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Embedded system used for classifying motor activities of elderly and disabled people

Nicolas Fourty [a,*], D. Guiraud [b,1], P. Fraisse [c,2], G. Perolle [d,3], I. Etxeberria [e,4], T. Val [a]

[a] University of Toulouse – UTM – LATTIS EA4155, IUT Blagnac, 1 place Georges Brassens, F-31703 Blagnac, France
[b] INRIA – LIRMM – Robotics Department, 161 rue Ada, F-34392 Montpellier Cedex 5, France
[c] University of Montpellier 2 – LIRMM – Robotics Department, 161 rue Ada, F-34392 Montpellier Cedex 5, France
[d] FATRONIK, Paseo Mikeletegi, 7 – Parque Tecnológico, E-20009 Donostia – San Sebastián, Spain
[e] INGEMA, Usandizaga, 6, E-20002 Donostia – San Sebastián, Spain

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ABSTRACT

Our modern societies are confronted to a new growing problem: the global ageing of population. In order to find ways to encourage elderly people to live longer in their own home, ensuring the necessary vigilance and security at the lowest cost, some tele-assistance systems are already available commercially. This paper presents an embedded prototype able to detect automatically the falls of elderly people while monitoring their motor activities. The classification algorithm using an artificial neural network, the communication and location capabilities of this system are specifically highlighted. In the last part, some experimental results and social issues stemming from Gerontologic Institute Ingema are discussed.

1. Introduction

Our modern societies are facing a new growing problem: the global ageing of population. Within few years, almost half of the population is expected to be over 50 years old (Commission of theEC, 2006). This situation brings many associated problems, such as the caring and the improvement of the quality of life of elderly people. Indeed, elderly people do need assistance in their day-to-day life, and providing them with this assistance is not an easy task. Today, different options to take care of old people exist.

Old people can live with the rest of their family, which gives them the support they need in their activities of daily living (ADL) (Judge, Ounpuu, & Davis, 1996). This situation is often difficult to bear, both for the family (due to the constant attention old people may need) and for the elderly (Hanson, Teltley, & Clarke, 1999).

Old people can stay at home and receive support from professional carers, allowing them to maintain a high quality of life and satisfaction. But this solution may be expensive to the social services, and it does not ensure full time vigilance of the elderly.

Old people can be admitted in a nursing home, which is most often not well accepted by the elderly themselves. Furthermore, places in specialized centres are becoming limited and can be very expensive.

The general social politic in our societies is to find ways to encourage elderly people living longer at their own home, ensuring the necessary vigilance and security at the lowest cost. Automatic devices to monitor and assist elderly in their activities of daily living (ADL) seem to be a good solution to reach this objective. The European supported CRAFT project HEBE goes that way.

1.1. Description of the HEBE project

The main objective of the Hebe project is to provide a new assistive device dedicated to elderly people for helping them to live longer in better health at home, including more autonomy and safe. The system performs different functions giving support to the elderly in their activities of daily living:

* Corresponding author. Tel.: +33 562 747 585; fax: +33 562 747 587.
E-mail addresses: fourty@iut-blagnac.fr (N. Fourty), guiraud@lirmm.fr (D. Guiraud), fraisse@lirmm.fr (P. Fraisse), gperolle @fatronik.com(G. Perolle), ietxeberria@matiaf.net (I. Etxeberria), val@iut-blagnac.fr (T. Val).
[1] Tel.: +33 467 418 621; fax: +33 467 418 500.
[2] Tel.: +33 467 418 585; fax: +33 467 418 500.
[3] Tel.: +34 943 005 500; fax: +34 943 005 511.
[4] Tel.: +34 943 224 143.

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- Automatic fall detection: the system is able to automatically detect a fall event, and send an alarm to a call centre with all the necessary information relative to the user and fall. Then, the call centre contact immediately after the elderly person and send the appropriate emergency assistance.
- Activity monitoring: the day-to-day motor activity of the elderly is monitored in order to find out any abnormal daily activity so that staying in bed longer than usual or at home as well. Thus, an emergency call will be transmitted to the patient for getting assistance if needed.
- User localization: the device has to provide a user real-time localization (via GPS service) to the call centre when needed (when a fall occurs, or the user is getting lost and asks for assistance for instance).

1.2. Technology to the rescue

Many recent research activities about devices dedicated to help elderly people living longer at home, in better health (giving them more autonomy and safe) are led. These works are most of the time, technological answers to a specific issue or pathology of the person (Martin & Rankin, 2002). The main issues of these technologies are: activity monitoring, fall detection and user localization. We propose to highlight how HEBE addresses the challenge in the next paragraphs.

1.2.1. Automatic fall detection

Fall detection devices are already in use in several nursing homes. Most of technical solutions are based on acceleration sensors. The main difficulty of this issue is the classification and fall detection algorithm. Solutions currently available are most of the time limited to indoor use. The HEBE device has been designed to automatically detect a fall event and send an alarm to a call centre with all the necessary information relative to the user and fall in both indoor and outdoor environments. The call centre can contact the elderly person and send the appropriate emergency assistance.

1.2.2. Activity monitoring

This field of the technological help aims at giving to the carers the best information about daily activities of the patient. Systems currently available to monitor activities often need a set of house sensors meaning an important cost of equipment (“ADLife” and “Quiet care” from Tunstall© for example). The HEBE project allows with a single device to monitor the day-to-day motor activity of the elderly while analysing and detecting any abnormal daily activity.

1.2.3. User localization

Some telehealth systems are already available on the market. The main target of these devices is the Alzheimer’s disease (Aloize system from IGL for example). The most usual one is the telehealth service that requires the user to press a button for triggering an emergency call. In the case of a fall causing loss of consciousness, such a system is unable to warn the call centre. The HEBE device avoids this issue by carrying out a user real-time localization (via GPS service) transmitted to the call centre when needed (when a fall occurs, or when the user is lost and asks for assistance for example).

The system developed in the Hebe project makes the difference by integrating a set of unseen functions: complete activity monitoring, outdoor user localization via GPS, indoor and outdoor uses via global wireless communication networks (GSM/GPRS). No commercial product currently offers such services yet. Such a complete system brings benefit to the user by allowing improvement of their quality of life without limiting their activity (non intrusive and discrete system, indoor and outdoor use, etc.).

2. The HEBE project

Focusing on the technological side of the project, the integration of all these functions to a small, light, user-friendly portable system is a very challenging task. The architecture of the HEBE device includes:

- A mobile module worn by the user, which performs activity monitoring, user localization and automatic fall detection. The mobile module also integrates a “Panic Button”, which allows the user to cancel an automatic alarm (if the situation does not require assistance), or to send a user generated alarm in case of necessity. The major technologies implemented are bi-axial MEMS accelerometers for activity monitoring, GPS receiver for localization, and GSM/GPRS communication for data sending.
- A call centre, including TCP/IP Server, receives the information from the mobile module (via GSM and GPRS), analyses and saves it. The call centre also identifies the emergency situation and manages emergency procedures.

Furthermore, bi-directional voice communication is implemented between the call centre and the user through the mobile module. This function provides to the carers working in the call centre a point-to-point communication with the user in case of emergency, in order to coordinate and optimize the emergency means. Fig. 1 describes the communication architecture.

2.1. Functional overview

Fig. 2 shows in a schematic way the different functions the system designed in the HEBE project will perform:

- 1: user localization and trajectory monitoring,
- 2: activity monitoring,
- 3: automatic fall detection,
- 4: medical assistance and survey,
- 5: emergency assistance and support.

Data for functions 1, 2 and 3 are acquired by the mobile module, and transmitted to the call centre, which also performs functions 4 and 5.

3. Activity monitoring

Normal ageing is characterized by functional changes in sensory, neurological and musculoskeletal systems (Fried et al., 2001). These changes affect motor tasks including postural balance and gait that are the main predictors of the risk of falling. Moreover, understanding the user’s preferences and having an overall view of falling issues is essential to develop a product that meets the user’s needs.

3.1. Fall analysis

The etiology of falls is multifactorial and the demographics is likewise somewhat complex. Falls are a very frequent pathology of the elderly and most of the time they have bad consequences. Nowadays this phenomenon is known as one of the great geriatric syndromes due to its frequency, the consequences involved and the possibilities of preventing them (Ramos, Simoes, & Albert, 2001).

Falls are the first cause of accidental deaths in people over 65 years old. It means nearly the 70% of the accidental deaths in people over 75 (Fuller, 2000).