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Software and Interfaces Including Assessment of Existing Technologies from US, Japan and EU WIKI Activities

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INTRODUCTION

The work here described is related to the first state of the art analysis on the research activities related to *Software and Interfaces developed for assisting elder or impaired people at home.* Since the aspects covered by this thematic are heterogeneous, it has been defined a structure in which to organize the activities, focusing the attention on the software solutions and the management of the data.

The identified categories are:

- Data acquisition,
- Data management,
- Data processing and,
- Data transfer.

For the European scenario it has also been realized an archive of projects related to monitoring the aging and improving the independent living. The underlying idea it to have a simple instrument for computing statistics (e.g. see in Fig. 1 the geographical distribution of the AAL projects on aging).

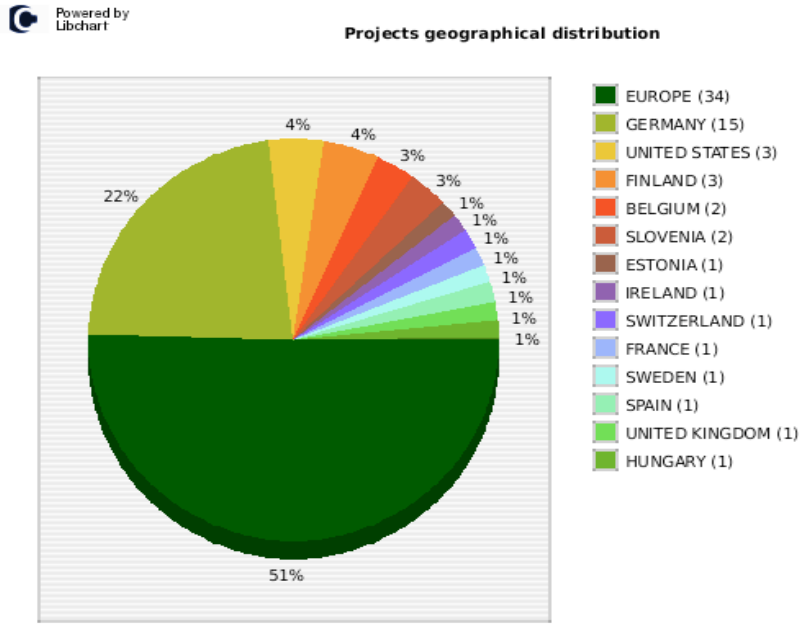

Fig.1 The geographical distribution of projects related to Aging and AAL in EU. In this graph was considered local project (i.e. supported by a local government) and European projects.

From this very first analysis two main approaches were highlighted that start their diversification from the data acquisition (both from ambient and physiological sources). The two main research areas are definable as:

- *smart house* → The aim is to realize a totally automatic ambient for the monitoring and the surveillance of the aging. The main effort is related to the sensors (power problems, wireless connection and so on) and to the decision making system for the identification of dangerous situations.
- *remote medical control and telemedicine* → The aim is to simplify the communication process between patients and clinicians located in different places. The main effort is on the simplification of the communication interfaces and on physiological and Kansei sensors.

The contributions to the wiki are reported below.

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Data Acquisition

In Assisted Living projects, the acquired data are gathered from different type of sensors.
Generally the used sensors are:

- Video cameras, mainly IR video cameras 352x288 pixels, 25/30 fps
- Body sensors for physiological data (e.g., ECG)
- Sensors on medical devices (e.g., on pill dispensers)
- Sensors on furniture for detecting events (e.g., opening or closing doors; pressure sensors on chairs)
- Microphones.

The heterogeneity of the related signals needs of preprocessing for synchronization and for selecting the data before the storage. Data processing depends on the activity to be performed.
There are two main research activities in Assisted Living:

- Remote medical control and telemedicine
- Smart house

1.1 Remote medical control and telemedicine

Remote medical control aims at developing a standard for controlling patients, when it is necessary, without moving them to the hospital. The idea is monitoring physiological data at distance.
This kind of control requires a static *station* where the technology is concentrated. Generally, it consists of a pc with a videoconference set up (normally a microphone and a webcam) plus physiological sensors, such as ECG, Blood Pressure Measurement and glucose tester.
At scheduled times, or if it is necessary, the patient goes to the station, starts the communication with his contact (e.g. clinician), adjusts the sensors on his body following the indication of the clinician, and, in case, receives a new prescription.
In telemedicine there is also the possibility to transfer image information, such as TAC images. In this case, generally the communication is from a centre endowed with the technologies but without personnel for diagnosis.
The main research tasks on technologies in this area are related to:

- the standardization of the file format
- the transfer protocol
- the security in transfer data.

For all of these tasks there are local standards (see for example the Spicca model for telemedicine architecture http://www.telemedicina.campania.it/telemedicina/progetto/spicca.jsp) and international standards as HL7 (*http://www.HL7.org/)* for describing the exchanged data. Normally data are in XML format. An overview on standards used in this area is available on the website of the ***E**uropean **H**ealth **T**elematics **O**bservatory* (http://www.ehto.org/)

Related projects, commercial solutions and publications

[1.1] *http://www.telemedicina.campania.it/telemedicina/progetto/obiettiviRisultati.jsp*
Italian project at regional level, for a standardization of telemedicine in Campania.

[1.2] http://www.asur.marche.it/media/files/3950_progetto_sistema_pacs_ris.doc#_Toc107718905
Italian project at regional level for supporting PACS and RIS standard for medical images.

[1.3] *http://www.health.gov.bc.ca/rural/initiative.html*
An archive of remote medicine including Telehealth projects in British Columbia.

[1.4] http://www.telesal.it/homecare.html
Italian project at national level for building a central homecare and telemedicine structure.

1.2 Smart house

Smart house projects aim at building an autonomous technological structure able to continuously monitoring a subject in his home.
The sensors used in this type of project have to be connected each other, and the signals have to be analyzed in order to produce alarms, feedback or reminds.
The data from sensors are heterogeneous and with different frequency or activation time, so they have to be synchronized and pre-processed before their analysis. In this case a centralized *station* is still present, but with a greater computational power since it has to receive all the signals, to process them and to generate the correct feedback, before communicating with the central archives.
To develop the architecture of the station there are no common standards; some approaches use standards to convert rules, or conceptual structures, in formal languages (e.g. XML approach to represent the rules scheme, other solutions use UML2/SYSML and VHDL-AMS).

In a smart house the sensors are distributed all over the house and they must be less invasive as possible. For this reason the sensors are generally connected to the station via a wireless connection,

so an important technological aspect is the power duration of these sensors and how to recharge them.
A doctor or a stakeholder should always be able to access to the current data (i.e. access to the home station), or to access to the history of the patient data (i.e. access to archives).
The platform used for viewing the data is not currently standardized: there are many different ad hoc solutions.
Another relevant aspect is enabling the possibility of viewing data from different devices such as Pc, mobile phones or PDA. The same devices are used in case of emergency to contact the clinicians depending to the alarm generated by the system.
For physiological data there are some solutions that aim to embed sensors on a wearable and comfortable jacket or T-shirt [2.5][2.10]. Other studies aim to develop wearable sensors with a reasonable power duration, but the dimensions for physiological sensors are not so small to be ignored by the monitored subject [2.1].

Related projects, commercial solutions and publications

[2.1] Robert Matthews, Neil J. McDonald, Paul Hervieux, Peter J. Turner, and Martin A. Steindorf, **A Wearable Physiological Sensor Suite for Unobtrusive Monitoring of Physiological and Cognitive State,** in proc of EMBS 2007, the 29th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2007.

[2.2] http://www-sop.inria.fr/orion/personnel/Francois.Bremond/topicsText/gerhomeProject.html *GER'HOME project A French project on smart home.*

[2.3] http://www.infomobilityforum.com/it/images/stories/donzelli.pdf *Italian project for smart home.*

[2.4] http://www.instantatlas.com/health.xhtml *Commercial platform for monitoring and reporting of general health data. It is a general platform that works on statistical data and maps, not only indoor.*

[2.5] http://www.microsystems.it/index.php/ita/Azienda/Divisioni/Webcare *Italian commercial solution for home care. It uses a core station receiving the physiological data, a jacket with ECG sensors a blood pressure measurement wireless connected to the core station. There are also possibilities for a mobile core station.*

[2.6] Bonhomme S, Campo E, Estève D, Guennec J. , An extended PROSAFE platform for elderly monitoring at home, in proc of EMBS 2007, the 29th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2007.

[2.7] Xuan Hoa Binh Le, Maria Di Mascolo, Alexia Gouin, and Norbert Noury Health Smart Home - Towards an assistant tool for automatic assessment of the dependence of elders in proc of EMBS 2007, the 29th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2007.

The focus of this work is the evaluation of the independency of the patients. They suggest three scales used in medicine. Their aim is to evaluate the Activities of Daily Living (ADL) i.e. the basic activities that an individual needs to perform to live independently. In this paper there are some interesting references on health smart works with non-invasive sensors, but such works do not evaluate the ADL. The approach is to identify two states of the patient, Immobile and Mobile, according to the sensors data in order to adapt the monitoring system to the user

.

[2.8] Datong Chen, Ashok J. Bharucha, MD and Howard D. Wactlar Intelligent Video Monitoring to Improve Safety of Older Persons in proc of EMBS 2007, the 29th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2007.

This work is more related to the management of multi-camera information for evaluation of "elopement" in dementia patient. They used HMM and find some problems with false alarm generation.

[2.9] Wan-Young Chung, Sachin Bhardwaj, Amit Punvar, Dae-Seok Lee and Risto Myllylae A Fusion Health Monitoring Using ECG and Accelerometer sensors for Elderly Persons at Home in proc of EMBS 2007, the 29th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2007.

Authors claim the importance of recorded heart rate with the posture and behavior information, in order to correctly monitoring the cardiovascular regulatory system of the patients during their daily life activity. In this study ECG and accelerometers data are continuously recorded and clinicians can monitor the data from the hospital with a special remote client software.
The paper explains the accelerometers characteristics, e.g. the acquisition frequency (40Hz). For the ECG analysis the authors used an improvement of the Pan-Tompkins algorithm developed in C# .NET . The sensors data are compared and manipulated in order to generate the alarm. No details on clinicians interface are provided. The data can be visualized on PC or PDA; the ECG parameter box shows values (R-R, QRS, PR etc) at different intervals.

[2.10] PERSONA, PERceptive Spaces prOmoting iNdependent Aging, Eu project, http://www.aal-persona.org/index.html

Data Management

Management of data has different key aspects starting from the privacy policy and the security of the transfer protocol. Since Internet is the common platform used for transferring data, the protocols used are generally TLS and SSL. Some approaches also used cryptography for the signature, and authentication processes with smart cards (e.g. Crypto-smartcard e Java-card) or Digital Identity. Normally data are stored in a data base and the access to the data follows the same rules used for the storage (authentication, cryptography and so on).
Moreover, following the countries laws, the personal data can be stored in a different site with respect to the related health data.

Data Processing

http://www.capsil.org/twiki/bin/view/Main/DataProcessing

Starting from the acquisition, data have to be processed in different steps. In the most complex scenario, i.e. smart house, the signals acquired from sensors have to be:

- noise filtered, (well know process that depends on the signal and communication channel);
- synchronized one other;
- analyzed in order to generate feedback/alarm;
- manipulated before the transmission and the storage process.

1.1 Data synchronization

Some of the data can be synchronized directly using hardware devices, e.g. in multi-camera monitoring systems, professional video cameras can be synchronized using a Genlock signal (that can be an external sensor signal).
In case no hardware solutions are possible, the used methods at the state of the art are: manually using time stamp synchronizations [1.1] or with software tools. For example an EyesWeb XMI server can analyze simultaneously, in a synchronized way, and transparently for the user, signals

from a wide range of devices (e.g., video cameras, microphones, physiological sensors, shock sensors, accelerometers) [1.2].

1.2 Data analysis

The analysis of the data in AAL is focused on the generation of alarms caused by potential dangerous situations.
The ambient sensors are related to individuate potential danger situations such as, for example, falls. Other controls can be related to the therapy e.g. to automatically control whether a patient has taken the correct tablet at the due time.
In order to perform these activities the data from sensors have to be automatically checked, applying some rules that can be complex. For example for fall detection it is necessary to track the subject in his house (or outside e.g., by means of devices as GPS) and to control whether he is moving or not. If the subject is not moving, the system needs controlling in which room he is, at what time (to avoid to generate false alarms), and how long is in his immobility. It is important also to check if there was motion in the floor direction before the immobility, e.g. using accelerometers of gyroscopes dressed by the subject. (See papers on fall detection from CAALYX European project http://caalyx.eu/index.php?option=com_content&task=view&id=18&Itemid=31)
Since the rules are complex there are no standard solutions to adopt. Some automatisms are used in the conversion phase between verbal rules and computer language (see data acquisition).
Another main aspect is the analysis of physiological data. In case of automatic generation of alarms, the rules to follow depend also on the kind of sensors and on the monitored subject.
For examples, in case of ECG signals, it is important to set the critical threshold, for generating doctors call, with respect to the normal values of the subject [1.5].

Data transfer

The privacy aspect is the main point for protecting the data over the communication channel (see section Data management)
The transmission of data needs some preliminary manipulation in order to reduce the size and to maintain data coherence, or simply to extract the required information.
Generally the video data used in the analysis are not stored in the archive. Some solutions at the state of the art store B/W images of a particular situation, e.g. pictures of the subject during an alarm event or video sequences of the subject during a communication with the clinician.
Since video cameras produce a big amount of data, before the transfer process, the image quality is reduced in time and spatial resolution and/or compressed.

The sensors on house furniture are normally stored when activated, e.g. infrared-sensor data monitoring a door are stored only when they recover an event. This data are normally associated to a timestamp.
Physiological data, instead, are converted in standard format (HL7, PACS, …) and totally stored for subsequent studies and statistics.

The transmission of the data is not only related to the storage process but also to the communication with, e.g., doctors (from the storage unit or from the real time acquisition).
The instruments used for receiving data vary from PCs to mobile phones [1.2][1.3][1.4][1.6], with different resolution and possibilities for receiving data. The data have to be manipulated in order to be transmitted on the correct channel, and in order to be correctly viewed on the chosen device (e.g., modifications of the resolution).

Related projects, commercial solutions and publications

[1.1] Xuan Hoa Binh Le, Maria Di Mascolo, Alexia Gouin, and Norbert Noury Health Smart Home - Towards an assistant tool for automatic assessment of the dependence of elders in proc of EMBS 2007, the 29th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2007.

[1.2] **EyesWeb XMI Server and EywRAD client (www.eyesweb.org)**
The EyesWeb XMI server exploits the EyesWeb XMI open platform and the EyesWeb Expressive Gesture Processing Library to provide services related to multimodal and/or physiological signals. EyesWeb XMI manages the synchronization of multimodal streams of data having different clocks. The EyesWeb XMI server can thus analyze simultaneously and in a transparent way for the user signals from a wide range of devices (e.g., video cameras, microphones, physiological sensors, shock sensors, accelerometers). As a result from such analysis, the EyesWeb XMI server generates metadata related to embodiment, expressivity, and gesture.
The EywRAD client is an application for both desktop computers and mobile devices running Windows Mobile operating system. In its current form, it is an user interface for the remote control of EyesWeb applications running on EyesWeb XMI servers. The EywRAD client might support transmission of the sensorial inputs available on the mobile device (e.g., webcam, audio input, accelerometers, gps, etc.) and could also exploit EyesWeb to perform some processing of such data on the mobile device itself (this may reduce the data to be transmitted, with benefit for power consumption). The EywRAD client comes with a designer (authoring tool) that let users draw the user interface for a specific EyesWeb XMI patch.

[1.3] A. B. José, T. M. G. de A. Barbosa Jr., I. G. Sene Jr., A. F. da Rocha, L. S. da S. Castro, F. A. de O.Nascimento, J. L. A. Carvalho and H. S. Carvalho, **A Framework for Automated Evidence Gathering with Mobile Systems Using Bayesian Networks** in proc of EMBS 2007, the 29th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2007.

[1.4] Pu Zhang, Yuichi Kogure, Hiroki Matsuoka, Masatake Akutagawa, Yohsuke Kinouchi, Qinyu Zhang **Remote Patient Monitoring System Using a Java-enabled 3G Mobile Phone** in proc of EMBS 2007, the 29th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2007.

[1.5] **CAALYX** Complete Ambient Assisted Living Experiment 6FP EU project eHealth. One of the objective is to "identify which vital signs and patterns are more relevant in determining probable critical states of an older persons's health"

[1.6] http://www.mobihealth.org/
European project for design GPRS/UMTS mobile services for application in health care.