Live Interactive Frame Technology Alleviating Children Stress and Isolation During Hospitalization

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Abstract. Children that spend long periods in hospitals suffer different negative effects that affect their emotional and psychological development including sleep disorders, stress, and degradation of school performance. A common reason behind these effects is related to breaking of normal relationships and lack of contacts with the daily environments (family, friends, school, etc.). In this paper we describe a system called Live Interactive Frame (LIFE), developed in DESEOS research project, to address this situation. The LIFE system provides children with live interactive visual contact of their school activities during hospitalization with the goal of reducing the stress and feeling of isolation.

1 Introduction

Ambient Intelligence (AmI) is a paradigm where Information Technology is applied to build networks of devices and services that are dynamically connected and collaborate to help people in different activities. These digital environments are aware of the presence of people, and can react and adapt to their necessities, habits, and movements [8]. Ambient Assisting Living (AAL) systems are designed to assist people with disabilities or health problems with the main goal of extending the period of time in which they live independently in their daily environment. Despite of the fact that this technology was initially designed to be applied to elderly and handicapped people [19, 7], today more and more scenarios for AAL are being developed.

In this paper we present an application of AmI technologies to develop an AAL system helping children that undergo long-term hospitalization periods, where this technology can offer interesting advantages. Children that have to spend long periods in hospitals suffer different negative effects that affect their emotional and psychological development and their family life [14, 17]. Some of the effects that have been studied and focus of our research are:

1. *Sleep disorders.* The experience of the medical and psychological team of DESEOS has revealed that even in cases of mild diseases, the children that stay in hospitals suffer sleep disorders that tend to be transitory, but that can have negative effects in the children's and their relatives' lives.

2. *Stress.* Stress is one of the most common effects of the stay in hospitals, both in children and their parents [2]. Studies reveal that this stress is caused to a great extent by isolation and lack of contact with their daily environments.
3. *Consequences on school performance.* This effect is not only caused by sickness, which undoubtedly has a negative influence on the children' education [18], but again has a strong relation with the lack of human contact and affection [1]. Several studies show that this happens even in cases in which the disease or sickness did not have a direct influence on the capabilities and abilities for studying of the child.

A common reason behind all these effects seems to be related with the breaking of the normal relationships and the lack of contact with the daily environments (family, friends, school, etc.). In psychology, the effects of the contact (or lack thereof) with others are related to the concept of 'attachment'. By definition, attachment describes "*the state and quality of an individual's emotional ties to another*" [4]. Attachment theory grew out of the research of British psychiatrist and psychoanalyst John Bowlby. According to his studies the "*observation of how a very young child behaves towards his mother, both in her presence and especially in her absence, can contribute greatly to our understanding of personality development*" [5].

Many different studies have shown the importance of the attachment between children and parents and also with the social groups they belong to, and have emphasized the role of visual contact and interactivity as solid basis for attachment. Attachment relationships have a "*direct effect on the development of the domains of mental functioning that serve as our conceptual anchor points; memory, narrative function, representations, and state of mind*" [21]. In fact, attachment relationships may serve to create the central foundation from which the mind develops [15].

Maintaining the attachment bonds is especially important in stressful situations, like the ones we are addressing in our research project. In reference [6] we read "*The infant and young child seeks closeness, especially to the mother, when he experiences anxiety. This may occur when, for example, he is separated from his mother, encounters threatening unfamiliar situations or strange persons, experiences physical pain, or feels overwhelmed by his fantasies, as in nightmares*". Not surprisingly, the parent-child relationship is not the only one that affects the development of the child. Bruce D. Perry states: "*There is no more specific 'biological' determinant than a relationship. Human beings evolved as social animals and the majority of biology of the brain is dedicated to mediating the complex interactions required to keep small, naked, weak, individual humans alive by being part of a larger biological whole -the family, the clan-*" [20].

It is widely recognized that visual contact and facial expressions provide important social and emotional information. Indeed, visual contact is arguably the most important form of non-verbal communication [16]. With regards to the role of visual contact in this attachment process Karl H. Brisch states: "*This search for closeness may be accompanied by visual contact with the mother or, especially, by seeking close bodily contact with her*" [6]. Furthermore, recent studies suggest

that eye contact has a positive impact on the retention and recall of information and may promote more efficient learning [9]. More recently, the importance of visual contact in remote communication has been determined [10].

The main target of the DESEOS project is the development and application of secure technologies for Ambient Assisted Living (AAL) systems to increase the quality of life of health cared children by developing novel devices and applications to enhance the contact with the different daily environments. With this goal, and based on the previous studies about the importance of visual contact and interactivity in the perception of closeness and immersion into the quotidian social relationships, we have developed a novel AAL system, called LIFE (Live Interactive FramE), providing an immersive interactive view of two separate physical spaces, used to help children maintain the contact with their school and to participate in classroom activities while being hospitalized. We present the technologies, devices, and software architecture realizing LIFE. One important goal of DESEOS is to develop devices that can be easily and inexpensively built and integrated into existing systems. The paper also presents the main LIFE use case and an evaluation methodology allowing validation of the effectiveness of the technology in reducing the stress and feeling of isolation.

2 LIFE Application Scenario

The main objective of DESEOS is to build an AAL environment to improve quality of life for hospitalized children, both during the hospitalization period and during the post-hospitalization time. In order to achieve this objective the research and development in DESEOS is guided by several selected scenarios. In this section we present one of these scenarios in order to illustrate the kind of situations and systems that DESEOS deal with. The scenario focuses on the provision of means to reduce the problems caused by long-term hospitalization of children and involves two spaces (physical environments): Hospitals where children are hospitalized and Schools where the hospitalized children' classmates and teachers are. In the scenario we consider several roles depending on the actors that interact (parents, teachers, doctors, etc) and the space where the activity is developed (hospital, classroom, home, etc). Our general goal in this scenario is to make the hospitalized child be able to continue attending school in his own class. Although all hospitals have a school where children can continue their education, we believe that the most important aspect that the child loses is not the education (lectures, tuition and exercises) but the human contact and the integration in the group. Several subgoals guided us to build our scenario:

- *Visual contact.* Eyesight is one of the main senses in human communication and interaction. Providing technical means for maintaining visual contact in the most natural way so that the child feels that he is attending his normal class is therefore very important. For this purpose we provide a special type of video streaming service that we call "Live Interactive Frame (LIFE)" because it acts like a window changing the part of the classroom displayed depending on the position and viewing angle of the hospitalized child.

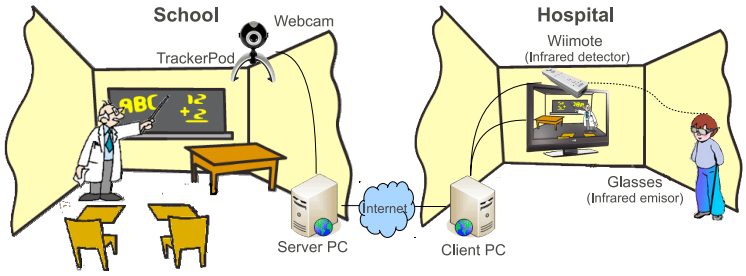

Fig. 1. LIFE Application Scenario

- *Auditory contact.* Another essential aspect in the communication is the auditory contact. It complements the visual contact helping the child getting integrated in his classroom as any other classmate. This is achieved integrating different microphones that are mixed depending on the relative position of the child and the Live Interactive Frame (LIFE).
- *Medical and school information.* In every situation there is certain information related with the hospitalized kid that is used by different actors. The level of access and the specific information that is made accessible is determined dynamically depending on the situation, the context and the actor.

We consider the following elements in each space: (i) A set of devices which form a local AmI environment (TV screens, webcams, microphones, electronic backboards, etc.), (ii) Information systems of particular domain (databases, servers, etc.), and (iii) A set of people who play different roles.

Figure 1 illustrates the elements in each of the spaces of the scenario. These elements are used to fulfil the above-mentioned goals. For instance, movable webcams and TV screens are used for achieving a satisfactory level of visual contact by implementing not only the LIFE application but also other uses like the replication of the classroom blackboard in the hospital room. To increase the feeling of natural interaction we use an accurate positioning system for the viewer (the hospitalized child) so that we can simulate the sensation of looking through a window by using camera movement and zooming. The positioning system uses a bluetooth infrared camera. For economy reasons we use a Nintendo Wii console remote for this purpose [13]. All devices shown in the figure have a role in order to make possible the interaction and the contact between hospitalized children and their schools. However, due to the nature of the managed information (medical, scholar, video, etc), some security issues arise which are addressed in [3].

LIFE Immersion View Effect. LIFE enables users to use a monitor (computer peripheral monitor) as a real world window giving the augmented impression of remote contact. This impression is achieved by means of sensing the user situation and movements to show the remote image according to these parameters. Transparently to user movements the motorized camera is rolled to provides the real world window impression. Figure 2 shows the virtual effect achieved. The

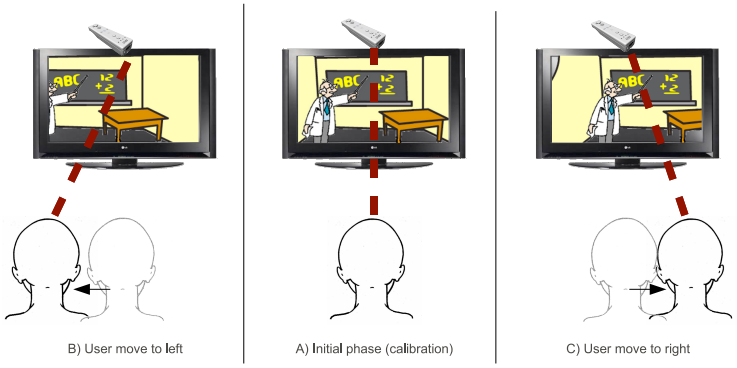

Fig. 2. LIFE Immersion View Effect

immersion view effect is the main aspect of DESEOS LIFE application providing the real psychological effect on hospitalized children.

3 LIFE Software Architecture

We will discuss the most relevant implementation details of DESEOS LIFE. A general overview of the DESEOS LIFE architecture is illustrated in Figure 3. LIFE application is based on a client-server model that establishes bidirectional communications between hospital and school realms. The WiiUseJ[1] library is used on a client side to support the remote control bluetooth connection of Wii (Wiimote) entertainment system. A WiiUse library is a dynamic access library located between WiiUseJ layer and the bluetooth stack. The server-side architecture makes use of the functionality provided by the library Xuggler[2] used to capture video streaming from a webcam or an IP camera, changing encoding format, frames modification, and so on. This server is in charge of processing video streaming and performing Trackerpot [3] device rolling that adds pan and tilt (PTZ) properties to a video device. Tracketpot has an associated HTTP server in charge of accepting, processing and performing rolling on the physical device.

LIFE application provides bidirectional (client-server) communications by establishing two separate connections. When the server is started, a control socket is opened on a predefined port so that the server is waiting for a connection request. Once the connection is established on this socket some control parameters are set. The server captures the video streaming (of school realm webcam) using the functionality provided by Xuggler and streams the video out to the client (school realm) application using the RTP protocol. We note that the con-

[1] `http://code.google.com/p/wiiusej`
[2] `http://www.xuggle.com/xuggler`
[3] `http://www.trackercam.com/TCamWeb`

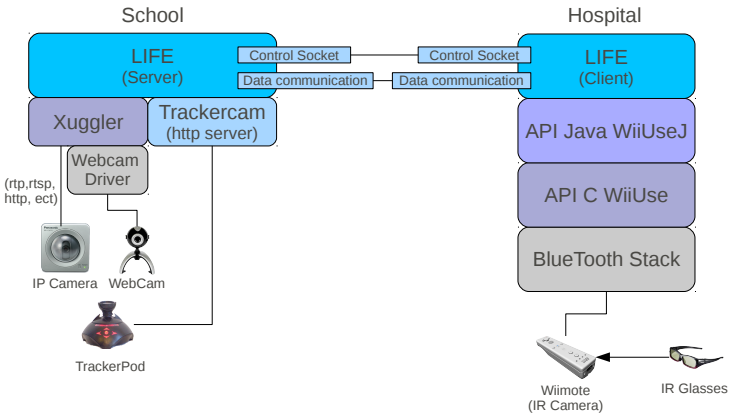

Fig. 3. LIFE Software Architecture

trol connection is kept alive in order to receive the tilt, pan, zoom information coming from head tracking and send this information to the Trackerpot.

The head tracking on a client-side is implemented by using infrared wiimote sensor which locates user position by taking user infrared sunglasses as a reference point. The WiiUseJ library functionality is used to process input information from the wiimote sensor. The LIFE application decides how to transform video streaming frames to simulate the real movement and how much tilt, pan, and zoom is necessary to apply. Figure 4 shows the relation between the head position with the tilt, pan and zoom parameters.

Basically, we make use of trigonometry to calculate the ratio between user head position and the angles PTZ. The figure shows all directly related angles with the screen, user previous position and user current position. In the bottom

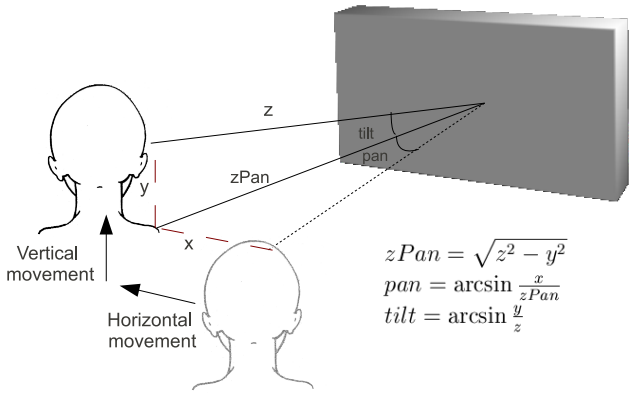

Fig. 4. LIFE Tilt-Pan Calculation

right part of the figure we also show the functions used to calculate x, y and z values, known thanks to the wiimote use.

4 Methodology Evaluation on Effectiveness of LIFE

An important part of LIFE technology is performing evaluation of its real psychological effect on reducing stress and isolation of hospitalized children. For this propose it has been defined a methodology of how to achieve evaluation on the effectiveness of the technology.

The objective of the methodology is to validate the pilot prototype of LIFE in collaboration with psychologies, teachers and doctors. The evaluation is planned to cover 30 school-age hospitalized children selected from the pediatrics unit at the Hospital Clínico Universitario de Granada[4]. The selection criteria is rather generic where the consensus of the parents and the child are required, as well as, acceptable conditions of the child for use of LIFE technology.

In the following we summarize the methodology steps performed on every selected child:

1. Use an actigraph for 72 hours before LIFE is used by a child to have control data.
2. Complete questionnaire STAIC [22] and CDS [12] for setting control data of stress and anxiety levels of the child.
3. Use of LIFE technology for a predefined period of time (for a week) where the time of LIFE usage is incremented gradually day after day until it reaches some acceptable duration of time allowing the child to follow classes in school. The acceptable duration will be defined in accordance to the actual school program and the doctors at the hospital.
4. Use an actigraph for 72 hours after the child has used the LIFE application to analyse the sleep-wake rhythms of the child and its motional conditions based on the data of steps 1 and 4.
5. Complete again the questionnaire STAIC and CDS after using LIFE to analyse the child stress and anxiety levels the LIFE has caused.
6. Conduct a poll to parents, teachers, family and doctors evaluating level of satisfaction and acceptance of LIFE.

5 Related Work

A Virtual Window system implementation [11] uses head movements in a local office to control camera movement in a remote office. The result is like a window allowing exploration of remote scenes rather than a flat screen showing moving pictures. This work is an initial step of our work.

Chung Lee [13] uses the infrared camera in the Wii remote and a head mounted sensor bar (two IR LEDs) to accurately track the location of user head

[4] http://www.juntadeandalucia.es/servicioandaluzdesalud/hsc/

and render view dependent images on the screen. This effectively transforms a display into a portal to a virtual environment. The display properly reacts to head and body movement as if it were a real window creating a realistic illusion of depth and space.

6 Conclusion and Future Work

We have presented a novel AAL application, called LIFE, applying AmI technologies to increase the quality of life of health-cared children. The LIFE application scenario provides immersion interactive view of school activities taking place during children hospitalization period. We have presented the technologies, devices, and software architecture underlying LIFE. We have also presented a LIFE use case evaluation, an important aspect of LIFE technology adoption, and its related methodology to verify the effectiveness of the technology in reducing the stress and feeling of isolation.

Current prototype implementation allows unidirectional video streaming. A future work is to enable bidirectional (a second) video streaming channel of classmates seeing hospitalized kid. This is an important aspect from a psychological point of view of allowing hospitalized kids having visual feedback from their classmates in school. However, a privacy issue is to be considered providing the hospitalized kid with the option to disable the second video streaming channel due to possible discomfort of the children who might do not want to be seen in this way.

Another direction of future work is related to the usability of LIFE technology where children might feel uncomfortable using the system due to its reaction time. If the system take too long or too fast compared to the small movement of the children the result might lead to motion sickness. Part of the solution to that will come from the methodology evaluation results where some default calibration can be achieve. However, we plan to provide a calibration setting where the children can adjust system reaction time to their current emotional feeling.

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