A wearable fall-detection system based on Body Area Networks for smart cities

Luigi La Blunda[a], Lorena Gutiérrez-Madroñal[b], Matthias F. Wagner[a], I. Medina-Bulo[b]

[a]WSN and IOT Research Group Frankfurt University of Applied Sciences, Nibelungenplatz 1, 60318 Frankfurt am Main, Germany
[b]UCASE Software Engineering Research group, University of Cadiz

Abstract

Falls can have serious consequences for people, which can lead, for example, to restrictions in mobility or in the worst case to traumatic based cases of death. To provide rapid assistance, a portable fall detection system has been developed which is capable of detecting fall situations and, if necessary, alerting the emergency services without any user interaction. The prototype was designed to facilitate a reliable fall-detection and to classify several fall-types. This solution represents a life-saving service for every inhabitant which would significantly enrich the development of smart cities and smart factories where fall-events are part of daily-life. This paper will also introduce the fall analysis, which includes the generation of test events. To guarantee functional safety, the hazard analysis method STAMP (System-Theroetic Accident Model and Processes) will be applied.

Keywords: e-Health, fall-detection, Body Area Network, safety, STAMP, Smart City

Email addresses: `l.lablunda@fb2.fra-uas.de` (corresponding author) (Luigi La Blunda), `lorena.gutierrez@uca.es` (Lorena Gutiérrez-Madroñal), `mfwagner@fb2.fra-uas.de` (Matthias F. Wagner), `inmaculada.medina@uca.es` (I. Medina-Bulo)

1. Introduction

Fall-detection is gaining in importance not only in aging societies, but also in working society and in daily activities. According to the World Health Organization (WHO), 646,000 fatal falls are estimated to be the second leading cause of accidental or unintentional death worldwide each year. People over 65 suffer the most fatal falls. Another high risk group is children. Taking into consideration their evolving developmental stages, the increasing curiosity to explore the environment or the inadequate adult supervision lead to fall-events [1]. In everyday life we are also confronted with risk of falling. Working in hazardous working conditions is another risk factor for causing fall-events. An exemplary event could be a worker that falls during the night shift in the factory and no one is there to provide prompt assistance. Another example could be a technician which falls from height while maintaining windmills. Mostly windmills are installed in uninhabited areas where no immediate rescue measures can be taken. Considering these events the consequences can be fatal for the affected people. The World Health Organization stated that annually 37.3 million fall-events are severe enough to require medical treatment [1]. Fall-events leads to the side effects of physical inactivity and loss of balance, especially among old people. Elderly people are scared to fall again and this uncertainty of movement increases the risk of repeated falls. To counteract these life-threatening events fast assistance is necessary due to the fact that an unconscious person may not be able to call the emergency services. An approach could be the continuous tracing of medical and /or physical parameters via a wearable sensor network (see Figure 1).

A prototype in form of a belt was developed which includes an Electrocardiogram (ECG) - harness and is based on a five sensor nodes Body Area Network (BAN). Each sensor node of the belt acquires continuously acceleration data including time stamp and the sensor node of the ECG-harness provides the analog value of the voltage including time stamp. In case of a fall the system should be capable to autonomously call the emergency services. Applying sen-
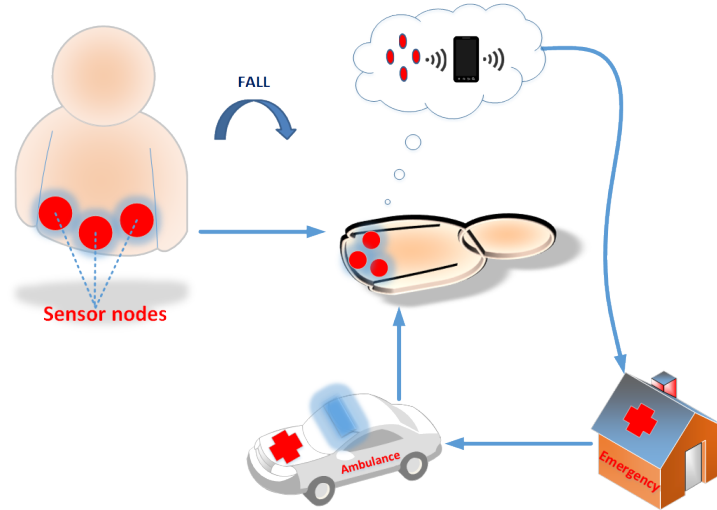
Figure 1: Escalation scheme simulation [2, 3]

sor fusion of physical and medical sensors we expect to improve the reliability of fall-detection and possibly fall-prevention. Another expectation is that the integration of medical sensors may facilitate the classification of different fall-types. In terms of smart cities our expectancy is to significantly provide an important e-health service for smart cities which is an essential life-saver for the population.

The paper is structured as follows. Section 2 describes the related work regarding fall-detection. In this section a short overview about existing solutions and different approaches for fall-detection is given. Section 3 will describe the basic principles on which our ongoing fall-detection research is based. In the successive section (Section 4) a detailed description of the fall-detection prototype, including the usage of sensor are introduced. Additionally, this section contains the generation of test events which includes the results of the fall-analysis and detected problems. Section 5 will introduce the Hazard analysis method STAMP which is applied on the fall-detection prototype. Finally, in section 6 a conclusion about this ongoing research is given, including some indications for improvement which could be applied in the future work.

2. Related Work

The author names and affiliations could be formatted in two ways:

(1) Group the authors per affiliation.

(2) Use footnotes to indicate the affiliations.

See the front matter of this document for examples. You are recommended to conform your choice to the journal you are submitting to.

3. Background

4. Fall-detection system prototype

4.1. Architecture

4.2. Sensor fusion

ECG

4.3. Generation of test-events

Lorena's part

4.4. Detected problems

5. Example application of STAMP as hazard analysis method

5.1. Introducing STAMP

5.2. STAMP - Hazard analysis

6. Conclusion & Future work

7. Bibliography styles

There are various bibliography styles available. You can select the style of your choice in the preamble of this document. These styles are Elsevier styles based on standard styles like Harvard and Vancouver. Please use BibTeX to generate your bibliography and include DOIs whenever available.

Here are two sample references: [4, 5].

References

[1] World Health Organization (WHO), Fact - sheets : Falls, `http://www.who.int/news-room/fact-sheets/detail/falls`, Last access: 08-07-2018.

[2] L. La Blunda, M. Wagner, Fall-detection belt based on body area networks, in: Proceedings of Biotelemetry XXI (ISOB conference), Vol. 1, Faculteit Ingenieurswetenschappen KU Leuven, Leuven (Belgium), 2016, pp. 21–24.

[3] L. La Blunda, M. Wagner, The usage of body area networks for fall-detection, in: Proceedings of the eleventh International Network Conference (INC 2016), Alekseev, S. and Dowland, P. S. and Ghita, B. and Schneider, O., Frankfurt am Main, 2016, pp. 159–163.

[4] R. Feynman, F. Vernon Jr., The theory of a general quantum system interacting with a linear dissipative system, Annals of Physics 24 (1963) 118–173. `doi:10.1016/0003-4916(63)90068-X`.

[5] P. Dirac, The lorentz transformation and absolute time, Physica 19 (1-–12) (1953) 888–896. `doi:10.1016/S0031-8914(53)80099-6`.