Workshop: Sensor-based fall detection and prediction

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Abstract and Objective

Falls are among the predominant causes for morbidity and mortality. Recent developments in sensor technology and algorithms allow for the assessment of mobility-associated parameters using small mobile or home-based devices. The data gathered can be used both for detecting fall events and for predicting future falls. Following an introduction to the clinical problem area of falls, fall-related consequences and established clinical fall risk assessment tests, the aim of this workshop is to provide and in-depth introduction to current research in the field of sensor-based fall detection and prediction. Furthermore, different technical approaches will be discussed with the participants as well as possibilities to evaluate these approaches in realistic settings.

Keywords: accidental falls, motor activity, assisted living facilities, sensors

Workshop description

Background

Falls are among the predominant causes for morbidity and mortality. Approximately one third of all people over 65 years of age are expected to fall one or more times per year. The consequences range from simple abrasions to fractures, sometimes with lasting functional disabilities and severe complications such as thrombotic embolism and subsequent death. In addition to this, fall events often trigger the so-called 'post-fall syndrome' with a rising fear of falling, leading to a vicious circle that includes social isolation and further reduction of functional ability. The annual costs of falls among elderly persons in the U.S. alone have been calculated to amount to about $20 billion.

Recent developments in sensor technology and algorithms allow for the assessment of mobility-associated parameters using small mobile devices that often include accelerometers and/or gyroscopes or using optical sensors in homes. These devices may on the one hand be used for detecting fall events, but on the other hand can provide longitudinal data for relevant mobility parameters that may be used to construct fall prediction models.

Sensor application scenario 1: fall detection

One of the major contributors to adverse physical and psychological outcomes for sufferers of falls is the 'long lie' scenario, whereby the subject is incapacitated by the fall event and cannot request assistance, thus resulting in an extended period during which the subject's condition may deteriorate. The ability to detect falls events in an unsupervised manner would eliminate this undesirable situation and lead to improved prognoses for falls victims. Several wearable accelerometry and gyroscope-based falls detection devices have been described in the literature; however, they tend to suffer from unacceptable false positive rates, due to the vast array of movements related to daily activity which generate large acceleration spikes, similar to those associated with falls. Recent research work will be presented, investigating the augmentation of such systems with a barometric pressure sensor, as a surrogate measure of altitude, to assist in discriminating real fall events from normal activities of daily living.

Furthermore, a hybrid approach using an accelerometer and a home-based optical sensor system will be presented along with results of a first evaluation trial.

Sensor application scenario 2: fall prediction

In addition to falls event detection, the proposition of falls risk estimation in the unsupervised environment by accelerometric and optical means will also be discussed. Clinical research groups have developed models which can predict, with a reasonable degree of accuracy, the likelihood of a subject experiencing a fall in the near future. Subjects with an identified increased risk can be targeted for clinical intervention. Some of the predictive models in question are founded upon a Physiological Profile Assessment (PPA). The PPA tests represent a validated tool for quantifying risk of falling based on a combination of physiological measures, such as visual contrast sensitivity, knee extension strength, proprioception, reaction time and postural sway. The PPA provides a valuable tool from the standpoint of population screening; however, given that the PPA must be performed in the supervised clinical

setting, its scope for screening the general population is somewhat impeded. An elegant solution to the limited scope of the clinical PPA, which would broaden the reach of falls risk screening, is the translation of the clinical assessment to its unsupervised analogy, to be performed in the home environment. The advantage of employing an accelerometry-based system in subjects' homes is that a significantly larger population may be screened. Furthermore, the greatest significance lies with the ability to regularly perform remote screening. Regular screening will offer a means to anticipate an increased risk of falling through an observed deterioration in functional ability, as measured by the accelerometry-based assessment.

Aims

Following an introduction to the clinical problem area of falls, fall-related consequences and established clinical fall risk assessment tests, the aim of this workshop is to provide an in-depth introduction to the current research in the field of sensor-based fall detection and prediction. Furthermore, different technical approaches will be discussed with the participants as well as possibilities to evaluate these approaches in realistic settings.

Structure (3 hour, half-day workshop, +30 min. break)

Part 1: medical background [45 min.] *(Michael Marschollek)*

- incidence of fall events in different population groups
- types of falls and consequences
- established (clinical) fall risk assessment tests
- intervention methods, preventive measures and their effectiveness
- results of a requirements analysis (focus group interviews with patients and relatives)
- discussion with the participants

Part 2: fall detection [45 min.] *(Michael Marschollek, Stephen Redmond)*

- introduction to sensors used (accelerometers, gyroscopes and optical sensors) including a live demonstration
- basic algorithmic approaches for fall detection
- trial design and results
- discussion with the participants

break (30 min.)

Part 3: fall prediction [45 min.] *(Stephen Redmond, Michael Marschollek)*

- an introduction to the *Physiological Profile Assessment* (PPA)
- algorithms for fall prediction with different sensor systems
- trials and results
- discussion with the participants

Part 4: open discussion and conclusion [45 min.] *(Michael Marschollek, all)*

- critical reflection of current fall detection and fall prediction approaches
- the need for future trials, opportunities for cooperation
- questionnaire provided to participants to gather expert group opinion on the area, based on some useful comments gathered at a recent workshop on the same topic at MedInfo2010
- conclusion of workshop findings

Educational goals

Upon completion of the workshop, participants will

- understand the impact of falls and fall-related consequences to health care
- know established clinical fall risk assessment methods and interventions to prevent future falls
- understand the relevance and the possibilities of automated fall detection and prediction systems
- understand the basic features of the sensors used (accelerometers, gyroscopes and optical sensors) and the data generated (live demonstration), and will realize the problems that come along with each of these
- get an overview of current algorithmic approaches as well as first trial results for fall detection and prediction
- have been able to discuss their questions in depth.

Expected attendees

Health/medical informatics researchers, patients, health professionals, biomedical engineers, and policy makers involved or interested in sensor-based fall detection or prediction.

Workshop speakers

Stephen James Redmond was born in Dublin, Ireland. He received the BE (Hons) degree in electronic engineering from the National University of Ireland, Dublin, in 2002. He received the degree of PhD in Biomedical Signal Processing from the same institute in 2006. He is currently a lecturer in the Graduate School of Biomedical Engineering, University of New South Wales, Sydney, Australia. His PhD focused on the application of biosignal processing and pattern classification techniques to cardiorespiratory signals to achieve automated at-home sleep staging. His recent research interests include: signal processing techniques for quality determination in unsupervised telehealth recordings; the design of intelligent analysis tools to identify health deterioration among longitudinal telehealth records; and the use of triaxial accelerometry in the detection of falls and the estimation of falls risk among the elderly.

Michael Marschollek received his MD and Dr. med. degrees from the Medical School in Hannover, Germany, in 1999 and has worked as a surgeon and specialist in sports medicine. He received the M.Sc. degree in computer science (2004) and the PhD degree in engineering from the University of Braunschweig – Institute of Technology (2009). His PhD thesis focused on sensor-based activity recognition and fall risk assessment. He is an assistant professor at the Peter L. Reichertz Institute for Medical Informatics of the University of Braunschweig – Institute of Technology and Hannover Medical School. His recent research interests include: medical data mining and pattern recognition, accelerometry, sensor-enhanced health information systems and decision support systems for exercise rehabilitation.

Acknowledgement

Part of the work that will be presented by M. Marschollek has been done in the German Lower Saxony research network “Design of Environments for Ageing” (www.altersgerechte-lebenswelten.de). It has been partially funded by the Lower Saxony Ministry of Science and Culture through the “Niedersächsisches Vorab” grant programme.

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