SKETCHAND+

a collaborative augmented reality sketching application

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Abstract. The sketch is the embodiment of the architectural discussion. It incorporates rapidness and fuzziness and as this it is an object of interpretation. The interesting thing there is the question, if the usage of VR/AR already in the early phases of a design can have an impact for the quality of a design-process. Examples like VRAM (Regenbrecht et al., 2000) or TAP (Seichter et al., 2000) showed that there is a huge potential for research. The sketch as one of the parts of an early design is tightly coupled with cognitive aspects and communication. Pictured by a sketch is just a snapshot of what have to be discussed in the ensuing design procedure. The intention behind this work is an exploration about a medium which is not yet adapted to the digital world (Myers et al., 2000) and it can be easily be described with the words of Harald Innis:

Mankind constantly being caught in his own traps: language and systems, developed and most difficult to break down. (Innis, 1951)

The sketch is a kind of language used by the architect. But how we can go on further? sketchand+ is an experimental prototype to make a first attempt to gather information about the usage of augmented reality (Milgram, 1995) for the early architectural design stages.

1. Preface

Creating ideas in architectural design is one of the essential creative tasks a designer faces. Nothing else in the design process needs to incorporate such a variety of media. Furthermore, media describing sketches are fuzzy, incomplete but still connected. In consequence, the sketch is a complex media structure describing and interlinking ideas. Therefore it is a syntactical meta-medium because the overall meaning is created by the sum of sub-media like text-notes, elevations, plans, diagrams and sections. Quality of a design can partly be measured by the intensity and richness of the communication of the used media. That means that a tool, which wants to provide sketching has to integrate support for a big variety of media and should be able to arrange them for further discussion.

Another issue is: what can be done to go further than the current sketch? Isn't a sketch about arranging space and is it suitable to have a two-dimensional medium, carrying textual, drawn or perspective data – what about the third and the fourth dimension. Design is process and not a static medium. One can argue that making video and creating working models also is enough. But the question is: how can we connect them directly to create a better understanding? A problem, which needs to be considered, is that the usage of the computer changes the media paradigm. At the moment architectural computing – let it be virtual reality or CAAD – mostly only adapts certain parts of the architectural design process without interlinking them (Garner, 2000). The hypothesis is, that complex linking of media can result in better understanding of interrelations of problems in design. But it also needs to take in count that this complexity needs a new interaction paradigm.

2. Featuring a new kind of 'sketch'

The term sketch will be used here as a rough collection of ideas not necessarily dependent on certain media. The ideas represented by sub-media and linked in a dedicated order, form a sketch.

A three-dimensional sketch is a fairly unconventional medium to express ideas. Therefore the features of the geometry tools need to be easily accessible in order to provide decent usability. The interaction paradigm is tightly connected to the markers of ARToolKit (Billinghurst, 1999). Especially in the architectural design process it is obvious to connect virtual and real world through so called props. This interaction paradigm tries to adapt the usage of working models in a contextual model.

Behind the scenes this software is an advanced prototype based on the TAPframework, which glues together other third-party API's, namely: NURBS++ (NURBS geometry kernel – non uniform rational b-splines),

ARToolKit (marker recognition), PortAudio (audio recording and replay) and ffmpeg (video encoding/decoding). Sketchand+ is in the first place a Windows®-application written in C++ and can also easily be ported to Linux® and Mac OS® X.

2.1 CREATING A MODEL

The modeling part of sketchand+ shows a fairly experimental way of sketching. First of all it utilizes a freeform modeling approach. The idea behind is that even if it is on a low level, rulers and other aiding things do not belong to a sketch and can disturb the creative design process. In order to this the main creation tool is an augmented digitizer tablet with a stylus. This tablet is used to create a plan, which is extruded to a predefined height. Technically behind is a NURBS geometry kernel, which uses the input data from the tablet to create control points on a NURBS-curve, which will automatically be extruded to a surface according to some predefined values. It is using a single stroke to create a plan. Additional strokes are used to refine the curve by inserting more control points. For instance creating a box needs an initial square shaped stroke (Figure 1). If the user performs a second circular shaped stroke the software uses this one to round the box from the step before.
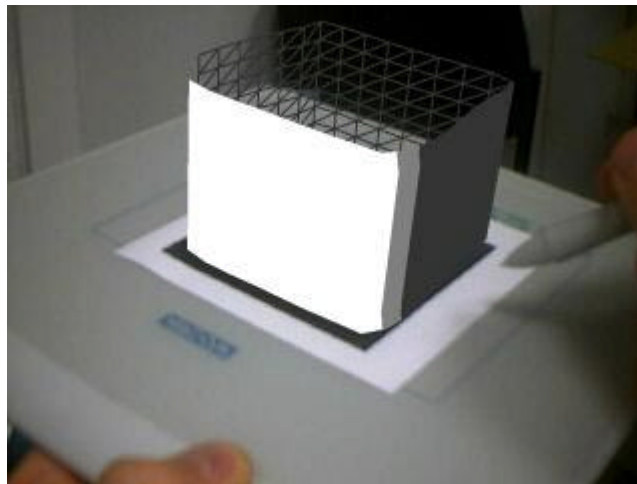

Figure 1: creating a box on the graphics tablet

This interaction technique tries to adapt the style of a pencil used with sketching paper. If using a Wacom Graphire® Tablet (or any other digitizer with more than one button at the input device) it is possible to modify the objects more precisely. For instance, pressing another key on the stylus and performing a stroke effects the geometry in the section by refining the shape

and height of the extrusion rail curve. Thus, it needs only two strokes to create a quite complex design. Most tablet pens are equipped with eraser buttons, used in sketchand+ as it is supposed to be – to clear the geometry from the tablet. In the background all these actions are tracked by sketchand+'s repository function. Finalizing a stroke adds iteration to the design and deleting opens a new branch. The repository module takes care of the additional data, which need to be stored for a design step.

To emphasize it once more: this modeling technique is just an experimental way to create models. In no circumstances it should be misinterpreted as the final way to go for modeling architectural designs in a sketch.

2.2 EASY COLLABORATION

While sketching, one should not need to care about something like networking and handling extra interfaces for communication. Sketchand+ tries to tightly integrate it in the modeling process. Therefore, it introduces a non-intrusive interaction technique, bound to the usage of props. It utilizes special storing slots. The interaction with them is quite simple. All what it needs is put them directly aside of the graphic tablet's marker and the software assumes that the designed geometry should now be stored and distributed (Figure 2).

Figure 2: Snapshot from a collaborative session with virtual models within a real model.

In order to this, it copies the geometry of the design tablet to the slot. When sketchand+ is running in collaborative mode it is now also sending the geometry-data including additional metadata to the server. The server stores it in an internal repository and parallel to this it distributes it to the other

clients, which than can see it inside their augmented environment exactly on the same marker (prop). So just the simple storing of a design cascades internally to a complex distribution mechanism. The advantage of this technique is quite simple: sketchand+ is supporting far distance collaboration as well as near direct collaboration. Users can directly communicate with each other and discuss design proposals (Figure 3).

Figure 3. Collaborative design using sketchand+

Currently the software works with a first-in technique. That means that there are no policies applied to certain participants of a design session. This issue will also be tackled in the ongoing development process. Based on the TAPframework user-policies will be implemented.

2.3 WORKING MEDIUM APPEARANCE

The sketch is a working medium, never becomes perfect in appearance. It is a psychological phenomenon as well, because even if it is not holding all information the architect can get a clue about the structure just by perceiving roughly structured fuzzy visual signals and restructure them into a mental representation (Bruner 1986). For this reasons the sketch is a syntactical medium, following the psychological laws of the "Gestalt" which are described by von Ehrenfels (Goldstein, 2002). It can describe roughly defined data and for this reason uses rough defined appearance. That differs completely from normal virtual reality appearance, which mostly tries to adapt features of reality. To achieve that the sketch is recognized as such, sketchand+ utilizes NPR (non-realistic rendering) and a special tessellation

method. Using NPR let the geometry appear as a kind of comic-styled figures even if they are recognizably three-dimensional. The style of the NPR can also be changed from within sketchand+. Another point is rough tessellation to create triangle meshes from NURB-surfaces. There are several methods around for rendering NURBS, but sketchand+ uses a special kind of processing those meshes from the geometry according to the intensity of the stroke the designer performs on the tablet. That's why slowly drawn strokes will result in smooth and swift strokes in splattered surfaces.

2.4 ATTACH COMMENTS DIRECTLY

One thing, which can be seen on fuzzy sketches, that they are highly commented with certain notices or labels. It happens that the pure visual representation does not show all the intentions behind a decision made for it. Therefore architects are used to label parts with descriptions about material, textures or just explaining what this thing literally is. If this is well done and someone can went over the notes parallel to perception of the visual representation a better understanding can be mentally constructed because object of explanation and explanation are tightly coupled (Landay, 1995). Thus, the media based complexity or richness of a sketch can lead to a better design. Sketchand+ uses two possibilities for commenting: one possibility is a simple text message, which can be attached to a design, readable through a special marker. Another possibility provided, is the direct attachment of audio messages. To every storing slot belongs an audio file, which can be written or listened to by just connecting a play/record marker aside a model. The idea behind is to store additional information directly with the representing geometry and consequently provide a consistent interface for all actions.

2.5 REVIEW DESIGNS FROM EVERYWHERE

Even nowadays not everybody has the chance to use augmented reality equipment. To provide a possibility for low-end equipped participants, sketchand+ also can create an internal repository. This repository currently is only for reviewing, not for reusing, but could easily be extended to this. The application renders HTML and VRML97 files for any design step made and create an index with a brief overview to the linked steps. These pages can be accessed with any web browser and if the output directory is located in the root path of a web server they can be accessed from everywhere. The stored data contain information about the designer, a timestamp, a screenshot (which shows the contextual situation) and an embedded VRML97-world. So everybody with a VRML97 enabled web-browser can have a look at the design-steps made.

2.6 EXPORT TO OTHER SOFTWARE

It occurs that the rough output might not be suitable to explore the geometries created by sketchand+. For this purpose, every design step also is stored as a RenderMan® RIB (https://renderman.pixar.com, 2000), taking advance of the NURBS description capability of this file format. With visualizing in RenderMan® or any RenderMan®-compliant rendering program this feature adds an additional level for reviewing and reusing design proposals.

3. Intermediate Results

3.1 USING THE SOFTWARE

The setup is quite easy. It can easily be installed and if suitable, the software provides guiding wizards. Nevertheless, first-time users seem to be confused about the HMD and the handling of the props. This is due to some technical restrictions as well as a first-usage borderline regarding an augmented reality application. Because of very view but powerful and easy to learn interaction techniques they feel confident with the system in a very short time. This needs to be investigated in upcoming usability studies.

3.2 TECHNICAL ISSUES

The development and the tests of this project clearly show some technical issues. First of all, the video see-through augmented reality is highly limited by a number of optical constrains: the field of view of the camera, the field of view of the HMD and additional lens distortions. The problem with this is, that the user needs to adapt his movements to the processed video while acting in a real environment. Thus, his visual perception does not completely match the actual movement. For instance, hand movements, which are visually round shaped, appear actually as an ellipse. Because of the mimesis a human being is capable of, this lack of direct mapping occurs just in a certain learn phase, when the user is starting to act within system. Another issue leads to some problems within ARToolKit, namely occlusion. It happens easily while the designer is working on the model, just due to the fact that the whole interaction is coupled with the markers. There are already some workarounds included (using some additional markers) but it is mostly a lack of this programming library. And at least the usage of lightweight HMD is a compromise between quality and comfort for the user.

4. Future development

4.1 OTHER MODELING TECHNIQUES

As already explained the modeling is just a first attempt to design geometrical objects inside an augmented reality system. Even if it is quite intuitive it not fits to the broad variety of design tasks. One approach would be to refine the current modeler and make it more precise in the results. Another possibility would be to introduce certain recognition within the sketching which than creates objects in the augmented space. But this approach needs to be discussed very carefully because it introduces a bias to a design and could not be named a sketch anymore. Also the digitizer tablet approach does not fit for in-situ sketching, which later will be discussed.

4.3 EXTENDED REPOSITORY

To understand a design, one may need information about the process and the history of its development. Understanding the past can lead to better design in the future. And it should start already in the very early stages of a design. The design-process needs to be opened for discussion and for this purpose it needs to be easily accessible. One step further to this would be to extent the repository to a decent automatic and dynamic database. The base for this is already integrated. One idea would be to use horizontal and vertical mapping for a visual representation of continued design-steps (horizontal direction) and stalled one (vertical direction). This would result in a genealogy of a design. Experiments with visualization and access of the repository (also from within the augmented environment) will show if this is a suitable feature for the design-process.

4.2 IN-SITU SKETCHING

One of the most interesting possibilities of this software prototype is the usage directly on a site. Some experiments had already taken place (Figure 5).
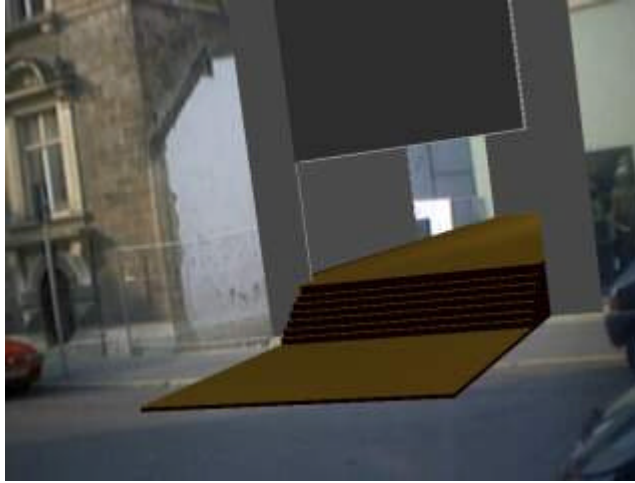
Figure 5: in-situ design review on an empty plot with sketchand+

The needed equipment is a notebook equipped with decent OpenGL® accelerated graphics and WLAN. It needs to be noted that normal augmented reality rendering is not working correct when used on an empty plot, which is surrounded by high buildings. In our real world the surrounding buildings will occlude the infilled building in depth. Therefore they have to be registered into the software and than be used as culling geometries to get a visually correct view of the site with the supplement. Sketchand+ is capable of using an external geometry-file for culling the actual model and can show a visually correct infill. Another feature is that sketchand+ can instantly change the rendering mode. Standing in front of the building site the designer can decide if he wants to use non photo-realistic rendering or photo-realistic rendering, which is probably needed while discussing with colleagues or clients. There are a lot of problems which need to be solved that it will be finally usable for the on-site design. For instance it is necessary to get rid of the markers. The optical limitations of nowadays web-cameras lead in the mobile sketchand+ to more and more bigger markers in order to track the user. An idea would be to use linear supports directly from the surrounding buildings or site appearance to get data for position and orientation. One can also think about using the surface of a white rounded sphere for getting a clue about the surrounding lighting conditions and apply them to the virtual model or for instance to simulate physically correct shadows.

4.4 DISTRIBUTION WITH VIDEO STREAMING

As mentioned before, not everybody can use augmented reality applications due to limited equipment capabilities. But it would be helpful for a discussion to brief other experts and gather more information on a task. To

provide a bi-directional communication between architects and colleagues it would be helpful if also somebody with a mobile device like a wireless PDA or a multimedia-enabled mobile phone could attend a session. Therefore, the new sketchand+ can provide a MPEG4 video stream. The video is the raw video produced by the camera used by the augmented working user plus so called opaque frames for distributing additional data, which can be the computed positions and orientations of the visible markers or certain metadata.

Conclusion

With sketchand+ it could be shown that it is possible to create a new kind of sketching. The implementation is quite rough but it shows how future design systems could be designed. According to this, the features implemented in sketchand+ need further investigation. It has to be proven if there is a remarkable qualitative or quantitative impact for architectural design. Thus, some usability tests need to be performed in the upcoming research. The results will lead to new experimental implementations and prototypes. Furthermore, the work on sketchand+ has a direct influence to the TAPframework. New developments directly will be back ported to it.

Finally, sketchand+ is a sketch for a sketching software. Research is going on, in order to bring creativity to virtual reality software and not leave creativity behind when "going immersive". The creative user needs not a tool to think for him rather than an aid to think ahead.

Everybody is invited to download and experiment with sketchand+, which can be found on http://www.technotecture.com/software/sketchand

Acknowledgements

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