From campuses to living rooms - European Universities and Industry Co-Create Smart Furniture

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1. Smart furniture to solve societal challenges

The aging population poses a substantial challenge, but it also serves as a powerful catalyst for innovation. With technology development capabilities advancing rapidly, we have the opportunity to create inventive solutions specifically tailored to address the needs of our aging population, but the solutions could serve all demographics as well as people with disabilities.

Despite the potential help that technology offers, technology solutions targeted towards seniors or disabled may possess an associated stigma, affecting potential acceptance. Instead of underlining the need for assistance, assistive functionalities could potentially be embedded in everyday living such as in furniture. [1]

Smart furniture could be one means to enhance people´s participation and inclusion into their own lives and increase feelings of empowerment and life control. Smart furniture could provide for example assistance, important information or they could be used for activation and entertainment. Despite the significant opportunities that smart furniture offers, its development remains a challenging task. The complexity arises from the need for multidisciplinary skills and intensive user involvement**.** In this article, we present smart furniture prototypes and introduce the collaborative approach to their development.

2. Combining skills to create smart solutions

User-Centered Design (UCD) has been the key in the smart furniture development. In UCD, designers collaborate with users, incorporating their insights and feedback to create highly usable and accessible products [2]. The smart furniture prototypes have been developed in various projects including BaltSe@nioR [3], Satakunta DigiHealth [4], TEKOS as well as ReactiveToo [5] in collaboration with various organization such as SME:s, public service providers and universities, but the users have been in the center point of the development. The concepts have been transferred to prototypes iteratively through multiple iterations. The concepts have fist been codesigned together with users and multidisciplinary group of experts. The process has put significant effort on understanding the user needs and opportunities the technologies offer. The ideas have been transferred into prototypes which are also tested by multiple users. New stakeholders have been invited to join the process based on the needs for their skills. This has led to functional prototypes which are introduced next.

2.1 Smart chair as an activator

The idea of a smart chair is based on the fact that seniors tend to fall as their functional ability decreases. Falling may significantly affect the persons abilities and its consequences often are expensive for the society. One mean to prevent falls, it is to support the target groups physical activation and avoid inactivity such as too long periods spent sitting. Thus monitoring of sitting (posture and time spent sitting) as well as motivation are important. [6] Smart chair prototype was developed to this purpose in BaltSe@NioR (the chair hardware) and Satakunta Digihealth (the minigames) projects in collaboration with Satakunta university

of applied sciences, Poznan university of life sciences and a Finnish furniture company Junet Ltd. as well as many users who have been involved in the prototyping process.

In the prototype (Fig. 1), 9 pressure sensors are used to detect a person sitting in the chair. The same chair can be used both for monitoring sitting as well as for controlling exergames which aim to motivate person by providing fun way to exercise. In the gaming case, the user's movements are measured through the pressure sensors, located under the cushioned sitting surface of the chair. The sensors are wired up to an Arduino, along with a Bluetooth module. The sensors send their analogue data to an Arduino that converts it into a readable format for the receiving device. It is also responsible for sending the data to the Android device. To access the chair data, a connection must be established from within the exergame. The smart chair exergame developed utilized two minigames: ski-jumping and snowboarding which require sit-to-stand as well as weight shift movements.

Fig 1. Smart chair can be used to control exergames. Photo: Sari Merilampi

The next step is to develop monitoring software to visualize the sitting ergonomics. Additionally, improvement of the sensors is required to make them more comfortable and suitable for more precise monitoring. This work has been started in ReactiveToo project. Two new companies have joined the activities: DZP technologies from the UK and Dyme Solutions from Finland. Dyme Solutions is a software company which has developed a smart monitoring system for beds [7] which could also be applied to a chair. DZP develops smart materials and printed sensors which will be utilized in the next prototype.

2.2 Smart mirror to support daily living

The idea of creating the smart mirror is already a few years old. Prototypes of such appliances appeared in Japan in 2002 [8], and 2005 [9]. The second one could recognize the user with their toothbrush colour and display the daily calendar and other useful information. An interesting and compact prototype was presented in Barcelona in 2004 [10]. It was possible to control the displayed information with simple voice commands. Another prototype [11] was capable of connecting with user's sports or health wearable devices and presenting important information like heart rate, breathing rate, blood pressure, body temperature, ECG and saturation. An interactive mirror needs an Internet connection and a built-in controller with the possibility of displaying graphics like a PC computer. With the growing popularity and lowering prices of small, but still powerful microcomputers like Raspberry PI, the creation of affordable and useful smart mirrors became possible. The

smart mirror project, realised at the Silesian University of Technology is based on the interesting MagicMirror2 design [12]. The prototype (Fig. 2) has a semi-transparent mirror with a computer monitor mounted on the aluminum frame. The heart of it is the Raspberry PI 3B+ microcomputer with the MagicMirror2 software installed. It is a perfect solution which helps remind the user of important activities like taking medicine and doing some physical exercises but also supports daily live in such activities like scheduling, task list and weather forecast. This functionality can be an invaluable help for older people, persons with memory problems, as well as for busy people who have a lot of things to remember. The voice recognition module was also developed. What is important it can recognize commands without the need for cloud service use, which makes the equipment independent of the Internet connection and third-party services. Smart Mirror replaces IoT-class voice assistants, e.g. Alexa, Siri or Google Assistant, extending their user experience beyond voice interaction. The next step planned is integration of the main mirror with the voice module which will make our mirror more interactive.

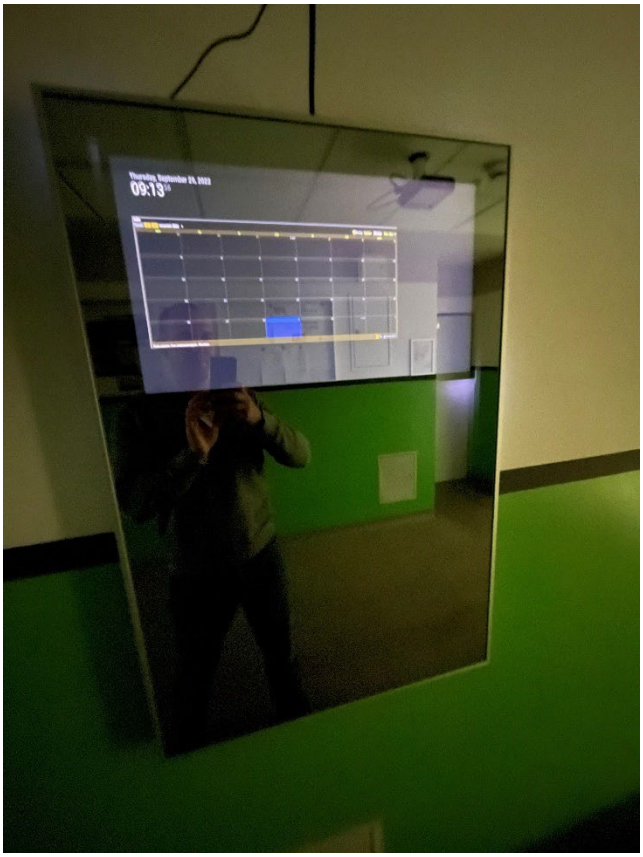

Fig. 2 Smart mirror can remind users about important activities. Photo: Krzysztof Tokarz

2.3 Smart table gives advice to user

A smart table typically refers to a table that contains embedded technology. It could have features like built-in touchscreens, wireless charging capabilities and connectivity to other devices or the internet. In our case we wanted to minimize the complexity of the electronics embedded into the table. We used NFC stickers which were embedded inside the table laminate (Fig. 3), so the table looks like any regular table. The idea was to be able to easily give information in a form accessible to the user. This happens by the user touching the NFC

spots on the table with a phone to active the content that is then presented through the users phone. The content that opens (pictures, spoken information, videos etc.) is determined from an easy-to-use user interface on a website, which is meant to be used by a therapist or relative, for example. This way the user of the table does not need to set-up the system but customized content can be easily provided in the location the advice is needed.

This versatility makes smart tables useful in rehabilitation, education, executive functional skills development, and remote rehabilitation, such as telerehabilitation or virtual rehabilitation. For example, in schools smart tables could be used in interactive learning, customized education like teachers can tailor lessons to meet the needs of indiviadula students through smart table. Features like spoken information, customizable visual appearances, and multiple language options, smart tables accommodate diverse learning styles and abilities. Smart tables can be particularly beneficial for students with special needs. In rehabilitation at home, smart tables can be used for cognitive rehabilitation, and motivational tools. For individuals recovering from brain injuries or cognitive impairments, smart tables offer cognitive rehabilitation exercises. They can incorporate motivational prompts to encourage consistent participation in rehabilitation activities.

The potential applications of smart tables continue to expand, promising innovative solutions for diverse needs and environments.

Fig. 3. Smart table looks like any regular table. Photo: Fideline Tchuenbou-Magaia.

Conclusions

The diversity of stakeholders involved in the smart furniture development underlines the need for the various skills which are required in the creation of such products. Thus the rapid prototyping is not always a very rapid process. However, iterative and user centric approach significantly improves the match between the products and the user needs.

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