CAPSIL

International Support of a Common Awareness and Knowledge Platform for Studying and Enabling Independent Living

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Initial Software and Interfaces Roadmap Including Assessment of Existing Technologies from US, Japan and EU

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1. BASELINE ANALYSIS

(Where are we)

This section provides an overview of the state-of-the-art in the field of Ambient Assisted Living and Aging, both in the commercial and research context.
Performing this review we found a big gap between commercial solutions and research activities. Common interest to these issues has been increased in recent years in correspondence to a major attention of the world governments to elderly care. This attention is probably due to the significant increasing of the elderly care health social costs. The costs increased significantly both in relation to the increase in life expectancy and in relation to the aging of "baby boom" population.
The main reasons slowing down the reception of new technologies (research results) by the society can be trace in the following two main factors:

- acceptability of technologies by the elderly. Up to now, there are difficulties in the acceptance of technological devices (both wearable and not) until the computer anxiety phenomenon especially in cognitive disease pathologies;
- network availability. Research solution frequently requires a network infrastructure.

These two factors are closely connected to geographical and cultural aspects.
A example of cultural effect is Japanese elderly people that does not have problems in technologies acceptance. Differently from European population, Japanese people is familiar to technological devises and related innovation in all the age bands. This factor influences especially the commercial aspect that require a customization of the products.
From the point of view of the network availability, there are difficulties to reach all the houses, included rural realities, with an adequate and up to dated network covering, as broadband internet connection.
For these reasons, the available commercial solutions are more related to objects or furniture for supporting simple daily activities. Table 1 shows some examples.
In this direction, the E-Health Insider has published a study to highlight the market metrics and market profiles "*detailing how web 2.0 technologies have the potential to put the patients in the driving seat and trigger far-reaching changes in healthcare*[1]" .

[1] http://www.ehealtheurope.net/ehi_reports/

Table 1 – commercial solution for supporting elderly independence.

Examples of websites to spread commercial solutions and retrieve information	http://www.lifesolutionsplus.com/
	http://www.adultcareproviders.com/
	http://www.independentliving.co.uk/
	http://www.ehealtheurope.net/
Examples of commercial solutions	Electric beds to simplify the wake up, avoid bed sore etc.
	Medicines organizers
	Dressing Aids
	GPS location services, an example is http://www.buddi.co.uk/index/

Research activities instead, cover a bigger amount of areas highlighting the multidisciplinary nature of this type of research. The state of the art activities are presented in three different subsections: acquisition, management (accessing and archiving huge amounts of data), and processing of data.

1.1 Data Acquisition

There are two main research activities in Assisted Living:

- Remote medical control and telemedicine;
  - Chronic Disease Management
    - Vital sign monitoring e.g. Blood Pressure
    - Medication reminders and compliance checking
    - Trend analysis and alerts
    - Connect with care givers
    - Connection with Clinical Expertise
  - Health and Wellness
    - Social Networks
    - Fitness
    - Extneral Comunications e.g. Email / chat / video
    - Appt scheduling
    - Personal Health Records

- Smart house.
    - Activity Monitoring/ADL tracking
    - Security /Energy Management
    - Personal health records.

1.1.1 Remote medical control and telemedicine

Remote medical control and telemedicine are related to different aspect of the same aim, i.e. allow a medical intervention without to require the physical presence of the clinician.
The underlying idea is to use communication and information technologies for the delivery of clinical care.

Remote medical control, also called Home Health Telemedicine, allows the remote observation and care of patients at home. Depending on the specific home health devices the control can be scheduled at specific time or on alarms and consists of vital signs capture, and devices for audio and video transmission.
Remote medical control requires an integrated *station*. In general, it consists of a custom build device, similar to a PC, equipped with a videoconference setup (e.g., a microphone and a webcam) integrated with physiological sensor systems, e.g. ECG, Blood Pressure Measurement and glucose tester.
At scheduled times, or on demand (e.g. an emerging sickness in the patient), the patient goes to the station, and starts the communication with his contact (e.g. a clinician), he/she adjusts the sensors on his body following the indication of the clinician, and possibly receives a new prescription. Alternatively the device may guide the person through the measurement process in an automated fashion using audio/visual supports and may dynamically modify the clinical pathway depending on the result of previous measurements.

Telemedicine instead is a very old practice starting with the usage of postal communication. With the venue of broadband connection and new communication equipment, as Video-conference equipment, the telemedicine concept enlarges its objectives and its possibilities, from a phone consultation to a remote real-time intervention. Moreover the development of specific devices for the acquisition and transmission of clinical data allows telemedicine to improve its possibilities in provide clinical services through different countries or continent, creating a wide specializations of telemedicine in different branches as tele-radiology or tele-cardiology.
Usually with telemedicine are identify the services (clinical and technological) necessary to receive services on demand, in a place/zone where there is no physical personnel able to provide the required action. There are two main concept of telemedicine: the real-time and the asynchronous mode.
In the real-time case, at the same time both the involved parties are connected through a known technological infrastructure to exchange medical data (as live images, bio-signals, images from medical devices as ECG etc.) in order to have an immediate consultation.

Additionally there is the field of telesurgery, allowing surgeons to perform operations on patient's miles away.
In the case of asynchronous communication there is not a simultaneous connection between the parties, the data to be exchange are stored and read by the receiver in a second time for the offline assessment.

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;
- Contextual information supports;

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.

[1.5] Mitsuishi Mamoru, Arata Jumpei, Tanaka Katsuya, Miyamoto Manabu, Yoshidome Takumi, Iwata Satoru, Warisawa Shin'ichi, and Hashizume Makoto, "Development of a Remote Minimally-Invasive Surgical System with Operational Environment Transmission Capability", Int. Conf. Robotics and Automation 2003.

[1.6] http://www.tmd.ac.jp/med/mtec/wakamatsu/e_index.htm
Tokyo Medical & Dental University Laboratory specializing in biophysical systems engineering.

[1.7] http://www.ntt.co.jp/csr/2007report/special/05.html
Nippon Telegraph and Telephone (NTT) system involving net-based patient examinations.

[1.8] http://pegg.postcom.co.jp/egg/index.php?view=2294
EGG co.ltd. service providing for in-home monitoring of patients.

1.1.2 Smart house

Smart house projects aim at building an autonomous technological infrastructure capable of continuously monitoring elder and impaired subjects at their homes.
The telemedicine case described in the previous section consists of a single station integrating all the sensors, installed in a PC workstation in a fixed place. On the other hand, in the smart house scenario the whole house is sensorized and the whole living space is potentially capable of extracting and processing data from the patients living in the house e.g. activities of daily tracking. Sensor networks are typically used; the extracted signals are analyzed in order to produce alarms, feedback, or reminders to the patient. The data can also be mined to determine patterns of behavior and deviations from the norm which can be the early inidicators of disease on set such as Parkinson's etc
The data from sensors are heterogeneous and with different sample rate and/or activation time; therefore, they have to be synchronized and pre-processed in order to be analysed as a multimodal stream. In state of the art smart house applications, a centralized *station* is still present, but with a higher computational power, since the station has to receive all the signals, to process them and to generate the correct feedback, before communicating with the (remote) centralised archives (some projects envision "villages" of smart houses).
No shared standards are available to develop the data architecture for the station and the supporting backend data architecture. Some approaches use standards to define and translate rules describing the behavior of the smart house; conceptual structures in formal languages are also used, e.g. XML-based languages to represent the rules scheme, UML2/SYSML, VHDL-AMS.

In a smart house the sensors are distributed all over the house and they must be as minimally 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 battery power duration of these sensors and how to recharge them.

A doctor, or a stakeholder, should always be able to access the current data (i.e. to access the home station), or to access the history of the patient data (i.e. to access the archives).
The platform used for viewing the data is not currently standardized: there are many different ad hoc solutions. As patient numbers grow manual review of the data becomes more difficult and time consuming. New methods of presenting large-scale data sets in intuitive and actionable formats will be required. Secondly automated methods to manage data monitoring will be required coupled with an automated notifications mechanism to engage health professionals when required based on predefined conditions and limits.
Another relevant aspect is enabling the possibility of viewing data from different devices such as a Pc, mobile phone or PDA. The same devices are used in case of emergency to contact the clinicians depending on the alarm generated by the system.
Additionally, there is a growing interest in the use of robotics in smart homes. Not only do they add an in-home mobile base for sensors and interfaces, but they also allow for actuation, such as assisting the patient in rising from or laying down on a bed [2.11].
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 small enough 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

[2.11] http://twendyone.com/index_e.html

Robot intended to demonstrate usefulness of robots for in-home support.

[2.12] **Matsumoto, N.; Yamazaki, T.; Tokosumi, A.; Ueda, H.**; An Intelligent Artifact as a Cohabitant: An Analysis of a Home Robot's Conversation Log, Innovative Computing, Information and Control, 2007. ICICIC '07. Second International Conference on, 5-7 Sept. 2007 Page(s):21 – 21

[2.13] **Sato, E.; Sakurai, S.; Nakajima, A.; Yoshida, Y.; Yamguchi, T.**; Context-based interaction using pointing movements recognition for an intelligent home service robot, Robot and Human interactive Communication, 2007. RO-MAN 2007. The 16th IEEE International Symposium on, 26-29 Aug. 2007 Page(s):854 - 859

1.1.3 Sensor Systems adopted in Remote medical control and telemedicine, and in Smart house

The most common sensor systems include the following:

- Webcams and industry video cameras. In most cases IR videocamera are used, at low resolution (e.g. 352x288) and standard frame rate (25/30fps);
- Body sensors for physiological data (e.g., ECG, EMG) and accelerometers; in several cases they are integrated in "life jackets";
- 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);
- Sensors on robots (e.g. haptic, visual, audio, and biometric sensors)
- Microphones, to measure vocal controls and to communicate with clinicians in remote medicine applications.

Sensor networks are usually adopted in Smart house applications. All the sensors used in Smart House are design to be less-invasive as possible trying to reduce the impact on elderly life stile and daily activities. The design of smart house architecture in fact, try to follow the concept of Pervasive computing ,Ubiquitous computing, and Context-aware computing.
The heterogeneity of these signals needs for preprocessing and synchronization. Usually, a selection process is defined to individuate the data to be stored.

1.2 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.
In current state of the art, there are no examples of management of huge databases of patient's data.

1.3 Data Processing

Starting from the acquisition, the 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 known process that depends on the signal and communication channel);
- synchronized with one another as a multimodal stream;
- analyzed in order to extract higher-level information, and to generate feedback/alarms;
- manipulated before the transmission and the storage process.

1.3.1 Data synchronization for multimodal processing

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. Genlock can be an external sensor signal.
In case no such hardware solutions are possible, the methods at the state of the art are the following: manual synchronization using time stamps [1.1] or synchronization using software tools.
For example, the 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].

1.3.2 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, in fall detection it is necessary to track the subject in his house (or outside e.g., by means of devices such as GPS), to determine whether he is moving or not and to determine the context for the lack of motion e.g. are they sitting reading or have they fallen and are lying on the floor. Context is provided by determining location (i.e. in which room they are located), , time of day (to avoid generating false alarms), and duration of immobility etc. It is important also to check if there was motion in the floor direction before the immobility, e.g. using sensor combinations e.g.accelerometers or gyroscopes worn by the subject. See the papers on fall detection from the CAALYX European project http://caalyx.eu/index.php?option=com_content&task=view&id=18&Itemid=31
Since the rules for behavior analysis in the smart house are complex, no standard solutions are available in current state of the art. Some automatisms are used in the conversion phase between verbal rules and the programming languages seen in the previous section on data acquisition.
Another main aspect concerns the analysis of physiological data. In the case of automated alarm generation, the rules to follow depend also on the kind of sensors and on the monitored subject.
For examples, in the case of ECG signals, it is important to set the critical threshold, for generating a doctor's call, with respect to the normal values of the subject [1.5].

1.3.3 Data transfer

The privacy aspect is the main point for protecting the data over the communication channel (for details on speed, reliability and so on see the WP2 report on Sensors).
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 large amounts of data, the image quality is reduced, before the transfer process, 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 (e.g., HL7, PACS) and are all stored for subsequent studies and statistics.
The transmission of the data is not only related to the storage process but also to the communication, e.g., with 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 of 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 objectives 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.

2. VISIONING

(Where do we want to go)

Following the scenarios, the technologies in a future ambient assisted living situation should include:

- Adaptable interfaces, able to evolve with the subjects and with the situations under analysis;
- Paradigms of interaction that exploit other channels of communication such as expressive gesture [2.1];
- Natural interfaces enabling everyday objects to be transformed into interfaces for monitoring elderly activities without impact on their life, e.g. novel multimodal interfaces such as tangible acoustic interfaces [2.2];
- Novel "social interfaces", capable to measure social cues, such as empathy, emotion entrainment/synchronization among subjects, to analyze the involvement of the elder in social interaction, leadership and integration measures in groups of elder subjects, attention cues.
- Interactive therapeutic exercises based on multimodal interaction and interactive multimedia (audiovisual) stimulation in real-time. Moreover, novel measures of the effect of therapies should be extracted during the exercises performance.
- A flexible support for clinicians with tools and interfaces enabling intelligent browsing and querying techniques on huge amounts of data from a potential high number of patients.
- System for monitoring impaired vital functions, to generate the correct alarm and the first aid action/call. The system should also communicate with the device of the caregiver, or clinician, to transmit all the needed data for a very fast triage and intervention.
- Robotic systems can be used to help supplant the growing need for labor that will arise with aging societies.
- Robotic systems that are intelligent, can sense Kansei factors from humans, are multi-functional, and can reliably sense their environment to provide not only health support, but also utility in day-to-day life.
-

Related projects, commercial solutions and publications

[2.1] A. Camurri, B. Mazzarino, G. Volpe (2004), "Expressive interfaces", Cognition, Technology & Work, 6(1): 15-22, Springer-Verlag, February 2004.

3. GAP ANALYSIS

(What are we missing)
Current state of the art is trying to exploit some main results in ICT during the last 20 years: namely, wireless internet, sensors networks, early results on smart homes.
In the next 5 years, future 3D internet and user-centric media will have a strategic impact on the development of novel software applications and services for the elderly people. International expert panels, including the NEM Community (http://www.nem-initiative.org/public/community/community.asp) and the EU ICT “Networked Media” Task Force on User Centric Media and Future Internet (http://cordis.europa.eu/fp7/ict/netmedia/publications_en.html), recently produced white papers which individuate the strategic directions for research and industry developments, which are an important reference for future applications and services for the elderly. Such directions include the following:

- <u>high-speed intelligent computer networks</u>: the possibility to have high-speed, content- and context-aware networks will enable the real-time sharing of medical and strategic data on patients, supporting cooperative work and social networks of both elderly and medical staff;
- <u>novel multimodal interfaces</u>: current sensors and measures are intrusive, and/or not enough powerful and sensitive to capture the subtleties and the details of the motor activity and of the body signals. Future novel multimodal interfaces will enable, from one hand, to extend the sensitivity of computer systems, e.g. provide the “sense of touch” to everyday objects such as tables, chairs, furniture, walls (see e.g. the TAI-CHI EU project); from the other hand multimodal interfaces will enable detailed measures of human behavior, of the qualities of movement which are of great importance, e.g. in fall prevention and in monitoring of cognitive decline;
- <u>networked media</u>, including novel and emerging mobile systems, will open novel possibilities for services and applications in “ubiquitous healthcare”, The evolution and convergence of television, computer, and internet (interactive TV) will provide a basic platform for interaction with elderly people in novel applications and services (also keeping into account the level of familiarity with technology of elderly people in the 5-10 years timespan);
- the huge amount of data which will be possible with high-speed networks and multimodal interfaces will require the development of novel, effective techniques to manage huge archives of data in distributed databases, with a special focus on multimodal content-driven information retrieval from such huge archives of medical and health data,

- security policies and privacy of data will play an important role, and political and strategic decisions will be necessary to regulate these novel scenarios.

Such Future 3D internet will be the basic platform for the following emerging applications and services: <medical driven apps and services>

A summary of some strategic research gaps and areas to support medical driven apps and services is in Table 1.

Interfaces	1. Product level interfaces even in experimental environments; 2. User centred and participatory design; 3. Research into older user needs/abilities with a specific focus on: - presentation: meaningful representation for different user bases/skills/cultures; - customisation/personalisation of interfaces to the specific user and the specific health requirement; - adaptive interface e.g. 'grow' over the users life; - customization of the interface to the specific device used (i.e. in home monitoring or in outdoor monitoring using mobile devices); 4. User recognition of surface user interface, tangible user interface, ambient user interface, haptic interfaces, affective interfaces; 5. Standardised service, interoperability, basic structure of the interface; 6. Reliable and robust indoor location tracking
Software	1. Standardization process that should involve: - service platforms/interoperability; - benchmark/guidelines, i.e. testing for robustness/fault tolerance : where do Consumer and Healthcare standards meet? - data interchange formats e.g HL7; 2. Analysis of the effect of data compression; 3. Automatic measurement of human behavior and qualities of movement (e.g. for fall prevention and monitoring of cognitive decline); 4. Difficulties in proving software/hardware equivalence, especially for advance processing like data reduction etc.
Networking	1. High speed context sensitive 'intelligent' computer

	networks; 2. Context awareness e.g. use of push based p-to-p; 3. Internet vs future Internet (e.g. 3D internet): – access to broadband; – geographic differences/definitions : Rural areas still a problem; – user perception of need security;
Networked media	1. Mobile/Ubiquitous healthcare: – Outdoor/mobile use: cross network compatibility; – Management of data interchange between providers (network, devices, bandwidth throttling)→ more of a problem in EU than US/Japan? – Security and privacy policies across providers and networks; 2. Social networks for elderly, medical staff and : – user centric media; – supporting to cooperative/interactive works and experiences;
Data reduction/retrieval/mining	1. Customization of data to the use of mobile devices; 2. Randomised trials/proofs; 3. Round trip clinical validation of data inference; 4. Advanced data mining in the face of interpretation of privacy/security/national data constraints; 5. Standardised data production and consumption and provenance; 6. Interjurisdictional control/delivery of data; 7. Effective techniques to manage huge archives of data in distributed data base; 8. Multimodal content-driven information retrieval;
Security and privacy	1. Health data management: different policies between countries and states. 2. Security and privacy policies across providers and networks: policies to share data using public/private network infrastructure; 3. Privacy policies to manage huge archives of data and to share health data between different countries. 4. Need for International standard for FDA/CE type compliance - CRITICAL for TeleHealth;

4. IMPLEMENTATION

(Suggested methods to realize research actions)

As for fall prevention and cognitive decline, we propose to reinforce activities on the following topics:

- Research on novel multimodal interfaces and novel behavior descriptors to monitor more carefully elder patients;
- Research for novel paradigms for rehabilitation exercises based on « aesthetical resonance » paradigms;
- Research for novel movement and gesture descriptors. This action has to be based also on research in expressiveness and emotions, and on research in experimental psychology and related disciplines;
- Research for a better support for clinicians by automated quantitative and qualitative measures of the evolution over time of the performance of motor tasks.
- Research in multimodal information retrieval from huge distributed databases of medical data
- Research on robot systems whose actuation can provide physical support for the elderly and disabled.
- Research on Artificial Intelligence systems including not only robot control aspects but Kansei-based interfaces.
- Research on robot sensor systems for monitoring of the human user and recognition of the environment for navigation and interaction.