Abstract. The problems of inspecting urban design proposals are different to that of architecture. The larger context is a crucial aspect in urban design. Generally the issues are not of detailed design but rather understanding space and spatial features. Discussions about proposals use plans and large urban design models. The models are cumbersome and access difficult for collaborative consultation. This paper introduces a prototype for an Augmented Reality system for analyzing and representational design in an urban design scale. The system is designed as a workbench for collaboratively and dynamically exploring in an urban design model.

1. Introduction

Computing faces a challenge: the scale of representation. Even if architecture can be described as built information (Schmitt, 1999), there is no consistent interface to make it accessible. As one can observe, current architectural computing is used to create non-digital content like plans and models. Design systems are not applied in a sense of a medium but rather as a tool. They do not fulfill the four requirements for a medium (McLuhan, 1994). This is partly due to the difference of virtual and real worlds in regard of their representation and lack in haptic appearance. Architectural computing tries to reiterate the same metaphors used in other domains (like text-processing, image manipulation), trapped in the existing systematic of a 2D workspace (Innis, 1951; Mitchell and McCullough, 1991).

Desktop design systems overcome some of these accessibility problems with non-mapped interaction techniques. Panning and zooming inside of a
two-dimensional representation on the screen constantly changes the scale and visible area of an architectural problem. The mental load required by this is tremendous, as the user needs to keep a mental image of the whole scenery. This has been addressed by computer human interface research and suggested respective measures (Nielsen, 1993; Hinckley et al., 2002). Some of the issues have been tackled in Immersive Virtual Environments (IVE) by so-called travel techniques (Bowman et al., 2001). Here the user is relocated without moving physically or can reach areas impossible to reach with conventional interaction. Even as this became of necessity in large-scale simulations it raises a new problem: the overlapping of direct and indirect navigation methods. The relocation in the virtual world without physical movement can result in a loss of orientation. In contrast, with Augmented Reality (AR) there is no possibility of indirect mapped navigation techniques as the virtual models integrate into the real environment. The ubiquity of data in those environments requires an interface that keeps the advantages of dynamic content and maps them sufficiently to reduce the differences between real and virtual worlds.

2. Objective

Urban design starts of with analyzing. Exploring the relationship of human kind and the city, in regard of tangible and intangible features, is of major influence for the design. Approaches of representation have been discussed earlier (Bosselmann, 1998; Pérez-Gómez and Pelletier, 1997). No designer will agree on a standard for analyzing. Subsequently, a multiplicity of representations is needed.

BenchWorks is an AR system focusing on techniques and devices needed to create 3D models for urban design. It is a test bed for interaction techniques, investigating the most common activities of urban designers working together.

The predecessor of BenchWorks, sketchand+ (Seichter, 2003), has demonstrated that collaborative tangible interaction with models can be more appropriate in early design investigation. Research from other domains indicates support for this. In prototypes for the application of AR in medicine (Kaufman et al., 1997) and geography (Shelton and Hedley, 2002), tangible interfaces and augmented vision seems to provide measurably better handling of spatially complex problems. Thus, the user is aided in understanding the provided 3D information more easily and therefore can speed up the time for decision-making.

Though the sketchand+ prototype has a positive effect on handling 3D data, it reveals the downside of those interfaces. Real and virtual world depend on each other. Therefore the restrictions arising for sketchand+ are
coupled with the physical handiness of the device and have ultimately implications on the area of application. 3D models are only usable inside a physical urban design model and can only take a small footprint. The crucial point in the technical setup is the sensitive area of the main input device – the digitizer tablet. In conclusion of the problems described above, the idea of BenchWorks was born; a test bed for Augmented Reality Design Interfaces.

Earlier approaches of desk-like systems have proven valuable support for direct interaction in Immersive Virtual Reality (VR), AR and other simulation technologies. Fröhlich and Krüger (1994) have shown with the Responsive Workbench (RWB) a system for direct manipulation on a projective VR active stereo display. It provides a high degree of immersions for the user but it is not able to integrate real world objects. The aspect of mixed reality has been explored by the Urp Workbench and Augmented Workbench or Luminous Table (Underkoffler and Ishii, 1999; Ishii et al., 2002), which both use monoscopic projection and investigate on the opportunities of different media as planning instruments in a face-to-face collaborative environment. MouseHouse and iCube (Jeng and Lee, 2003; Huang et al., 2003) went on to explore the interaction of tangible media in architectural computing on a desk-like device.

The missing link in this chain is a system able to act as a device vanishing the borders between remote and local collaboration. Designing in an urban scale is a process that includes a lot of parties, which are partly at the planning site and partly far away in other locations. In consequence the device needs to go beyond the physical representation and provide new tools for analyzing and designing in an urban scale.

3. Technology

BenchWorks combines optical tracking in form of the AR Toolkit (Billinghurst and Kato, 1999) and magnetic tracking. AR Toolkit provides an easy way to create input devices that do not rely on wires and therefore are more convenient in a multi-user setup. Magnetic tracking on the other hand provides higher precision for head orientation and in consequence provides more stable augmented vision. Thus, major benefits for this early prototype are combined: the precision of a magnetic tracking systems, the freedom of tangible interfaces and it oversees the obstacle of occlusion within the scene.
Base of the system is a *SmartTech SMARTBoard™* with a 65x40 inches sensor area, four digital pens and a digital sponge. The *SMARTBoard* is mounted horizontally to provide a table surface (see Figure 1). Users can integrate urban design models and plans by placing them on the table. A server handles the proprietary input from the board and distributes it to the client systems via XML-RPC (2003) in order to make it more accessible. All the software is based on the *libTAP* (Seichter et al., 2003) development system. To provide highest flexibility by keeping a maximum of performance, the client software is scriptable with a *Lua* (2003) interpreter. This technological base yields enough computing performance to integrate all the interaction techniques and experiments and to rapidly amend behaviors for the interaction part.

There is one client system per person to capture the video of the scenery, combine the capture with the virtual world, handle the interactive input and do the rendering for augmented vision. A lightweight head-mounted display (HMD) combined with a simple webcam need to be worn by the user.

### 4. Shared Tangible City

Choice and combination of media play a key role in the investigation of space and subsequently architecture (Kvan et al., 1999). *BenchWorks* goes beyond that, creating a toolkit for investigating the spatial features of a site dynamically in a setting with local and remote collaboration capabilities. It is not a modeling system in any conventional sense. The way a user can design in *BenchWorks* is by representation of void and non-void space of the city,
adding volumes and making notes. The modeling capabilities are completely inherited from sketchand+

No user policies are implemented in this prototype due to the fact that they implicitly exist as a kind of round-robin principle. Only one tangible interface can be active at a time, which is similar to a microphone in a podium discussion. This seems to be more intuitive for an AR system instead of abstract policies.

The interaction is tight-knit with tangible interfaces. There are two different classes of tools, the toolbox and modifiers represented by the pens and the sponge. The toolbox is used to choose the actual tool. The modifiers represent (or load for that matter) the current tool and apply them to the scenery. The toolbox as well as the modifiers can easily be shared between the users. There are different modes and tools that can deal with the scene.

4.1. TOOLBOX

The toolbox is a simple foam-board box, augmented inside the scene holding all tools.

Interaction techniques are loaded to and from the toolbox. Due to that, the four (or five including the sponge) pens can represent different tools and can be freely connected. For example the red pen can be a scribble tool and the black pen the spy-through tool (see 4.6). The designer can use them one after the other and can share them with other participants. The toolbox unfolds a three slices menu around its base. Actions can be dragged from the menu and also pop back into it.

One side of the toolbox is open. This opening is used to drag a reference of a model into the box. It then becomes temporarily stored and distributed to other connected BenchWorks systems. Similar to a “teleporter”, shown in several science fiction films, the model dragged into the box pops out of the toolboxes of the other client systems. If the users on that side accept (s/he need to drag it out) this model it becomes shared and will act like a token between all participants.
4.2. DRAGGING, SCRIBBLE AND WIPE

Another simple interaction mode is the dragging tool (see Figure 2). A user can drag around a model by simply sticking the pen through it and then dragging it along the table surface. This interaction is used transparently with other methods. If that model is shared, all instances (local and remote) will be dragged around at exactly the same position in the model space.

In order to make a certain area more important or to annotate, architects use their pencil and scribble in the plans, emphasizing a certain area, adding arrows and descriptions. This action is hardly seen in 3D models but can provide an important mode for collaborative work. To scribble (see Figure 3), the user drags a bubble out of the toolbox menu. If the scribbling finishes a flag will be set on that area with a billboard like bubble floating ahead of it. The scribbled bubble is distributed to all connected clients. In the remote location they can be accessed via the flag and also deleted.

Like a usual sponge, the digital one applied to the model can wipe out buildings and shared objects. The setup of BenchWorks can define default keywords to allow exceptions from this behavior in order to avoid landscape or similar object get wiped away. Also scribbled notes, pictures (virtual) and shared models can be cleaned away with that tool; it also deletes reference objects sent by other parties.
4.3. FACSIMILE

Plans and pictures might be important to understand the site. They can be a great source of contextual information. In order to share them between the different parties the facsimile facility can grab pictures from the augmented system and send them to the connected parties. On the receiving side they pop out from the toolbox as a flag. They can be dragged around onto the surface and expanded to show the full picture. Thus, the user can organize them spatially and display only the important information.

4.4. SPY THROUGH

If two groups work together on a design they usually share the same virtual model. Inside that model they can analyze and design. To check what the other side has done on a certain area this tool can be applied to temporarily merge the designs. Drafting a loop on the bench inside of a design replaces the existing parts with the one from the other party (if there are more parties the respective one needs to be selected first). After a short time this merger will be reversed again. The models, temporarily merged in, are colored red to emphasize them over the local ones. In future that could also be used for live-updated areas, where the design of the remote group would merge in real-time in the local model according to the given boundaries.

Figure 3. Scribbling inside the model
4.5. PISTOL

The pistol is an input device independent from the table surface. It will be used in future development to trigger actions within BenchWorks, which need to be started from an elevated position or need to be dynamic in themselves.

4.6. PUT-YOUR-INTERACTION-HERE

As mentioned before, BenchWorks uses the Lua interpreter to make the system more accessible. All interaction is scripted and a user can amend it or completely change it. It is necessary to have little programming knowledge, but there no other tools are needed. Thus, it is possible to try a vast variety of interaction techniques without changing the whole system setup.

![Figure 4. Desk review using BenchWorks](image)

5. Conclusion

This paper demonstrates several interaction techniques that could lead to a new kind of urban design interface. The major contribution of BenchWorks is the integrated remote and local collaborative Immersive AR enabled desk and its tangible media aided working environment.

Further research will investigate in the issues of usability. The interaction techniques introduced above need to be tested in a design studio setting. The planned experiments will gather data, in order to compare the experiences of designers between BenchWorks and non-augmented systems. This will lead
to a framework for design interaction techniques in urban scale Immersive Augmented Reality.

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References


Kvan, T., HungYip, W. and Vera, A.: 1999, Supporting Design Studio Learning: An investigation into design communication in computer-supported collaboration, in C. M.
Hoadley and J. Roschell (eds) *Computer Support for Collaborative Learning (CSCL)*
Lawrence Erlbaum Associates, Palo Alto, Stanford University, California, pp. 328-332.