UWB-Radar Monitoring of Movements in Homes of Elderly and Disabled People – An Interdisciplinary Perspective (RAD CARE)

Tobba T. Sudmann 1,2, Ingebjørg T. Børheim 1,3, Knut Øvsthus 1,4, Tomasz Ciamulski 1,4, Frode F. Jacobsen 1,5

1 Centre for Care Research, Western Norway, Bergen University College, Bergen, Norway
2 Department of Social Science and Social Education, Bergen University College, Bergen, Norway
3 Department of Occupational Therapy, Physical Therapy and Radiography, Bergen University College, Bergen, Norway
4 Department of Electrical Engineering, Bergen University College, Bergen, Norway
5 Betanien University College, Bergen, Norway

Abstract—The task of this interdisciplinary Polish-Norwegian project is development of radar technology for care services. The project has mainly an exploratory design where the capabilities of radar technology are tested out, related to elderly or disabled people living in their own home. A system for preventing and detecting falls, or detecting other potential injurious situations e.g. as nocturnal seizures, is the main goal.

Norwegian health care policies suggest strengthening community based services and home based care. Facilitating innovation and appropriation of ambient technology is part of this strategy. The present project relates to telecare as part of ambient assisted living.

Keywords—radar monitoring; telecare; interdisciplinary perspective; movements; function;

I. INTRODUCTION: INTERDISCIPLINARY DEVELOPMENT OF RADAR TECHNOLOGY FOR CARE SERVICES - RAD CARE

The task of this Polish-Norwegian project is interdisciplinary development of novel technology for care services. Designing a system for detecting falls or other conditions detrimental for health as nocturnal seizures is the main goal. Falls among elderly people are one of the main causes of hospitalization of elderly people [1-9]. The number of deaths globally caused by fall events was around 391,000 in 2003, where approximately 40% of the falls were from people over 70 years of age [10, 11]. In Norway, a new Report to the Storting suggests that it is possible to reduce number of falls with 40% by appropriating diverse preventive measures [12], including technology.

Recently published Norwegian policy documents [12-15] suggest that future health and care needs should be met by strengthening health promotion and community-based services, and by acknowledging next-of-kin and informal home based care. These ends are to be reached by facilitating innovation and appropriation of ambient technology, and by opening up the field of health and care services for private and non-governmental health and care service providers. The Radcare project deals with development of the telecare part of ambient technology. We aim at developing a system, which is less invasive and provides more accurate information than existing sensor technology, involving typically a unit attached to a person or a video camera. This paper will convey some preliminary experiences regarding opportunities and challenges in this interdisciplinary project.1

II. SCOPE: MAIN AREAS ACCOUNTED FOR

Igual and colleagues point to several challenges, issues and trends in fall detection systems [16]. Amongst them are a call for awareness of the limitations and possibilities of fall detection systems, e.g. user acceptability and performance under real-life conditions. Skubic and colleagues highlights the need for creating robust systems for translating from physical measure to clinical space, and the challenges arising from different aims in monitoring e.g. physical assessment, mental assessment, cognitive health assessment or management of chronic conditions [17]. Even though these might overlap, the needs for different sensors or data processing methods need to be considered. Both research groups acknowledge the need for interdisciplinary research.

Interdisciplinary collaborations involve a joint effort by academic disciplines to produce a solution, do

1 This work has been supported by EEA Grants – Norway Grants financing the project PL12-0001 (http://eeagrants.org/project-portal/project/PL12-0001). The involved institutions are the Warsaw Technological University (WUT), with Prof. Wieslaw Wieniecki as principal investigator and The Center of Care Research – Western Norway at Bergen University College, with Prof. Knut Øvsthus as principal investigator, Associate Prof. Dr. Tobba Sudmann, Assistant Prof. Ingebjørg Børheim and Associate Prof. Tomasz Ciamulski as co-investigators, and Prof. Frode F. Jacobsen as project leader.
research, etc. The present Radcare project has three main academic disciplines; health sciences (occupational and physical therapy, nursing), social science (sociology/anthropology), and electrical engineering.

This paper reports on:
1. the importance of establishing such an interdisciplinary project to establish applicable technical solutions, and of
2. interdisciplinary experiences with regard to designing a non-invasive system for fall detection, and,
3. preliminary findings in the project.

The lessons learned are likely to be applicable to several technology development projects.

III. METHODS RELATED TO FALL EXPERIMENTS

Experiments related to development of the Radcare technology has focused on movement analysis, based on the understanding of a fall as an unexpected event where the person comes to rest on the ground, floor or a lower level [18]. Henceforth fall detection or fall prevention is part of movement analysis, i.e. assessment of physical, mental and cognitive health.

First fall experiments were set up in collaboration with physiotherapists at Bergen University, Norway, and performed using APDM system with Opal [19] sensors and wireless control, readout and synchronization of data from the sensors. The sensors contained accelerators for each 3 axis of movements and additional sensors, which were helpful in processing, and interpretation of data from accelerators (gyro and magnetic). The sensors were attached to the body at different levels: hip, shoulders and head. Fall experiments were performed in cooperation with WUT, which stated some requirements. Collected raw data were sent from BUC/Norway to WUT/Poland for further processing. Trajectories of movement were calculated based on recorded accelerations at WUT and used as input to algorithms under development, before first data from Radcare radar sensor would be available.

Second fall experiment was set up in collaboration with physiotherapists in the movement laboratory at BUC, using Qualisys [20] motion capture system based on a set of very sensitive infrared cameras which can observe markers reflecting the infrared radiation. We explored falls based on typical ADL (Activities of Daily Life) situation and known fall risk situation, like stumbling (e.g. related to doorsills and carpets) and sitting to standing movements (e.g. from bed or toilet). This broad focus covers falls due to intrinsic (e.g. low blood pressure), extrinsic (e.g. walking sticks) and environmental causes (e.g. insufficient light). The test person was marked with approx. 20 markers in frontal, sagittal and transversal planes (bilateral on ankles, knees, hips, shoulders, elbows, wrists, forehead, ears, back head, and the back). We had 7 motions capture cameras, and an area of approx. 3 x 3 meters covered with thick Airex mats. The results from these experiments were also forwarded to WUT/Poland.

Third experiment was set up at BUC/Norway, using the radar technology developed at WUT/Poland. Ten different movement scripts were chosen, e.g. sit to stand, stand to sit, walking, turning, lying down, rising from floor, and sitting activities as drinking from a cup, doing ones hair and tying/untying shoe laces. Fig. 1 and Fig. 2 show the Radcare technology and extracts from raw data.

So far, the data obtained indicates possible detection of amount of movement in different positions (lying, sitting, upright), distance covered during monitored space, quality of gait (rhythm, sway). The technology holds potential to detect nocturnal unwanted events as seizures (excessive movements) or fainting (no movements to detect), but is not tested on real life sleeping situations yet.

IV. RESULTS: PRELIMINARY FINDINGS AND EXPERIENCES

Detecting and defining falls are intertwined matters begging for interdisciplinary approaches. The relevance and accuracy of the system developed hinge as much on health sciences insight and health worker experiences as
on technology knowledge and experience. Besides a prolonged process of cross-disciplinary sharing of knowledge between engineers and health scientists, a need for continuously working on a common vocabulary has been proven in the project, with regard to strictly scientific concepts and to concepts like “privacy”, “risk”, “movement”, “fall”, and “fall prevention”.

The experiments challenged the key question of what is a fall, how to fall, and what happens during fall. The technology also posed some challenges when came to production of artefacts and markers falling off the test person. However, planning and discussing the session afterwards have lead our focus in the project towards identification of a long lie – a problem not yet solved in satisfactory ways. The long lie frequently increases morbidity and mortality more than the fall itself. The long lie is characterized with lack of movement. Detection and rising of alarms when no movement is observed, is as important as rising alarms in cases of excessive movements.

The data generated in the two first experiments did not fully meet expectations when it came to descriptions of falls. They were, however, helpful in calculations of fall trajectories, which were temporarily used by WUT. Further works with radars revealed that it is not easy to track trajectories and other details of movements by the radar. Next steps of development and experiments in Radcare will be focused on other types of movements which radar is capable of detecting (boundary conditions). The project will invest more in detailed analysis of movements in later phases of the project. Capabilities of movement tracking at BUC were recognized and awareness about this will be helpful in a more advanced continuation of the project.

Radcare technology seems not yet capable of delivering data that can be used in fine-tuned movement analysis, or data that are refined enough to calculate the relationship between base of support and center of mass, or detecting the amount for compensating movements during everyday living (would infer reduced balance and increased risk of falling). I.e. presently, the internationally agreed upon definition of falls, an unexpected event in which the person comes to rest on the ground, floor or a lower level, may have less bearing on the Radcare technology than expected from health care side. However, when it comes to providing data that can be used for fall prevention, it is promising. Observed changes in gait is a robust indicator of increased risk of falling and reduced physical, mental or cognitive health [21-24]. However, when it comes to fall detection, the project reveals that the most important issue does not appear to be the trajectory of a fall, or fear of falling, or even risk of falling, but to differentiate between injurious and non-injurious factual falls. It is the long lie after a fall that dramatically increases morbidity and mortality – i.e. increased risk of contracting additional ailments and sequels, and increased risk of death. We are presently exploring to which extent the Radcare technology can contribute to making this most important distinction.

The BUC-team has furthermore put forward that any technology must acknowledge that tomorrows care recipients are co-producers of the services they need, and are expected to and probably inclined to, move around indoor and outdoor to preserve physical and mental health. User acceptability and appropriation of ambient assisted technology must be considered [25-31].

V. Concluding Remarks

A project tasked to develop novel technology for the health and care sector needs to be designed as an interdisciplinary collaboration, where insight from health and social scientists and practitioners is as important as technical knowledge. Based on our experience from a project mandated to design a system for detecting falls by way of analyses of everyday movements / ADL, we have illustrated some challenges, opportunities and important lessons learned. The wider context of unwanted events or falls in the home needs to be taken into account in the furthering of the Radcare project; e.g. intrinsic, extrinsic and environmental factors, user-technology interface, personalization of monitoring, and individual preferences and understandings of health, safety and well-being.

From our point of view, a scenario where Radcare technology and other types of technology in combination can contribute to information that can be used to prevent falls, is still an option, and a much needed [16, 17, 32].

Acknowledgment

The Radcare-team at BUC/Norway thanks the Radcare-team at WUT/Poland for valuable comments on earlier drafts of this paper.

References


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