An intelligent medication assistance system

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Motivated by the increased need for assistance systems in the ambient assisted living domain and the challenges posed by non-adherence to medication plans by the elderly, we have developed a hardware and software-based medication assistance system in the form of an intelligent and interconnected pill dispenser. The system maps needs for an elderly-appropriate assistance system through automation and artificial intelligence features as well as flexibility through an IoT-based, location-independent use. In this short contribution, the concept as well as the prototypical implementation are presented.

I. Introduction

As the population is aging, the need for assistance systems in the ambient assisted living domain is high. With the increased availability of data provided by ambient sensors, devices, wearables and the improvements in the artificial intelligence field, there lies great potential for inferring knowledge about the elderly and the context, in which assistance is provided by a system. Being able to correlate and learn from dynamic and variable data enables a continuously optimized, individualized and effective assistance. The goal of this research is to develop an underlying, reusable concept for intelligent and user-centered assistance. Therefore, we experiment with several automation systems as use cases for elderly assistance.

II. The networked pill dispenser

As the average number of medications prescribed increases with age and the more the number of medication, the less adherent patients become, not taking medications correctly can lead to major health risks, a possible loss of autonomy and a degrading lift quality [1]. This is why in this use case we focus on developing an automated, interconnected and intelligent pill dispenser system to assist the elderly with medication management. Following a multidisciplinary design process, system's requirements were concluded and merged with aspects of automation, intelligence and the Internet of Things. The target group hereby are multimorbid, elderly patients who are independently living at home with occasional assistance of caregivers. The design aspects dealt with the ergonomic design, the average needed pill capacity [2]. A conducted literature and systems review helped identify state of the art as well as challenges and potentials. The requirements are as follows [3]:

- **Embeddedness**: The system needs to be unobtrusively embedded in the daily life environment of its users.
- **Automation**: The system should exhibit high level of automation to require minimal effort from an elderly.
- **Intelligence**: Continuous optimization of assistance based on the user's individual behavior is needed.
- **Usability**: The system needs to be intuitively useable through its user interface by non-tech-savvy users.
- **Privacy and security**: privacy concerns as well as security regarding acquired data should be addressed.

III. System overview

In this section, the system architecture as well as the fulfilling of the requirements will be described in detail.

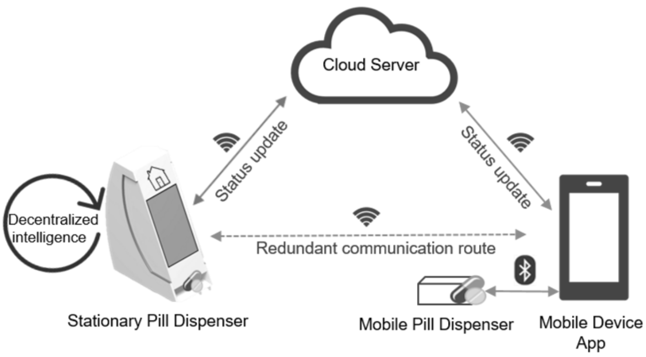

Figure 1: Pill dispenser system overview.

Fig. 1 illustrates the system architecture of the interconnected pill dispenser system.

The system consists of a stationary pill dispenser, which is responsible for managing medications at home. Through its user interface, the user can activate a pill filling assistance to fill the correct pills in daily compartments. Individualized alarm settings are possible within the time periods indicated in the medication plan. Upon confirming the alarm, the system automatically dispenses the correct doses and detects pill removal from a tray. The internal database is linked to the control logic and enables the system to function independent of any outer connectivity. Interoperability is demonstrated when switching to mobile mode, where a mobile device and a mobile unit to uphold one daily compartment at a time is included. For an overall system synchronization, a central cloud server is connected to the mobile device as well as the stationary pill dispenser to ensure data synchronization for all systems. In the following sub-sections, important aspects for the development of the described concept will be presented.

III.I. Information and communication redundancy

As an approach to increase reliability and decentralize the system, a redundant communication path is architected between the mobile end device and the stationary pill dispenser to decouple the system from the central server whenever needed. Data is stored on the local database and connected with the control logic. Scenarios for initiating communication include sharing updates about alarm settings and medication intake times.

III.II Automation level

The approach to automate the system as much as possible aims at relieving an elderly with decreasing working memory from executing complex tasks. To this end, a pill filling assistance is designed to extract data from the medication plan and graphically inform the user of the compartments to be filled with which pills. The dispensing of the correct doses at the correct time is then automated as well as the pill removal detection. An update on the current pill and medication intake statuses also takes place.

III.III. Flexibility and individualization

To integrate the assistance system in the daily life of its users, a further system function is demonstrated by the flexibility of using the pill dispenser at home or outside via the stationary or mobile part, while still being reminded and keeping track of the overall medication intake.

III.IV Ease of use and multimodality

As different people age differently, making the system easily useable is achieved by multimodality through including visual and audio interaction channels. For an intuitive communication similar to a natural one, elderly-appropriate voice control is also included.

III.V Intelligence

The system adapts its assistance to the patient's behavior through monitoring, learning and providing individual suggestions to improve medication adherence. An approach to map a non-adherent state to dynamic individual quantitative as well as qualitative factors is realized through reinforcement learning.

IV. System implementation

The system is currently implemented using multiple technologies and software packages. As for the stationary pill dispenser, the electronics used are infrared sensors for the detection of pill compartments and for the removal detection. Alarms are given by LEDs and speakers, whereas the main user interface is by a touch display. The user gives his voice commands via a microphone, a motorized mechanism and a linear magnet are responsible for compartment opening. The electronics are connected to a Raspberry Pi, on which a python-based control software is implemented. The control logic is linked to the local database, as seen on Fig.2. As for the user interface, we have chosen to implement it within the Electron Framework using web-technologies, as they offer more

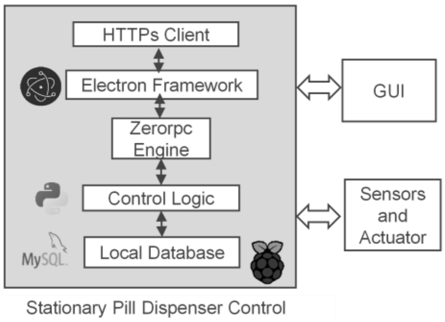

Figure 2: Stationary dispenser software architecture

flexibility for designing graphical interfaces. The interface is linked to the python code via a socket.

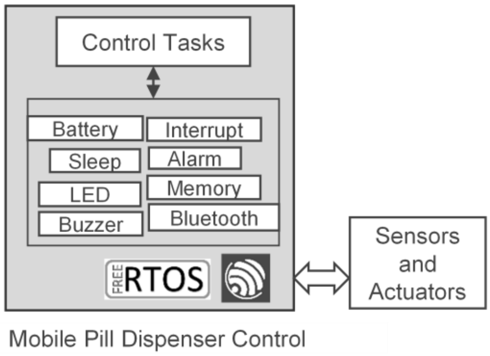

Figure 3: Mobile dispenser software architecture

The electronics used for the mobile dispenser are for the alarm and the detection of a compartment's manual opening. The control software is written on an ESP32 microcontroller within FreeRTOS as seen on Fig.3. The communication interface to the mobile App is implemented in Bluetooth Low Energy.

V. Summary and outlook

In this contribution, we have discussed the need for elderly-appropriate, intelligent assistance systems. As a use case, we presented a medication assistance system, considering aspects of automation, flexibility, ease of use as well as intelligence. Privacy is provided as the system can run locally and decentralized, while security will be regarded when sharing data with a cloud server. As an outlook, the system is to be validated by users to continuously optimize the provided assistance through learning their behavior.

AUTHOR'S STATEMENT

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REFERENCES

[1] C. M. Hughes, Medication non-adherence in the elderly: how big is the problem?,in Drugs & aging, vol. 21, no. 12, pp. 793–811, 2004.
[2] F. Reichelt et al., User Centered Design of a Pill Dispenser for the Elderly in Advances in Intelligent Systems and Computing, Human Systems Engineering and Design II, T. Ahram et al., Springer International Publishing, 2020, pp. 699–704.
[3] N.Sahlab et al., Development of an Intelligent Pill Dispenser Based on an IoT-Approach in Advances in Intelligent Systems and Computing, Human Systems Engineering and Design II, T. Ahram et al., Springer International Publishing, 2020, pp. 33-39.