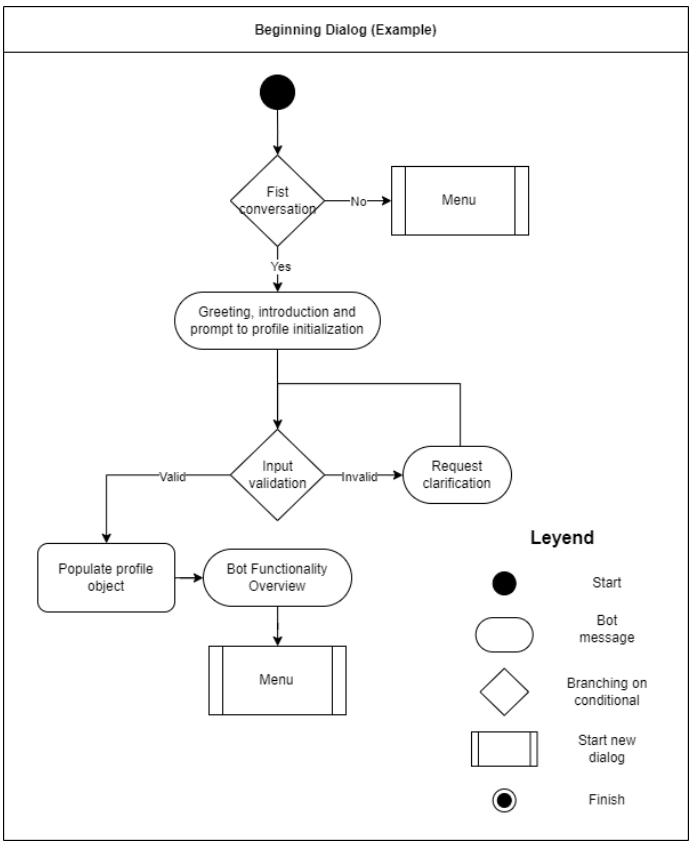

Fig. 5. Sample diagram of dialog of chatbot for people with dementia.

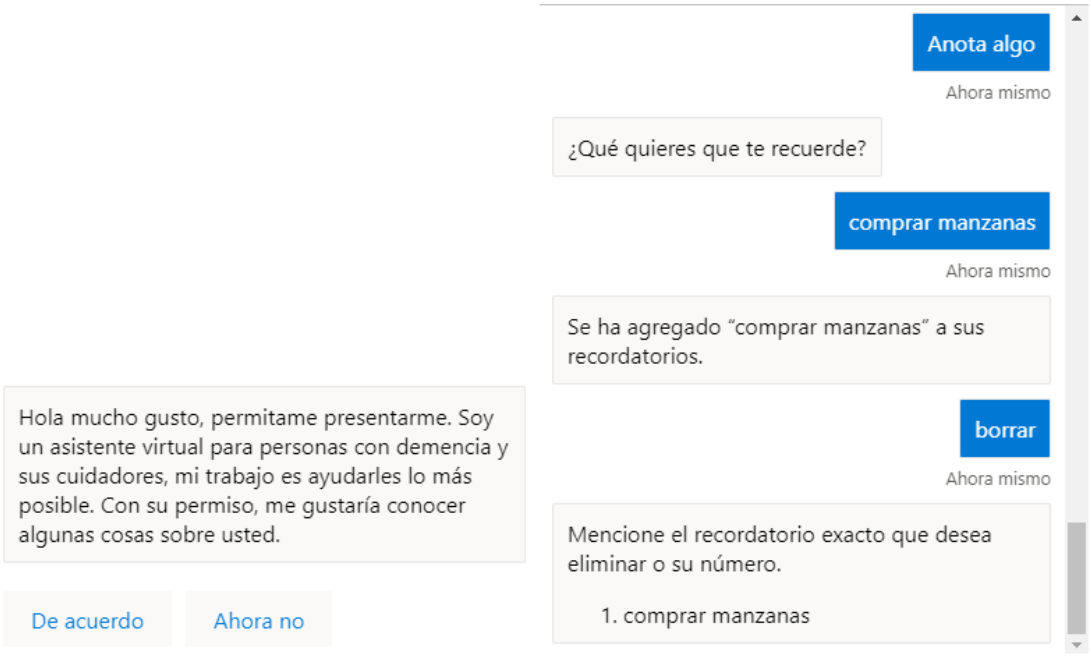

Fig. 6. Chat sample showcasing suggestions and variable storage.

not ideal it still an improvement over the intelligence of most bots found in the systematic reviews mentioned [10, 15, 11, 14], and it would be the first one in Spanish made for people with dementia. Though the he bot is very basic in features, Azure´s bot framework makes it easy to modify and expand upon it. The way the conversation flows using triggers makes

it so one can potentially add more and more modules without getting in the way of existing ones. It is very easy to connect one bot made in composer with another and connecting it to another one requires separate hosting and an API but it is still manageable.

To make a chatbot that can apply humanitude, it needs to be a virtual companion and pass the turing test, and virtual companions are much more complicated than an intelligent assistants. The proof of concept made could be used to develop any of the two but the companion would probably require much more time. Making a full-fledged virtual assistant for people with dementia and their caregiver would solve a lot of problems, since their biggest issue es inexperience. Caregivers will probably not be replaceable by technology in the near future but a lot can be done to assist them

References

[1] Richard A. Hickman, Arline Faustin, and Thomas Wisniewski. "Alzheimer Disease and Its Growing Epidemic: Risk Factors, Biomarkers, and the Urgent Need for Therapeutics". In: *Neurologic Clinics* 34 (4 Nov. 2016), pp. 941–953. ISSN: 15579875. DOI: 10.1016/j.ncl.2016.06.009.

[2] Joseph Gaugler et al. *2019 ALZHEIMER'S DISEASE FACTS AND FIGURES Includes a Special Report on Alzheimer's Detection in the Primary Care Setting: Connecting Patients and Physicians*. Alzheimer's Association, 2019.

[3] Alzheimer's Association. *Treatements*. 2022. URL: https://www.alz.org/alzheimers-dementia/treatments.

[4] World Health Organization. *Dementia*. 2022. URL: https://www.who.int/news-room/fact-sheets/detail/dementia.

[5] Clifford R. Jack et al. "Introduction to the recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease". In: *Alzheimer's and Dementia* 7 (3 2011), pp. 257–262. ISSN: 15525279. DOI: 10.1016/j.jalz.2011.03.004.

[6] Alzheimer's Association. *Medical Testing for Diagnosing Alzheimer's*. 2022. URL: https://www.alz.org/alzheimers-dementia/diagnosis/medical_tests.

[7] Jimmy Choi and Elizabeth W. Twamley. *Cognitive rehabilitation therapies for Alzheimer's disease: A review of methods to improve treatment engagement and self-efficacy*. Mar. 2013. DOI: 10.1007/s11065-013-9227-4.

[8] Esther M. Friedman et al. "US prevalence and predictors of informal caregiving for dementia". In: *Health Affairs* 34 (10 2015), pp. 1637–1641. ISSN: 15445208. DOI: 10.1377/hlthaff.2015.0510.

[9] Kyungyong Chung and Roy C. Park. "Chatbot-based heathcare service with a knowledge base for cloud computing". In: *Cluster Computing* 22 (Jan. 2019), pp. 1925–1937. ISSN: 15737543. DOI: 10.1007/s10586-018-2334-5.

[10] Alaa A. Abd-alrazaq et al. "An overview of the features of chatbots in mental health: A scoping review". In: *International Journal of Medical Informatics* 132 (Dec. 2019). ISSN: 18728243. DOI: 10.1016/j.ijmedinf.2019.103978.

[11] Fadi Thabtah et al. "Dementia medical screening using mobile applications: A systematic review with a new mapping model". In: *Journal of Biomedical Informatics* 111 (Nov. 2020). ISSN: 15320464. DOI: 10.1016/j.jbi.2020.103573.

[12] Ramakrishna Kumar and Maha Mahmoud Ali. "A Review on Chatbot Design and Implementation Techniques". In: *International Research Journal of Engineering and Technology* (2008). ISSN: 2395-0056. URL: www.irjet.net.

[13] Iulian Vlad Serban et al. “A Survey of Available Corpora for Building Data-Driven Dialogue Systems”. In: (Dec. 2015). URL: http://arxiv.org/abs/1512.05742.

[14] Theresa Schachner, Roman Keller, and Florian v. Wangenheim. “Artificial intelligence-based conversational agents for chronic conditions: Systematic literature review”. In: *Journal of Medical Internet Research* 22 (9 Sept. 2020). ISSN: 14388871. DOI: 10.2196/20701.

[15] Nicole Ruggiano et al. “Chatbots to support people with dementia and their caregivers: Systematic review of functions and quality”. In: *Journal of Medical Internet Research* 23 (6 June 2021). ISSN: 14388871. DOI: 10.2196/25006.

[16] Ronan Collobert et al. *Natural Language Processing (Almost) from Scratch*. 2011, pp. 2493–2537.

[17] Jonathan Grudin and Richard Jacques. “Chatbots, humbots, and the quest for artificial general intelligence”. In: Association for Computing Machinery, May 2019. ISBN: 9781450359702. DOI: 10.1145/3290605.3300439.

[18] Li Zhou et al. “The design and implementation of xiaoice, an empathetic social chatbot”. In: *Computational Linguistics* 46 (1 2020), pp. 53–93. ISSN: 15309312. DOI: 10.1162/COLI_a_00368.

[19] Emilio Soria Olivas. *Handbook of research on machine learning applications and trends : algorithms, methods and techniques*. Information Science Reference, 2010, pp. 242–264. ISBN: 9781605667669.

[20] Kellie Morrissey, John McCarthy, and Nadia Pantidi. “The value of Experience-Centred Design approaches in dementia research contexts”. In: vol. 2017-May. Association for Computing Machinery, May 2017, pp. 1326–1338. ISBN: 9781450346559. DOI: 10.1145/3025453.3025527.

[21] Francisco de Arriba-Pérez et al. “Automatic detection of cognitive impairment in elderly people using an entertainment chatbot with Natural Language Processing capabilities”. In: *Journal of Ambient Intelligence and Humanized Computing* (2022). ISSN: 18685145. DOI: 10.1007/s12652-022-03849-2.

[22] David Griol and Zoraida Callejas. “Mobile Conversational Agents for Context-Aware Care Applications”. In: *Cognitive Computation* 8 (2 Apr. 2016), pp. 336–356. ISSN: 18669964. DOI: 10.1007/s12559-015-9352-x.

[23] Federico Tiersen et al. “Smart home sensing and monitoring in households with dementia: User-centered design approach”. In: *JMIR Aging* 4 (3 July 2021). ISSN: 25617605. DOI: 10.2196/27047.

[24] Ponnusamy Subramaniam and Bob Woods. *The impact of individual reminiscence therapy for people with dementia: Systematic review*. May 2012. DOI: 10.1586/ern.12.35.

[25] Mariona Carós et al. “Automatic reminiscence therapy for dementia”. In: *ICMR 2020 - Proceedings of the 2020 International Conference on Multimedia Retrieval* (June 2020), pp. 383–387. DOI: 10.1145/3372278.3391927.

[26] Martín Abadi et al. *TensorFlow: Large-Scale Machine Learning on Heterogeneous Distributed Systems*. URL: www.tensorflow.org..

[27] Francois Chollet et al. *Keras*. 2015. URL: https://github.com/fchollet/keras.

[28] Google Researchers. *Tensorflow*. URL: https://www.tensorflow.org/.

[29] Navin Sabharwal and Amit Agrawal. *Cognitive Virtual Assistants Using Google Dialogflow*. Apress, 2020. DOI: 10.1007/978-1-4842-5741-8.

[30] *Azure Bot Service Documentation*. URL: https://learn.microsoft.com/en-us/azure/bot-service.

[31] Sensely. *Molly*. URL: http://www.sensely.com/.

[32] National Health Service. *Baylon*. URL: https://www.nhs.uk/.

[33] Healthtap. *Healthtap*. URL: https://www.healthtap.com/.

[34] Trevatt Design. *My Life Story*. URL: https://trevattdesign.com/my-life-story/.

[35] Neurotrack. *Neurotrack*. URL: https://neurotrack.com/.

[36] Michael F. McTear. “Spoken Dialogue Technology: Enabling the Conversational User Interface”. In: *ACM Computing Surveys* 34 (1 Mar. 2002), pp. 90–169. ISSN: 03600300. DOI: 10.1145/505282.505285.

[37] Heung yeung Shum, Xiao dong He, and Di Li. *From Eliza to XiaoIce: challenges and opportunities with social chatbots*. Jan. 2018. DOI: 10.1631/FITEE.1700826.

[38] Tom B. Brown et al. “Language Models are Few-Shot Learners”. In: (May 2020). URL: http://arxiv.org/abs/2005.14165.

[39] Nikita Smetanin. *cakechat*. 2020. URL: https://github.com/lukalabs/cakechat.

[40] *Azure Bot Service Documentation*. URL: https://learn.microsoft.com/en-us/azure/bot-service.

[41] *Health Bot Overview*. URL: https://learn.microsoft.com/en-us/azure/health-bot/overview.

[42] Instituto Nacional de Geriatría. *Mini-Mental State Examination (MMSE) Mini-Examen del Estado Mental*. URL: http://inger.gob.mx/pluginfile.php/96260/mod_resource/content/355/Archivos/C_Atencion_Mixto/Materiales/Sesion_4/8%20Mini-Mental.pdf.