Ambient Intelligence: technological solutions for wellness and supporting to daily activities

Vladimir Villarreal
Technological University of Panama, Republic of Panamá, vladimir.villarreal@utp.ac.pa

Jesús Fontecha
MAmI Research Lab-Castilla-La Mancha University, Ciudad Real, Spain, jesus.fontecha@uclm.es

Ramón Hervás
MAmI Research Lab-Castilla-La Mancha University, Ciudad Real, Spain, ramon.hlucas@uclm.es

José Bravo
MAmI Research Lab-Castilla-La Mancha University, Ciudad Real, Spain, jose.bravo@uclm.es

ABSTRACT

Ambient Intelligence (AmI) is a new paradigm in information technology, in which people are empowered through a digital environment that is aware of their presence and context, and is sensitive, adaptive, and responsive to their needs, habits, gestures and emotions. In this document we present the activities, projects and research that we have addressed today, based on ideology proposed of Ambient Intelligence. The document has been classified in the following way: we present a related ambient intelligence research overview to the lines of research that we are developing. We studies aspects of ambient intelligent and ubiquitous computing; augmented reality; semantic web; health and ambient assisted living (AAL). Some projects in which it has worked, projects that are currently being developed around intelligent environments are also presented. Some initial ideas proposed as a future work plan. The inclusion of aspect about ambient intelligence in the computer science engineering is very important to explain to the students about this new and promise technology.

Keywords: Ambient Intelligence, Ambient Assisted Living, Augmented Realty, Semantic Web, e-Health

1. INTRODUCTION

The Ambient Intelligence (AmI) concept has emerged to "describe interactions between a multitude of network-enabled devices, services and artifacts. The technology will be almost invisible, embedded in all kinds of objects and everyday environments, such as the home, office, car and train. Users' access to applications and services – many of which will be delivered within mobile environments – will be simple and effortless" (ISTag, 2006). The origin of the AmI concept lies in the conjunction of Ubiquitous Computing, Ubiquitous Communications and Intelligent User Friendly Interfaces (ISTag, 2001). An AmI environment must be context awareness and sensor technology is the key for this. We are working in this area development research, projects and activities based in ambient intelligence approach. We present different research about ambient intelligence, ubiquitous computing, and activities of ambient assisted living. We study each of one of the development work, work in progress and the future work related to study field.

2. AMBIENT INTELLIGENCE RESEARCH OVERVIEW

Some researchers are implemented different approach to ambient intelligence solution. We are focused on several research lines related to Ambient Intelligence, more specifically regarding to computational intelligence and interaction issues; the components closer to the user.

In order to make more understandable these lines of research, just think on the human communication; Think on the principal features of the human communication: we need to share a language to communicate ourselves. A difficulty of this speech is that we don't have the same language and it may make harder the communication. For this reason, I'm using slides with text in you language and pictures that you can easily understand; also, the shared knowledge that we have helps in the communication. I can use technical concepts like Bluetooth or Java and I don't need to explain then because we share knowledge in our area of interest and also the context in which the communication is performed is important. Thus, we are researching on interaction with smart environments and our objective is to achieve an interaction similar to human to human communication.

To this goal, we are working on intelligent user interfaces and natural interaction to make easy the communication with the environment and gap between the human and the devices in the environment (figure 1). Also, we are working on give knowledge to the devices and application to know how their surrounding works, similar to the way in which human act. That is, giving context awareness to the smart environment.
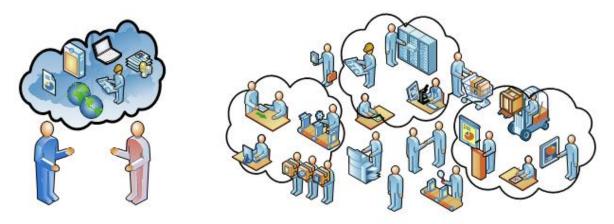

Figure 1: Human-Human Interaction (left) vs. Human-Smart Environment Interaction (right)

However, from these research lines we consider the application of Ambient Intelligence in other scenarios. Therefore, we are researching in different areas with new technologies which facilitate the development of the concepts of Ambient Intelligence and Ubiquitous Computing. In figure 2, all of our current topics and research lines are shown.
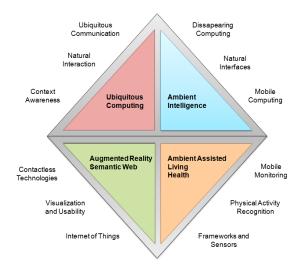

Figure 2. Main research's lines

2.1 UBIQUITOUS COMPUTING AND AMBIENT INTELLIGENCE

In this area, we are interested in models and technologies to get services from the environment in a natural way. For that, disappearing computing, ubiquitous communications, natural interfaces and interaction, context-aware, and mobile computing are essential components to achieve our goals. Nowadays, there are different technologies which provide us mechanisms to enable an embedded interaction with the environment in a natural and implicit way. These technologies must consider two principles: ***embedding technologies:*** linking information and capabilities to inanimate entities such as tables, doors, areas, displays among other. This includes embedding technologies into artifacts, devices and environment objects; and ***embedding interactions***: acquiring information from these actions which enables the inference of the user tasks and needs. This includes embedding of interactions in the user activities (tasks or actions). Context-Aware is an important line in our daily activity. In this sense, the distribution of context information into everyday objects offers adaptative services. For that, we have developed the concept of "Tagging-Context" in order to distribute information embedded in the environments (including users, objects and places).

2.2 HEALTH AND AMBIENT ASSISTED LIVING (AAL)

In recent years we are focusing several projects on *Health* and *AAL* fields. AAL initiative promotes the use of technologies for helping elderly people to maintain their autonomy, increasing their quality of life and facilitating their daily activities, but bearing in mind that it is crucial serving users in terms of usability. It is important to consider that an important number of elderly people present disorders of memory, orientation and cognition. Cases in which these disorders are severe need holistic attention by caregivers, however, slight cases can achieve a personal autonomy adapting technologies to the performance of their daily activities and needs. In this case, we try to offer to elderly people new ways for getting natural and implicit services by using pervasive mechanisms.

We consider that the integration of new technologies in these environments conveniently is the key to improve the life quality of our independent or autonomous elders. To achieve a smart environment, the deployed services must be adapted and context-dependents. In this sense, we try to apply our knowledge about Ambient Intelligence in health scenarios. Also, we work on other lines in these areas but only making use of them, not researching.

2.3 IDENTIFICATION TECHNOLOGIES – RFID AND NFC

The use of different devices with computing capacities dispersed around our environment, allows making the interaction easier and simple between users and computers. We development an easy and simple approach in the handling of information, for it, we have adapted two technologies: RFID and NFC. In the first case, user only must take a tag embedded in any daily use object and in the second, a mobile telephone equipped with a radio frequency reader. These two experiences have been applied in cooperative work with students of Teacher-Training to transmit the knowledge to other members of each group.

2.4 AUGMENTED REALITY AND SEMANTIC WEB

We has been working on supporting daily user needs by simple interactions with the environment through an augmented-reality perspective and applying proactive adaptation through knowledge representation. The result of that work is **i-ARA** architecture that makes use of principles of Semantic Web that endow context-awareness and user personalization. In addition, this kind of services allows the supervision and management of what is happening at the environment and, in consequence, to improve information offered to users. The architecture has been used to implement applications using *iPhone* technology and applied to illustrative scenarios such as libraries, educational environments and people with special needs.

In others hands, Semantic Web languages provide mechanisms to enable a formal knowledge representation that enhance the capabilities of model computational processing, its adaptability, and even promote their massive use. In general, the adaptation of Semantic Web principles to pervasive environments offers important benefits. The representation of context, in particular by means of Semantic Web languages can provide a richness and

unambiguous definition of relevant concepts in the environment domain. The architecture of the Semantic Web is built upon a set of languages and technologies.

3. RESEARCH RELATED WORK

This section includes a set of research works related to financed works, dissertations and more. Several relevant projects have been developed in recent years. Most of them have in common the use of natural interaction technologies and personalized information retrieval mechanisms to make easier the daily activities in general or particular work flows. Some of them are the following.

3.1 AMBIENT INTELLIGENCE FOR SUPPORTING CHRONIC DISEASES:

In order to facilitate people lives, we are working on a mobile monitoring system (Villarreal, Bravo et al., 2009) which allows patients with diabetes to have a constant control of their glucose tendency as well as direct communication with their doctor. Furthermore, we aim to educate these in people in their disease; so that, we are elaborating an education component meant to allow them to know more about the disease and how to make their daily routine more comfortable. As part of our proposal we have included a diet and a prevention unit; these aim to ensure a healthy lifestyle without annoying surprises for the patients. This proposal is show figure 3 (left).

3.2 ALZHEIMER INTELLIGENT AMBIENT DOMOTIC SYSTEM (ALIADO)

Alzheimer's (Bravo, López-de-Ipiña et al., 2008) patients need a widespread attention by assistants due to the disorders of memory and orientation they present. However, the knowledge of each daily patient is sometimes deficient. Assistants have no time to supervise patients' records because they don't have to distract the attention of care. In this work we present a proposal to solve this problem. A complement to support the information manages routine by adapting the Near Field Communication Technology is offered. By means of touching tags with mobile phones, day centre assistants make it possible via tags placed through context, it means, patients, places, devices and applications. With this simple interaction, some aspects of the routine in this kind of context: basic status patient information, orientation, doors' security, therapy and other activities can be solved as show in figure 3 (right). In addition, this proposal concludes with an information filtering process with the purpose of reaching an easy interaction method with mobile phones and providing recommendation to assistants and family. Finally, this process offers the adequately information to physicians. For tagging the day center we consider different places depending on the activity. For example the most important is therapy. In it, some exercises are tagged. Recognizing family members or objects is possible with a single touch with the mobile phone. All of these tags are complemented with the representative photo or icon. In addition, a tagged interaction display can be managed in this activity. For that, we distribute some tags near the display and assistants are able to interact with the information of each patient. With it, family photos or videos are an excellent support to refresh memory.
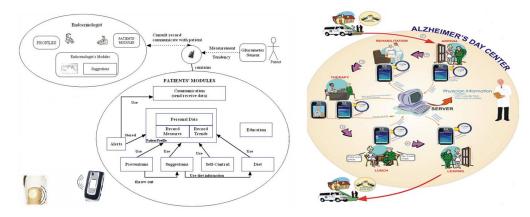

Figure 3: System Architecture for chronic diseases (left) and ALIADO System (right).

3.3 NFC Adaptability for Dependency

Care-dependent people need assistance to carry out the normal daily activities. A situation that many of these people have to face up is going to the doctor in order to obtain the needed drugs' prescriptions. This work presents a proposal to enable patients getting prescriptions from home (Bravo, Vergara et al., 2009), avoiding going to the health-care center. With the aim of achieving a natural user interaction, something necessary because of the physical and mental limitations of care-dependent people, we have adapted Near Field Communication (*NFC*) technology (Bravo, Hervás et al., 2006).

Figure 4: Ambient Assisted Living System examples.

Using a *NFC*-enabled mobile phone, the user interacts with different tags to obtain the required services in an easy way as show in figure 4. The following scenarios have been developed:

- **Shopping list**. Care-dependent people can order their daily shopping by using *NFC* mobile phone and RFID Tags distributed in a tag panel.

- **Delivery food**. Care-dependent people can order meals in the same way as before.

- **Family calls**. By using the same philosophy, a person could make a call by using the *NFC* phone and a photo of the relative which integrates a tag.

- **Mobile prescription**. Many of care-dependent people have to face up is going to the doctor in order to obtain the needed drugs' prescriptions. This work allows enabling patients getting prescriptions from home, avoiding going to the health-care center. With the aim of achieving a natural user interaction, something necessary because of the physical and mental limitations of care-dependent people, we have adapted Near Field Communication (*NFC*) technology.

3.4 mPhysio: Personalized Accelerometer-based Physical Rehabilitation Platform

This project (Raso, Hervás et al., 2010) proposes a rehabilitation system based on new technological tendencies in the mobility and ubiquitous computing areas.

Specialists and patients related to rehabilitation area can use this proposed system to improve the fulfillment of exercises and the supervision of rehabilitation tasks. We have developed our system using a mobile device and a bracelet to capture patient's rehabilitation relevant data. As a pre-process procedure, raw data output by mobile device accelerometer is filtered, and then we use the technique called Dynamic Time Warping to train and recognize movements. Based on this recognition, patients can perform rehabilitation without the continuous specialist's surveillance and can be sure of its accuracy. Experimental results show us that our system is able to adapt itself dynamically to the peculiarities of each user and enhance healthy rehabilitation in a proactive way. A general view of the system flow is presented in the following figure 5.
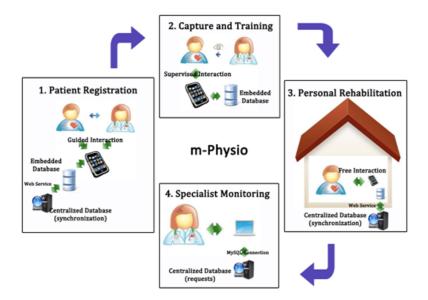
Figure 5: Flow of mPhysio System.

3.5 ADAF: ACCELEROMETRY FOR PHYSICAL ACTIVITY DETECTION

We have developed a mobile system based on Android technology to detect several physical activities and create a specific user profile. The application collects data about the following movements: slow walking, fast walking, run, get-up and sit down. Through an experimental study by using classification and data mining methods, the previous movements are recognized in an efficient way. With this, the system calculates the calories burned and allows a complete study of obesity level by charts and recommendations (Figure 6).

Step 1: Start activity recognition   Step 2: Physical activity performing   Step 3: Finish activity recognition

Figure 6: Example of ADAF use.

3.6 MODELLING OF AN AMBIENT INTELLIGENCE ENVIRONMENT THROUGHT CONTACT INTERACTION

This work (Chavira, Bravo et al., 2010) uses contact interaction mechanisms to get services from the environment. These implicit services are dependent of the context and user who has a mobile device to interact with different objects in an explicit way.

Through methods of rules and knowledge, the system generates information and save the context changes performed by the user according to specific properties. This system is named *PICTAC*. This project was evaluated in a Research Lab environment. In figure 7 (left), an example of service is shown. In this case, a user needs to print a file with a printer. User can print if he satisfies certain conditions (for example: access).
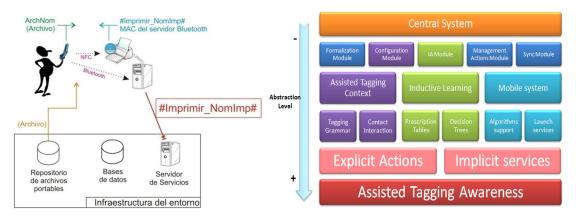
Figure 7: A PICTAC service example (left) and Layers of ACA-ICo Architecture (right)

3.7 ACA-ICO: A CONTEXTUAL ARCHITECTURE PROPOSAL FOR AAL BASED ON CONTACT INTERACTION OBJECTS

This work presents a dynamic architecture based on context awareness and ambient intelligence to attend nurses and physicians in their daily activities. The system is divided into several layers formed by modules. The goal of this work is to complement nurses and doctor tasks, managing the information of the environment in a simple and natural way by using implicit services, making a profile to help him on next actions. This work has different advantages in patient monitoring and control. User can get services interacting with objects distributed in the environment. At the end, all the actions performed must be synchronized with the central system. In figure 7 (right), we show a general view of the architecture layers.
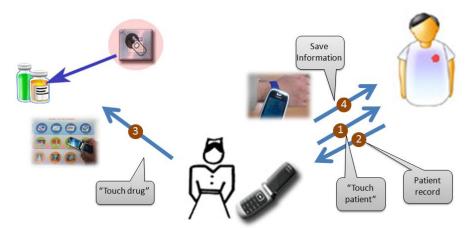

Figure 8: The procedure of medication administration by using this system is shown.

3.8 AMBIENT INTELLIGENCE IN AN EDUCATION CONTEXT

We (Fontecha, Hervás et al., 2011) have developed a system based on NFC technology and touching interaction to help nursing students to perform patient care tasks with simple interactions, including medication administration, clinical tests, and vital signs supervision among other. This is achieved through *NFC* services deployment in the environment. Also, an evaluation of the system was performed. The aim of this system is to reduce the information management from the environment and the implementation of this system in a hospital plant would increase the time that nurses spend with their patients. For this, each nurse has associated a *NFC* phone. Turn, the *NFC* mobile phone can interact with *RFID* tags (known as *NFC* tags) distributed by the environment. The necessary process is launched automatically when the interaction happens (Bravo, Hervás et al., 2005). In figure 8, we show touch screen that is used to display and synchronize the clinical records of the patients.

4. WORK IN PROGRESS

Nowadays, we are working in several projects related to Context-Aware Modeling, Ambient Assisted Living, Semantic Web, Augmented Reality and Activity Recognition. Some of these projects are presented below.

4.1 MOBILE MONITORING FRAMEWORK (MOMO)

MoMo (Villarreal, Bravo et al., 2010) (Villarreal, Bravo et al., 2010) is a framework that enables patient mobile monitoring by using biometric devices (e.g. glucometers, blood pressure meters) to send data to a mobile phone via technologies such as WiFi, NFC or Bluetooth. An ontological architecture has been created in order to catalogue the framework elements. In addition, we provide a predictive model for managing patient history based on an analysis of past situations in order to predict future difficulties (e.g. variations in vital signs). In general, a *MoMo* (Mobile Monitoring) framework uses mobile phones and biometric devices to facilitate patient monitoring. Data are recorded in a central server and stored in a database to be used by the architecture (Figure 9).
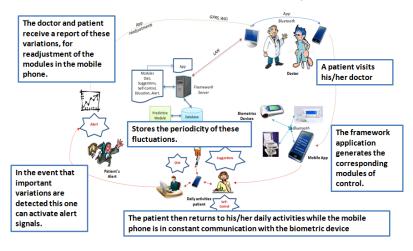

Figure 9: Functionality of MoMo Architecture.

The framework initially defines a common structure for every patient´s data. Next, the data generated by the common structure are customized for each patient´s profile, which corresponds with each patient's measurement data (disease, doctor, and others). Secondly, the framework allows for the definition of all modules deployed by patterns (*MobiPattern*), thus establishing relationships among each module and taking into account the individual profiles. With each module's definition, a relationship among them and individual profiles is possible, which enables the generation of correspondent mobiles applications. Third, the communication structure defines the protocol for device measurement, trend management and modules. The device works by collecting data from sensors and sending it wirelessly.

4.2 ARCHITECTURE FOR FRAILITY DETECTION AND DIAGNOSIS OF ELDERLY PEOPLE

Frailty concept is being developed in the last two decades. For its detection, it is classically appreciated the performance of *ADL* and *IADL*. Also, other indicators have been proposed to detect signs of this symptom in early stages. Elderly people become weak until reaching this frailty state. At this time, health begins to get worse and is easier to suffer bone fractures, for example. Our work (Fontecha, Navarro et al., 2011) tries to offer a more accurate and thorough assessment of frailty and pre-frailty state, trying reducing or delaying this disease. One of the most important factors for the early frailty detection is the assessment of physical condition by studying gait and other physical activities. In this sense, geriatricians and physiotherapists are using several tests and scales based on indicators for diagnosis. However, the assessment of frailty remains dependent of a subjective viewpoint of the geriatrician. Thus, by studying and analyzing of gait as an indicator from the clinical point of view, our system complements the diagnosis by means of the accelerometer embedded into the mobile phone. We are

developing architecture to study gait and balance, combining these ones with relevant clinical factors to establish a support for decision-making and subsequent treatments by geriatricians as show figure 10.
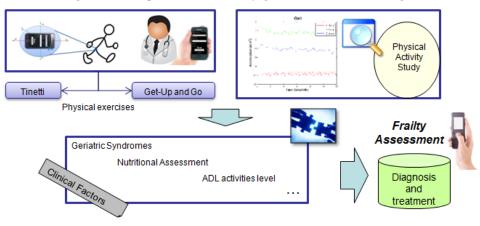

Figure 10: Frailty Architecture parts

5. FUTURE WORK

We are interested in continuing with our main research lines, maintaining the paradigms of Ambient Intelligence and Ubiquitous Computing as the most important elements. Also, the emergence of new mobile technologies enables us to expand our research horizons to other scenarios. In this sense, we are focused on the following:
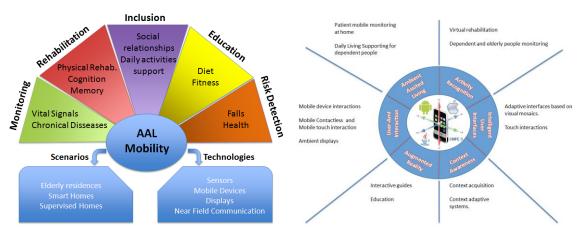

Figure 11: Ambient Assisted Living topics (left) and Ambient Intelligence topics (right)

- **Ambient Assisted Living (AAL)**. Deployment of services in *AAL* scenarios is not easy because, in most of cases, are heterogeneous environments such as retirement homes, smart homes and supervised ones. Integration of technologies should be transparent and minimize user interactions. This includes the use of sensors, mobile devices, displays and contactless technologies such as Near Field Communication (*NFC*). For that, a successful Inclusion of systems here covers several approaches and topics: monitoring, rehabilitation, education and risk detection. In figure 11 (left), a diagram of this is shown.

- **Sensors**. Integration of sensors in ubiquitous devices such as mobile phones and autonomous sensors among other facilitates the setting-up of Ambient Intelligence services, improving the user's connection with the environment. In this sense, adaptive systems based on User Context are essential to achieve an intelligence environment where user interactions with smart objects are natural and intuitive.

- **New interaction ways and interfaces**. The search for non-intrusive mechanisms of interaction is the main goal in the development of new systems. For example, by using new mobile capabilities such as cameras,

touch displays, accelerometers, contactless sensors and network services, among other, is possible to create an ideal scenario where user gets services from the environment with minimal interaction. Also, acquisition of these services in a natural way is very important to the user. For that, Adaptive Interfaces and Ambient Displays, on public or mobile devices, is another of our research lines to continue. The development of our future work includes the following current topics, see figure 11 (right).

6. CONCLUSIONS

In this paper, we presented an overview of AmI work conducted over the last years by us. We have present different solutions for some usual situations of aging people. These solutions include vital sign measurement for chronic diseases (Alzheimer, diabetes, etc), medicine prescription control, rehabilitation activities, accelerometers for dependency, patient record management, and frailty detection and diagnosis. All of them allow the simple interaction, which includes mobile devices, biometric devices, *NFC* tags, RFID and accelerometers. These devices allow the adaptability and the easy to use of technologies that possible to control of certain activities without specialization and elderly people could be controlled without effort. I think that is very important to include the ambient intelligence technologies like a novel area in the education for computer science engineering.

REFERENCES

Bravo, J., R. Hervás, et al. (2005). *Ubiquitous Computing at classroom: An approach through identification process*. Journal of Universal Computer Science 11(9): 1494-1504.

Bravo, J., R. Hervás, et al. (2006). *Visualization Services in a Conference Context: An approach by RFID Technology*. Journal of Universal Computer Science 12(3).

Bravo, J., D. López-de-Ipiña, et al. (2008). *Enabling NFC Technology for Supporting Chronic Diseases: A Proposal for Alzheimer Caregivers*. European Conference, AmI 2008, Nuremberg, Germany, LNCS, Springer.

Bravo, J., M. Vergara, et al. (2009). *Adaptabilidad de la tecnología NFC para AAL*. Congreso Anual de la Sociedad Española de Ingeniería Biomédica, CASEIB 09, Cádiz, España.

Chavira, G., J. Bravo, et al. (2010). *PICTAC: A model for Perceiving Touch Interaction through Tagging Context*. Journal of Universal Computer Science 16(12): 1577-1591.

Fontecha, J., R. Hervás, et al. (2011). *Módulo educativo basado en tecnología NFC para la realización de prácticas de enfermería*. XI Conferencia Iberoamericana de Educación en Enfermería de la ALADEFE, Coímbra, Portugal.

Fontecha, J., F. Navarro, et al. (2011). *Detection of Frailty through gait assessment and accelerometer mechanisms*. 7th Congress of the EUGMS (European Union Geriatric Medicine Society), Malaga, Spain.

ISTag, I. S. T. A. G. (2001). Scenarios for Ambient Intelligence in 2010. E. Commission. 58.

ISTag, I. S. T. A. G. (2006). The Networked Future: Mobile and Wireless Communications., European Commission.: 39.

Raso, I., R. Hervás, et al. (2010). *m-Physio: Personalized Accelerometer-based Physical Rehabilitation Platform*. International Conference on Mobile Ubiquitous Computing, Systems, Services and Technologies, Florency, Italy.

Villarreal, V., J. Bravo, et al. (2010). *MoMo: A Framework Proposal for Patient Mobile Monitoring*. 5th Conference of the Euro-American Association on Telematics and Information Systems. Panama, ACM.

Villarreal, V., J. Bravo, et al. (2010). *Towards Ubiquitous Mobile Monitoring for Health-care and Ambient Assisted Living*. International Workshop on Ambient Assisted Living, 2010. Valencia, Spain.

Villarreal, V., J. Bravo, et al. (2009). *Diabetes Patients' Care based on Mobile Monitoring*. IADIS International Conference, Applied Computing 2009, Rome, Italy.

Authorization and Disclaimer