Avatar concepts in self healthcare systems

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***Abstract*—This paper gives an overview of different ICT avatar concepts, which aim at developing personalized self healthcare systems, thus enabling societies to enter the essential new e-Health era. Our goal is to define and explain how the avatar concept applies in solutions for increased accessibility. Broadly, the purpose of this research is to explore the avatar design technology in order to contribute in increasing the lifespan of the elderly, by providing them with active aging based on a sophisticated, newly developed personalized self health-care system.**

Index Terms*—*Avatars*; *Health-care*; *Virtual Reality*; *ICT*; *elderly

I. Introduction

The research in the Information and Communication Technologies (ICT) area has helped the development of automated concepts to be used in personalized healthcare. This implies that we are entering in the e-Health era, particularly at the early majority stage followed by the stage of mass adoption, after the period of innovations and early adopters.

However, a lot of research is still ongoing in some related areas and technologies that support new innovations and products. For example, newly developed self health-care systems are characterized by new ways of healthcare delivery through a broad range of teleservices. However, providing ubiquitous access to high-level healthcare for everyone, anytime, anywhere requires real integration of the various technological platforms [1].

In this paper we address the concept of avatars applied in self healthcare systems. Several definitions about the avatar concept and related issues are presented in Section II and an overview of avatar application in related domains and self healthcare are discussed in Section III. An overview of intelligent personal assistants, as a special mobile device application is given in Section IV. Section V presents avatars for increased accessibility and Section VI a short summary of state of the art technology to implement avatars. Finally, the conclusions are presented in Section VII along with elaboration of future trends.

II. Definition

There are various definitions of avatars in the ICT terminology. For example, Faloon et al. [2] define the term *Avatar* as an online manifestation of self in a virtual world (VW), which is designed to enhance interaction in a virtual space. This definition is extended by adding that avatars allow the user to take on a visible persona within a VW, providing them the opportunity to engage in surreal and imaginary experiences that transcend the actual world in which they live. Another definition given by Hemp et al [3] addresses avatars as ”the most conspicuous online manifestation of people’s desire to try out alternative identities or project some private aspect of themselves”.

Several concepts are related to the avatar concept. Virtual reality (VR) correlates to an experience in which a person is surrounded by a 3D computer-generated representation, and is able to move around in the VW and see it from different angles, to reach into it, grab it, and reshape it [4].

Presence is defined as the subjective experience of being in one place or environment, even when one is physically situated in another [5]; and as applied to a virtual environment (VE), presence refers to experiencing the computer-generated environment rather than the actual physical locale.

Steuer [6] defines VR in relation to other media, not just in terms of technological hardware. It is based on concepts of ”presence” and ”telepresence”, which refer to the sense of being in an environment, generated by natural or mediated means, respectively.

Avatar describes complex beings belonging to a shared VR, and also describes any visual representation of a user in an online community. For example, more than 7 million people have created Yahoo avatars, simple but personalized cartoon-like characters used as pictorial signatures in activities ranging from instant messaging to fantasy sports. [3].

Any avatar can be customized or personalized to a range of appearances, from cartoony to fairly realistic, from animals to fantastic creatures.

Morie describes the system based on a VW, where hundreds of users are logged at same time, each one represented by an avatar, and where each user downloads a software client that runs locally on his computer, synchronizing to the data server in a continuous real time process [7].

Aside from entertainment purposes, avatar concepts can also make a huge difference in the area of social networking, education, as well as personalized self-care.

The potential the VEs have to enhance social interaction was reported long time ago [8], [9]. The application in various domains is also reported a lot. For example, Antonacci et al [10] use avatar VWs in education concluding considerable potential of a VW as a powerful media for learning.

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III. Avatars in self healthcare systems

There are several examples of using avatars in self healthcare systems.

Virtual spaces allow placement of virtual sensors to record various forms of data in VWs, and potentially use them in telehealth therapy. According to Morie at al. [11] VWs are not the same as VR, since they provide much easier accessibility (the only thing a user needs is a computer and an Internet connection).

A typical application of the avatar concept in self healthcare systems embeds the following features:

- Creating an avatar with proper customization;
- Navigating in the VW;
- Sending notifications about reminders from personalized and shared calendars, or events that trigger specific actions;
- Interacting with other avatars and/or applications and services;
- Analyzing and interpreting the results from sensors and healthcare devices;
- Exchanging information with expert systems and eDoctor services; and
- Decision making about relevant actions based on built in intelligence services.

A typical conclusion is that the avatar concept is not just a representation of a tele healthcare service, it adds on several functions from built in intelligence and wider exchange of information with remote sensors, third party services and applications.

The overall benefit of applying the avatar concept in the self healthcare is not just in provision of healthcare services, but in having a trusted person to talk about and providing relevant advices. The advantages this system exploits over the traditional approach include at least the following issues:

- Virtual 24x7 face-to-face healthcare and increased contact;
- Accessibility from rural and distant locations (including islands or regions hard to access);
- Remote patient monitoring;
- Cost and time savings (including travel costs, experts' time, patients' time, avoiding hospitalization in some cases, costs of supporting personnel, etc.); and
- Provision of enchanted continuity of healthcare, especially important for elderly.

One example of personalized healthcare avatars is introduced by Morie et al. [7] as "a novel method for engaging an amputee in rehabilitation activities delivered through an advanced telehealth mechanism using virtual worlds". This system places the avatar, being the graphical, embodied representation of the user, as the basic, most essential element through which each user accomplishes all socialization in the newly developed VW.

A lot of research is ongoing in the self healthcare and related areas, such as Ambient Assisted Living (AAL), and some of them analyze the potential benefit from the integration of avatar concepts in telemedicine. An example of this is presented by the AALuis project [12] aiming at a practical solution for adapting user interfaces and services to changing needs and wishes of older adults in a flexible way by providing various devices, I/O modalities, and avatar integration, providing consistent look and feel.

The avatar concept and virtual user models are also an objective of the Veritas EU funded FP7 project [13], with goal to develop an open library of various categories of virtual user models, including VR models, covering a wide range of population groups and especially focusing on groups in risk of exclusion. They plan to develop an Open Simulation Platform (OSP) for VR simulation and testing of new products at all stages of iterative product planning and development as innovative concepts to address ambient, multi-device, universally accessible and usable multimodal interfaces, along with an extensive list of VR tools for supporting accessibility testing for automotive, smart living spaces, workplace design, infotainment, personal healthcare and wellbeing.

IV. Intelligent Personal Assistants

Personal software assistants are those products that help users to realize tasks to find information, schedule calendars, or manage work-flow. In addition if a corresponding intelligence is built, they can provide more complex tasks that enable users a comprehensive advice in decision making and related issues. There are a lot of software products that can support users in learning [14] or knowledge management [15]. Different styles of assistive technology suit different applications, depending on the types of problem to be addressed and the balance of expertise and knowledge between the user and the system [15].

Watson is probably the best example of the avatar presentation of an artificially intelligent computer system capable of answering questions posed in natural language [16], developed by IBM's DeepQA project. Although the computer system was specifically developed to answer questions on the quiz show Jeopardy! (where it won the first prize in 2011), it is advancing to deliver its artificially intelligent wisdom to research organizations, medical institutions and businesses so that they can process big data for detailed answers to complex questions via Watson services offered via cloud. It is now a top research IBM project, especially in provision of clinical decision support system, based on natural language processing, structured knowledge in electronic medical records and big data analysis. It has already been proven as better at diagnosing cancer than humans.

Recently, mobile device producers and providers have started a lot of research and development in the area of intelligent personal assistants, as a kind of a mobile software agent. These products use mobile device sensors and Internet accessed information to provide services that will present and advice the mobile device holder via an avatar concept. Some examples of such products include Apple's Siri [17], Google Now [18] etc.

Siri is such an intelligent personal assistant and knowledge navigator especially built for Apple's iOS running on iPad and iPhone devices. It is an application that uses a natural language user interface to answer questions, make recommendations, and perform actions by delegating requests to a set of Web services, and adapting to user's individual preferences [17]. Interaction with speaking only, where the user asks questions, and the Siri application provides answers based on integration of a lot of services (including mail, contacts, messages, maps, etc.) is a classical avatar approach, based on the fields of Artificial Intelligence and Natural Language Processing realized by 3 software components (a conversational interface, personal context awareness and service delegation) [19].

Another example of these personal assistants is Google Now, which is an intelligent personal assistant developed by Google mainly supporting the Google Search mobile application made for mobile devices using the iOS and Android operating systems. It uses a natural language user interface to answer questions, make recommendations, and perform actions by delegating requests to a set of web services, passively delivering information to the user that it predicts what they will want, based on their search habits [18].

The basic idea behind Google Now application is to use the history of search, location and time events to figure out what information users might need in certain time periods, (such as being able to tell users how long their typical commutes will be given current traffic conditions, and being able to figure out how long in advance users will have to leave for them to make appointments) won the "Innovation of the Year" prize for 2012 [20].

V. Avatars for increased accessibility

Accessibility is mainly defined as a feature about products usable by people who have disabilities, or as context of a wider concept of software usability, as larger issue of acceptability, which basically is the question of whether the system is good enough to satisfy all the needs and requirements of the users [21]. In this paper, we target those who can not have sufficient resources or opportunities for classical face-to-face healthcare, and are keen on telemedicine. Therefore, in this section, we analyze the accessibility as a feature to which telemedicine is provided, or as the "ability to access" and benefit from personalized self healthcare.

Considering the elderly population, we can conclude that proper human computer interaction with complex ICT systems is very difficult, due to typical impairments (e.g. limitations on upper limbs movement). Also, a unimodal system may prevent the presented information from reaching those who suffer from impairments affecting the sensory channel needed to perceive a particular modality (e.g. a blind person cannot see graphical information and a deaf person cannot hear sounds). On the other hand, human impairments that are most likely to demand user interface improvements are classified as visual, hearing, motor and mental impairments [22].

Avatar concept in the field of accessibility is mainly based on multimodal interaction, user interface adaptation, simulation of user impairments, as well as using interaction filters. Multimodal interaction aims at "providing a more natural and transparent way of interaction with users, and making use of several modalities like gestures (and pointing), speech, gaze, etc." [23]. So far, scientists have succeeded in enhancing human-computer interaction through improving user satisfaction, increasing robustness and accuracy, efficiency and reliability, as well as increasing flexibility [24], [25].

Coelho et al. [23] elaborate the GUIDE (Gentle User Interfaces for Elderly People) project, which adopts multimodal interaction as a natural interaction approach to give its target users a simple and more intuitive way of controlling TV based applications in different modes, compensating sensorial impairments and offering users the possibility to interact in the most suitable way (choosing from a range of alternative devices of interaction). This research includes a specification of user preferences regarding button layout, color combinations, font size, and use of interaction filters.

Avatars for increased accessibility have been used in various domains, such as the development of an interactive tour-guide robot able to provide individual access to museums' exhibits and cultural heritage over the Internet [26], audio and video game interfaces [22], etc.

VI. Technology

A successful avatar implementation should use a 3D avatar based visualization using various technologies and methods to enable increased interactivity and overcome resistance of new technological products. For that purpose, anatomically correct 3D human models can be created using standard modeling applications like Blender, Autodesk Maya, 3D Studio MAX, Modo etc. Using animation or game-based software, the model can be deformed and controlled using various techniques like bone-system animations and mesh shape key techniques [27], [28].

Meshes have become a widespread and popular representation of models in computer graphics. Morphing techniques aim at transforming a given source shape into a target shape. Morphing techniques have various applications ranging from special effects in television and movies to medical imaging and scientific visualization. Not surprisingly, morphing techniques for meshes have received a lot of interest lately, especially in usage of avatars [28].

Chuang and Bregler [27] describe a method of creating facial animation using a combination of motion capture data and blendshape interpolation. An animator can design a character as usual, but use motion capture data to drive facial animation, rather than animate by hand. The method is effective even when the motion capture actor and the target model have quite different shapes.

Besides the video presentation of the avatar, the sound channel communication is also essential. In this context the natural language processing software and related artificial intelligence algorithms need to be implemented, such as in the example of IBM's Watson solution [16].

VII. Conclusion

An avatar environment for increased interactivity between users and the prototype system was analyzed for telemedicine application of self healthcare.

The avatar communicates to the user via sound and video delivery channels for notification messages including reminder for calendar scheduling activities, events or triggered actions by other services including expert systems and other eDoctor services.

Simple UI enables easy switching between various applications such as reminders, social network communicator, and add-ons that include interfaces to various medical sensors and instruments. The input from these data serves as a basis for initial medical advices and expert opinions and connections to third party cloud services.

The avatar mainly communicates by sending audio messages to the user and displaying images. Not only the sound channel is used to accept commands or establish a communication to the system, but also motions discovered on a human or by using commands on remote controllers, multitouch screens or mouse pointing devices. In this way, all major needs of elderly people or those with limited accessibility are being covered.

In this paper we give an overview of related definitions and approaches to build avatars, and analyze several existing solutions of healthcare systems, intelligent personal assistants, and avatars for increased accessibility. We elaborate the features and benefits that an avatar concept should have in a self healthcare system and specify essential technologies for avatar realization.

However, so far there is no integrated approach aimed at developing a self-care social interactive system as a service. Integration of existing approaches for realization of independent ICT solutions into one interoperable ICT solution represented by an avatar and delivered as a cloud service, that can be interoperable with the third party solution may benefit with innovation solutions that will reduce the overall costs of healthcare for elderly or those with limited accessibility.

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