The Multisensory Interactive Window: Immersive Experiences for the Elderly

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Abstract
This paper presents the Multisensory Interactive Window, a system that allows experiencing distant places and communicating with distant people through a tangible installation that exploits the window metaphor and multisensory feedback. Thanks to the feeling of being just in front of a natural landscape or a room inhabited by a beloved person, we strive to enhance the older adult's well-being at home. We illustrate two interaction concepts and a feasibility study for the implementation of the first prototype.

Author Keywords
Multisensory experience; telepresence; interactive window; tangible interaction; elderly.

ACM Classification Keywords
H5.2. Information interfaces and presentation: User interfaces, Interaction styles, User-centered design.

Introduction
One of the major causes of frailty for older adults is the gradual loss of mobility, which forces them to spend most of their time at home. There are several causes for this condition: sometimes the older adult's loneliness could generate a simple lack of motivation for traveling outside; in other cases, the lack of an appropriate transportation infrastructure could hinder older adult's outdoor movements. Older adults that experience this condition are exposed to a double

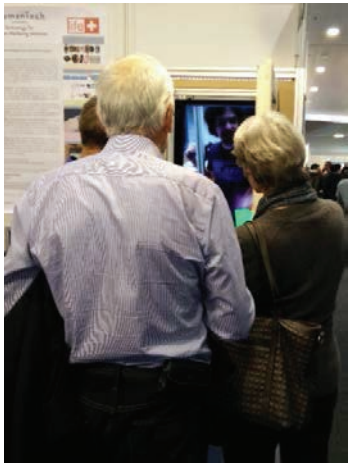

Figure 1. Older adults interacting with a displaceable version of the Tangible Interactive Window during a healthcare event in Lausanne, Switzerland.

danger: both their physical and their cognitive health are threatened. Indeed, not only the lack of physical activity can have a negative impact on their health, but also the lack of social contact with the external world can lead to cognitive impairments. Indeed, there is scientific evidence that having stronger social connections is generally associated to better health [1] and higher cognitive abilities [8]. To cope with these situations, we propose the Multisensory Interactive Window as a tool for facilitating the social exchanges with distant people. Thanks to the window metaphor, it boasts an intuitive and natural interface that everyone should be able to use without or with little training. Research studies have demonstrated also that the travel experience has an important role for the improvement of the elderly leisure and for their overall quality of life [5]. In particular, experiencing natural environments can improve not only the restoration of the human, but also of the overall health [11]. Indeed, yet in 1984, Ulrich found that the sight of nature could help the recovery of patients in a hospital [10]. In 2011, Kaplan presented an interesting study about the benefit of the different views from the windows [4]. Kaplan suggests that the window can be seen also as a sort of protection from the outside environment, giving the inhabitant all the benefits of experiencing the external environment without exposing her to any risk. Since experiencing different environments, especially natural environments, could have important benefits on the human everyday wellbeing, we strive to give older adults access to these experiences, from the comfortable and reassuring domestic environment. In particular, we focus on people living in urban environments that are not able to travel to a naturalistic place. More in general, the Multisensory Interactive Window could provide such experiences for any category of people, even those without any experience with technologies.

In this paper, after an analysis of related work, we describe the Tangible Interactive Window, a system built to connect permanently two distant research labs. After testing this system for several months and showcasing it during public events (Figure 1), we realized the potential benefits of adapting the Tangible Interactive Window to older adults' needs. Therefore, in this paper, we propose two concepts and scenarios of usage of a new Tangible Interactive Window, enhanced with multisensory interaction for a more immersive experience. Then, we present an improved system architecture and a feasibility study for the realization of the Multisensory Interactive Window.

Related Work

There is a consistent body of literature for telepresence systems based on audiovisual communication. Media Spaces were born about 25 years ago, in the analog communication era, mostly to connect distant offices. Since these systems are able to increase fortuitous exchanges between the distant places and the social closeness of the connected people, there is a great interest in applying them also in the domestic environment. In particular, the window metaphor has already been explored in the Family Window system to establish a 24/7 audiovisual connection between distant members of a family [7]. Nevertheless, to the best of our knowledge, no system proposed a tangible implementation integrated in the environment, following the Mark Weiser's vision of calm and ubiquitous computing [13]. Such tangible implementation could have a positive impact on the acceptance and the usability of telepresence systems

Figure 2. The Tangible Interactive Window installation in Biarritz, France, seamlessly integrated in the environment and connected to the University of Applied Sciences of Western Switzerland, in Fribourg.

for elderly. Indeed, in the Televisits study [6], researchers demonstrated the benefit of a video-based telecommunication system, although a more usable interface was advocated. A tangible implementation based on the window metaphor could facilitate the learning phase and could increase the acceptance of the system, thanks to the transparency of the underneath technology. Communication through other senses has also been explored in the past: yet in 1996, Strong and Gaver designed distant intimate communication through scents. More recently, Tsujita et al. proposed SyncAroma [9], a device that allows a partner to know the feeling of the distant beloved through different scents. Wei et al. Co-Dine system [12] is probably one of the few audio-visual telepresence system that integrated also other senses: the users can dine remotely and synchronously and share printed edible messages with different tastes. Contrarily to remote communication, scientific research projects for experiencing natural environments through artificial systems are quite rare, despite the large diffusion of commercial systems such as Google Earth[1] and Google Street View[2]. Although those technologies are not immersive, nor integrated in the environment, there is scientific evidence that they can be used to improve the mental well-being. In [14], Williams investigated the positive effect of visiting remotely famous religious places. A remarkable commercial product that is fully integrated in the environment is the SkyFactor eScape 2.0 system[3], which displays recorded HD audio-video streams of beautiful natural landscapes inside a false window. The Multisensory Interactive Window exploits a similar setup, although the experience is consistently enhanced through the involvement of almost all the senses and thanks to the intuitive tangible interface. Although Morton Heilig developed the Sensorama multisensory system yet in 1962 [3], nowadays, multisensory installations can still be experienced only in theme parks or in special events. The Multisensory Interactive Window aims at bringing these digital multisensory experiences in every home, exploiting an intuitive interface that can be easily learnt by older adults.

The Tangible Interactive Window

The Tangible Interactive Window (shown in Figure 2) is a tangible interface that allows telecommunication over a distance. The novelty of the Tangible Interactive Window is the implementation of the window metaphor to provide the user with a simple and natural way of interacting with the interface. The display is vertical and shows the image of the people in front of the connected window but it is on mute while the window is closed. When users open the windows on both sides, the audio channel is activated and the users can communicate verbally. The window glass is interactive and recognizes the knocking gesture to call the attention of the people around the window remotely connected. The window can be connected to multiple other windows distributed all over the world or to webcams streaming views of beautiful landscapes. It is possible to switch sight performing a swipe gesture on the window glass.

[1] https://www.google.com/earth/

[2] https://www.google.com/maps/views/streetview?gl=us

[3] http://www.skyfactory.com/products/eScape/

Figure 1: A demonstration of the Virtual Tourism Concept. A Tangible Interactive Window playing a HD portrait video of a natural landscape.

Existing Architecture

In the existing system, a 50" television is positioned in portrait orientation behind the frame of a tangible window, which can be physically opened and closed. The glass of the window is a PQLab G4S multitouch overlay, which allows the recognition of gestures performed on its surface. The window frame is positioned in a false wall, giving the feeling of a seamless integration in the environment. A physical frame reduces the field of vision of the television and allows a 3D effect thanks to parallax. A tiny HD camera is glued on the center of the TV screen, at about 1 meter and half from the floor. A hand crank allows closing virtual blinds. An All-In-One Touchscreen PC positioned as a windowsill handles the software part of the system and offers an additional interactive surface to the user. The audiovisual communication between distant windows or with live webcam is managed by a Google Chrome web application based on the WebRTC protocol. A .NET application running on the touchscreen PC manages all the devices connected to the system and provides inputs to the web applications.

The Multisensory Interactive Window

In this section, we present two interaction concepts for the Multisensory Interactive Window and the necessary extension to the existing architecture to implement them.

Concept 1: Family Connection

In this scenario, the user has the possibility to talk face to face with distant people through the window: "While sitting on an armchair, reading a newspaper, Jane hears somebody knocking at the window. She looks towards the window and she sees her sister waving her hand. Jane goes in front of the window and she is now in front of her sister, who appears inside the window at human size. When Jane opens the window, she can clearly hear her sister speaking. They start chatting at the window, looking each other in the eyes. Jane can also smell the fresh perfume that her sister is used to put since when she was a teenager. Jane feels just a meter away from her sister, although they are separated by thousands of kilometers and they had no chance to meet in the last years".

This first concept aims at supporting a feeling of connectedness between family members living apart. It presents a tangible interface that allows having a permanent video-communication system. In this concept, the touch plays a crucial role since the tangible nature of the interface allows providing a natural means of interaction that can ease the access to video-communication technology. The sight and hearing are obviously elicited during the video-call. The use of fragrances associated to the distant person in the video-call can involve the use of smell, which is often associated with a stronger sense of presence. When a user feels the necessity to be disconnected, she can close the virtual blinds using the tangible hand crank or can pass to the second modality of use of the interactive window: the virtual tourism.

Concept 2: Virtual Tourism

In this scenario, the user can rely on the imaginary possibility to wake up each day in a different location. "Once woken up, Jane will open the blinds to look out the window and admire the life of the outside world, for example, a seaside landscape. Opening the window, she could hear the pleasant sound of the waves softly breaking on the beach. Moreover, she will be able to feel her hair blowing in the fresh and humid wind of the

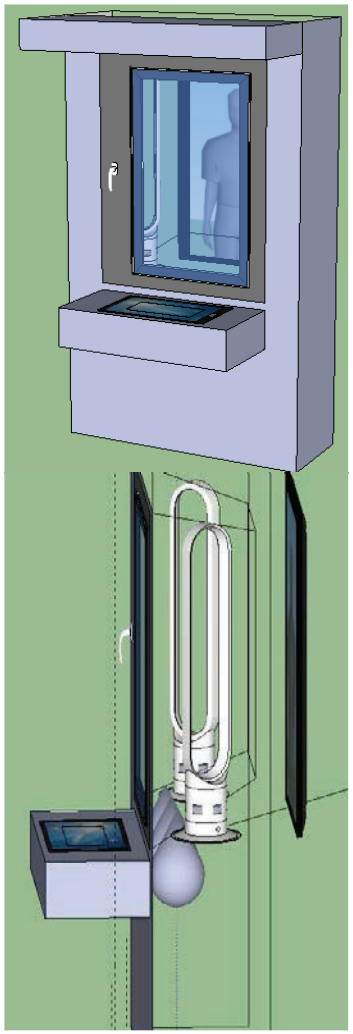

Figure 2. Design of the Multisensory Interactive Window with air blower and scent diffuser placement.

sea. She will breathe deeply, enjoying the smell of the sea".

The second concept for the Multisensory Interactive Window aims to allow experiencing an immersive virtual tour around the world providing multisensory stimulation according to the displayed animated landscape. The user can explore distant places moving through static content of streets and open spaces (similarly to Google Street View) or experience live or recorded streams of particular landscapes. These audiovisual streams can be further enhanced with multisensory information concerning the current air temperature, the wind, the humidity or the scents that can be perceived. The Multisensory Interactive Window will recreate this condition at the best of its technological capabilities.

Multisensory Window Architecture

Since the existing window can easily stream an audio-video stream from a webcam through the WebRTC protocol, there are no additional modifications required to stream the content from a live webcam pointing to a natural landscape. However, the current setup requires a webcam oriented in portrait mode, which is actually very uncommon for existing live webcams. Therefore, ad hoc webcams should be installed in the desired landscapes to be streamed. Alternatively, recorded portrait videos could be displayed in the window. This requires the realization of long HD videos that can be streamed to the same web application that displays the WebRTC streams. In order to implement the multisensory stimuli, we modified the existing hardware architecture by integrating in the space between the window and the television an array of scent diffusors, an air blower with heat function and an ultrasonic vaporizer in front of one of the air blower. The software architecture is also slightly modified in order to provide the appropriate multisensory stimuli according to the content displayed in the window. Obviously, since the glass of the window has an isolation function from wind, heat, scents and sounds, the multisensory stimuli will be generated only when the window is open. In order to match the multisensory stimuli with the watched place, weather conditions, such as temperature, wind and humidity will be retrieved from open weather API, according to the remote place global position. Fixed scents will be assigned for each remote place or person and the corresponding diffusor will be activated accordingly.

Feasibility Study

During the preliminary tests of the Tangible Interactive Window, we validated the possibility of obtaining an audiovisual communication that is highly realistic and that can make the user feel she is speaking to a person that is just in front of her. The positioning of the camera on the center of the screen contributes to this feeling, allowing eye contact between the interlocutors. We tested in the window also high quality videos of natural landscapes, which granted a high realism effect.

We performed a market analysis to understand the type of scent diffusors and air blowers that can be integrated in the Multisensory Interactive Window. To the best of our knowledge, no controllable scent diffuser or air blower offer open APIs for a remote control from a PC. Therefore, we have either to revers engineer and modify them, or to implement a mechanical actuation for their original interface. We selected an ultrasonic humidifier (Crane Drop) with a single mechanical switch that can be switched on and

off by simply controlling the electrical plug in which they are connected. With this solution, it is possible to install and operate up to four humidifiers, each filled with a different scent. For the air blower we selected the Dyson Air Multiplier AM09, which include also a heater. This particular fan can be easily integrated internally on the sides of the window or in the top, without affecting the design of the structure, as shown in Figure 4.

Discussion and Future Work

Although the Tangible Interactive Window has been extensively tested in two research labs, specific test with older adults are needed to validate the proposed system. Preliminary test during demonstrations in public events obtained encouraging results, thus, we are planning to conduct long-term tests in a retirement home. However, a complete prototype based on the concept presented in this paper has still to be implemented. Finally, although the Multisensory Interactive Window can be of particular benefit for older adults, we believe that it could be appreciated from many people, either in domestic, work, or healthcare environments as an unobtrusive and ready-to-hand restoration and communication facility.

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