Videogames and Elders: A New Path in LCT?

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Abstract. The current demographic ageing in Europe is the result of a relevant economic, social, and medical development. Nevertheless, this is also leading to an increase in the demand for Long Term Care (LTC) by seniors. One viable way to offer qualified cares at home, while at the same time containing costs, is to exploit digital technologies as enablers of a constant interaction with assisting personnel. The main contribution of this paper is to propose a design methodology to put the basis for deploying, step by step, a "virtual hospital at home" based on an Ambient Intelligence (AmI). The envisaged system will integrate consumer-grade devices for videogames consoles which, thanks to their user-friendly interfaces and smooth learning curve, will contribute in minimizing the interference in the elder's private life.

Keywords: Ambient Intelligence (AmI); context awareness; videogames; healthcare; LTC (Long Term Care); usability.

1 Introduction: An Ageing Europe

It has been estimated that, by 2025, people over 60 worldwide will be 1.2 billions, and by 2050 they will reach 2 billions (in 2000 they used to be "only" 600 millions). In the same year (2050), in Europe, the number of over 60 will equal the 40% of the total population, and the 60% of the population in working age – that is to say 15-64 years old (see e.g., [1, 8, 10]). In the following decades the so-called "baby-boomers" (i.e., the huge generation born in the 50s-60s) will start to retire, further exacerbating the situation. In particular, Italy is among the oldest Country in Europe with a ratio of 143 elder to 100 people under 65 [7]. The demographic ageing in Europe is the result of a relevant economic, social, and medical development, that provide us with longer and better lives compared to those of our parents and grandparents. Nevertheless, this progressive increase in population age, beside creating new opportunities, impacts deeply on a number of areas, such as: healthcare, pensions, housing, community care, etc. Among these areas, one of the most afflicted is the long-term socio-medical assistance. This picture turns even darker when coped with the lack of support once

V.G. Duffy (Ed.): Digital Human Modeling, HCII 2011, LNCS 6777, pp. 245–254, 2011.

offered by the traditional "enlarged" families. The percentage of elders living alone and at risk of losing their independence and autonomy due to permanent diseases or health deterioration is drastically increasing.

The OECD (Organisation for Economic Co-Operation and Development) defines the Long-Term Care (LTC) as *any kind of cure supplied for a long period of time, without any pre-defined end date* (see e.g., [11]). The LTC encompasses a heterogeneous set of cares, both highly specialized and not: medical and paramedical assistance, domestic help, personal care, and social assistance. The shifting balance of percentages between the younger and the elder population in the European Countries implies an increase in the demand for LTCs that is supported by declining (or, at best, growing at a slower pace) public financial resources. Consequences of this emerging situation are forcing governments to adopt countermeasures. On one hand it is necessary to reorganize the assistance supply through the development of innovative management approaches, the enrichment of socio-medical services, the integration between hospitals and local communities, and the adoption of multidisciplinary perspectives. On the other hand, it is urgent to collect the resources needed to satisfy the growing demand for LTC services. In spite of all these efforts, at the moment, the supply of services addressed to elders is largely insufficient in all the EU Countries. As an example, in 2006 the northern EU countries had the best ratio between need and supply: the 12% of elder received home cares, while in Japan the ratio was 73,4% already in 2003. The situation is even worst in the southern EU Countries, with, e.g., a ratio of 3% in Italy and of 1% in Greece [7].

2 AmI for an Effective Technological Support to LTCs at Home

In Italy, as we saw, elders' percentage is growing at a fast pace, as a consequence the quantity of hospitalizations is growing as well. Often hospitals are often forced to prolong patients staying because of the shortage of services able to support LTC at home. In spite of this, domiciliary cares would be en effective alternative to long-term hospitalization from several points of view. From the patient perspective the psychological and affective benefit would be huge: this will lead to a stronger commitment towards therapy and, as a consequence, a more easy and rapid recovery. From the community perspective, shorter hospitalizations would mean shorter queues to access public health services and a shrinkage in costs.

One viable way to offer qualified cares at home to elders, while at the same time containing costs, is to exploit digital technologies as enablers of a constant interaction between the elder and the people in charge of her assistance. Ambient Intelligence (AmI) is a fast developing multi-disciplinary field which promises to have a significant beneficial influence into our society. AmI *"aims to enhance the way people interact with their environment to promote safety and to enrich their lives*" [3, p.1]. AmI enriches an environment with technology (mainly sensors and devices interconnected through a network) with the goal of providing help and/or support in an "intelligent" way to the user. In this context "intelligent" means that the support provided by the system should ideally be "in tune" with the person mood and needs. To supply this kind of assistance, AmI enabled environments borrow aspects of many cognate areas of Computer Science: HCI, Artificial Intelligence, Pervasive-Ubiquitous Computing, computer networks, sensors hardware and software [2, 9].

We are developing a medium-term joint project with a non profit Italian organization (namely Assoaqua - www.assoaqua.it) focused on home LTCs for elders. The main goal of the project is to put the basis for deploying, step by step, a "virtual hospital at home". Assoaqua needs an AmI solution which is able to support their multiple activities (among which physiotherapy) by allowing remote interaction, on a daily basis, with elders (especially those living alone) to assign exercises, to verify progresses in mobility, to monitor health/environmental parameters, etc. Providing all these functions implies the adoption, and the consequent integration, of a number of different devices and technologies, namely: domotics, support to social interaction, remote monitoring, audio-visual monitoring, movement and presence detection, humidity and temperature measurement. In particular, several among these functions could be provided exploiting specific features of several consumer-grade devices recently introduced in the videogames consoles market (namely Sony PS3 Move and Microsoft Xbox Kinect), beside the – already adopted in the medical field – Nintendo WII. Due to their intended usage, these devices already have user-friendly interfaces with a quick and smooth learning curve. Nevertheless, one of the main constraints of the project is to minimize the number of devices to be put in the elder's environment, in order to reduce to a minimum the interference in her private life.

In Fig.1, we have summarised which interactions between the caretakers and the elder – embedded in her *environment* – could be supported by an integrated digital system. Note that the figure voluntarily does not include explicitly the whole variety of possible interactions that could take place among the caretakers, nor all the interactions that likely could take place through other media (e.g. home visits, phone calls, etc.).

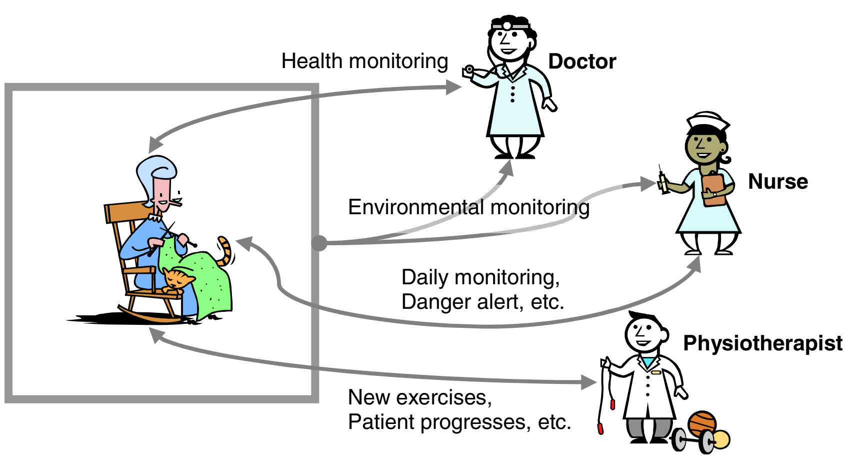

Fig. 1. Interactions with the elder and her environment that could be supported by ICTs

3 A Methodological Approach Based on the Dyad Elder-Caretaker

In the project framework, we are defining and testing an approach for supporting effectively the design phase of the AmI system. Actually, one among the main critical points is to provide an interface (in the broader sense of the term) to the system that respects several mandatory constraints, such as being: enough friendly with elders, not obtrusive, resilient to unforeseeable behaviours, context aware, etc.

In our vision, and according to Dey approaches (see e.g. [4, 5]), these goals can be achieved only if the intended "user" (the dyad elder-caretaker, who can be – in different moments – an elder plus a doctor, a nurse or a physiotherapist), embedded in its environment, is put "at the centre" of the design process, especially during the definition of the *problem space* [12]. Actually, not only the requirements and constraints provided by the dyad should be taken into appropriate consideration, but also those deriving form the environment into which the LTCs take place. This implies analyzing also which the more diffused issues deriving from elders homes – at large – are. In this category we can count e.g. size of the rooms, presence of pets, habits and technological proficiency of domestic workers living with the elder, etc. According to us, it is hence mandatory to explore requirements and constraints through an *immersive* approach, which is the only viable way to define clearly the problem space in this specific situation. To address this issue, we have envisaged a methodological approach to the design of the AmI solution that aims at intermingling tightly the different competencies present in the project: those of the computer science with those of the caretakers-senior dyad. In particular, we have organized mixed teams (typically: a physiotherapist or a nurse and a computer scientist, or a physiotherapist, a nurse and a computer scientist) that conducted an on-the-field research to collect qualitative data about needs and constraints encountered by the dyad. This lead to multiple multidisciplinary brainstorming on the emerging results, in order to define the most suitable interaction model and, subsequently, the candidate technological architecture.

More in detail, the methodological approach we are following is composed by three iterative and subsequent phases, each of which collects feedbacks from the others and takes as inputs a certain number of constraints and requirements (see Fig.2). Moreover, different actors (the caretakers, the elder and the computer scientists) are involved with different emphasis in each phase (see Tab.1: a major number of "+" stands for a more intense involvement).

Table 1. Involvement of different actors in the main phases of the process

	Computer Scientist	Elder	Caretaker
1. Multidisciplinary Brainstorming	+	+	+++
2. Technical validation	+++	+	+
3a. On the filed data collection	++	+	+++
3b. On the field candidate solution testing	+++	++	++
4. Prototype design	+++	++	+
5. Prototype development	+++	+	+
6. Prototype testing	++	+++	+++

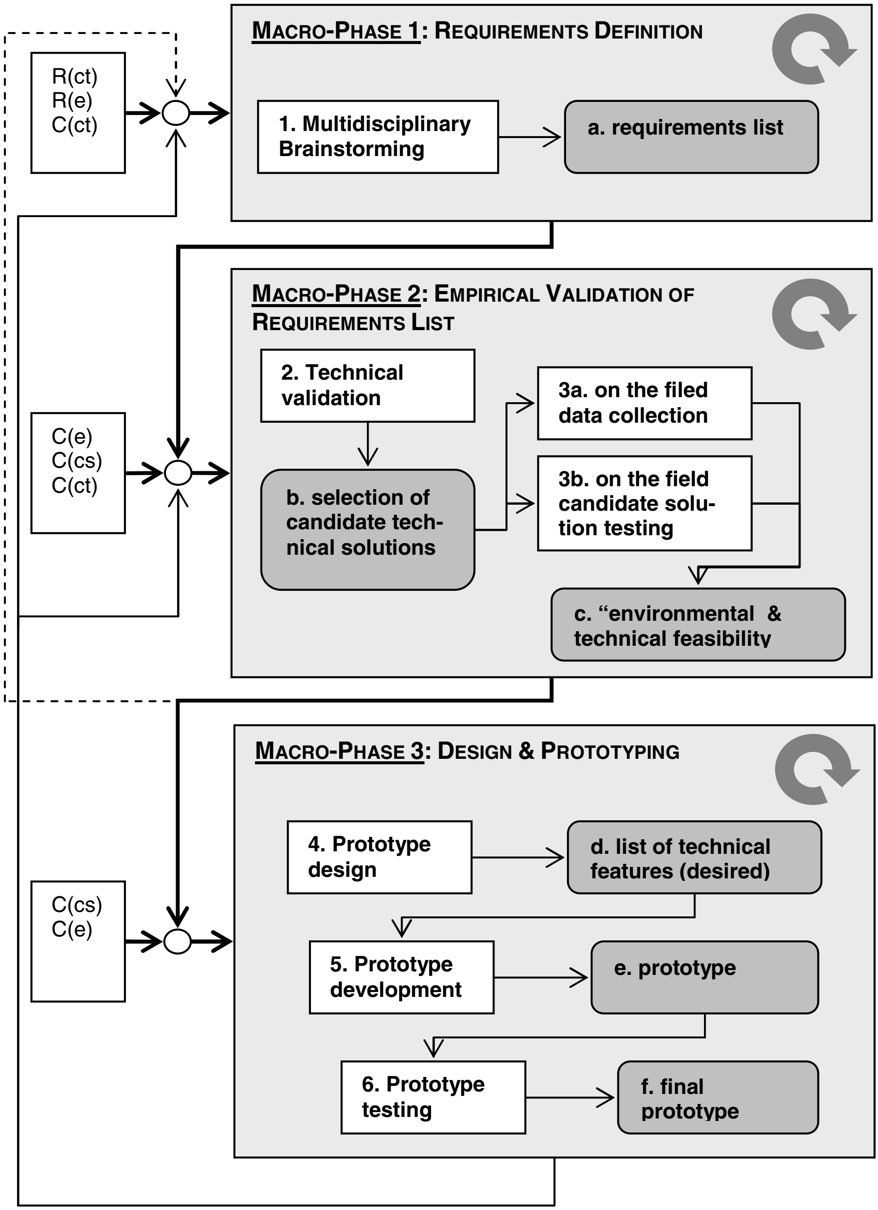

Fig. 2. Methodological approach to the design phase of the AmI system

3.1 Macro-phase 1: Requirements Definition

The first macro-phase of the process focuses on the definition of the overall system requirements, and required multiple interactions between the caretakers (physician, nurse, physiotherapist) and the computer scientist. Preliminary inputs to the phase were the requirements defined by the caretakers (R(ct) in Fig.2, e.g. list of environmental parameters to monitor, etc.) and by the elder (R(e) in Fig.2, e.g. system non-obtrusive, physiotherapy effective, etc.), and the constraints posed by the caretakers (C(ct) in Fig.2, e.g. maximum error/delay acceptable when collecting physical data, etc.). After several iterations, a list of desired features for the system was produced. This list, together with several constraints produced by the elder, the caretakers and the computer scientists, became the input for the subsequent phase 2. The involvement of the computer scientist in the first phase was very light, and the inputs she provided must be quite general and uniquely aimed at excluding “a priori” features that would not be achievable through existing technologies. This would guarantee that the brainstorming focuses effectively on *what* is really relevant from the point of view of the dyad, without worrying in advance for *how* the technology would possibly support it.

3.2 Macro-phase 2: Empirical Validation of Requirements List

Once the first list of requirements has been produced, its actual feasibility had to be proved. This task has been accomplished mainly by the computer scientist, who has been in charge to develop an extensive survey of existing technologies able to support the requirements listed in the first phase. The outcomes of the survey produced a list of candidate technologies, whose features were proved against requirements during an ongoing interaction with the caretakers. In particular a young computer scientist has been relocated in the ONG, and he actively interacted, on a daily basis, with the caretakers for more than three months. This made possible at least:

- further refining of the list of the candidate technological choices;
- developing a deeper understanding of the envisioned system from the perspective of technological issues (e.g. the choice of connecting the Kinect to a PC equipped with free software instead of a “native/proprietary” Xbox derived from the necessity of collecting data also from environmental sensors, etc.)

Nevertheless, in our opinion, several aspects needed a further investigation. In particular, the idea of moulding technologies intended for entertainment purposes to become a support to physiotherapy called for a deep comprehension of the implications of such a choice. To achieve this goal we set up two processes to collect data on the field, jointly with the dyad.

On the Field Data Collection. To complete this activity a team composed by a computer scientist and a physiotherapist conducted 30 on-site visits, each of the duration of 45 minutes, during one month. The team carried no technical equipment, except for the usual tools of the physiotherapist. The goal of these visits has been, on one hand, to determine which the major constraints to the deployment of the envisaged solution in the elders’ homes would be, and, on the other end, to observe how a physiotherapy session takes place.

The first goal produced a list of environmental constraints (e.g. in which room the television is placed, how much empty space there is left on the floor, how the room is lighted, etc., see § 4). The second goal produced a list of key-points that should/could be supported by technology (typically: which are the movements that elders are required to do during the session, how they are oriented in the space, which are the specific movements upon which the therapist's attention focuses, etc. see § 4). The output of this sub-phase is more precise and objective list of the features the envisaged system should – and could – provide. As a consequence, a certain number of possible technical solution were discarded, among which, e.g., Sony's Playstation Move and Nintendo's Wii (this latter already adopted in clinical environments, see e.g. [6]), and one candidate solution selected, i.e., Microsoft's Kinect.

On the Field Candidate Solution Testing. Since the candidate technology (Microsoft Kinect) is quite recent and aimed at the entertainment market, its features are not yet explored enough for our purposes. This called for a further phase of on the field data collection. During this phase, the same team (a computer scientist and a physiotherapist) conducted several other on-site visits, equipped with a Kinect connected to a laptop. This allowed verifying objectively the feasibility of employing this solution to support physiotherapists' work. Several new constraints emerged (see Fig. 5): for example the fact that a room excessively lighted by the sun may cause troubles in movements recognition, and the necessity to verify how much movements tracing is precise, since, e.g. a too wider extension of limb may cause damage to a patient (we are planning to compare the tracing produced by Kinect with one produced by a motion capture system). Parallel to the on the field experiencing, several experiments – more focused on the technical issues – have been conducted by the computer scientist alone. In particular, she has investigated issues related to the availability of effective software applications for PCs (Kinect is intended for the videogame console Microsoft Xbox), to the quantification of the space necessary for a good tracing of an entire/partial human shape, and to the hardware requirements able to guarantee performances good enough, in term, for example, of lag.

The output of macro-phase 2 has been a final list of requirements and technological solutions that could satisfy them effectively. This outcome, jointly with several preliminary constraints produced by the computer scientists and the elder embedded into her environment became the inputs for macro-phase 3. Note also that the output of this phase could lead to reconsider one or more decision taken in macro-phase 1 (see Fig.2).

3.3 Macro-phase 3: Design and Prototyping

This last phase, currently under development, is aimed at converting the outputs of the previous phases into a prototype. The prototype design (see Fig.2, phase 4 inside macro-phase 3) will define detailed technical specifications. In particular, the design will be informed by the output of the previous phase, and will respect several further constraints set by the computer scientist and by the elder, whose involvement from now on will increase more and more (see Tab.1). Actually, the elder at her home is the one whose interaction with the interface to the system should be studied even more deeply, in order to anticipate possible difficulties which could frustrate the benefits (in terms of reduction of home-visits and increase in monitoring) provided by the system.

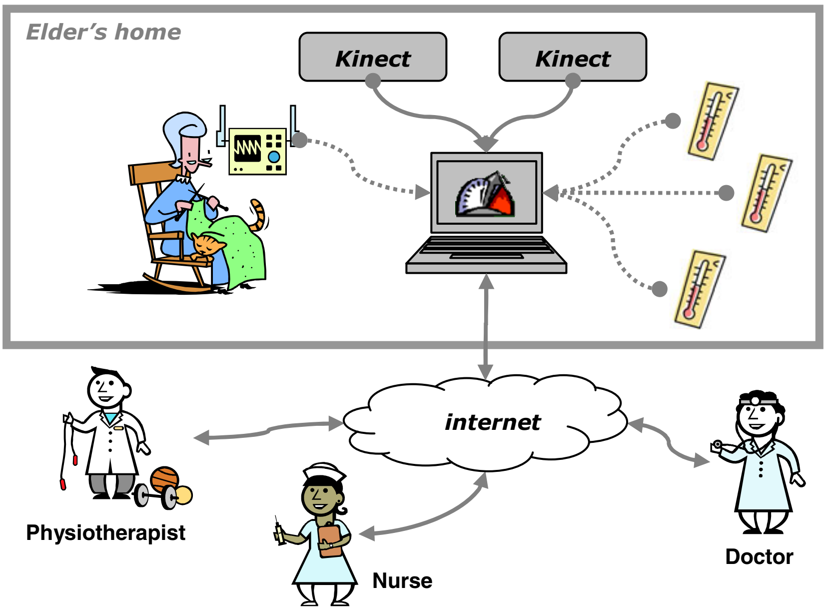

Fig. 3. The general structure of the envisioned system

In Fig. 3 we have sketched the general structure of the system. To notice that, for minimizing the intrusion in the elder's private life/home, we will install only one personal computer, in charge of providing the interface between her home and the caretakers (dashed lines represent wireless connections). Through this channel will be exchanged data (environmental, medical, physiotherapy exercises, alerts, etc.) and supplied the possibility to interact remotely with the caretakers. Fig.3 shows more than one Kinect connected to the PC, since we are planning to adopt this technology also for monitoring elders status (e.g. if the elder falls and cannot get up, does not wake up in the morning, etc. an alert is issued) in a more fine-grained way than with, e.g., usual movement sensors: this would guarantee a more effective monitoring and less false-alarms.

Phase 3 will end producing a final prototype and a set of generalized guidelines aimed at supplying help and advices to people interested in creating solutions to enact the interaction between the elders and the people providing them LTCs.

4 What We Have Discovered: Some Data about Physiotherapy

The deployment of our methodological approach seems to prove that this is a promising path toward the definition of one possible effective paradigm for the design of

AmI solutions. As an example, in the following figures we summarized several data we have collected that affected proactively the design process: this data could hardly have been figured out without immersing in the dyad environment. The data about *where* in the elders' homes and *how* (Fig. 4) the physiotherapy exercises are performed produced gave us a precise idea of several constraints on the choice/use of the devices (e.g. excluded the adoption of Sony's Move). The data about the temporal distribution of different activities during the same physiotherapy session (Fig. 5, left) informed us about keylines for the future development of appropriate software applications based on the use of Kinect. In the same vein, we have established the list and importance of problems that could afflict the use of a Kinect (the priority is ranked on the frequency of the problem as observed during phase 3b, see Fig 5 - right).

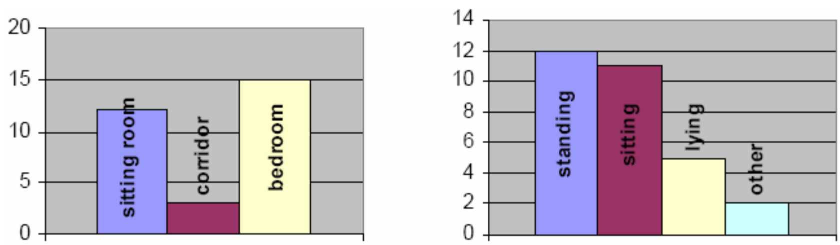

Fig. 4. *Where* (left) and *how* (right) physiotherapy exercises are performed (30 patients)

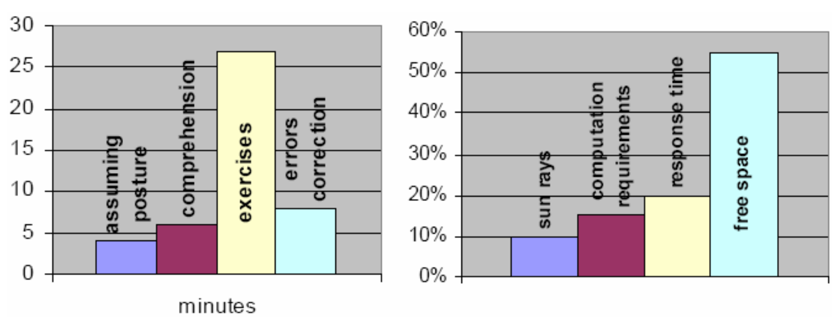

Fig. 5. Average time required for each phases of physiotherapy rehabilitation (left) and Major constraints to the use of Kinect encountered during 30 site-visits (right)

5 Conclusion

The preliminary results we have obtained so far seem to confirm our hypothesis about the necessity to immerse deeply and iteratively the designers of an AmI application in the "world" of its intended users, that is to say the recipient/s of the service in her environment. This approach should lead to a better design, hence to application that will have more chances to be adopted and to effectively enhance the way people interact with their surroundings – in the broadest sense of the term.

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