Voice Assistant to Remind Pharmacologic Treatment in Elders

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Abstract. Nowadays, the European population is dealing with a serious ageing increment. It is estimated that almost half the population will be over 65 in the next decades, involving society into a vital challenge. This context is specially impacting on the healthcare industry which is facing a significant increase in service and medicine petitions. Elders daily cope with multiple medicine doses, a complex scenario due to the difficult management of drugs and affected by other factors such as solitude or neglect. In this paper a solution is introduced: a voice assistant that reminds the daily pharmacologic dosage using an autonomous system that operates without internet connection.

Keywords: Elder healthcare · Medicine disposal · Ambient assisted living · Voice assistant

1 Introduction

The ageing of European population is an existing fact. Only in Spain, the current percentage of people who is over 65 involve a 20% of the total population, becoming more than 50% in the next decades [1]. Rural areas are the most affected by these circumstances where more than 30% of the population are already senior and aspects like solitude get intensified [2]. The increment of third age individuals implies several challenges to society, specially for the healthcare industry. During the last years, health services and medicine requirements have experienced a severe increase [3]. Almost 50% of health resources expenditure have been intended to third age people eliciting a 30% of all medicine doses and a 75% of chronic treatments.

Elders have the defiance of managing medicine takes, meeting a conflicting scenario due to difficult administration of medication. Around a 15% of elderly population are polimedicated patients [4]. It means that there is a big percentage of third age people who takes five or more medicines for a period of six months or more. This problematic context is specially favoured by the absence of assistance and the age-related cognitive issues. Statistically, this background has an strong impact in society: around 5% of emergencies related to elderly are due to bad medicine management and almost a half of chronic patients at third age does not

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follow properly prescriptions. This set of conducive circumstances are favourable to the use of technology.

Recent technological advances have been specially influenced by new interaction ways. Voice assistants have been one of the most disruptive tendencies at human-computer interaction [5] and has teared down many constraining barriers. Taking advantage of this new paradigm, elders can easily engage with devices which could help them in day-to-day situations.

Taking this into account, voice assistants can be a very suitable technology to remind the elders their daily medicine doses. However, there are some important restrictions derived from the own context that limit possible options. In this paper a possible solution is explained as well the main factors that have been taken into account in the implementation of the project: a voice assistant that helps elders at rural areas reminding the daily medicine takes and clinical appointments. In the following chapters, the platform performance is expose as well as the future possibilities.

2 Overview

The idea of this research project involves a set of challenges that implicate environmental and human factors. There are some important restrictions derived from the own context that limit possible options at development: (1) voice assistant at rural areas and (2) appropriate speech with elders.

1. **Voice assistant at rural areas.** Population in rural areas is generally the most aged [2]. This fact induces that the main targets are those elders who live at rural areas where, widely, homes do not count with an Internet connection. This limitation discards the use of the most popular voice assistant devices such as Alexa from Amazon or Google Home since they require a constant Cloud connection [5].
2. **Appropriate speech with elders.** Since the target users are elders, it is necessary to take into account this fact at speech composition, specially when it references medicines and doses. Usually, third age people do not identify medications through the name or trademark. Physical descriptions or even personal specifications [6] such as position inside a storage rack, are more common. This way, the voice assistant has to allow high customizable options.

On the basis of these two main limitations, the project has been implemented over Snips [7], an open source voice assistant which operates autonomously without Internet connection. Thus, the device has been adapted and integrated into a platform that helps elderly to remind medicine doses and takes. Through this system, medical personnel are able to configure the voice assistant and add prescriptions and appointments (Fig. 1).

The platform follows a simple working scheme that tries to diminish configuration processes and user intervention. *The data synchronisation is the most relevant process. It is based on three main steps: (1) Elderly information*

configuration, (2) Snips synchronisation and (3) Snips operation. This procedure has to be done every time a change is made in the prescriptions or appointments (step 1).

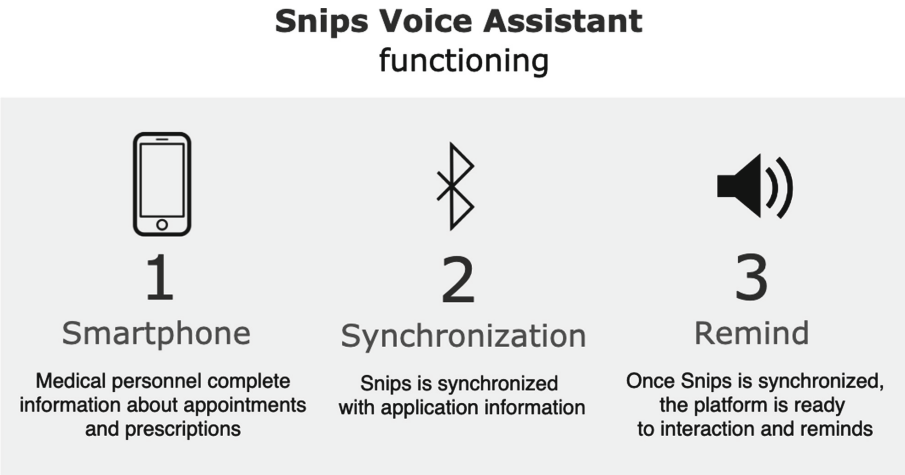

Fig. 1. System overview.

(1) Elderly information configuration. The first step is to specify the elderly information in the smartphone application. Since prescriptions and appointments are clinical data, the medical personnel are in charge of completing this information. Initially, personal data is provided in order to create a new patient profile, once this task is completed, prescriptions and medical appointment can be made. These specs implicate several details:

Prescription. Prescriptions are one key piece in the application and in the full system. This concept associates the elderly with the medication prescribed by the doctor. This way, a medicine can be specified as well as the doses. Since drugs can be consumed at several takes, days of the week and hours are selected, stating the set of reminders that will be lately announced. It is quite important to take into account that the project targets are older adults, therefore, the way medicines are identified has to be taken into consideration. It is usual third age people identify medication following a physical description or even a more personal denomination. This way, the application provides the option of specifying a custom overview to solve this matter.

Appointment. Clinical appointments are really common on elders routine. The variety of motives, places, dates and hours at appointments can turn out to be confusing to elders. In order to solve this, the application integrates a personal user calendar that allow appointments specification. Thus, it includes the involved medical specialist, the place where the meeting will be and the full date.

Once the full information is provided, the application is ready to synchronise with the Snips device.

(2) Snips synchronisation. In contrast to most popular voice assistants, Snips platform is designed to operate in an autonomous way. This means that internet connection is optional, being capable of performing interactions without any Cloud processing. On this basis, an Snips Skill has been develop in order to program schedule reminders using the information from the application. Once all data has been provided in the app, the synchronisation is simply made by Bluetooth, selecting the Snips device as destination. The full step is invisible to user and does not demand any effort. Once this quick step is made, the device is ready to announce the elder's appointments and medical prescriptions.

(3) Snips operation. As a result of the previous tasks, Snips is able to work autonomously and remind elderly about the appointments and medicine takes. This way, the device will announce the medicine that should be taken followed by the custom description at the corresponding daytime. Also, within few days before, medical appointments will be reminded.

The system functioning is really easy and involve just three simple steps. Each component of the platform works independently and they are implemented involving several technologies. In the next chapter, technical architecture details are drawn.

3 Architecture

The platform has been developed into several components that conform the full system. Each element evolves a concrete function to the architecture and can be clearly differentiated through the defined working steps: (1) Smartphone application used to fulfil elderly information and (2) the skill developed over Snips platform.

(1) Smartphone Application. As an starting point, the platform needs information input and requires a way of synchronising Snips devices with that information. Taking into account that one of the premises is the absence of Internet connection at Snips devices, the most suitable idea is using an smartphone application. Thus, data can be easily kept and managed while the physical independence of the phone allows carrying this information into voice assistants installed at elders home.

The smartphone application has been developed using Kotlin. This programming language has motivated the agile development of the platform and has allowed the multiple management of the resources at phone. Through a tab-based navigation model, a fluid browsing has been reached, enabling an easy use and interaction of patient, appointment and prescription information (Fig. 3). Once the application keeps all valid information, synchronisation process is made via Bluetooth (Fig. 2).

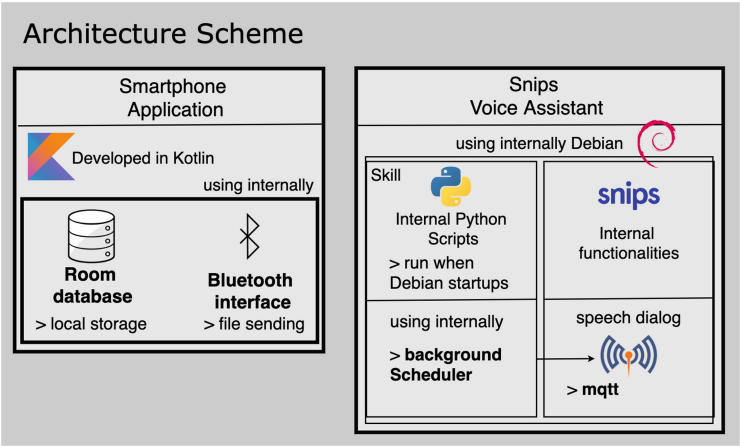

Fig. 2. Voice assistant architecture.

*2) **Snips skill.*** Snips device is a voice assistant which main feature is the autonomous working and the independence from Internet connection. This platform integrates a NLP (Natural Language Processor) component that allows the programmer identifying key words and sentences in order to perform tasks. *When the key words are recognised, the instructions to execute are specified using Python language. Internally, Background Scheduler library is used to program reminds. Then, Snips internal functionalities are invoked in order to allow the device to speak.*

Another relevant factor is the capability of integrating functions that commercial platforms disable such as proactivity or device internal settings modification.

Once the full patient information is completed in the smartphone application, Snips can be synchronised. In order to perform this communication, the system follows a quick dialog process: firstly, the application creates a JSON format file (Fig. 4) with the full information of the patient, then, this archive is sent by Bluetooth to Snips and, at last, the device reads this data and programs reminders. Next, this process is explained detailed.

1. **File generation.** When the sync option is selected in the application, it generates a file with the full information of the patient, including appointments and medicine prescriptions. The content is specified in JSON format, enabling an easy interpretation of data.
2. **Bluetooth sending.** Once the application generates the file, it is sent via Bluetooth to Snips.

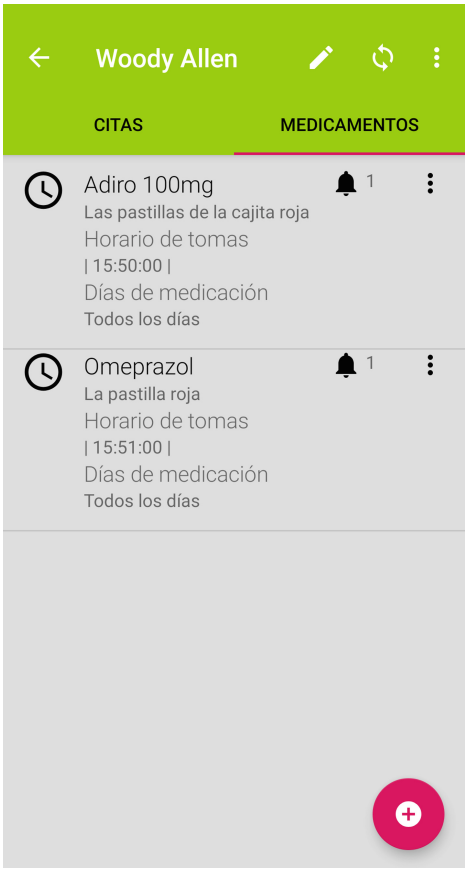

Fig. 3. Application screenshot.

3. **Snips processing.** When Snips receives the file, it identifies the content and new appointments and prescriptions. This way, once information is interpreted, the device launches the reminders and speeches coordinators. As a result of this last step, Snips will remind elderly the medicine doses and takes while announces clinical appointments.

As a result of the development process, Snips is able to recognise the detailed information about prescriptions and appointments. When the corresponding taking hour is reached, the device will announce the medicine name joined the custom description. Furthermore, clinical appointments are notified few days before they take place. All this functions conform the current working of the platform, opening a work line full of possibilities and options to the voice assistant and assuming a very significant improve in elders' life.

Fig. 4. Json file format.

4 Related Work

Technology is a discipline closely linked with health. The possibilities and advances at digital healthcare are quite relevant and they are becoming a very significant branch in research. Elders are the target users of many projects and the literature offers many ideas to improve their day-to-day activities. In this Section, several projects related to medicine prescriptions reminders are collected, exploring the working and studying the possible impact. This way, related articles are classified into two main clusters: (1) medicine takes reminders and (2) elderly healthcare assistants. This two working groups explore the two main lines of this project.

(1) Medicine takes reminders. Several projects and patents about medicine takes reminders can be found in the literature. The main objective is helping elderly or dementia patients at daily drugs ingestion. Thus, some of the most relevant works are: Medicine Reminder and Monitoring System for Secure Health Using IoT [8], Feasibility study of a robotic medication assistant for the elderly [9] and Multimodal and adaptable medication assistant for the elderly: A prototype for interaction and usability in smartphones [10].

Medicine Reminder and Monitoring System for Secure Health Using IoT [8] specifies the working and architecture pattern that medicine reminders implement. In order to identify the functioning core of these ideas, the article assembles

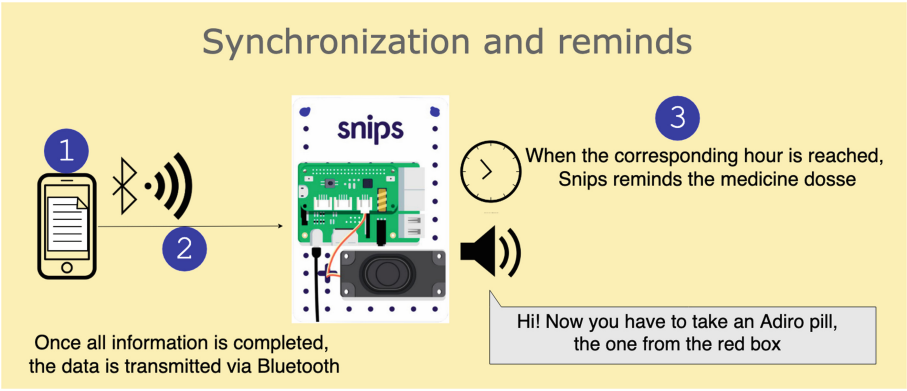

Fig. 5. Synchronization process.

several projects and previous work, drawing a performance schema and analysing the useful use of IoT devices (Fig. 5).

Feasibility study of a robotic medication assistant for the elderly [9] brings the mixed concept of robotic assistant and medication reminders. This way, using a robot equipped with a touchscreen, the device reminds the elderly the drugs that should take, checking if the doses has been taken.

Multimodal and adaptable medication assistant for the elderly: A prototype for interaction and usability in smartphones [10] proposes a solution based on mobile devices that reminds elderly the daily medication. One of the main strengths of the platform is the capability of adaptation to the context, adjusting information output to the user's situation: distance from user's face and screen is calculated thus, icons and fonts are scaled while ambient noise is checked in order to establish a right notifications volume level in each case.

(2) Elderly healthcare assistants. The developed skill in Snips platform opens up a full future work line where options like deep speech responses and proactive care of the elderly can be finely integrated. This way, elderly assistants can be a very powerful tool in order to provide wellness to the user. Literature offers several relevant ideas that match with this premise: iCare: A Mobile Health Monitoring System for the Elderly [11], Pearl: A Mobile Robotic Assistant for the Elderly [12] and Tele-medicine system based on a personal robotic assistant [13].

iCare: A Mobile Health Monitoring System for the Elderly [11] is a healthcare platform based on smartphone and wearable that monitors elderly vitals. Moreover, the system can identify possible emergencies and provides multiple information about the user, allowing relatives, friends and health personnel know about the progression. Furthermore, iCare also includes functions about reminders and medical guidance.

Pearl: A Mobile Robotic Assistant for the Elderly [12] is a platform based on a robot that helps elders at day-to-day tasks. The device works as a personal assistant with two main functions: reminding elderly about tasks like taking

medicines or drinking; and guiding people through environments. The robot is based on a well-defined action scheme which includes the possible programmed actions like informing, moving or reminding.

Tele-medicine system based on a personal robotic assistant [13] introduces an elderly tele-assistance system implemented on a robot assistant. In this manner, the system is able to communicate and interact with the elderly on a natural and intuitive way. One of the main functions of the project is remote telemedicine which is mainly based on a video-conference system that allows medical personnel to keep a visual and telematic diagnosis.

All this works are perfect examples of the encouraging work line this project follows. The possibilities new advances provide to the research bring the opportunity of improving notably the elder's life through technology.

5 Conclusions and Future Works

Many older adults daily face with multiple medicine doses. The difficult of managing several medicine brands with various doses and different takes becomes a hard situation for ageing people. Technology can be a suitable option to improve this daily routine, specially voice assistant devices. The purpose this paper describes has the main objective of reminding elderly of the daily medicine takes and the clinical appointments. This way, a voice assistant is a matching solution to the polymedical problem at third age, working successfully at helping in medicine management. *Nevertheless, not all voice assistant platforms adapt to the context of the problem. Popular devices such as Alexa or Google Home require a constant Cloud connection. Therefore, deployment is not possible in areas where there is not Internet connection. Moreover, these voice assistants provide a very restricted development environment. Thus, the Skills operations are limited and functions like proactivity are not possible. On the other hand, Snips Platform is a voice assistant that operates without Internet connection. The working of the device allows the developer to operate with internal options of the voice assistant. This way, it is the best option to the purpose.* The custom capability of the platform assures that user understands the device indications, improving elderly-machine interaction. Since Snips Platform is used to define the assistant, deployments are immediate in every context. The Internet independence enables the use of the device in rural and isolated areas, assuming one of the most disruptive concepts of the project.

The voice assistant has been tested in several lab contexts. During these tests, researchers and students have been using the platform in order to detect possible functional errors. It is quite relevant to guarantee a successful working in the prototype before next versions since it is planned to involve real users in next tests. Moreover, results have been favourable. The voice assistant device has successfully stored and reminded all prescriptions and appointments. Thus, next versions will be tested with final users in a real context.

The implementation of the prototype adjusts elder's need and allow interaction based on natural language and without any learning curve. However, this is

the first step in a very relevant work line thanks to the possibilities of autonomous connection and programming faculties. There are pendent interesting tasks that will notably increase platform possibilities like a deep speech implementation or proactive care of the elderly. Next, some of this ideas will be detailed.

A deep speech implementation will be specially useful at user-device interaction. The potential of these functions translates the usage into a better experience that improves medicine management, allowing consults about prescriptions details. *Therefore, the elderly will be able to interact with the voice assistant, asking about the next medicine takes or precising details about future appointments. It will be a substantial feature since it provides an easy interaction between the user and the system. This communication will play a key role in future developments since it can be extended in order to provide fluid speeches with the elderly. This way, the conception of the voice assistant will change into a companion device.*

Proactive care is also a keystone on the future work line. The opportunity of using context information and elderly health reports brings the option of proactive care. This way, the system asks the user about his wellness and medicine effects, giving advices about prescriptions, health and physical care. *It is also a key part at healthcare. The voice assistant device will be able to ask the elderly about issues related to medication. Moreover, a deep study of prescription symptoms can be developed. Since the elderly will answer about doses effects, the voice assistant device will store the reply. When the next synchronisation process is made, the device will provide the information to the medical personnel. This feedback can be essential to successfully adjust the dosage.*

System interconnection is a technical challenge that improves system effectiveness. The possibility of connecting the assistant into several wearables and devices assure medicine notifications will be received. Appliances like vibrating bands and smartphones are examples of devices that would notably increment the platform presence.

This paper brings an idea that notably improves elder's day-to-day. The project is a solid approach to solve polymedical derived problems and provides an easy reference to drugs management and recognition. Future works are evidences of the disrupting ideas the system brings.

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References

1. Bloom, D.E., et al.: Macroeconomic implications of population ageing and selected policy responses. Lancet **385**(9968), 649–657 (2015). https://doi.org/10.1016/S0140-6736(14)61464-1. http://linkinghub.elsevier.com/retrieve/pii/S0140673614614641
2. Rodríguez Rodríguez, P.: Envejecimiento en el mundo rural: necesidades singulares, políticas específicas. Observatorio de Personas Mayores, Madrid. NIPO: 216-04-006-9. http://www.imsersomayores.csic.es/documentos/documentacion/estudiosyresultados/perfiles/boletinsobreenvejec11.pdf. 30 p.
3. McDonough, R., Cooper, J.J.: Drug-related problems in older adults. J. Am. Pharm. Assoc. (Washington, DC: 1996) **42**(5 Suppl 1), S32–3 (2002)
4. Mira, J.J., et al.: Physician patient communication failure facilitates medication errors in older polymedicated patients with multiple comorbidities. Fam. Pract. **30**(1), 56–63 (2012)
5. Hoy, M.B.: Alexa, siri, cortana, and more: an introduction to voice assistants. Med. Ref. Serv. Q. **37**(1), 81–88 (2018)
6. Cardarelli, R., Mann, C., Fulda, K.G., Balyakina, E., Espinoza, A., Lurie, S.: Improving accuracy of medication identification in an older population using a medication bottle color symbol label system. BMC Fam. Pract. **12**(1), 142 (2011)
7. Snips Corp.: Snips. https://snips.ai/
8. Zanjal, S.V., Talmale, G.R.: Medicine reminder and monitoring system for secure health using IOT. Procedia Comput. Sci. **78**, 471–476 (2016)
9. Tiwari, P., et al.: Feasibility study of a robotic medication assistant for the elderly. In: Proceedings of the Twelfth Australasian User Interface Conference-Volume 117, pp. 57–66. Australian Computer Society, Inc. (2011)
10. Ferreira, F., Almeida, N., Rosa, A.F., Oliveira, A., Teixeira, A., Pereira, J.C.: Multimodal and adaptable medication assistant for the elderly: a prototype for interaction and usability in smartphones. In: 2013 8th Iberian Conference on Information Systems and Technologies (CISTI), pp. 1–6. IEEE (2013)
11. Lv, Z., Xia, F., Wu, G., Yao, L., Chen, Z.: iCare: a mobile health monitoring system for the elderly. In: 2010 IEEE/ACM Int'l Conference on Green Computing and Communications & Int'l Conference on Cyber, Physical and Social Computing, pp. 699–705. IEEE (2010)
12. Pollack, M.E., et al.: Pearl: a mobile robotic assistant for the elderly. In: AAAI Workshop on Automation as Eldercare, vol. 2002, pp. 85–91 (2002)
13. Barea, R., Bergasa, L., López, E., Escudero, M., Hernández, J., Willemaers, Y.: Tele-medicine system based on a personal robotic assistant. In: 10th IEEE International Conference on Methods and Models in Automation and Robotics MMAR, vol. 4, pp. 909–915 (2004)