WP 4 Mediated Presence Components

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Context

WP 4 Mediating Presence Components

WPL Alex Jonsson, KTH (following amendment. Previously: Ericsson)
Task 4.2 Mediated Space (with contributions from T4.1 Virtual Cameras)
TL Charlie Gullström, KTH

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## Abbreviations and Terms

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<tr>
<td>Chromakey</td>
<td>Chroma key compositing - a special effects technique for layering two images together based on colour hues. The technique is typically used to remove a background from the subject of a photo or video.</td>
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<td>COMPEIT</td>
<td>Connected Media and Presence from European Institute of Technology (this project)</td>
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<td>DoW</td>
<td>Description of Work</td>
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<td>EIT ICT Labs</td>
<td>European Institute of Innovation and Technology, Information and Communication Technology Labs. Since June 2015 it has changed its name to EIT Digital.</td>
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<td>WebRTC</td>
<td>Web Real-Time Communication as defined by the W3C</td>
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1. Summary

COMPEIT creates a web-based system for highly interactive, personalised, shared media experiences. The new technologies will improve the feeling of being together in a shared mediated space and support interaction and collaboration between people who are separated in time or space.

Immersive Spaces 1.0 is a software component for the COMPEIT presence system with a feature set that allows users to interact and perform shared actions in virtual spaces, simply using their web browser. The main features are called SharedSpace, a virtual 3D environment which users can redesign and populate by scaling and rearranging their avatar-like live videostream representations; and PixelPresence which is an overlay technique that offers a pixelated view of a livestream, hereby adding an ambient and discrete presence filter, which indicates movement and subtly prompts users to enter a mediated interaction.

The presented component lets users design their own Immersive Space, which in its most basic implementation can be described as a “group video chat” or a shared video window in which participants develop a rich sense of being together in a mediated space. This ease of access opens up for a wide range of tools that facilitate co-creation of virtual spaces and shared actions. These functionalities derive from an iterative co-design and prototyping process in T4.2 Mediated Spaces and T5.1 Shared Media Distribution, and were informed by early user tests and results from D2.4 Value Sensitive Requirements 1.0. Early versions of components were represented already in D2.3 High-Fidelity Mock-up, such as environmental displays (PixelPresence, Softwall) that form part of a building interior and invite users to monitor features both in their immediate physical environment as well as in online virtual spaces, in other words, to collaborate in mixed-reality spaces. What emerges from the ongoing research in WP4 is a digital toolbox of new design materials to furnish interiors and create mixed-reality spaces. Real-time video and audio streams are combined with embedded smart devices and physical building components that respond to users’ presence by local action or remote interaction.

While not originally planned, the Immersive Spaces component has been included in D3.4 First Prototype. The COMPEIT prototype supports individuals and distributed groups who want to stay close with each other on a regular basis, ready to spontaneously interact in mediated and virtual spaces. Feedback from users and user requirements in WP2 showed that people want to be subtly aware of what others are doing, and if they are at a particular place at a given time – which, of course, is quite different from keeping a videolink open 24/7. Regardless if the context is professional or social, ambient forms of presence are thus called for, in order to support gradation and, perhaps more importantly, to prompt users to join a shared virtual space when desired. The way in which immersive experiences take place in everyday communication and meetings differ greatly from that of for example gaming contexts.

One of the design goals in WP4 has been to support this gradation of immersiveness, and study the result of changing focus and attention between on one hand fully immersive virtual meeting spaces, composed from the audio-visual and 3-dimensional data of remote locations, and on the other hand the peripheral, ambient awareness of potential for engagement, through what we tentatively call environmental displays (which in some cases can also consist of audio and video). When a space has immersive properties, it has the prerequisites to deeply involve and engage the user. An immersive space allows the user to not only consume media in an engaging way, but also to manipulate, monitor and control the communication channel(s) and the remote location(s) where other users are present and where events occur that can be mediated back to the user’s own display and physical node.

The report also discusses the wider application area and potential commercial exploitation of Immersive Spaces 1.0 in light of the planned piloting (see D6.2 First Pilot Report), and for...
which several possible use contexts are currently investigated. While the Immersive Spaces feature set supports socialising and co-creation of virtual shared spaces for generic office contexts and for children with special needs (who can use paint and other overlay functionalities to creatively transform live videostreams and co-create 3D virtual environments etc), it may also be applied to more specific professional contexts, such as mobile journalism and broadcast settings.

Finally, the report presents an instance of Immersive Spaces, the COMPEIT Fun Palace, which has been made public at http://experience.compeit.eu [D6.1 COMPEIT Experience Lab and Piloting Framework] and used in an internal online pilot study supporting the development of SharedSpaces.
2. Introduction

This short report represents the software prototype D4.4 “Immersive Spaces 1.0” and describes the current state of ongoing work in the COMPEIT project. This report describes the background and functioning of the software, its role in D3.4 First Prototype and possible wider applications of our results.

D4.4 “Immersive Spaces 1.0” has a feature set which together helps to create the illusion that the local space and the spaces where other live media streams originate are one and the same. It is the fourth software component to come out of WP4 “Mediated Presence Components” and represents the first result from T4.2 Mediated Spaces, with contributions from T4.1 Virtual Cameras 1.0 and T5.1 Shared Media Distribution. The delivered software can be found here: https://github.com/mylikerala/compeit and the most recent demonstration of Immersive spaces can be tried out here: http://compeit.eu/sharedspaces. The latter link will be updated for the next iteration of Immersive Spaces. For basic user instructions, we refer to the online COMPEIT Experience Lab, where some of the features we describe below are also available, and where instructions for first users can be found: http://experience.compeit.eu.

The main objective of work package 4 is to research key COMPEIT knowledge areas and to embody the new knowledge in beyond state-of-the-art software components to improve quality of experience of mediated spaces using interactive connected media. We have operationalised our definition of quality of experience in COMPEIT in three domains; namely spatial, social and information connectedness, as described in DoW. In T4.2 Mediated Spaces, we carry out iterative design and prototyping experiments with users dedicated to specific shared activities by linking two or more architectural, physical spaces (geographically distributed) and by experimenting on architectural interfaces to support ambient presence and mediated interaction in mixed-reality environments.

The work in T4.2 specifically addresses the fusion of architecture and interactive media to support mediated presence [1] [2]. ICT-mediated architectural design and prototype components are developed to support collaboration and the experience of mediated presence. The new components will improve the feeling of being together in a shared mediated space and support interaction and collaboration between people who are separated in time or space. The experience of presence is closely linked to the concept of immersion and relies on trust-building processes [3][4]. Mixed-reality spaces to support immersion (‘immersive spaces’) are created by integrating live media streams into the user’s physical environment (e.g. using large displays, embedded actuators, sensors etcetera) in combination with software components and tools that empower users to actively control features in local and remote spaces as well as in a shared virtual space - results from T4.3 Tangible Interaction are used for this.

When a space has immersive properties, it has the prerequisites to deeply involve and engage the user. An immersive space allows the user to not only consume media in an engaging way, but also to manipulate, monitor and control the communication channel(s) and the remote location(s) where other users are present and where events occur that can be mediated back to the user’s own node. The concept of immersiveness is often associated with the use of virtual reality and the generation of environments in which users, through their deep focus on the interaction, feel immersed in it [5]. Interchange of data between the physical space and virtual spaces can also add to the sense of sharing the same spatial experience.

The way in which immersive experiences take place in everyday communication and meetings are quite different than that of gaming contexts where it originated, or of other forms of interaction requiring the constant full engagement of users. A meeting, or any related type of communication such as an ordinary conversation, has a number of degrees of
engagement between which the participants can subtly shift: For example, a discussion we are not taking part in but only hear in the background, may suddenly move from the periphery of our attention to its very centre, as we are compelled to contribute and participate in it, perhaps because it has aroused our interest or has otherwise prompted for our participation. Similarly, a meeting in which an issue close to us has just been discussed, may move into other matters and shift to the fringes of our attention, if we instead dedicate to perform some other work, such as reading related texts and reports, while the meetings and discussions take place in the background. These typical cases from real life exemplify the fluctuations of our attention between two poles, one represented by full engagement and focus, that is, immersiveness, and the other being a background or ambient awareness of events, which only has potentials for full engagement. In terms of interaction, this opposite pole of background awareness is close to the concepts discussed in paradigms such as ambient intelligence, pervasive or ubiquitous computing, in which we relate to information in a casual, non-engaged way. As in Mark Weisner’s original proposition[6], ubiquitous computing “does not require active attention, but the information to be transmitted is ready for use at a glance”, in contrast to multimedia machines that “makes the computer screen into a demanding focus of attention rather than allowing it to fade into the background. “

Accordingly, one of the design goals of the development of immersive spaces within COMPEIT has been to support this gradation of immersiveness, and study the result of changing focus and attention between on one hand fully immersive virtual meeting spaces, composed from the audio-visual and 3-dimensional data of remote locations, and on the other hand the peripheral, ambient awareness of potential for engagement, through what we tentatively call environmental displays (which in some cases can also consist of audio and video). These two modes (the one involved in immersive interaction and in ambient awareness) are antipodal to each other: while immersive spaces are often generated as another virtual space outside the immediate physical surroundings of the users in which engaging interaction takes place, environmental displays follow the ubiquitous computing paradigm of bringing information to the actual physical space of the users for perceiving it in the background.

Some of the above issues were addressed already in D2.3 High-Fidelity Mock-up, which demonstrated executable early versions of components, such as environmental displays like PixelPresence and Softwall, that form part of a building interior and thus invite users to monitor features both in their immediate physical environment as well as in online virtual space, in other words, to collaborate in a mixed-reality space.
3. **Immersive Spaces Features**

In this Section we describe the features provided in the Immersive Spaces 1.0 component. Note that immersive spaces were also adopted as the starting point for the upcoming D5.5 Multi-Device Tangible Experience Service, and the results reported here were co-developed by T4.2 Mediated Spaces and T5.1 Shared Media Distribution. For simplicity, no distinction is made below between the component aspects (user interaction and possibility to use by any COMPEIT service) and the end-user experience (the service), and the service-related material will be updated in the later WP5 deliverable.

Immersive Spaces is integrated in D3.4 First Prototype as a separate room type "Immersive Space" that will continue to evolve to study its immersiveness properties. The upcoming D5.5 Multi-Device Tangible Experience Service can be developed as a separate room type for piloting, focusing on functional requirements from users for user interface automation, shared apps, multi-device operation, recording, and possibly a slightly different approach (a virtual mirror) to representing a 3D-consistent meeting situation.

Immersive spaces 1.0 has a feature set that allows users to connect and interact with each other over the Internet and perform shared actions, solely using their web browser. Social interaction is further supported by a series of features that allow users to collaboratively explore and experience the concept of spatial connectedness in real-time:

**SharedSpace** is the core feature of the Immersive Spaces 1.0 component. [Figure 1] It enables users to enjoy chromakey functionalities by choosing among preset backgrounds for the interaction, or upload a customized background. It enables users to design and create a shared 3D virtual environment in which they are represented live from the video stream, and where different functionalities can be allocated to different parts of the 3D space. In its first iteration (the current deliverable), users’ video images can be scaled in size and transformed, using the **Rearrange** feature, which allows the participants to regroup each other inside the virtual space (avatar-like way). [Figure 2] There is also a **Paint & Point** feature. [Figure 3, Figure 4] This is an overlay technique that enables drawing, painting and writing directly in the livestream.

**PixelPresence** [Figure 6] is an overlay technique that creates a pixelated view of a livestream, and contributes an ambient presence trigger to enter a mediated interaction. Future iterations will include a notice board can be moved around and be scaled, and for example a memory wall that represents the users who were recently in the virtual space, and a library wall which allows the users to highlight references of shared interest. Continued design and development will introduce additional cameras to the virtual space, providing multiple view points and inviting users to take control of the viewing experience.

Immersive spaces 1.0 thus strives to enhance users’ feelings that they are physically and socially “close” to one another. In its most basic implementation, it is a “group video chat” or a shared video window in which participants develop a high sense being together in one space, from the easy access to a wide range of tools that facilitate co-creation of virtual space and shared actions. What emerges from our design-led research is a digital toolbox of new design features to furnish interiors and create mixed-reality space. Real-time video and audio streams are combined with embedded smart devices and building components that respond to users’ presence by local action or remote interaction.

Similar functionality can be found in the other architectural interfaces that are being developed at KTH and LTU in T4.3 Tangible Interaction, such as Little Polyhedron and Little LED Matrix. These two interfaces are low-bandwidth components similar to PixelPresence. Also similar is the Softwall by TUD-associated WhyFactory. The Softwall is currently implemented as a Softwall Puff & Wave prototype at KTH and as a panel version by TNO.
There are also similarities, of course, in terms of functionality, to the TangiBall by LTU, see D4.3 Proxies and Devices.

Future iterations of the Immersive Space component will integrate additional virtual cameras to the 3D environment (from T4.1 Virtual Cameras), enabling participants to share and manipulate various different camera feeds. In the current version of the COMPEIT café, users can navigate around the 3D space (using the space bar) hereby monitoring a basic virtual camera.

Figure 1. Chroma key composition to share a virtual space between physical nodes.

Left: The photo shows the composite result in real time, in this instance a mediated yoga session carried out at KTH with student participation. Right: Although these five people appear to be in one place, they are actually all hundreds of kilometers apart! The careful observer may see that the illumination of the faces comes from different sides, and that some are wearing a T-shirt whereas others are dressed for colder climates.
Figure 2. Rearrange feature - participants can fit the respective livestreams, scale and transform them in relation to the background.

Figure 3. Paint & Point and Rearrange features - in a background image which has three dimensional qualities, the different overlay techniques serve to create an immersive space in which the participants take different positions in the pictorial space.

Here the participants are using the Paint & Point and Rearrange tools to transform their livestreams, inside a drawing by architect Cedric Price of the iconic Fun Palace project.
Figure 4. Paint & Point feature - invites users to experiment and to have fun by drawing together on top of their video chat canvas.

Note, again, these users are not really in the same place: they just appear that way.

Figure 5. The COMPEIT Café, a work-in-progress 3D virtual environment which, in the current iteration provides a situational framework.

Given the right prerequisites it will mature into a customizable shared workspace in which documents can be stored and relevant information can be highlighted in the peripheral areas while maintaining a high level of interaction.
4. SharedSpaces

In the current implementation of “Immersive Spaces”, the feelings of social and spatial connectedness are targeted by placing all participants in the communication together in front of the same background. This feature is referred to as SharedSpace. The background of the live video stream from each user is stripped from the foreground using a chromakey filter. The video streams are then super-positioned in layers on top of each other to create the illusion for observers that the remote users are all together in the same space or view. A screenshot of the SharedSpace in action is shown to the left in Figure 1 at a mediated group yoga session, with the picture-in-picture showing the composite result of video fed from each of the two nodes. The picture to the right shows a more ordinary meeting situation, with users from three different physical nodes who for an on-looker seem to all be gathering at Beaubourg, the Centre Georges Pompidou in Paris, France.

As shown in Figure 2, the participants can scale and transform their respective video streams, using the Rearrange feature, and in various ways adapt their representation to the background. These shared actions in effect lead to the collaborative design of a shared virtual space, where the process as such arguably strengthens the experience of mediated presence and immersion. In Figure 3, the participants have chosen a background image with strong three-dimensional qualities, which creates an experience of a shared virtual space that can be monitored in various ways, for example by using the Paint & Point feature. The feature allows users to be inventive and creative, and in this way it supports socialising and having fun, as seen in Figure 4.

A key factor in immersive spaces, we think, is the possibility to create something together, sharing various kinds of media and using interaction tools to discuss and share ideas. We have therefore added functions for providing means of input via PCs and mobile platforms; instantiated as a paint overlay function as well as a text-based chat feature. The paint overlay lets users draw together on top of the shared video chat window, using typical computer drawing tools. These include a brush, an eraser, various shapes, and a colour picker. This is a very typical setup, similar to drawing programs such as Microsoft Paint, and should therefore be familiar to most users. In order for all users to have a consistent view of the drawing, each user's actions are shared via WebRTC data channels. By having the drawing area on top of the shared video, new interactions are made possible: for example, users can draw clothes on top of each other or point to each other's drawings.

To further support collaborative creation, a feature currently labelled COMPEIT Café, offers a shared 3D virtual environment in which the chosen background appears on the far end wall. As seen in Figure 5, the participants have moved to the COMPEIT Café, a space in which the different planes and surfaces in this space offer great potential for collaborative work and interaction and will be developed as a separate room type in future iterations of the Immersive Spaces.

A straightforward way to give people the impression that they are together is to place them all in a common virtual environment. Sharing spaces, or rather sharing sensory stimuli originating from one location with someone located in another space, arguably gives each participant a sense of being together with others. In a first step we have created a common background using a simple chroma key filter. In short, a chroma key filter selects pixels of a certain colour range in an image or video stream and replaces them with the pixels of a second image such as for example a background photo of a public or private place (e.g. Paris, or a picture of the interior of our labs). When the user is standing in front of a uniformly coloured background (green or blue work best), the resulting image shows the user in front of a new background.

In immersive spaces the video streams from several users are combined. Chroma key compositing is used to place all users in the same virtual environment. Examples are shown
in Figure 1 and Figure 2. Each participant can set a colour range to act as a transparent part of the video image being sent in collaboration with others, but the dominant colour range in a user’s video can also be detected automatically and made transparent. This allows video layers to be partially visible on top of each other - where the set key colour areas become transparent. It also allows a common background, such as a still image or video, to be shared amongst the participants creating a sense of togetherness. Each user sees their own image together with the images of others in the same composite browser window, with no mirroring applied.

In order for chromakeying to function properly, a single-coloured background has to be set up visible to the camera. This could be the wall itself, but it is more effective to use a fabric or paper background in a uniform colour that does not occur in the foreground, such as signal green, very saturated blue or similar.

The use of chroma key in this context can be seen as a technology transfer from the broadcast industry where chroma key is used extensively in weather forecast presentations, advanced trick photography and film-making. Users are free to re-size and rearrange the chroma keyed videos (Figure 2). Changing the size of the video in the plane of the screen is an effective way to create the illusion that participants are moved forward or backward in the virtual environment (in this case created by a static background image). Users are also free to upload their own background images. This means that each video chat session can be uniquely customized to fit the users’ current needs.

Taking a step further from a single, flat background, towards a more immersive experience, introducing layers “rendered in 3D” is a natural step. Chromakeyed video streams can also be rendered as textures in virtual “3D” environments. This has many advantages. An important advantage is that the background can be rendered in a geometrically correct way and is not restricted to the viewing geometry of the camera that has created the (static) background. Furthermore and linked to the notion of viewing geometry, it gives the possibility to add perspective cues to the common virtual space.

Linear perspective in images and in the “physical world” is a strong depth cue for people. Earlier research has shown that people are sensitive to incorrect perspective renderings [e.g. 6,7]. In a geometrically correct perspective, the picture on the screen projects into the eye as the real world would. In this case the viewer is positioned at the picture’s centre of projection. However, this is usually not the case: that is, usually the viewer is not at the centre of projection, which would make the drawing geometrically incorrect. The geometry of perspective rendering is described in [7][8] . A geometrically correct drawing is sometimes also referred to as an Alberti window. Ling et al [7] found earlier that feelings of spatial presence are affected by the perspective shown. Interestingly, they also showed that the amount of perspective in the image that gives the highest sense of presence is not the geometrically correct perspective, but a perspective that is geometrically correct for a viewing distance of about 1.5 meters in front of the display screen. Pont et al [8] also showed that perspective drawings of a simple wire frame cube were judged to be most geometrically correct for a fixed distance. Using input from task T4.1 Virtual Camera 1.0 we have created a virtual 3D environment to hold the chromakeyed remote videos. At present we do not know how feelings of presence are affected when the perspective renderings are updated dynamically. That is, of course we know from the literature that the related phenomenon of motion parallax leads to strong perception of depth, but we do not know whether this motion parallax should be calibrated to be geometrically correct or like for static images best be rendered from a slightly incorrect view point.

Known problems associated with chroma keying apply to our software implementation as well. First, and most obviously, a large, monochrome screen or wall is required. This greatly limits the number of users who can make use of the functionality. Second, users cannot wear clothes of the same colour as this background screen, since they will be removed from the video. Finally, relatively even lighting is required for the chroma keying to work properly. A
possible solution for these problems would be to use depth-based compositing instead of chroma keying, or full static background removal in the absence of a depth-capable camera. A depth sensor could be used in combination with regular video to remove the background from the video.

The quality of service in WebRTC is foremost limited by each participating computers data throughput capabilities, graphics card rendering, audio capabilities and in some cases also the CPU. In a peer-to-peer setup, there is no server component however to limit the level of data interchange. We note that this is a key scalability problem for the COMPEIT Media Framework (see D3.4 First Prototype) to address.
5. **PixelPresence**

The COMPEIT presence system supports individuals and distributed groups who want to stay close with one another on a regular basis, ready to spontaneously interact in video windows such as SharedSpace. Whether the context is professional or social, ambient forms of presence are also called for, to support gradation of the immersiveness and perhaps especially to prompt users to join a shared virtual space. From D2.4 Value Sensitive Requirements 1.0, we learned that people want to be aware of what others are doing, and also where they are. This, of course, is quite different from keeping a videolink open 24/7. For example, a child’s use story states: “It’s also nice to have a little bit the feeling about what others are doing”. Children want to know who is at the playground, at this moment. Based on this information, they may decide to join, or not to join. Similarly, professionals have a need to access other people’s schedule, and may choose to drop by the office (or make a phone call) at a time they are sure not to disturb. In traditional office environments, it was fairly easy to know when someone was available or not, because people normally worked in the office environment, but in today’s society this is no longer the case, as people have multiple workspaces some of which are virtual. This was reported on already in D2.3 High-Fidelity Mock-up and illustrated the need for ambient presence prompters, such as the PixelPresence, the Softwall, the TangiBall (see D4.3 Tangible Interaction) or Little Polyhedron. These design features form part of the physical interior environment and take the role as signifiers (with varying meaning, depending on a user group’s preferences), to display a person’s “declaration of presence” or “willingness” to be present in a mediated space.

PixelPresence is a feature in Immersive Spaces that we can imagine projected onto a wall, almost like a painting or a wallpaper [Figure 6]. The pixelation contributes a discrete and aesthetically appealing representation of a remote space(s), and will flicker when users move remotely. From afar, this means we will know when a space is populated, and we may feel prompted to make contact. On agreement, the participants will decide to “de-pixel”, i.e. to see and hear each other, either in a traditional video window, or using the SharedSpace feature. PixelPresence thus promotes continuously open video windows (between friends or colleagues in a social group) using large displays, to render something that appears like a wall-paper or a painting in a physical environment. Pixelation can be seen as one way to *shroud* the video channel, and a similar shrouding mechanism would be possible to add for the audio channel.
Figure 6. PixelPresence - the pixel pattern creates a filter through which presence and a flickering movement can be detected for the remote viewer.

*The video stream becomes an artwork, less revealing and intrusive than a traditional livefeed.*

In the current iteration of the Immersive Spaces component, we have not yet implemented all the functionalities we foresee in terms of PixelPresence. We are currently experimenting with relevant functionalities in a prototype for a local user:

The local prototype allows a user to modify the pixelation in different ways, for example by resizing and remodelling the pixels and their borders. In consideration of the PixelPresence as an artwork in a home environment these are useful features, both for users who want to create their own PixelPresence art work, or who would like to project an existing painting as a basis for PixelPresence. In the screenshots below we have used Paul Klee’s work “Ancient
Sound, Abstract on Black” slightly, which will flicker beautifully when someone passes by.

[Figure 7]

Figure 7. PixelPresence - more artistic possibilities planned for the next iteration.
6. Use Contexts

In this section we discuss the relationship between Immersive Spaces and user requirements and how we expect to customise the Immersive Space component for the planned piloting (see the upcoming D6.2 First Pilot Report) as well as for wider commercial applications. Tentative scenarios for different use contexts that are currently in preparation, are described below.

For example, we foresee that Immersive Spaces components may be customized for three specific target use contexts, i.e. distributed work, supporting young people with special needs in care centres, and mobile journalism. Further users from online communities is also a particular use context to study.

The below use contexts are our hypothesis for how Immersive Spaces can be used, to be verified through piloting and reported in D6.2 First Pilot Report.

6.1. Immersive spaces for distributed work

A distributed work team can have SharedSpace video windows open 24/7, projected onto large surfaces that become wallpapers in a local office environment. By agreement, the image is pixelated (PixelPresence) in all locations, which means that when there is movement in a remote space, the image flickers on the local wall. This feature supports the experience of a shared mediated space, since it also invites the users to take various actions:

- By agreement, PixelPresence can be switched to become a clear video window. Such actions can be prompted by additional features in the COMPEIT toolbox, for example Photoframes, TangiBall [Figure 8 and D4.3 Tangible Interaction] and other COMPEIT components that trigger colleagues to declare their presence and availability in real or virtual spaces; and to prompt each other, e.g. as Softwall, Little Polyhedron and Little LED Matrix.

- In an informal context, users may now talk and interact in realtime across two or more locations, for example to enjoy a “mediated coffee break in a park setting”, although everyone actually remains in their respective office interior. [Figure 9, left]

- In a formal context, a slide presentation can be brought into the background, and users can point and draw together (Point & Paint). Further, the presenter can choose to be displayed in front of the slides. S/he can use the Scale feature, and will appear to be inside the slides presented. [Figure 9, right]

- Users can also decide to interact inside the 3D COMPEIT café, which can be designed as a virtual representation of the actual office interior. The SharedSpace functionality can be used (currently appears on the back wall). The users’ live videostreams can be scaled, skewed and transformed, hereby allowing users to take different positions in the 3D environment. The planned development of the tool will make it easy to share and visualize files as a ‘library’ (in the current iteration this is represented as bookshelves on the right hand side). The space will ‘remember’ who was recently here (if authorized), by adding and displaying snapshots of the users on to a ‘memory wall’ (currently the left wall). Virtual representations of tangible devices and architectural features will also be available to prompt actions in the shared workspace.
In a formal meeting room, the above will allow a seating of participants around a table, where each participant is granted a non-hierarchical ‘round table view’, by monitoring the virtual camera view.

In future iterations, additional virtual cameras will be added, and the possibility to create eye contact/motion parallax will be explored.

Figure 8. PhotoFrames - Demonstrations at EIT ICT Labs in December 2014.

Left: PhotoFrames. The portraits reflect an individual’s availability and declaration of presence (in physical or virtual space) using LED indicators. Right: Tangiball. The Tangiball features two LED displays: one for direct communication, and one for displaying data in an ambient way. Three touch points enable simple, tangible interaction, while a Web application provides more fine-grained control (e.g. for setting the ambient light on the Tangiball, sending “light smileys”, and creating light animations.

Figure 9. Office workers at Ericsson, Stockholm, try the SharedSpace as a presenter tool.

The participants have chosen a “park environment” as their shared setting and thus appear side by side on the screen. After a moment of introduction in this informal setting with both (all) participants, the video is switched off for all but the presenter. The presenter can scale him/herself and also appear live inside the presentation!

Immersive Spaces components can thus be used in professional contexts, for example as envisaged above by distributed office workers or academics. This will be a great use context for evaluating key aspects of immersive spaces, and we have already made preliminary user tests with a unit at Ericsson, Stockholm and with EIT ICT Labs, both interested to implement parts of the system in different work locations [Figure 10]. We expect to test immersive spaces as part of D3.4 First Prototype, to be reported in D6.2 First Pilot Report.
Further, within our own team of academics and professionals in the COMPEIT consortium, we have integrated several of the COMPEIT features to create a shared work environment between KTH, LTU, TNO and TUD, and we also carry out expert evaluations on a regular basis as part of our iterative design process. This is for example illustrated by the research team’s own prototypic environment, the COMPEIT café described earlier, which provides a shared 3d virtual workspace, where we already meet, draw, create whiteboards instantly on various surfaces etc, and soon will explore further, for example by storing frequently used documents.

Figure 10. Distributed user tests at EIT ICT Labs in Stockholm and Helsinki, Nov-Dec 2014.

Finnish National Television (MTV 7pm news) captured SharedSpace during their documentation of Results Day.

Expert evaluation of separate features in the Immersive Spaces component have been ongoing in 2014, involving researchers, students and office workers in distributed setting, in a manner that continuously informs the design work. While the above mentioned professional contexts are fairly generic, we also seek to customise specific features from the toolbox to suit particular user needs, as part of the preparation for piloting, to be reported in D6.2 First Pilot Report. As an example, the Paint & Point feature was developed in direct response to user requirements raised in WP2 by professional medical doctors who contribute remote expertise to colleagues, and expressed the need to draw and highlight features in the live videostream, for example to indicate a proposed action relating to a particular part of a human body, as depicted on the video. This example may lead us to prepare a pilot of this feature with the involved unit at Karolinska University Hospital in Stockholm and the local hospital in Visby, Gotland (a large island in the Baltic Sea that belongs to the same organisation within Swedish healthcare).
6.2. Immersive Spaces for socialising and fun

The same features as described above can be customized to suit the interests and needs of young people, and any distributed group of people interested in socialising and having fun together. From WP2 User Requirements we learned that young people want elaborate support for ‘doing things together’ and in the planned piloting we will prioritise visual tools (e.g. touch/feel/create/design your own) and functionalities for users that may have difficulties or are uninterested in following text instructions in traditional computer interfaces, as an example.

In one test scenario, a teenager lives in a special needs home environment. In his/her room, a computer is connected to a short-throw projector which displays a large image on the wall. Pixelated and like a wall-paper, this creates a mediated extension to a friend’s room, somewhere far away. The pixelated flickering that occurs across the wall, when someone passes by or moves a lot in the remote space, creates a feeling of togetherness, of sharing a space, and invites engaging in an immersive space. The two friends may have agreed that “when Tangiball goes green”, or, “when Little Polyhedron flips over” (or other signifiers) - the pixeled wallpaper (i.e. **PixelPresence**) should automatically turn into a video window, so the two friends can interact by seeing and hearing each other in real time. They can also select various features from the **SharedSpace** toolbox, allowing to creatively design and elaborate in relation to their shared interest areas:

- In the SharedSpace they appear side by side, and can change the background setting to anything they like, by choosing a preset background, or uploading an image, or pointing to a live-feed
- They can use the **Paint & Point** function, and also Scale, transform, and skew their respective video feeds, hereby creating fun 3D effects, also by designing their own 3D virtual space for the interaction. Inside this space, they can move features, build and design artifacts, store digital resources that they like, share them with other friends, create extensions to other virtual spaces, and add cameras.

6.3. SharedSpace for mobile journalism

While the Immersive Spaces feature set already supports socialising and co-creation of virtual shared spaces, it also creates new potential for specific broadcasting professional contexts.

An example is that **SharedSpace** can be adapted to commercial mobile broadcast settings, for which the chroma-key component can be very beneficial to broadcast situations (bringing field and studio together) and where the **Paint & Point** feature enables presenters to point and highlight actions by drawing directly in the livestream video. The broadcast audience and other individuals will produce and consume video in broadcast settings. This could become a consumer oriented service similar to what is going to be used by professional broadcasters. COMPEIT will allow broadcasters to access broader content than today, since consumers would be able to communicate directly with the broadcasters and become reporters and producers of content.

Environmental data (usually public) from the physical environment, can lend input to events showing up in the virtual space. As an example, a room being warm, could render a beach-like backdrop with palm trees and umbrella-toting drinks. Similarly, an alert on-screen or on a tangible device can originate from a CO2 sensor with a high reading, or, in rooms that are densely populated, thus triggering many motion-sensor events, can show up highlighted in a floor-plan map inside the SharedSpace. The relation between physical and virtual spaces is thus tightly tied together with technology for making collaborative work and communication more lively and immersive.
6.4. The COMPEIT Fun Palace in the Experience Lab

The COMPEIT Fun Palace is an online toolbox with select features from the Immersive Space component that is available via D6.1 COMPEIT Experience Lab, inviting users to create their own SharedSpace for socializing and fun. It has been online since October 2014 and was created specifically to invite users from the Fun Palace web community, a UK-based initiative (www.funpalaces.co.uk) that we approached since it gave us the possibility to identify test users for continuous piloting [Figure 11]. Between October 2014 and April 2015, the Experience Lab (experience.compeit.eu has received over 620 visits).

The name “Fun Palace” originates from an acclaimed future-oriented initiative in 1961 by the British architect Cedric Price, film director Joan Littlewood and cybernetician Gordon Pask. The Fun Palace was intended as a novel and highly flexible public performance place in London, facilitating artistic and architectural experimentation and research based on user feedback loops. Its framework was a building structure where few components were fixed and where interactive media installations would serve temporary performances and events of different kinds. The vision was a completely new form environment “capable of adapting to meet the possibly changeful needs of a human population and capable also of encouraging human participation in various activities.” [9]

The reason why we describe this initiative is that, today, it would be fully possible to design a mixed-reality WebRTC Fun Palace that serves as a fruitful analogy to the COMPEIT presence system [10]. Once complete in 2016, COMPEIT will support a wide spectrum of mediating presence, for example allowing users to control features inside a building (and its virtual representations), in ways not dissimilar to the original ideas of the Fun Palace. The original Fun Palace was designed with the intention to let a building transform, following the interests from its visitors. In line with several other initiatives at the time, the proposed structure incorporated change, chance and uncertainty, as a self-regulating process, modelled on computer programming and Cybernetic thinking and, not least, linked to avant-garde trends such as Pop Art and Fluxus. The project was never realised as a building, which to some extent can be explained by its high ambitions in terms of media and communications hardware, technologies which at the time created very obvious limitations, but that today can be implemented in everybody’s web browser!
Figure 11. COMPEIT Fun Palace SharedSpace initiative - presented online 4th Oct 2014.

The online 2014 version of the COMPEIT Fun Palace invited people to meet in joint mediated spaces via their web browsers, sharing preset backdrops, live video and overlays. [Figure 12] Following simple instructions on the Fun Palace community website, a participant would simply need a laptop with a camera (or a smartphone). A short filmclip was made to show how easy it is to calibrate and create a SharedSpace: Seated in front of something green or blue, one simply opens the indicated web-browser and enables the camera. [Figure 13]
Select a room

Figure 12. Fun Palace browser window - offers a range of preset architectural atmospheres, such as ‘Centre Pompidou, Paris’ or ‘Fun Palace, London’.

Figure 13. A short filmclip to show how easily one creates a SharedSpace:
https://www.youtube.com/watch?v=7zyL6GcGlBc
7. **Future Work**

In D4.8 Immersive Spaces 2.0, there will be general improvements on key aspects like *spacial connectedness* (DoW), *social connectedness* (DoW), and *relatedness* (D2.4).

In addition, the core features will be documented with separate Javascript APIs:

- **SharedSpace** - a VideoCanvas module that allows arbitrary mixing of video streams
- **Paint & Point module** - if desired separate for each VideoCanvas
- **Rearrange** - a Resizable module.
- **PixelPresence module** - also supporting the artistic modifications described in chapter 5

This will make it possible to add ImmersiveSpace features also to other room types, in particular the room types that implement the services created by WP5.
References


Web resources

COMPEIT Experience Lab: http://experience.compeit.eu/

SharedSpace web resources

Filmclip from EIT ICT Labs Stockholm: http://youtu.be/10zp2rzpbu4
Filmclip from EIT ICT Labs Helsinki by Finnish Television MTV (18-minute mark): http://www.katsomo.fi/?progId=419824
Video instruction on how to create a SharedSpace: https://www.youtube.com/watch?v=7zyL6GcGiBc