MR Tent: A Place for Co-Constructing Mixed Realities in Urban Planning

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ABSTRACT

This paper describes how mixed reality (MR) technology is applied in the urban renewal process to help mixed groups of stakeholders collaboratively construct, explore and discuss their vision of a particular urban project on site. It introduces the *MR Tent*, a physical enclosing for a collection of MR prototyping tools. We report findings from the most recent participatory workshop with users on an urban planning site concerning the interaction space, views, tangibility and representational formats.

KEYWORDS: Mixed Reality, tangible user interfaces, urban planning, architecture, participatory design.

INDEX TERMS: H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems – Artificial, augmented and virtual realities; J.5 Arts and Humanities - Architecture

1 INTRODUCTION

Urban planning today needs to explore a wide range of aspects concerning the built and social environment. Hence, projects are vastly complex; they affect investors, technical specialists and citizens, and they play an increasing role in community politics. To avoid planning mistakes, it is very desirable to involve the stakeholders from an early stage on [1,2]. Stakeholders bring their different viewpoints into the urban planning process. The objective of this process is to confront and refine these viewpoints and to ultimately achieve a common vision of the urban project. In order to obtain a satisfactory outcome, it is essential that stakeholders' different points of view are successfully expressed and apprehended. We contend that bringing participatory media technology onto the site itself will spur the participants' engagement and their understanding of the urban planning issues at stake. It allows them experience the 'aura' [8] of the place, while expressing, confronting and aligning their visions.

We approach this goal by supplying users with a set of MR tools that allow them create and manipulate visual and auditory scenes, and mesh these scenes with the real environment of an urban planning site as an integral part of expressing and experiencing an evolving project. The technical infrastructure is housed in a specifically designed *MR Tent* (Figure 1), which allows bringing technologies that are normally available only in laboratory settings to the site of an urban project registering reality with the co-constructed virtual scene.

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Figure 1: The MR Tent is a portable lab for using Mixed Reality in urban planning on location

Related works deal with the use of a tangible planning table (e.g. [6]), the use of MR directly on the construction site [3,13] or the idea of painting on virtual 3D surfaces (e .g., [5]). In this paper, we focus on how the MR Tent combines these approaches to support different types of stakeholders in the collaborative creation of mixed reality scenes as an integral part of expressing their ideas about an urban planning project.

2 THE MR TENT FRAMEWORK

The MR Tent was developed in a participatory design process undergoing several cycles of development-evaluation-redesign, each connected to a participatory workshop in the context of an urban planning project. It involves a multi-disciplinary team of technologists, artists, and social scientists working together with experienced urban planners. The urban specialists in the team suggested a set of 'urban themes' they considered as particularly relevant for urban projects and illustrated these by providing a number of visual examples: scale, temporality, borders and layers, fuzziness, ambience, and mobility. These themes guided technology development, as well as scenario and content creation for the workshops with users.

The technical infrastructure is set up outdoors in the MR Tent (Figure 1) on the site of the urban project. It is a combination of previously developed components (sketching tool, tangible tabletop, Hypermedia Database) that have been significantly extended and integrated to support the participant's interventions in a seamlessly united workflow. While certain aspects of these components have been studied in previous work [9,10,11,12], we describe here the novelties of the integrated framework.

The MR Tent becomes the head quarter for a workshop aimed at stakeholder participation, which incorporates MR as well as conventional planning activities (Figure 2 left). A round table in the centre of the MR Tent provides a top view of the MR scene [10]. Users can move and turn objects of different colors and shapes, while an overhead video projection on the table provides interactive feedback. While our previous systems were limited to the detection of positions, colors and sizes, the latest version is able to additionally recognize the shapes and orientations of the colored objects. A physical map representing the urban site can be placed on the table and is pre-registered to define the coordinate system of the interaction.

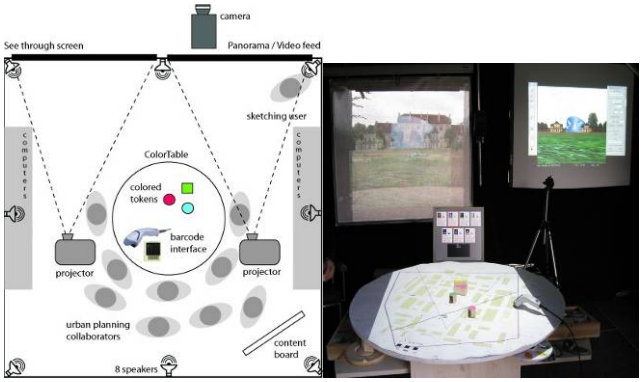

Figure 2: The technical setup inside the MR Tent is centered around the two projection walls and the projection table

Inside, two large screens show views of the urban site (Figure 2 right). The views are alternatively fed by a live video stream from a remote controlled camera, a live video transmitted by a 'scout' in the periphery of the tent, a panorama image prepared previously or a direct view seen through a half transparent screen. This see-through screen is made of a white grid providing both a reflective surface for virtual objects and an amount of transparency enabling a view onto the real scene. The multiple interactive views convey and encourage the urban design process. The vertical screens show egocentric views directed "into the environment", while the horizontal surface (table) shows an exocentric, top-down view "on the environment", inspired by maps.

The new framework supports several interaction possibilities of the base components, such as sketching [11], navigating [10, 11], placing and modifying objects [10] and generating geometry [11]. Significant extensions of these interactions are:

Rows of identical objects: Square objects of a color previously loaded define the end points of such a line and are filled up with identical objects, spaced at adjustable distances.

Roads and flows: In a first step, a network of streets and paths is defined. To create roads, rectangular objects have to be positioned at both endpoints (Figure 3). Colors differentiate highways, normal roads, footpaths and waterways. The second step consists of users defining a start and endpoint of the flow. Pedestrians, bicycles, cars and boats advance on the closest connection between both points. In order to animate the moving objects, we store view dependent cyclic flip-frame animations.

Defining land use: For the rapid definition of land use we used an automatically computed Voronoi decomposition using circular tokens placed by the users as anchor points. While the top view projection shows the borders of each Voronoi polygon in wireframe, the cells in the egocentric view texture the ground (Figure 3). Eight colors are reserved for different types of land use, the corresponding texture is illustrated on the side of each object.

Figure 3: Example of a composed scene (top and perspective view)

Soundscapes: The MR Tent supports the exploration and manipulation of soundscapes. Each object has both a visual representation and a 3D sound associated to it. The resulting soundscape can then be explored in three different manners by activating a different hearing position. Users can activate the camera view as hearing position and listen to the sound which corresponds to the panorama or video feed. Another possibility is to activate the hearing position as part of the flow, the resulting soundscape corresponds to the path of an element moving in the flow. Finally, the hearing position can be interactively controlled by a colored token, defining the virtual listener's position and orientation.

History and persistency: The overall configuration of the MR Tent application framework can be stored in a history file. When the users agree that an interesting scene has been composed, they can trigger a 'freezing'. All color tokens currently placed on the table are permanently added to the scene, and the corresponding tokens are freed. A frozen object can only be removed with a special eraser token. In addition to the freezing capability, users can take snapshots of their compositions at any time. The current exocentric and egocentric view is then saved as an image and automatically printed.

3 Field Study

The participatory workshop reported here is the latest of a series of five such events, aimed at confronting end users with the evolving technologies of the MR Tent in the context of real urban planning projects. The workshop in Cergy-Pontoise, Paris, took place Sep 10-13, 2008 and was organized around a project still in its conceptual phase. The objective is to convert 'La Caserne Boussut', an old military territory encircled by high walls, into a space that will connect the new town of Cergy with the old town of Pontoise.

Several urban planning issues were identified: how to connect the site with the surroundings; how to regulate mobility; how to think about the central public space; which housing types to introduce; which activities to invite, as well as the overall ambience of the site. Different types of stakeholders were selected and consented to participate in the workshop - urban planners and specialists, members of the municipality, including the director of planning, as well as representatives of the local community.

All participants had received a set of 'cultural probes' [4] in July 2008 and our research team had met them to help them elaborate their vision of the future of the site in the form of a participatory interview. From these visions we extracted two scenarios as well as visual and sound content. We also prepared four photographic panoramas from different viewpoints and two maps of different scale for the table.

All workshop sessions were videotaped. In addition we took pictures, focusing on participants' interactions both, with the technologies and with each other, and saved relevant scenes.

Constructing a vision of the site. To give a flavor of participants' interactions, we focus on one of the two key sessions with six participants. The group had quickly accommodated to the MR technologies after the initial tutorial. After that they decided on the questions they wanted to focus on: how to connect the site with the two towns, the university and the river Oise; how the centrality of the site should be; and what kinds of habitat and activities to envision.

For a while they simply discussed which types of connections to plan for, switching between the two maps, to then create three transversal roads and a pedestrian path following the main axes on the table using the tangible objects. The group 'invented' a way to

introduce flows on all of these roads, which added to the depth of the panorama view of the site.

The next step was to introduce objects in the scene. Their first move was to place a bus stop next to one of the roads, together with a bus. They immediately reacted to the noise of the bus, replacing it by a tram. Some time was then dedicated to placing different residential buildings. As they felt that the prepared 3D objects were too big, they used the sketching tools to reduce their size and changed their appearance. Participants created two rows of two different types of buildings (six-storey building, individual housing). In this moment they started making more regular use of the different views, switching between the panoramas and the video-augmentation in order to better understand the spatial arrangements they were constructing.

They also went back to the question of connectivity, adjusting the position of one of the roads to the new housing situation. Satisfied with their result, they started adding other content, such as billboards of a concert hall, a library, a park in between the buildings. Activities where visualized by people sitting on terraces, a playground, and so forth. They also decided to place one object for indicating varied ground use from grassland to a more abstract pattern. In the end they explored the soundscape, using the object for changing the hearing position and 'following the sound scout' on his way through the site providing an audio impression on his way through the scene. The session concluded with one of the urban specialists of our team giving feedback. He used the sketching function on top of the last panorama image for discussing the skyline of the participants' view of the site for making comments. Then followed a debriefing session around the table where participants commented on their experience.

4 DISCUSSION

Our general impression from all the sessions was that the participants organized themselves very well and appropriated the tools and objects they needed for constructing and debating their vision of the site.

Appropriating the interaction space - the MR Tent creates a particular combination of inside and outside, of views and perspectives. Participants convene and collaborate within the 3D spatial arrangement of table, whiteboard, and projection surfaces. Their interaction with the technologies is constrained to the 2D space of map (on the table) and projection screen (for sketching and painting objects). The egocentric view onto the projected scene invites individual interventions, such as sketching or texturing an object. We observed participants walk up to the screen and point to something the others had not noticed. We contend that the affordances of this interaction space are crucial for experiencing the mixed reality configurations participants develop.

Participants assemble around the table with a view onto the map to discuss an intervention; they select content cards from the whiteboard, pick up different types of tokens for enacting their interventions (building roads, activating flows, placing objects or creating rows of them), and they use the barcode reader for activating different views onto the scene. At the same time they orient themselves in the space of the tent towards the two projection screens, one of which provides a direct view of the site through the frame of a window.

Connecting views - the exocentric top view onto the map on the table mainly affords exchanging opinions, constructing interventions and discussing them. It provides the best overview of the site, represented by a map. It also shows the objects placed in the scene, represented by circles, dots and bars. This 'diagrammatic' representation provides feedback – participants can check all the elements in the scene. We identified a need for even more visual feedback on the map although.

The attraction of the 360° (photographic) panorama lies in the possibility of exploring the whole site, turning into different directions and looking at interventions from different viewpoints. The panoramas we produce contain depth information, which supports participants' spatial understanding. Such an understanding is crucial to aligning the virtual with the real scene in a meaningful way. The advantage of the video augmented view is the temporal aspect of the live video stream visualizing and combining the created scene on site allowing a direct reflection on the reconstruction site. The real site allows an appreciation of the space and an experience of its 'aura', which is multi-sensorial. From an experience point of view these different representations provide different resources for understanding and experiencing. The strength of the MR-Tent lies in the combination of real site and physical map with other perspectives on reality.

We could not identify any patterns in how participants used the different views available to them but we could observe them frequently switching between panoramas and video, looking around and zooming in and out, eventually but not always commenting on the different views (Figure 4).

Figure 4: Looking at a scene from two different viewpoints

The role of materiality - the tangible user interface we have built affords simultaneous, embodied interaction. Through activities, such as placing objects, moving them on the map, changing their parameters, directing flows on the map, and so forth, participants 'perform' a mixed reality configuration, adding a dynamic element to a scene. The material artifacts we have designed take a key role in the process of creating the MR scene (Figure 5). While the haptic qualities of different materials and the rather intuitive interaction modes clearly support participants' engagement and co-constructing, there is need for even more simplicity in the choice of shapes, materials, and interactions in order to support the accomplishment of complex tasks.

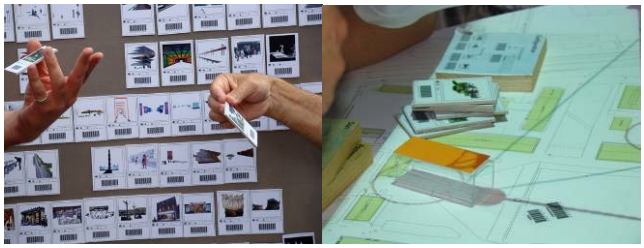

Figure 5: Selecting card; combining different materials.

Representational formats - many authors suggest that visualization is the key to public participation (see e.g. [7]) but the question remains how to enrich the available repertoire of representations – from abstract sketching to realistic 3D renderings - with visualizations that enhance stakeholders' understanding of an urban situation. We provide 2D (billboards) and 3D objects, moving elements, and sound.

3D objects are important elements of the constructed mixed reality scenes. Some content, such as for example buildings, has to be 3D so as to maintain the sense of volume and orientation within space. On the other hand, 2D objects are needed for conveying 'telling detail' and creating ambience. They support the construction of narrative on top of an architectural intervention (Figure 6 left).

Moving objects – pedestrians, cyclists, cars, and boats – not only introduce an additional scale in the scene and provide depth information, but also animate it. Participants' gaze drifted between the map view, where the flow was represented as moving dots, and the animated mixed reality scene. They examined the spatial arrangements of 2D and 3D objects they had created in relations to these flows, eventually changing the position or type of road.

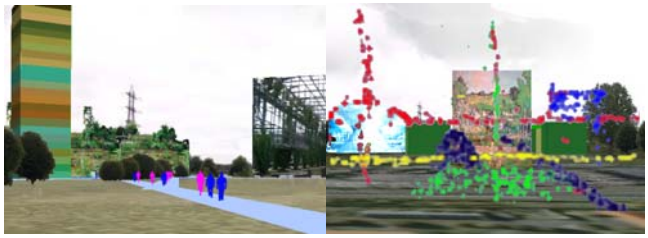

Figure 6: Combining 2D and 3D objects; sketching on a scene

Sound proved to be a fascinating but complex medium. Although participants sometimes changed the sound file connected to a visual object, the sound, if not intrusive, mostly stayed in the background. Only when asked to explore the soundscape associated with a scene from the point of view of a pedestrian's moving position, as well as by moving the hearing position (represented by a red token), participants became aware of sound as an additional medium for representing and evaluating the site.

Working with the sketching tool requires stepping out of the circle around the table, moving in front of the screen and changing tools. We identified two typical situations that encourage this step. First, participants are interested in working on the rather abstract 3D objects we provided: to cut out parts, change texture, transparency, add color. Secondly, there is a need to sketch on a composed scene, adding a whole layer onto the scene, making annotations, adding an object 'on the fly', explaining some of the implications of participants' decisions (Figure 6 right).

Participation - all participants appreciated the collaborative aspect of the MR Tent. The table acts as a mediator insofar as participants do not have to discuss in a confrontational way face-to-face but by means of gesturing, setting interventions, commenting, and modifying. This is an inclusive mode, which does not favor the expert. It leaves space for everybody. The MR Tent provides a space for 'mixing realities' that can be viewed and evaluated together. The diversity of perspectives as well as the presence on the site enlarge this interaction space, hence also the means of expressing and experiencing. People point to the panorama view, they cluster in front of the see-through, they look for content, they zoom into the video-augmentation, they may even step out of the tent to look around.

5 Conclusions

We have developed a prototype of an integrated framework of tools, an MR application supporting a range of devices for collaborative multimodal interaction and individual expression for novice and expert users. Specific to the MR Tent is the mixing of many elements – views onto an urban planning site, a diversity of materials and forms of content – in one application.

Users appreciate the range of possibilities, the simplicity of the tools, as well as the great freedom this gives them to work on the questions at stake engaging with maps, projections, cards, sketching, painting in real-time and on site. The MR-Tent is a medium for communication, bringing people together and offering a new, equal level of discussion for all participants. Our experimentations help identify salient features of embodied interaction in support of collaboration in heterogeneous teams. They provide a better understanding of how to systematically exploit the diversity of material resources for developing a 'language for shared creativity' in a complex context, such as urban planning.

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