Security System Technologies Applied to Ambient Assisted Living

Juan J. Villacorta, Lara del Val, Mª Isabel Jimenez, and Alberto Izquierdo

E.T.S.I. Telecomunicación, Universidad de Valladolid
Camino del Cementerio s\n, 47011 Valladolid, Spain
{juan.villacorta,larval,marjim,alberto.izquierdo}@tel.uva.es

Abstract. The increasing elderly population has increased interest in the Ambient Assisted Living systems. This article presents a system for monitoring the disabled or elderly developed from an existing surveillance system. The modularity and adaptability characteristics of the system allow an easy adaptation for a different purpose. The proposed system uses a network of sensors capable of motion detection that includes fall warning, identification of persons and a configurable control system which allows its use in different scenarios.

Keywords: Disabled people, elderly, Ambient Assisted Living, sensor network.

1 Introduction

Most of the industrialized countries tend to an increasingly aging population, causing a rising in the percentage of elderly and disabled population. This growing group of people usually requires a greater number of medical and social attentions. Programs like AAL (Ambient Assisted Living) of the European Commission [1] promote the application of information and communication technologies to enable that elderly or disabled people can remain longer living independently in their own house with a improved quality of life. At the time that the costs to public health and social systems are reduced by avoiding the need to go to medical or social centers frequently.

The Ambient Assisted Living systems, also called Home Care Systems, are based on the use of a set of sensors interconnected by different types of communication systems in order to get information about the status of the patient and to provide care in his own home.

In [2] Ambient Assisted Living solutions are defined as the application of Ambient Intelligence (AmI) technologies to allow the adaptation of home environment so people with specific demands, such as disabled and elderly, can live longer in their own homes. These AmI systems are composed of a top-level control entity which provides intelligence to the system and network of sensors whose goal is to get information from the environment.

As AmI systems, security systems have a network of sensors that gather information from the environment in order to perform the tasks of surveillance and intrusion detection and to control the access, among other tasks. The difference is in the actions that the top-level module performs from the information obtained. In the case of AmI

M.D. Lytras et al. (Eds.): WSKS 2010, Part I, CCIS 111, pp. 389–394, 2010.

systems the top-level entity uses that information to improve the quality of life of the users, while security systems are designed to ensure the integrity of the persons and objects monitored. The flexibility of the top-level module can transform a system designed for surveillance or AmI into an Ambient Assisted Living system. In this article presents how a multisensor surveillance system [3] can be adapted to the area of AAL.

2 System Architecture

The designed system presents a modular and distributed structure that can be easily modified to suit the particular conditions of the operating environment and expanded by adding new modules, depending on the specific needs or the future advances in technology.

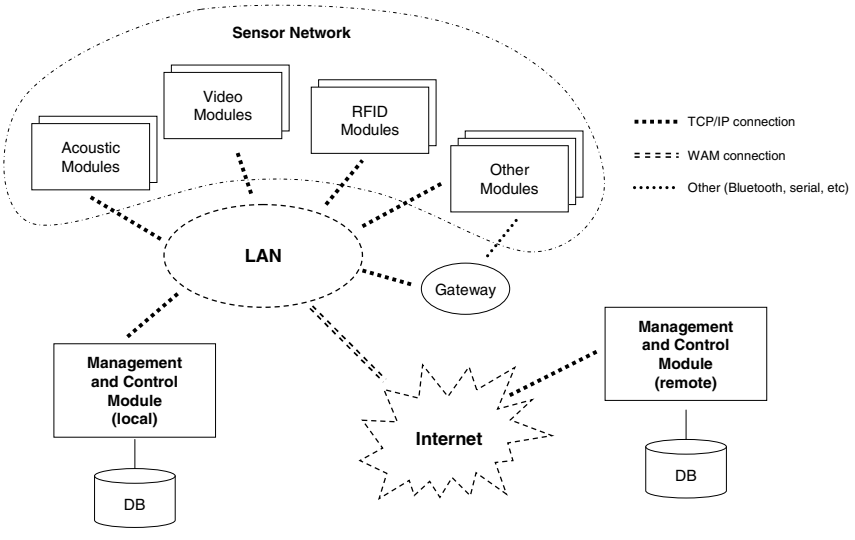

Fig. 1. Block diagram of the system

The system shown in figure 1 consists of two types of modules: management and control modules and sensor modules, such as the acoustic, image or RFID modules.

The control and management modules are the top-level entity of the system. All implementations must have at least one of these modules that are the central and indispensable element of the system. Its function is to establish communication with the other modules and to manage the tasks performed by each of them. During its operation this module uses a database that stores all information from the system, both its configuration and the data obtained from the various sensor modules.

The sensor modules are used to interact with the environment. Primarily they provide information to the system about what is happening but, in some cases, these modules are also actuators because they can modify the operating environment, e.g. allowing or not to open a door.

Communication between the different modules of the system is performed using the TCP/IP protocol through a local area network (LAN). The system also contemplates the connection of modules that do not include network capabilities by the use of gateways [4] that allow the translation other connection interfaces such as USB or Bluetooth to the system transparently.

2.1 Management and Control Module

The management and control module, or MCM, is the central and most significant element of the system. It is the responsibility of providing intelligence to the system by controlling the operation of other modules and the fusion and management of all information provided by all them.

To perform its functions, the MCM uses the following concepts [5]:

- A task is the execution of a series of actions by a module or device.
- An event is the response to an incident that happens during the accomplishment of a task. Events are generated by the sensors modules and received by the MCM.
- Policies of action: define the actions to be taken after the arrival of each event occurred. With the arrival of an event the MCM selects the set of policies associated with it and takes the decision of which policy to implement.

All the information about tasks, events and policies associated with a concrete system implementation is stored in a database connected to the management and control module. Likewise, in the database is also stored the system configuration including the modules that compose it and their properties. Thus, the individualization and adaptability of the system is based on the information stored in this database. On one hand, the modification of the stored policies will influence directly in the behaviour of the system, but also the inclusion of new modules in the database and/or the modification of the existing ones will provide with new functionalities to the system.

In the block diagram of the system shown in the figure 1 there are two management and control modules: a local module and a remote one. For proper operation of the system it is only indispensable to have the local module that is responsible for receiving events and applying the suitable policies. The remote MCM is an optional element and it can be viewed as a backup system of the local MCM storing a copy of all information of the local module. The second function of the remote MCM is to act as an alarm centre, since the local MCM can invoke a task in the remote MCM as a result of the application of a policy. For example, in case that the system detects an accident it can invoke an alarm in the remote module, allocated in a hospital, to request the sending of aid to the address where the system is located.

2.2 Sensor Network

2.2.1 Acoustic Module

This module is a application of SODAR (SOund Detection And Ranging) technologies that use arrays of sensors to realize the location and tracking of objects. Although based on the philosophy of RADAR systems, these systems differ for using acoustic waves instead of electromagnetic ones [6].

The use of an array of sensors allows, through beamforming techniques [7], positioning the monitoring beam electronically. The ability to change the pointing angle quickly allows these systems to carry out several tasks simultaneously, being able to track multiple objects while detecting the presence of new ones.

The main functions performed by the acoustic module are:

- Surveillance: with the purpose of detecting the presence of new objects.
- Tracking: updating the position of every object detected in the vigilance.

Taking into account the purpose of the system, we have adapted the module to enable the detection of a falls. The fall of a person supposes an abrupt change of his position, from a vertical position to a horizontal one [8]. The absence of later movement can also be used for the detection of a serious fall. These considerations have been taken into account in the processing algorithms to enable the fall detection in this module.

2.2.2 Video Module

The video module is responsible for the capture and processing of images from the room in which the module is located. Their integration into the system allows corroborating the information obtained by the acoustic module providing greater reliability to the system.

This module is divided into two subsystems: the acquisition subsystem that takes charge of controlling the camera itself and capturing images and the processing subsystem that is responsible for managing the sequence of images in order realize a detection of movement. The implemented algorithm uses a variation of the Sakbot algorithm [9] as it provides good results without a high computational load.

The main function of the video module is the confirmation of the detections made with the acoustic module due the more accuracy of it. This module is also used for fall detection using an algorithm for extracting vertical-horizontal dimensions of the detected objects [10] and generating a fall event when a sudden change is detected.

2.2.3 RFID Module

The purpose of this module is mainly for identification but also for access control. Each person who usually enters the house has a bracelet that includes a passive RFID tag. The RFID readers are distributed at the doors of the rooms. When a person crosses a door, the RFID reader detects the bracelet and identifies the person who wears it. This module is complementary to the acoustic and video modules, since it allows assigning an identity to people detected by these other modules.

Besides to this identification functionality, each RFID reader controls the operation of the electronic lock of the door, allowing or not the access to the room depending on the identity of the person that is going to use it.

2.2.4 Other Modules

The flexibility of the system architecture allows adding different devices depending on the needs of each particular case. Some examples of other modules included in the system are:

- Panic button: it is a large button positioned in an easily accessible place. Its pulsation indicates that an emergency has occurred.

- GSM module: the purpose of this module is to alert when an emergency takes place by sending an SMS to a telephone number previously stored in the system.
- Display module for notices: to notify important information to the patient or caregiver.

3 Case of Study: Nurse at Home

This case study is applicable to disabled persons or elderly who have a nurse to assist them living in the same house. The purpose of the system in this case is to provide to the patient greater privacy and freedom, since it is not necessary the presence of the nurse at all time, but in case of emergency the system will alert the nurse that will come quickly.

An example of a house implementing this usage scenario can be the following: the patient has two interconnected rooms for their personal use. Each room is equipped with an acoustic module and a video module. Also in the access doors of each room there is an RFID module. In the room assigned to the nurse there is placed a computer that integrates the MCM and a display module. The patient's rooms and the nurse's one are connected by a corridor that has a video module.

Action policies can be adjusted depending on the needs of the patient. The following examples of patients are contemplated:

- Patient who for his deficiencies or diseases should remain lying down. Such patient should stay in bed all the time. When the patient is alone, there should be no movement in either of the two rooms. Motion detection by the acoustic module, checked with the video module will generate an alarm on the screen of the nurse.
- Patient with episodes of disorientation: in this case the patient movement within his private rooms is allowed, so that the detection of movement does not generate an alarm to the nurse. Depending on the severity of the patient it is allowed to go out from his private area to the common corridor.
- Patient in relative good health: this is the simplest case. The patient can move without restrictions for their rooms and even go out to the common area. The system will record his movements for if an accident like a fall takes place.

The tests realized on the proposed scenarios have verified the correct functioning of the whole system including the detection and tracking of moving objects and the detection of falls and the usefulness of the double video-acoustic check to reduce the number of false alarms. We also found that the accuracy in the monitoring of patients with symptoms of disorientation allows the identification of such events by detecting erratic movements by the patient.

4 Conclusions

This article presents a system for monitoring the disabled or elderly developed from an existing surveillance system. The system includes different types of sensors for the detection, identification and tracking of persons in the workspace. Among these sensors it is necessary to emphasize, for its innovation, the acoustic sensor, which makes use of beamforming techniques, and its integration with the video module.

This is an open system that can be adapted for different situations as shown in the explained case of study. This flexibility is due to the management and control module that, through the use of policies of action, is responsible for merging the information from all existing modules and taking suitable decisions. The use of policies of action allows the modification and adaptation of the system behaviour to each particular case.

At this time the work team is focused on several lines of development, including the integration of new modules or the identification of episodes of disorientation. Likewise, we have experimented with acoustic signature techniques to identify people in order to assign an identity to the targets detected by the acoustic module, the obtained results, although promising, are still too preliminary for its inclusion in the developed system presented in this paper.

References

1. The Ambient Assited Living (AAL) Joint Programme, http://www.aal-europe.eu/
2. Kleinberger, T., Becker, M., Ras, E., Holzinger, A., Müller, P.: Ambient Intelligence in Assisted Living: Enable Elderly People to Handle Future Interfaces. In: Stephanidis, C. (ed.) UAHCI 2007 (Part II). LNCS, vol. 4555, pp. 103–112. Springer, Heidelberg (2007)
3. de Jesus, J.D., Calvo, J.J.V., Fuente, A.I.: Surveillance system based on data fusion from image and acoustic array sensors. IEEE, Aerospace and Electronic Systems Magazine 15(2), 9–16 (2000)
4. Hou, J.C., et al.: PAS: A Wireless-Enabled, Sensor-Integrated Personal Assistance System for Independent and Assisted Living. In: 2007 Joint Workshop on High Confidence Medical Devices, Software, and Systems and Medical Device Plug-and-Play Interoperability pp.64–75 (2007)
5. Rao, S., Cook, D.J.: Predicting Inhabitant Actions Using Action and Task Models with Application to Smart Homes. International Journal of Artificial Intelligence Tools 13(1), 81–100 (2004)
6. Strobel, N., Spors, S., Rabenstein, R.: Joint audio-video signal processing for object localization and tracking. In: Brandstein, M.S., Ward, D.B. (eds.) Microphone Arrays: Signal Processing Techniques and Applications, pp. 203–225. Springer, Heidelberg (2001)
7. Van Veen, B., Buckley, K.: Beamforming: A versatile approach to spatial filtering. IEEE ASSP Magazine, 4–24 (1988)
8. Noury, N., et al.: Fall detection - Principles and Methods., Engineering in Medicine and Biology Society. In: 29th Annual International Conference of the IEEE, pp. 1663–1666 (22-26, 2007)
9. Cucchiara, R., Grana, C., Piccardi, M., Prati, A.: Detecting moving objects, ghosts, and shadows in video streams. IEEE Transactions on Pattern Analysis and Machine Intelligence 25(10), 1337–1342 (2003)
10. Miaou, S.-G., Sung, P.H., Huang, C.Y.: A Customized Human Fall Detection System Using Omni-Camera Images and Personal Information. In: 1st Transdisciplinary Conference on Distributed Diagnosis and Home Healthcare, D2H2, pp. 39–42 (2006)