Adaptation for Ambient Assisted Living

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1 Introduction: Who?

The percentage of people over 65 years is expected to increase in Europe from 16% in 2000 to 28% in 2050 [1]. The aim of *Ambient Assisted Living* (AAL) solutions is to "extend the time during which elderly people can live independently in their preferred environment with the support of Information and Communications Technology" [2].

AAL technology should not over- or underchallenge the user, and therefore provide the level of support needed, but not more. As the needs and capabilities of users change, the support required varies over time. Adaptivity is a therefore a necessary feature of any assistive environment or device.

The German Research Center for Artificial Intelligence (DFKI-Lab Bremen) and the University of Bremen are currently cooperating in several projects related to developing adaptive AAL technology for the elderly:

SHARE-IT is an EU project with seven partners, in which intelligent wheelchairs, ambient intelligence and biometric monitoring are integrated in hospital and home environments.
`http://www.cosy.informatik.uni-bremen.de/shareit/`

I3-[SHARC], a project in the interdisciplinary Transregional Collaborative Research Center "Spatial Cognition: Reasoning, Action, Interaction", focusses on multi-modal shared control interaction in dialogue with a wheelchair.
`http://www.sfbtr8.spatial-cognition.de/project/i3/`

BAALL (BREMEN AMBIENT ASSISTED LIVING LAB), depicted in Figure 1, will be an environment in which to test intelligent wheelchairs and adaptive furniture, and validate them for everyday usability. This includes the interaction of the user with the environment to adapt it to individual needs, e.g. to open doors or to adapt the height of the kitchen counter.
`http://www.baall.net`

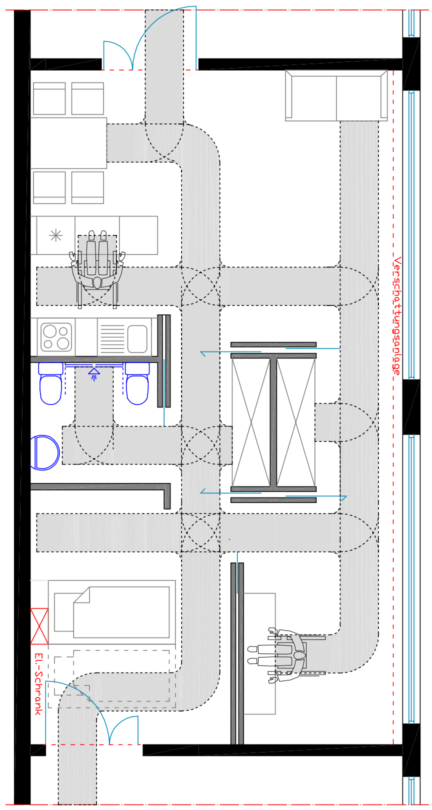

Figure 1: BREMEN AMBIENT ASSISTED LIVING LAB.

For medical questions and the analysis of assistive technology for various user groups with respect to everyday usability, we cooperate with Fondazione Santa Lucia, Rome, the University of

Göttingen and Stiftung Friedehorst, Bremen.

In this paper, we give an integrated high-level overview of these ongoing projects. First, we present methods for determining the right level of support on different time-scales. Then, we describe how the required adaptations are (or will be) achieved with respect to the user's mobility (intelligent robotic wheelchairs and walkers), the interaction (multi-modal interfaces), and the environment (adaptive furniture and ambient intelligence).

2 Adaptation: When?

A senior-to-be, or "senior-in-waiting"[1], is expectantly approaching a new phase of life. But what will the future hold in store? How to prepare for every eventuality, every possible affliction or impairment of old age?

An overwhelming desire of most seniors is to stay in their home. To avoid having to move when the actual transition from "senior-to-be" to "senior" occurs (or later if sufficient modifications are impossible), the senior-to-be should plan in time; the barrier to reside in the intentionally last home should be as low and the actual move into it as early as possible — a late move may be very cumbersome and hard, in fact too late. Thus the solution *now* is *design for later adaptation*. In the next section, we describe in which ways the house can be prepared for the transition from senior-to-be to senior.

Long-term changes in user profile. The increasing number of seniors leads to an increased prevalence of chronic morbidity and disability [8]. AAL is therefore particularly useful for seniors with disabilities. Due to frailty and the progression of diseases, the needs of disabled users change over the months/years. Such changes are determined by having doctors regularly assess the patients with respect to a set of standardized evaluation scales, as part of a Comprehensive Geriatric Assessment [10]. The performance of the patient on these scales are made available to the system.

Short-term changes in the cognitive state. Due to stress or off-phases (a symptom of many types of dementia), cognitive and motor abilities of the user may temporarily decrease. The interaction modalities and level of support must be increased during these phases.

We will determine the cognitive state of the user with a biometric sensor module. This module consists of a set of sensors that record biometric signals such as pulse and skin conductivity. The actual device is quite small, and can be worn as a wrist watch. Signals are transmitted with a wireless connection. These signals will be mapped to a set of cognitive states techniques. Note that this module must take the user profile into account, as different (combinations of) disabilities, diseases and medications require different signal interpretations.

3 Adaptation: What?

Mobility adaptation. The Bremen smart wheelchair Rolland [4, 5, 9, 7] safely avoids obstacles and can move autonomously along corridors. As an assistive device, is intended to compensate the user's physical or cognitive impairments and is adapted to the particular user in an initial configuration phase. Note that such an assistant should only compensate as far as necessary; for example, it should not be autonomous if the user can drive him/herself. In this case, it only guides in analogy to car navigation systems. However, when the user does not feel well, Rolland changes level of support and navigation mode to provide more autonomy, depending on the recommendations of the biometric sensor module. Similarly, the IntelligentWalker will guide a user with lack of short-term memory, e.g. to their friend's apartment – and back.

Interaction adaptation. Rolland provides several interaction modalities, configured to the user's needs: in addition to the standard joystick, a head joystick (for the paraplegic); instead of the usual "quantitative" joystick a "qualitative" joystick to denote the general direction in which to go (for users with tremor etc.); a graphic interface to show directions and routes, with a touch screen for gestures; a natural language interface for dialogue with deep semantic interpretation; etc. [9, 3, 7, 6].

Environment adaptation. Another challenge is *adapting to a dynamically changing environment*,

[1] "senior in spe" in German

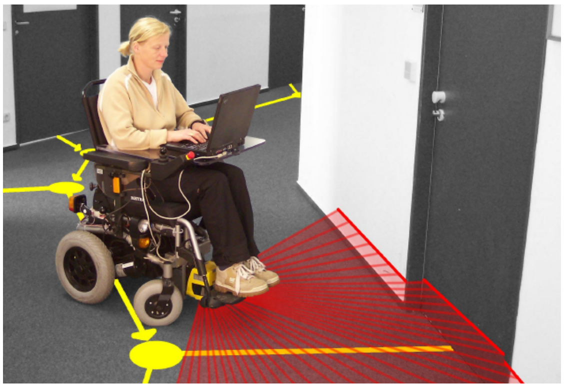

Figure 2: The Bremen smart wheelchair ROLLAND (in an office environment).

e.g. maneuvering in offices or rooms at home where furniture is moved around and space is tight. In the ROLLAND@HOME project, we are presently starting to experiment with RFID tags to be able to identify and track furniture items, including their orientation, in combination with other sensors such as ROLLAND's odometry and laser scanner.

Adapting the environment to the changing needs of different users is another matter. We are especially interested in *design for later adaptation*, in which the home can adapt to the transition from senior-to-be to senior. For user acceptance, the adaptive home should look, and feel comfortable, like any other home, conceived according to *design-for-all* principles; this is the major design rationale for the BREMEN AMBIENT ASSISTED LIVING LAB, modelled after Casa Agevole at Fondazione Santa Lucia, Rome `http://www.progettarepertutti.org/progettazione/casa-agevole-fondazione` .

The potential for easy adaptation must be in the design (without being apparent), for example:

- surface transitions, door frames, open floor space must be sufficient for moving around comfortably with the common kind of wheelchairs, *including electric wheelchairs*;
- the height of kitchen counters should be adjustable, with remote electric control as an add-on option (see e.g. `http://www.pressalitcare.com`);
- similarly, kitchen cabinets and closet interiors should be prepared for remote electric control;
- closets and rooms should be easily accessible, e.g. via electric sliding doors;
- lifts in the building should be remotely controllable, preferably by some kind of radio-control.

How to combine such a dynamic adaptation with remote control via the multi-modal interaction paradigms mentioned above, e.g. via natural language dialogue, is presently being investigated.

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