Fall Detection and Mobile Robot - Security in Advanced Age via Robots and Sensors Unobtrusively Embedded into the Home Environment

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Living in dignity at an advanced age means enabling seniors to live an independent life in their own environment. This is a challenge for the elderly, especially if they live alone and their family members reside far away. Such situations create anxiety and stress, which threatens their desire to live independently. Furthermore, with increasing age, limited mobility or impairment, the fear of a slip or fall in their own home grows (e.g. due to dizziness, lack of wariness or loss of consciousness, etc.) and being unable to help themselves. In the worst case, if no help is available after a fall, the affected person may remain laying unnoticed and die as a consequence. Another concern is the scenario of suffering further health complications due to a fracture (caused by the fall) or difficulties in the recovery process, which could result in the individual not returning to their own home afterwards.

However, elderly people who prefer to live independently in the own environment instead of in a retirement home like to be able to help themselves first before calling for help. For the purpose of providing the feeling of security and safety, especially for the case of falls as well as helping themselves first, the Fall Detection was developed in combination with the Mobile Robot, which form a system to help a fallen person by detecting the fall and offering stand-up support. The unobtrusive integration of the Fall Detection into a baseboard met the seniors' desire of not giving the impression that it is a senior housing.

The concept of the Fall Detection follows the idea of providing an affordable solution for the user, which can be integrated easily and unobtrusively into a baseboard, so that the system can be adapted to any existing room conditions within the private environment, even in the bathroom. The solution of using the baseboard for the Fall Detection offers the seniors and the furniture industry possibilities for variation regarding the selection of the design of the baseboard according to the individual's liking or existing furnishings. The only requirement for the baseboard is a notch where the fall detection sensors can be installed.

Each sensor of the Fall Detection consists of two infrared emitters and one infrared receiver. Furthermore, all sensors are connected to each other using flexible six-pole jumper cables and are inserted into a notch of the baseboard to set up an infrared light barrier system as shown in Figure 1 and Figure 2.

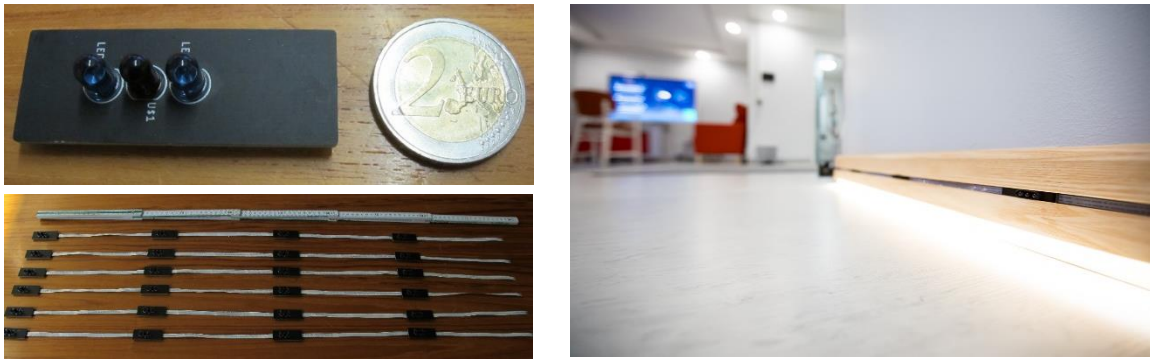

Figure 1: Fall Detection sensors and their integration into the baseboard

The number of sensors is selected according to the dimensions of a room. Furthermore, depending on the room conditions and the existing furniture, the necessary amount of hidden sensors for identifying a fall has to be set up individually. This means that the number of covered sensors need to be defined at least once at the beginning so that the system is able to distinguish between a standing or lying person (or between pets).

In the situation where no „fall event" occurs, i.e. nobody is lying on the ground, each sensor emits infrared light after each other, which the opposite sensor receives, see Figure 2 left. In the case of a fall, each sensor emits infrared light as before; however, the sensor on the opposite side does not receive the signal, as depicted in Figure 2 right. By the amount of sensors obstructed, the size of the obstacle can be estimated and the system can distinguish between a fallen person, furniture, walking or standing people, etc.

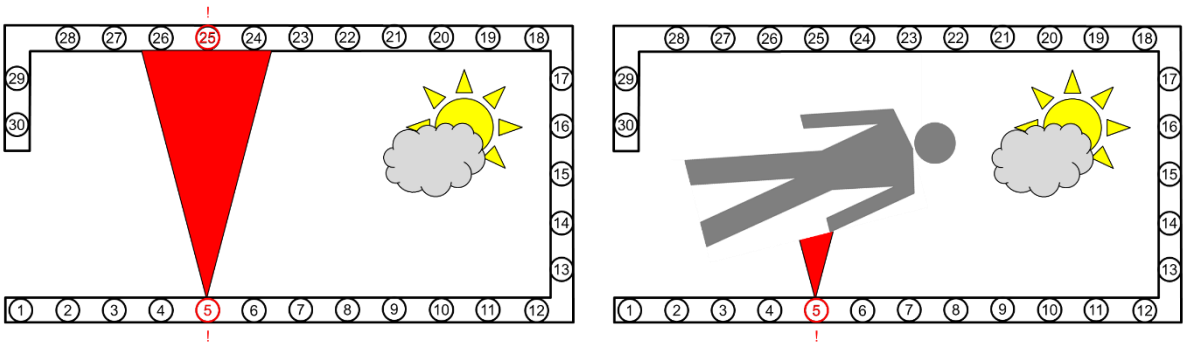

Figure 2: Functionality of the Fall Detection: standard situation (left) and emergency case (right)

If the system recognises that a person has fallen, the Fall Detection alerts the Mobile Robot, which is connected via a Server to the Fall Detection, and the Mobile Robot moves to the person in need. Through the implementation of speech recognition and sound output, the Mobile Robot communicates with the fallen person using the question: "Do you need help?". By answering: "Yes" or "No", it is possible to instruct

the robot whether help is required, as shown in the communication workflow in Figure 3 right. If the fallen person calls the command “Yes”, the Mobile Robot assists the fallen person either by the integrated handles, see Figure 3 left, which supports the person getting up independently, or with further devices like a mobile phone placed on the table of the Mobile Robot, see Figure 3 middle, enabling the fallen person to call for help. In the event the fallen person responds with a “No”, or the Fall Detection does not recognise any emergency any more, e.g. because the fallen person stands up successfully and the ”fall event” has finished, the Mobile Robot returns to its docking station hidden unobtrusively in a cabinet (freely designed by the furniture industry according to the user´s requirements) waiting for further instructions from the Fall Detection. The communication language between the person and the Mobile Robot can be selected according to the mother tongue of the elderly individual. Additionally, the environmental conditions have to be defined in advance (by a map) and are therefore customised. By using a laser range sensor as well as ultrasound sensors in the front and back of the robot, the robot is able to avoid obstacles which are not represented on the map (e.g. pets, visitors, or newly added furniture).

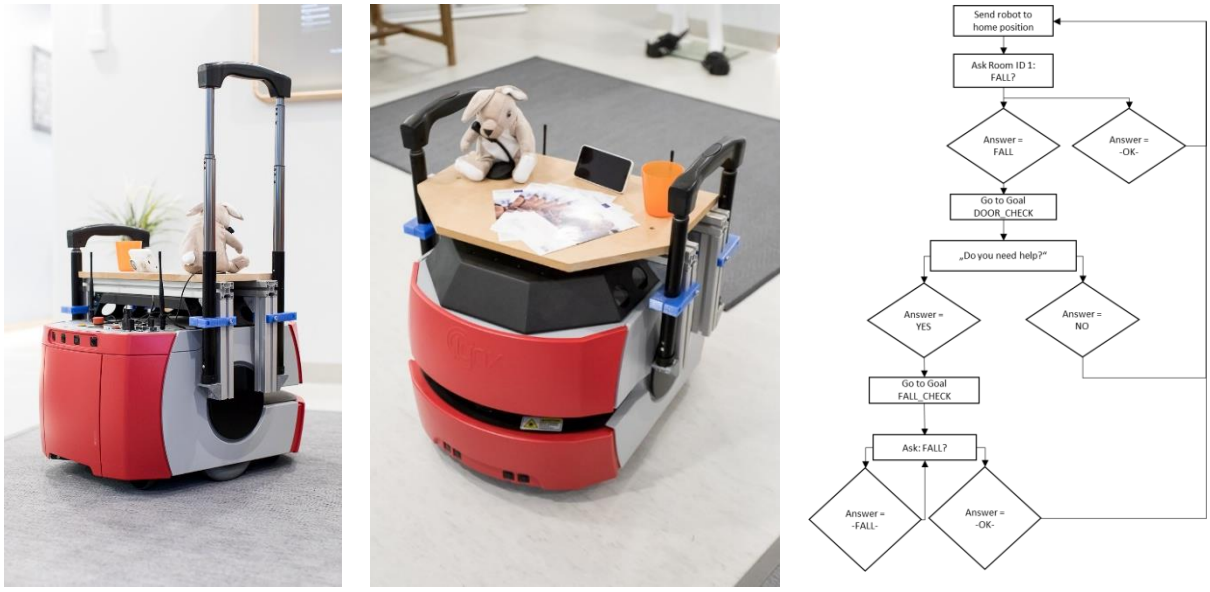

Figure 3: Mobile Robot equipped with supportive features and its communication workflow

The connection and communication between the Fall Detection and the Mobile Robot is managed by the BaltSe@nioR Server. It was developed in order to serve as a communication platform for different age-appropriate ICT furniture units/modules. According to the current health status or private requirements of the seniors, the ICT solutions that are embedded in the furniture can be added or removed modularly

from the Server. Thus, the modularity concept offers the opportunity to extend and adapt the system over time to the individual needs of elderly individuals, if required.

Within the project, the modular BaltSe@nioR Server follows the concept of connecting all ICT prototypes developed by the ICT partners to one common system, see Figure 4 left. The idea is that the Smart Chair, the ReAble Chair and the Fall Detection send security relevant data to the BaltSe@nioR Server. On the other hand, the Magic Mirror and the Mobile Robot receive the values in order to display them or to intervene. An example of the interconnection is shown in a simplified form in Figure 4 on the right side.

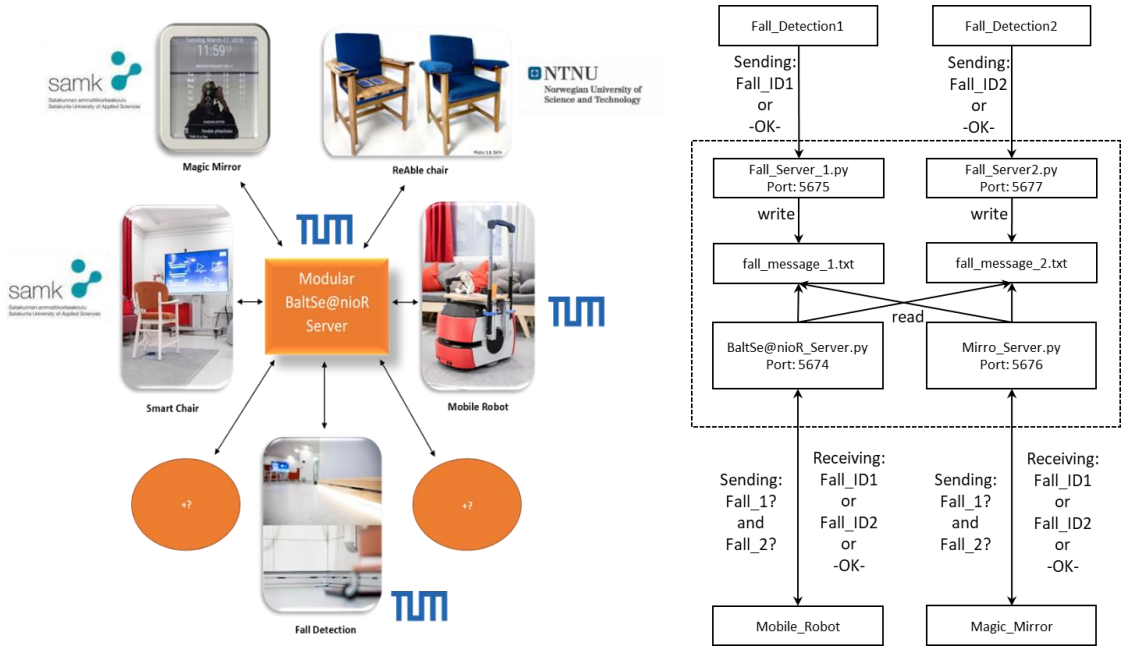

Figure 4: Modular BaltSe@nioR Server: concept of the implementation (left) and example of a workflow created for two Fall Detections connected with the Mobile Robot and Magic Mirror