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Thesis

Radiofrequency-based indoor location systems for ambient assisted living applications

Leticia Zamora-Cadenas *, Ainhoa Cortés and Igone Vélez
Electronics and Communications Department, CEIT and TECNUN (University of Navarra), Paseo Manuel de Lardizábal 15, 20018 Donostia-San Sebastián, Spain

Abstract. The present article summarises the doctoral dissertation of Leticia Zamora-Cadenas.

Keywords: Indoor location systems, radiofrequency, CSS, UWB, calibration, Kalman filter

On June, 20th, 2014, Leticia Zamora Cadenas defended her PhD dissertation at the University of Navarra, Spain, entitled "Radiofrequency-Based Indoor Location Systems for Ambient Assisted Living Applications". The research was funded by the Fundación de Centros Tecnológicos Iñaki Goenaga, the Asociación de Amigos of the University of Navarra and the European Community's Framework Programme (FP7/2007-2013): the EU projects CONFIDENCE, Ubiquitous Care System to Support Independent Living of Elderly People (grant agreement no. 214986), and EATS, European Train Control System Advanced Testing and Smart Train Positioning System (grant agreement no.: 314219).

Dr. Igone Vélez and Dr. Ainhoa Cortés were the doctoral supervisors. The viva took place in a publicly open presentation held at the Technological School (TECNUN) of the University of Navarra, Donostia-San Sebastián, Spain (Figs 1 and 2). The assessing committee included Prof. Dr. Andrés García-Alonso, Prof. Dr. Juan A. Montiel-Nelson, Dr. Amaia Méndez, Dr. Oihana Otaegui and Dr. Juan F. Sevillano. After commenting on every question raised by the assessing committee, she was awarded with honours.

Fig. 1. Dr. Leticia Zamora-Cadenas.

*Corresponding author. E-mail: lzamora@ceit.es.

Fig. 2. Picture taken during the viva.

Thesis summary

Ambient Assisted Living (AAL) applications try to solve some of the problems related to ageing society. They aim to provide the elderly with intelligent systems that transmit confidence and independence in their daily life with a threefold objective: improve their wellbeing, decrease the burden in their families, and reduce the public expenditure in healthcare.

A vast number of AAL applications can be found both in the literature and on the market that try to meet the elderly needs. These systems use wireless sensor networks to collect the necessary information to monitor the elderly and act in case of an unexpected situation, such as a fall, or unexpected behaviours that may be related to a health problem. However, most of these care systems have important disadvantages such as high false alarm rates or complex deployments.

The IEEE 802.15.4a radiofrequency (RF) family is a very promising indoor location technology for this kind of systems. This family has been specifically designed to develop low-cost, easy-to-install, and highly-accurate indoor location systems that can be used in a wide range of AAL applications. However, despite the potential of this RF family, care systems based on the IEEE 802.15.4a radiofrequency (RF) technology are still missing.

The main problem of RF indoor location systems is the degradation of their performance due to signal reflections. The IEEE 802.15.4a family copes with this problem using a wide bandwidth. Nevertheless, its performance can also be affected by the multipath channel, degrading the accuracy of the location system. This accuracy degradation affects to the reliability of the AAL system that will present higher number of false alarms and thus, will disturb the user. Therefore, in order to integrate IEEE 802.15.4a based location systems within AAL applications, their accuracy and performance must be improved.

In this research work we have studied and improved the performance of indoor location systems based on IEEE 802.15.4a RF technology so that, they can be used as a sensing technology within AAL applications [1–3]. Different methods have been proposed to improve both the ranging and positioning accuracy of a Chirp Spread Spectrum (CSS) system and an Ultra–Wideband (UWB) system [4–7].

This work shows that IEEE 802.15.4a based indoor location systems can be efficiently integrated into AAL care systems if the proposed enhancements methods are applied. For the case where a low cost AAL system is desired, the CSS location system together with the enhancements proposed in this work can provide the accuracy and reliability needed. For the case where high accuracy is needed, the UWB location system jointly with the enhancements proposed in this work will provide the required accuracy of 30 cm in 95% of the situations. Furthermore, this UWB location system combined with the proposals of this work has been integrated and validated within a real AAL system improving significantly its reliability [8]. This care system has been developed inside the FP7 European project CONFIDENCE, which has been led and coordinated by Centro de Estudios e Investigaciones Técnicas (CEIT). The result is a more reliable and helpful care system that improves the confidence and independence of the elderly and increases their quality of life.

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