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The «Intelligent Wardrobe»

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Abstract. In an ageing society technical systems that support the residents at home are becoming increasingly important. Many of the technologies available today focus on detecting falls or monitoring the health of residents. There are a few projects that focus the «smart home for the elderly» and offer support for the daily activities. The Institute of Medical Informatics of the Bern University of Applied Sciences has developed a prototype of an intelligent wardrobe. Based on sensor data from the apartment like inside temperature, weather forecast and todays events suggestions for appropriate clothes are generated and shown on a display. To facilitate the search, the garments are marked in the closet with colored LEDs

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1. Introduction

Ambient Assisted Living (AAL) is an emerging multidisciplinary field aiming at exploiting information and communication technologies for countering the effects of a growing elderly population [1]. A recent survey [1] identified current AAL systems, platforms, architectures and technologies. In Switzerland, the life expectancy has reached the record levels of 81 years in men and 85.2 years in women [2]. Many elder people wish to live independently in their own home as long as possible.

While the use of technological means is an attempt to assist the elderly in an independent life, it is important that the technologies do not interfere with normal daily activities and are not intrusive or dissuasive [1,3,4,5].

Many current AAL systems primarily monitor the residents [3,5,6] and trigger e.g. an alarm in case of an accident or danger. Sensor technology is used in three fields:

- Sensors for monitoring physiological values such as movement during sleep, ecg-measurement, toilets with built-in chemical analysis and many more [3,4].
- Sensors monitoring the behaviour of the residents: Sensors at different points of the household analyse the daily rhythm (e. g. use of toilet).
- Sensors placed directly on the body, such as fall detection sensors.

Our focus was different and aims towards an assistive device for people with mild dementia. A set of applications have been devised for people with dementia in the Gloucester Smart House project, the ENABLE project, Telecare and other projects

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described in [7]. Many of those again use sensor technology e.g. to monitor cooking activities, falls, medication dispensing or lost keys.

Our focus was somewhat different and aims at assisting the resident in typical daily activities. In mild dementia a living in the own home is still possible, potentially together with a partner or with the involvement of external assistance. For many people with mild dementia however dressing correctly is a real challenge [8,9] and a major stressor for caregivers [8,10]. Therefore a smart «dressing-aid» could be a real support und a relief for the caregivers [10].

Thus the goal of this report was the development of an assistive wardrobe, which uses of the shelf components to assist a person with mild dementia in daily dressing.

2. Methods

The Institute for Medical Informatics I4MI of the Bern University of Applied Sciences BFH maintains a so called living-lab for medical informatics, which comprises all the important stages of the Swiss healthcare system such as hospital, laboratory, intensive care unit, surgical theatre, pharmacy, physician's practice. Part of the living-lab is a complete one-bedroom apartment on the top floor of the building, which is gradually equipped with the latest sensor technologies and systems in support of its residents.

2.1. The construction of the intelligent wardrobe

The first prototype of the intelligent wardrobe was designed in a student's project. Its design was developed following an interview with a gerontologist based on user stories described in a storyboard. Sensor technology of a weather station was employed.

A modular software design based on PHP and the phpMyAdmin database [11] has been implemented (figure 1). It is centered around a PHP Servlet that reads the data of available garments and processes the rules for the choice of clothing. A Netatmo [12] weather station is used as sensor for inside and outside temperature and rainfall. The system integrates the weather forecast from OpenWeatherMap [13]. The scheduling tool Google Calendar is used [14]. The system has been implemented on an tablet PC with an HTML5 user interface. A physical wardrobe has been installed and "LED Strip Bricklet" (TinkerForge) [15] has been used for the illumination of compartments.

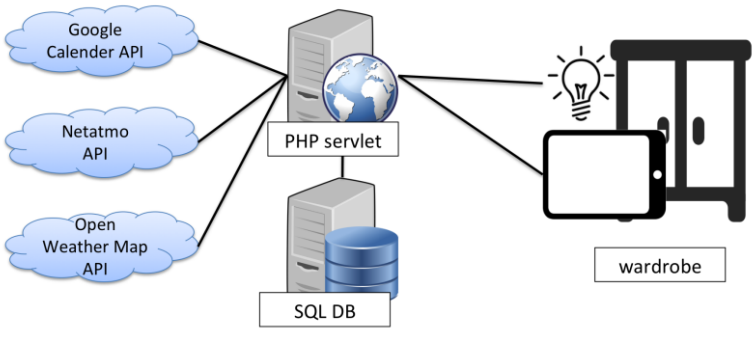

Figure 1. System architecture overview.

The data model is centered around two main tables «clothes» and «calendar events» to cater for the appropriate clothing for different events. The clothes table supports various attributes for garments, such as color, age, availability and supported outside temperature. Clothes can be associated to different types of events e.g. sport (e.g. playing with grandchildren), leisure (playing cards with friends) or formal (e.g. visit the doctor). The calendar entries are described with different categories; here the respective functionality of Google Calendar is used. Proposals and the choice of dresses will be logged and used to improve future proposals. On the administrative side a dialogue permits to add new clothes and to remove old ones from the database.

3. Results

At the heart of the work is the wardrobe in the bedroom. The tablet PC on the front door displays a summary of the appointments for the day, the inside temperature, the current weather conditions and the forecast. If a calendar entry is tapped, an appropriate clothing proposal is generated using the following data (figure 2): The current temperature in the apartment, the actual outside temperature, the weather forecast and the nature and duration of the event. The user receives a suggestion for clothes that are suitable for the chosen occasion and conditions. For appointments outside the apartment, the outerwear is calculated accordingly. If the user doesn't like the proposal, he/she can browse through more clothing suggestions. The system remembers in a learning algorithm whether certain garments are chosen more often and recommends their use more frequently.

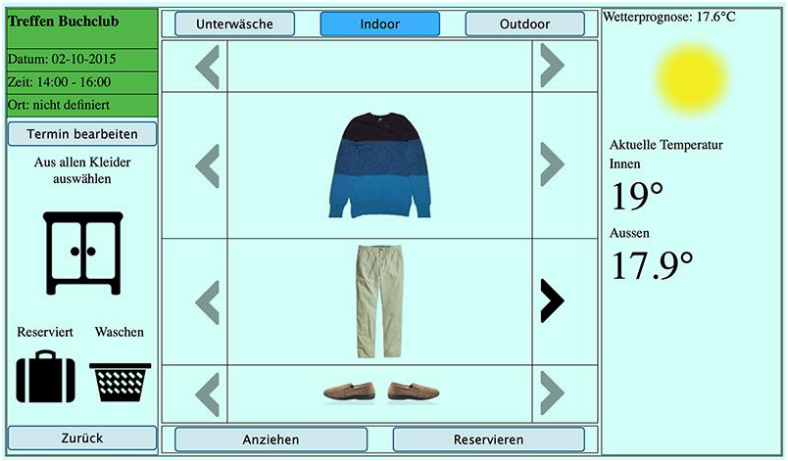

Figure 2. Display with the clothing suggestion and the current weather condition.

The user receives additional support for finding the garments in the wardrobe: if a garment is selected on the tablet PC, this garment is highlighted on the display and its compartment in the closet is illuminated in the same color. If various garments are chosen (for example a sweater and trousers), then two different colors are used to point to the location (figure 3).

Figure 3. On the display the sweater is marked in green as well in the wardrobe.

4. Discussion

The present prototype of the intelligent wardrobe is straightforward and therefore still requires some interaction with the user. Within the design phase we emphasized an easy to use screen design, which involves only two different screens with intuitive GUI. Evaluative tests with potential users are planned but have not yet been performed.

One weak point of the current implementation is the need of interaction between resident and system. The user has to activate the display and chose the event. Meanwhile we have integrated a full-surface capacitive sensor floor in our apartment, which is able to analyze pattern and direction of movement of the inhabitants. Thus we plan to use the floor and additional ultrasonic sensors (to measure the height of the person) to distinguish the inhabitants and further automate the interaction with the system. It is our goal to make interaction with the system almost superfluous.

We are fully aware not only of these shortcomings of the first assistive prototype, but also of the narrow window of potential users for this application who must still be able not only to operate the user interface but also to lay on the appropriate garments without help. There has been an interesting study of Mahoney et al. trying to assist demented persons with dressing called DRESS [7], which uses a padPC and camera recognition to assist the process of correctly dressing. They could demonstrate in a study with 25 families that an increase of correctness of the dressing process. Such applications could be joined with our approach to support as well the selection of garments and the dressing process itself. Thus some of our future efforts may center on the development of a 3D avatar, so the user can simply imitate the process of dressing.

4.1. Extensions

The existing system has a simple and easily expandable design. As next expansion step we will equip the clothes with washable RFID tags so that the cabinet can determine autonomously which garments are in the closet. A laundry basket with RFID reader permits the application to know which garments require cleaning and can no longer be proposed. The same technology could be used to detect which clothes a user is wearing.

The RFID technology offers additional interesting logistic prospects. The process of cleaning the clothes and refilling the wardrobe could be completely remodeled. In Switzerland, many older people are cared for by the SPITEX [16], which visits and supports the patient several times a week. Thus there is the option to improve the existing SPITEX washing services. Using RFID a «just in time cycle» may be realized

which could prevent unnecessary visits of SPITEX when supply is sufficient. Thanks to the smart technical support, interaction with the system will be limited to a minimum.

With the conversion of the platform on MQTT [17] additional sensors can be connected to the existing system very easy. MQTT is a machine-to-machine (M2M)/«Internet of Things» connectivity protocol. Our goal is to get the most accurate picture of health of the residents and to offer a maximum of (unobtrusive) support through the integration of more sensor technologies into the platform.

Our primary goal is the support of an independent way of life for elderly persons using information technology. In Switzerland we face not only an increasing gap between available versus needed nursing staff but also an increasing cost pressure. The more we can facilitate daily life in old age and potentially prevent harmful events the more we may be able to prevent inpatient episodes and decreasing quality of life. But to achieve such goals, technology must be safe, cheap and unobtrusive. Studies with real users in cooperation with SPITEX are planned for early 2016 to demonstrate this.

4.2. Conclusion

We demonstrated a first prototype of a decision support system to assist the demented user in the choice of garments. Currently extensions are being made to include RFID technology and improve supply routes for cleaning and delivery of clothes. Further promising research is required to assist the clothing process itself and to deploy the technology in the real world environment.

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