Cognitive Assistance to Meal Preparation: Design, Implementation, and Assessment in a Living Lab

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Abstract

This paper first sketches a living lab infrastructure installed in an alternative housing unit built to host 10 people with traumatic brain injury. It then presents the first research project in progress within this living lab. This interdisciplinary project aims at designing, implementing, deploying, and assessing a personalized assistive technology (PAT). Based on the needs and expectations expressed by the residents, their caregivers and their families, a cooking assistant appeared as one of the best suited PAT to foster residents autonomy and social participation. The resulting PAT will rely on pervasive computing and ambient intelligence. It will then be personalized according to each participant's capacities and specific cognitive impairments. The impact of the assistant on autonomy and quality of life will then be measured. The overall organizational impact of such assistive technology will be also documented and evaluated.

Introduction

In Canada, about 100 000 people sustain of a traumatic brain injury (TBI) each year (Billette and Janz 2011). 10% of them, most of who are less than 35 years old of age (Ponsford et al. 1995), must then live in long term care units (Colantonio et al. 2004) not suited to their conditions. Therefore, it is fundamental to provide them with adapted apartments enabling them to thrive and to foster their social participation. Social participation is operationalized via the concept of life habits, which are defined as daily activities and social roles valued by the person corresponding to his or her age, gender, and sociocultural identity (Fougeyrollas, Noreau, et al., 1998).

A living Lab

In 2011 the Center of Rehabilitation–Estrie built an innovative alternative housing resource specifically tailored for TBI. This residence hosts 10 people with TBI in 6 apartments, 4 bedrooms, and collective living areas (including a living room, kitchen, dining room, smoking room, laundry, and a shared bathroom). The final aim of this alternative housing project is to foster the residents' autonomy, especially focusing on improving their social participation despite the presence of some behavioral problems and cognitive limitations.

In 2014, the residence was converted into a living lab. The building was transformed into an augmented environment using sensors (motion sensors, door and window sensors, microphones, flow meters, water and flood sensors, temperature sensors, humidity sensors, light level sensors, intelligent stove, energy monitoring sensors, light switch sensors…), effectors (touch screens, mobile phones, tablets, interactive table, wireless screens, speakers, lights,

speakers…), and computing resources (servers and industrial-level programmable controllers).

This living lab will allow us to conduct research in ambient intelligence, and rehabilitation.

Assistive Technologies

Assistive technologies are developed within this living lab infrastructure. An interdisciplinary research team (computer science, engineering, occupational therapy, physiotherapy, speech-language pathology, neuropsychology, evaluative and implementation research) is closely collaborating with patients, their families, and caregivers (occupational therapists, social workers, and managers). A preliminary study identified the participation needs and expectations of the people living and working in this smart building (Levasseur et al. 2015). Both personalized and collective needs were considered for every resident, their families, and caregivers. Meal preparation was then identified as one of the most important needs and expectations of residents on their road to autonomy.

A Cooking Assistant

Therefore a second research project was started in 2013 to design, implement, and deploy a cooking assistant in the living lab. This project has 4 objectives:

- Design a cognitive orthotic specific for meal preparation, called the cooking assistant (O1);
- Develop a framework for implementing cognitive assistance orthotics (O2);
- Assess the deployment process of an assistive technology, the cooking assistant, in an alternative housing unit resource (O3);
- Assess the short term and long term effects and impacts of the cooking assistant on the residents' autonomy and the quality of life (O4).

Methodology

The project is organized in two closely linked core components: technology (O1 and O2) and evaluative research (O3 and O4). All the researchers and users are involved in every step of each aspect of the project.

On the technology side, the design and implementation of the cooking assistant rely mainly on two cognitive assistants built earlier by our team: Archipel, a cognitive assistant for people with mental retardation (Bauchet et al. 2009) and SemAssist, a cognitive assistant for people with semantic memory deficits (Bier et al. 2011). We are adapting and improving these assistants to meet the needs of people with TBI and their caregivers. Some of these needs were identified in our preliminary study. Others emerged from interactions with residents and caregivers: interviews, observations of residents preparing meals, and structured evaluations. The final assistant will be context-aware and personalized for each user. The current implementation integrates three modules: activity recognition, cognitive assistance, and distributed man-machine interface.

The evaluative side of the project is documenting and assessing the design, the deployment and the efficacy of the cognitive assistant. Data are collected through semi-structured individual and group interviews, non-participative observations and document analysis. Efficacy will be assessed for each resident individually through the analysis of multiple case studies. Measures will be taken during meal preparation without the cognitive assistant, during the learning phase of the assistant, during the supervised use of the assistant, and during the free use of the assistant at 1, 3, 6 and 12 months after the deployment of the assistant. Main measures address the capacity to prepare meals. Caregivers will also complete an observation notebook. Residents' satisfaction will also be measured by standard questionnaires at the end of the project.

Conclusion

TBI is a major health care concern for survivors and public administration. It has devastating impacts on people's lives and prevents them from participating socially. Too often, there is no housing facility adapted to the condition and the impairments of people with TBI. That is why an alternative housing resource was built in 2011. This residence was transformed into a living lab in 2014. The aim is to design, develop, and assess innovative assistive and monitoring technologies based on pervasive computing and ambient intelligence.

This paper first sketched the living lab infrastructure and then presented the current state of the first research project to take place in this living lab. According to a study on needs and expectations, a cognitive assistant for cooking was chosen as one of the most relevant choices. It relies on sensors network, activity recognition, assistance modeling, and tangible user interfaces. The methodology to assess the impact of the assistant on the residents' autonomy and quality of life was then presented. This interdisciplinary project is very complex. Multiple new challenges are continually raised at very different levels, namely technology, organization of care and research methodology.

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