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Designing an elderly-appropriate voice control for a pill dispenser

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Taking the correct medicine at the specified time is becoming an increasing challenge in light of the demographic change. In this contribution, we demonstrate a medication assistance system in the form of a pill dispenser and present an approach to make it elderly-appropriate and easily useable by including voice control. After discussing necessary aspects for designing the voice control system, we implemented it as an integral part of the pill dispenser control system.

I. Introduction

The demographic change poses technical, social and economic challenges, as more people require assistance for maintaining a healthy and good quality life. The emergence of technical assistance systems applying communication and information technologies as well as artificial intelligence present viable solutions for these challenges. The goal of this research work is to develop a concept for intelligent and user-centered assistance systems for the elderly at the example of a medication assistance system, a medicine cabinet as well as an automated walker. A significant aspect when designing the proposed assistance systems is their usability by the elderly. Although aging brings forth a gradual deterioration on a sensory, cognitive and muscular level, this declining process is variable for each individual as well as for one individual over time. An assistance system should, however, be made utilizable by everyone. One measure to develop an elderly-appropriate assistance system is to include a multimodal user interface. An interface is defined to be multimodal if it offers more than one interaction method. This includes auditory, visual, and haptic interactions [1,2]. Subsequently, the user can interact with the system regardless of the symptoms of aging which manifest over time [3]. Another aspect is the ability for the elderly to use the system and benefit from the emerging technologies, without directly having to deal with its increasingly complex structure. Hiding the system's complexity from the user is reasonable as many elderly people are not familiar with modern technologies. Arguing that both aspects play a major role when designing an elderly-appropriate and utilizable assistance system, applying voice control can provide a natural access to an assistance system. It enables multimodality as well as ease of use as verbal communication is the default and natural communication method among humans.

As an approach to make assistance systems elderly-appropriate and -useable, in this contribution, we focus on designing voice control for the medication assistance system, namely, a pill dispenser.

II. Elderly-appropriate voice control

Although there has been a lot of improvement in the field of speech recognition, designing voice control systems to be elderly-appropriate has not been investigated enough.

When implementing a voice control system, the signal processing chain consists of the three main components speech-to-text (STT) engine, logical unit, and text-to-speech (TTS) engine [4]. The STT engine is responsible for speech recognition, i.e. the conversion from speech signal to character-based text form [5]. The thus extracted text is passed to the logical unit. It consists of the natural language understanding (NLU) engine and the skills service. NLU refers to the interpretation of textual statements [4,5,6].The goal of the NLU engine in a speech processing chain is to extract the user's intent from the given sentences [4, 5]. After comparing the intent to a database of possible predefined intents, the skills service steps in and initiates the corresponding system reaction. If the system reaction includes a verbal output to the user, the third component, the TTS engine, converts the desired textual message back to a speech signal by using various approaches of speech synthesis [5].

Both speech recognition and synthesis are subject to constant improvements due to emerging machine-learning algorithms [5, 6]. However, no generic solution exists for either of them. This implies that there are successful speech recognition and synthesis algorithms; however, they are limited to a subject-specific predefined field of application.

II.I Design aspects

In order to design an elderly-appropriate voice control system, aspects of the physiological aging process have to be considered. The concept aims at optimizing usability by adapting to different users and to dynamically changing application environments.

In Table 1, we have mapped the aging phenomena to how they can be dealt with in a voice control system under design. The consideration is for both input and output speech

signals. For user-input signals, the system has to consider a slower speech and process the signals reliably.

Table 1: Mapping of age-related symptoms to measures in a voice control system

Age-Related Symptom	Measure
Hearing Impairment	Variable output volume
Reduced speech speed	Test for speech processing
Reduced working memory	Slow messages, considering variable inputs
Reduced audio memory	Simple, repeatable messages

Moreover, variable speech with the same intention has to be identifiable by the system so as not to bind a user with possibly reduced working memory to the same words. As for the system's output, a slower and repeatable message should be delivered. To cope with the reduced working and audio memory, simple and not too long voice messages have to be given to the user.

III. Voice control for a pill dispenser

Studies show that the more medications elderly people need, the lower their adherence is to the medication plan [7]. An assistance system can support these people with their medication management.

The proposed assistance system is an interconnected pill dispenser consisting of a stationary and mobile part to accompany patients in their daily life activities at home or outside. It is intended as a user-centric and intelligent system. More details can be found in [8]. Its main functionalities include pill filling assistance, reminder functions, medication history tracking and individualized alarm settings.

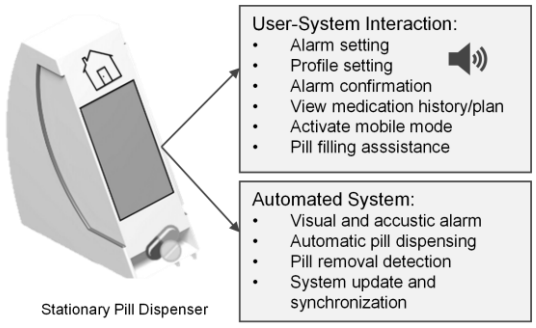

Figure 1: Pill dispenser with use cases. Design from [8].

The main user interface designed for the pill dispenser is a touch screen. To make the system useable by a broad number of elderly, voice control is added to the user interface. Figure 1 gives an overview of the use cases of the pill dispenser. We have worked on use cases, where information delivery via voice seemed reasonable. The considered use cases are: informing about the next alarm and giving an overview on correctly vs. incorrectly taken medications.

III.I Prototypical implementation

For the prototypical implementation of our concept of elderly-appropriate voice control, the Snips Voice Platform was chosen as a framework. This platform runs reliably and locally on edge devices. Moreover, it is private-by-design and was found to perform equally well compared to similar platforms in a benchmark test [3]. Additionally, it utilizes modern machine learning algorithms to perform speech recognition and natural language understanding.

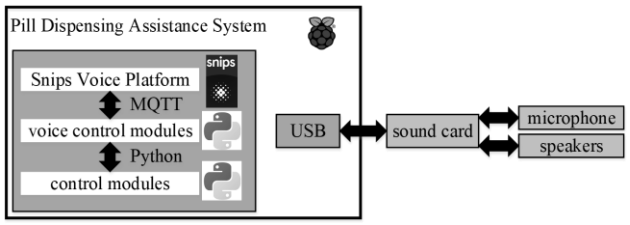

Figure 2: Architecture of the prototype including software and hardware components.

As presented in Figure 2, the software components include the Snips Voice Platform and modules for both the voice control and the hardware control of the prototype, coded in Python 3.5. The communication to the Snips Voice Platform occurs via the MQTT protocol, whereas the voice control modules communicate via Python scripts. The prototype runs on a Raspberry Pi 3 with the operating system Raspbian Stretch. Required hardware components are a USB sound card, a microphone and speakers.

IV. Results and discussion

In this contribution, an approach to design a multimodal user interface for a medication assistance system using voice control was presented. We argue that including voice control as a multimodal interface enables better access to the user and can lead to an optimized assistance. The system has been validated by four elderly users with accurate results. As an outlook, more adaptability through the interfaces can be introduced. An extensive user-specific voice analysis can be investigated to improve the delivered assistance through identifying distress or mood changes.

AUTHOR'S STATEMENT

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