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From Plan to Augmented Reality – Workflow for Successful Implementation of AR Solutions in Planning and Participation Processes

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1 ABSTRACT

This paper describes possibilities and examples in which augmented reality solutions can be implemented in planning and participation processes, based on an analysis of the results of the project “ways2gether – Target-group-specific use of augmented reality and web 2.0 in participative traffic planning processes”. An augmented-reality-demonstrator based on the free metaio Mobile SDK was developed as part of the project ways2gether. This new communication and information tool was practically evaluated in three test cases to show the benefit in planning and participation processes in transport planning.

The actual possibilities and challenges in implementing augmented reality in planning processes are discussed, the technical background and a possible workflow for the integration of augmented reality solutions in planning processes are described and finally the benefits and difficulties in using augmented reality in participation processes are explained based on the results of the test cases.

2 AUGMENTED REALITY AND PLANNING

Augmented reality (AR), a term that has been increasingly used since the 1990s, refers to one’s own perception – mostly visual – being enhanced through computer-generated information. This can be achieved in a variety of ways, though common to all systems is that virtual reality and reality are combined and overlaid. Another shared characteristic is also that these systems operate interactively in real time and three-dimensional information is provided (Azuma 1997).

The planning sector is becoming increasingly more interested in these instruments, with the opportunity for many planning fields to provide on-site geo-referenced information proving to be an especially interesting expansion of their repertoire of methods. The field of mobile augmented reality is particularly interesting for planning and participation processes thus an additional requirement is that the AR environment has to work on mobile devices.

Due to the increasing number of mobile devices that have a camera, data connection, GPS sensors on board and sufficient computing power, mobile augmented reality applications are becoming more and more interesting for a broader public. The dissemination of (powerful) smartphones and tablets as well as the possibility to use third party applications on mobile devices has caused a visible trend in augmentation in recent years. Augmented reality is seen as an important tool in planning processes, especially in participation processes, to improve communication with “non-planners”. Planning information can be shown location based, three-dimensional, and in the context of the “real world” on mobile devices (c.f. Azuma 1997, Azuma et al. 2001, Tönnis 2010, Carmigniani, Furth 2011).

2.1 The use of AR in planning and participation procedures

Current and future uses of augmented reality include the provision of three-dimensional information, such as navigation, marketing, and location information, as well as in the gaming and entertainment industry, assembly, the medical field, or real estate which can be supported by AR information. AR has also been used in advertising, where webcams are attached to PCs and the camera images were overlaid with objects usually supported by QR Codes. AR is also used in sports broadcasts, for example in soccer and ski jumping, where the offside line or the current maximum jump-distance appears virtually.

Even the planning and architectural sector is using augmented reality more and more. Currently the majority of AR applications are being used to provide location-based information. There are some (individual) projects which use three-dimensional AR renderings or provide three-dimensional information, such as

"Smart Vidente", where electric or gas lines in the underground are shown with a special mobile device (Junghanns S., 2008). Other examples, like the "Archeoguide" (Augmented Reality based Cultural Heritage On-site GUIDE), which shows multimedia information such as historical buildings, need special mobile devices (Vlahakis V., et al. 2002).

The other approach is to use common mobile devices such as smart phones or tablet-computer to provide three-dimensional information. The most popular AR browsers such as Layar, Wikitude or Junaio work on regular mobile devices.

The third approach is to use tailored apps on regular mobile devices. One example is from ovos, who developed their own app for the Seestadt Aspern in order to view the master plan on mobile devices (www.ovos.at.) You can view the future city from five different viewpoints which are defined by LLA-markers. However, you are fixed to the point where the LLA marker is set and are unable to move freely within the model.

The ways2gether project focuses on the use of common mobile devices, such as smartphones or tablet-computers, to reach a broader public. We also wanted to make it possible to move freely within the AR model.

For the development of the app we analysed different planning and participation processes in order to point out different possibilities for using AR (Reinwald et al. 2012). In short, the analysis showed a broad spectrum of possibilities in which AR can be implemented, from the possibility to use AR apps for information and consultation to the visualisation of drafts, different versions or final designs. For the ways2gether project we mainly focused on the augmented visualisation of drafts and final designs.

2.2 The project ways2gether

The assumption that by using AR it is possible to make planned changes visible and reduce barriers caused by a lack of three-dimensional imagination (c.f. Zeile 2010) was the starting point for the project "ways2gether – Target-group-specific use of augmented reality and web 2.0 in participative traffic planning processes".[1]

The idea that augmented reality has the potential to improve a participation process and make it more efficient (c.f. Nash 2010) was also a driving factor to start research in this sector. We also expected that new target groups, for example teenagers who are rarely interested in participation processes or people having little time to take part in participation processes due to care obligations, can be reached with these instruments (c.f. Jauschneg, Stoik 2012).

The following article is based on the results of the project ways2gether, which focuses on the reduction of barriers in terms of communication and accessibility in participative planning processes through a specifically tailored augmented reality application (more information on www.ways2gether.at).

3 CHALLENGES TO IMPLEMENT AUGMENTED REALITY IN PLANNING AND PARTICIPATION PROCESSES

The potential uses of AR systems are as described in chapter 2.1 manifold. In the following chapter the requirements and challenges implementing augmented reality solutions are described.

3.1 From reality to augmented reality

To illustrate augmented reality on mobile devices various system components are required. In short, it takes the reality, the built environment, a mobile device with a camera, a three-dimensional plan, as well as software that makes the overlay (see Figure 1).

[1] Project partners are: DIGITAL – Institute for Information and Communication Technologies, JOANNEUM RESEARCH Forschungsgesellschaft mbH, (Project Leader); Institute of Landscape Planning – University of Natural Resources and Life Sciences, Vienna; MJ Landschaftsplanung e.U.; Kompetenzzentrum für Soziale Arbeit GmbH – FH Campus Wien; verkehrplus – Prognose, Planung und Strategieberatung GmbH; Forschungsgesellschaft Mobilität – Austrian Mobility Research FGM-Amor gemeinnützige Gesellschaft m.b.H.

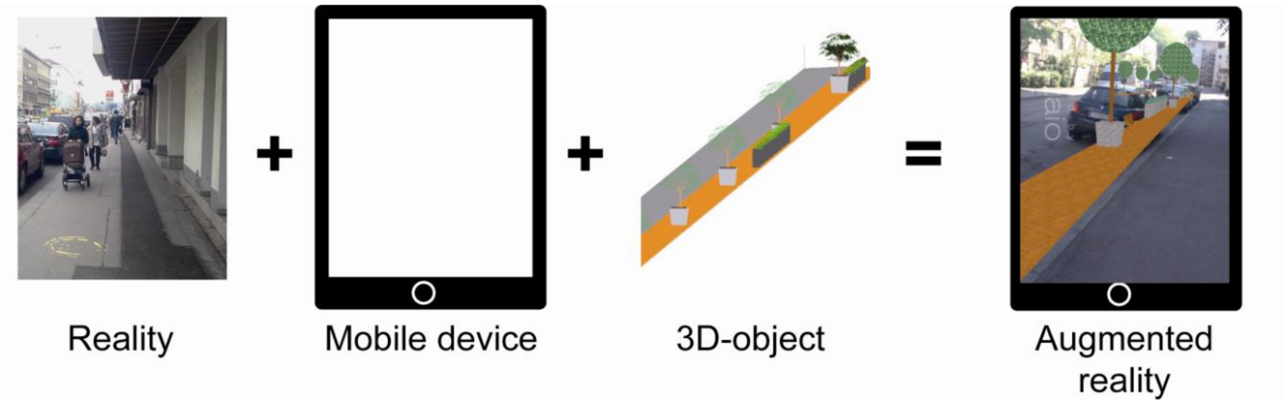

Figure 1: From reality to augmented reality

In detail, this means that by using the camera image, the real situation is recorded and by means of a tracker system (GPS, position sensor, compass) the exact spatial position and the direction of view of the mobile device is determined. This information is processed in an application and a three-dimensional rendering of the model is generated. Using an AR-browser the 3D rendering is shown on the display together with the camera image (see Figure 2).

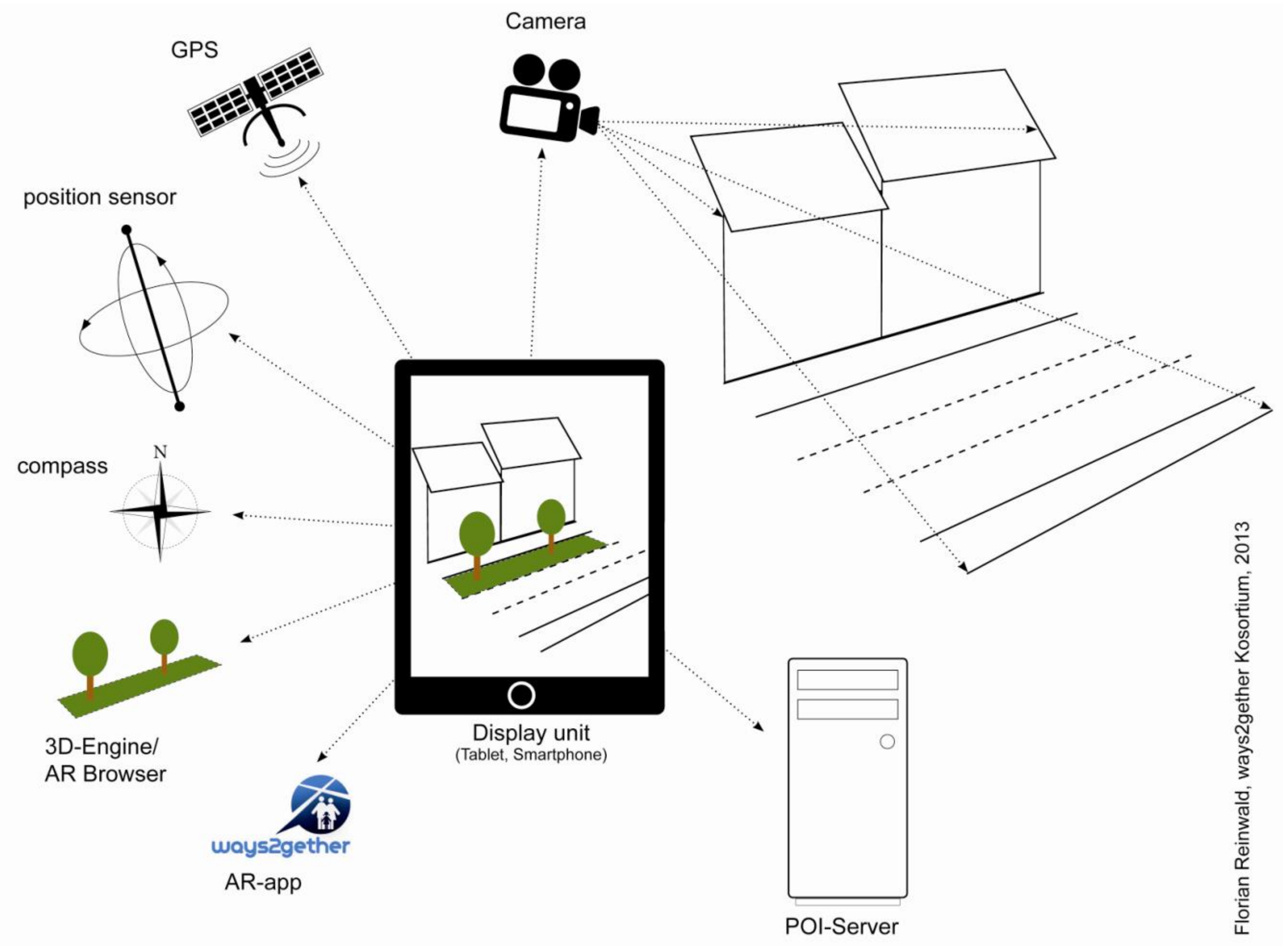

Figure 2: Components of the ways2gether AR system

3.2 Requirements and challenges concerning AR instruments in planning

In order to use AR instruments in planning, additional requirements have to be considered concerning usability, immersion, workflow and accuracy. For the development of the ways2gether app the requirements for an AR system which can be used for planning and participation processes were analysed in expert interviews and by literature research. The analysis shows that the effort for the operation and maintenance must be low for the process facilitators, planners and people who take part in participation procedures.

Whether or not AR is accepted as a tool for planning and participation procedures depends on how easily the AR system can be used.

From the perspective of planners and facilitators, the workflow within a planning process and the consideration of (currently used) data interfaces are of particular importance to the AR instruments. To ensure AR's efficient use in planning and participation processes, the extra effort and the necessary technical skills for planners are to be kept as low as possible. From a technical perspective, challenges are presented especially in relation to GPS accuracy, partially developed software products as well as limitations in the processing power and visualization possibilities (graphics performance) of the mobile devices.

Development in the smartphone and tablet sector is rapid, with new hardware and software products which better meet the high demands of mobile AR tools continuously being introduced on the market. The central challenge in adapting the ways2gether app is – and will remain for the foreseeable future – the inaccuracy of the GPS system, as deviations of up to 7-8m are possible. The restricted level of detail and the limited immersion of the model are a problem.

4 THE WAYS2GETHER APP

The AR framework used for the ways2gether project is based on the metaio Mobile SDK by metaio GmbH (http://www.junaio.com), which includes a 3D rendering engine and can be integrated into your own app. The ways2gether app (see Figure 3) runs in an IOS environment on iPhones and iPads, and is available through the Apple App Store (https://itunes.apple.com/de/app/id515300116?mt=8).

Figure 3: Screenshot of the ways2gether App – on left site the map overview that shows the Seestadt Aspern test case, on the right site the AR-viewer that shows the Seestadt Aspern 3D model.

The ways2gether app is divided into two main components. First there is the map view that provides the user with an overview of all available points of interests (POI) around him. This map view offers the users the ability to drag and drop a specific POI to the users current location, so they can easily visit the selected 3D model without having to go the actual physical location of the POI. Secondly there is the AR viewer, which is a component for visualizing the 3D model connected to each POI.

4.1 Test cases

Three test cases were performed as part of the project: in Wallensteinstraße in Vienna, in Aspern, an urban development project in Vienna, and in Hartberg, a town with 6,500 inhabitants in the province of Styria. The aim here was to test the developed app in the real world, reach different target groups and use the instrument in various planning and participation processes. The test cases were to cover research questions both in the field of technical development as well as in planning and participation procedures.

The central question for the tests was what are the advantages and disadvantages of using AR. A qualitative and quantitative approach was chosen to analyse the implementation of AR from different perspectives and different settings were chosen regarding the type of area (rural/urban, within a built area/new planning) or the aim of the participation process (presentation of results/consultation/information).

The test itself was conducted using a target and control group setting. One group used the ways2gether app, the other used printed 3D renderings and/or 2D plans to evaluate the planned design. The participants were then asked to fill out a questionnaire, which was quantitatively evaluated. The use of the app and the discussion within the groups were observed and group discussions with facilitators were conducted. The central task of the test cases was also the further development of the ways2gether app and especially to analyse the work-flow.

5 A POSSIBLE WORKFLOW FOR THE INTEGRATION OF AUGMENTED-REALITY SOLUTIONS IN PLANNING PROCESSES EXPLAINED USING THE EXAMPLE OF A TEST CASE

For a successful integration of augmented-reality models in planning processes a specific workflow is needed which considers interfaces, special requirements of the augmented-reality framework as well as the “regular” workflow within a planning and participation process (c.f. Kallenberg 2011, Schultheiß 2011). Central tasks for successful integration include the development of the 3D model and the transfer into the augmented-reality environment. Limitations in mobile AR frameworks mean that the design process necessary for 3D models to achieve the required complexity is quite complicated. Once the ideal complexity has been reached, textures on the model's surface are necessary in order to enhance the user's experience. Additionally, the workflow of the 3D model regarding the export in the OBJ format and the implementation in the augmented-reality framework is crucial.

5.1 Challenges in creating 3D models for augmented-reality test cases on mobile devices

Several challenges have to be overcome in the design process of augmented-reality test cases. The main challenge in this process is definitely the development of the 3D model itself. When developing the 3D model it is very important to keep the model as simple as possible. The metaio Mobile SDK has limitations with regards to complexity of objects in 3D models. Depending on the device (iPhone4S, iPad3, etc.), only a specific number of faces – a face being a closed set of edges which make up a model’s surface – can be processed. Different tests done within the ways2gether project confirm the maximum number of faces for the iPhone4S is approximately 8,000 faces, while the maximum number of faces for the iPad3 is approximately 20,000 faces.

First, planners need to ask themselves what kind of audience they want to reach. If the focus is set to the general public then it is recommended to choose a lower level of complexity for the model because the average mobile device only has a moderate computation power. However, if the focus is to impress investors by introducing a new prestige project, then the latest generation of devices can be used and a higher level of complexity can be selected.

There are two kinds of environment scenarios in which the augmentation can take place. It can take place in an urban area, e.g. where a pavement is going to be enlarged (which was the first test case in the ways2gether project done in Wallensteinstrasse) or it can be done in a new undeveloped area, e.g. where a new city district is going to be constructed (which was the second test case in the ways2gether project done in Aspern).

In regular planning processes 2D plans and 3D models are created. If the model or plan has already been created then we need to differ between three starting scenarios:

(1) Only a 2D floor plan has been created, so it is necessary to build the third dimension by hand, as described in more detail in 5.4.

(2) A 3D model has already been created, however the 3D objects inside the model are too complex, e.g. too complex buildings facades. In this case it is unfortunately necessary to reduce the level of complexity by hand, which is indeed a time-consuming task. This scenario is described in more detail in 5.5.

(3) The 3D model fulfills the necessary requirements for augmented reality on mobile devices, which represents the best case and the 3D model can be used without additional expenditure.

At the moment mobile device hardware is definitely the bottleneck for applications using augmented-reality. However, as already mentioned in 3.2, this sector is driven by a high rate of development and perhaps the challenge concerning the usage of realistic details in 3D models on mobile devices can be overcome in a couple of years.

5.2 Tools for the development of AR suitable 3D models

We decided to use Google Sketchup Pro for three reasons:

(1) Google Sketchup Pro can be handled quite easily by people with little to no designing skills. In contrast, acquiring fundamental skills for professional 3D design software such as Blender would take several weeks.

(2) The metaio Mobile SDK requires 3D models in OBJ format. Google Sketchup Pro supports the export of 3D models in OBJ format, so the models can be directly used for the augmented-reality test case.

(3) Google Sketchup Pro can import models in different formats, such as DXF and DWG created by common CAD software, like AutoCAD.

Additionally, Google Sketchup Pro is becoming more and more popular in the (3D) planning sector because it can generate simple and nice looking models within a short time.

5.3 Exporting the 3D model to the required 3D format

Depending on which kind of AR-framework is used, the model needs to be exported in a specific format. At the beginning of the ways2gether project, different AR-frameworks were evaluated (c.f. Reinwald, Murg, Damyanovic 2012) and the metaio Mobile SDK (http://www.metaio.com) was eventually chosen because it was the only framework which fulfilled nearly all of the requirements, such as fast and stable visualization of 3D models, a stable implementation of the device localization, LLA-code recognition (a GPS independent localization feature), and in-app integration – and all for free. The metaio Mobile SDK requires 3D models exported in OBJ-format for static content and 3D models exported in M2D-format for dynamic content, e.g. animated objects.

5.4 Floor plan to 3D model

2D floor plans are not the best starting point for the design task as it could take a great deal of time to build the floor plan up to a 3D model. We experienced this first hand during the ways2gether project when creating the Aspern test case. The planners could only provide a 2D floor plan of the street section which needed to be designed for the test case. This meant it was necessary to build the third dimension by hand, which took several hours. It is always recommended to use a 2D floor plan containing already closed polygon geometries. These geometries can be easily built into the third dimension, which saves valuable time and further costs.

5.5 Reducing the complexity of 3D models

If planners provide high complexity 3D models it is necessary to reduce the complexity to keep the graphic refresh rate running smoothly. There are different reasons for high complexity in 3D models:

(1) The 3D model is much too large, in which case unimportant parts of the 3D model should be removed.

(2) The model’s objects are too complex, e.g. buildings with a highly complex facade. The complexity of these objects could be reduced by using special software; otherwise this task needs to be done by hand which is a time consuming process.

(3) The 3D model contains objects that are not really necessary for the augmented reality test case, e.g. electric lines or water pipes that may be hidden behind walls or under the ground. In this case all unnecessary objects should be removed from the model.

5.6 Adding textures and details to the 3D model

To improve the experience of a test case appropriate looking textures should be used. For example, brick-textures should be used for brick walls, bitumen-textures should be used for bitumen roads and glass windows should be translucent (see Figure 4). Moreover, the effect of furniture should not be underestimated. As shown in Figure 5, it does increase the experience of the augmentation, while also providing an indication for the user so he can estimate the size of objects, e.g. buildings, street width etc. more easily.

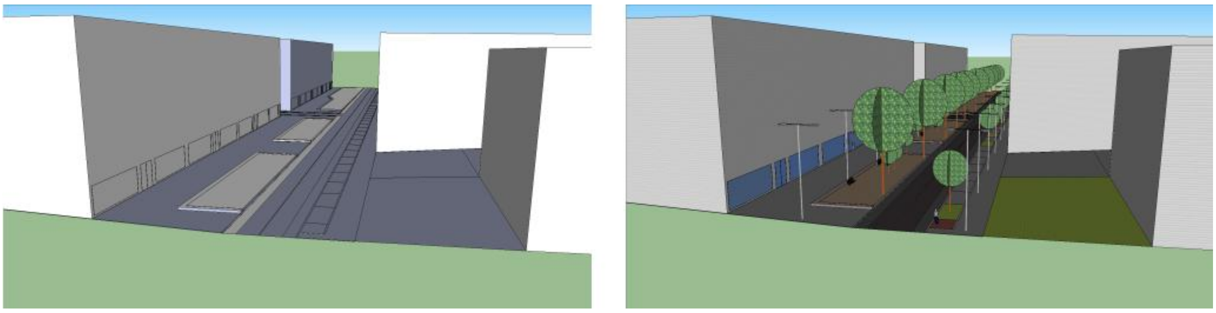

Figure 4: Google Sketchup Screenshot of the Aspern Seestadt – on the left site without textures and on the right site with textures and additional decorative items, to give depth and scale

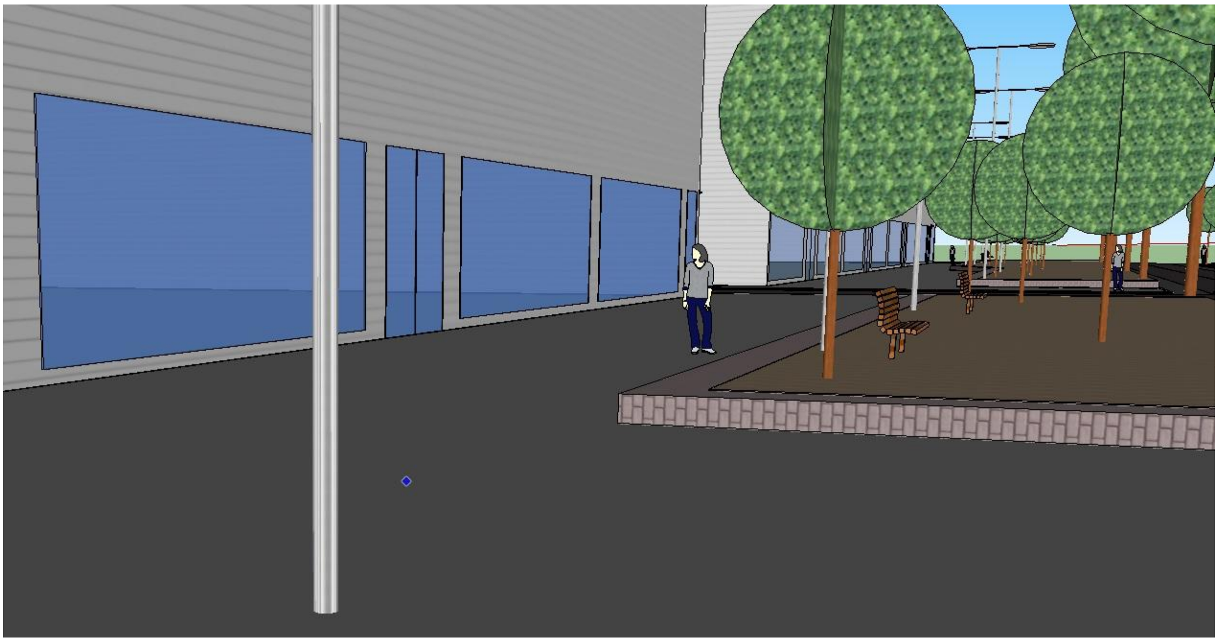

Figure 5: Google Sketchup Screenshot of the Aspern Seestadt – street view

5.7 Setting up the augmented-reality test case – export of the model in the AR framework

Due to the integration of the metaio Mobile SDK, setting up the augmented reality test case in ways2gether is quite an easy task. There are only a small number of files necessary that are grouped together in a repository on a FTP-server. Only a small number of files stored in the same directory on the FTP server are necessary. As shown in Figure 6, three files build the ground setup for an augmented-reality test case. Every test case is separated into a single directory. In the file Aspern.config.txt (marked by the red frame), basic configurations are stored, such as the model's location, orientation, and heading. The files surrounded by the green frame, Aspern_JRS_orig.mtl and Aspern_JRS_orig.obj, contain information about the 3D model itself. In addition to these three files, textures used in the 3D model also need to be located inside the directory.

The ways2gether app needs a mobile data connection in order to update new augmented reality test cases. After finishing the update process, there is no further need for mobile data connections as long as no new augmented reality test cases are needed.

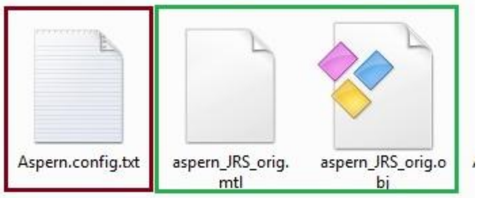

Figure 6: Example files of the Aspern test case used in the ways2gehter project

6 DISCUSSION – THE USE OF AUGMENTED REALITY IN PLANNING AND PARTICIPATION PROCESSES

The initial results of the test cases show a differentiated picture,[2] with around 230 people taking part in the test cases overall. The possibility to be quickly immersed in the situation appears to be an advantage of the augmented reality app. People who are not involved much in creating plans or only rarely read plans in particular can quickly imagine the situation in reality.

Figure 7: Test of the ways2gether App in Seestadt Aspern, Vienna

6.1 First results of the test cases

Augmented 3D visualizations have the advantage that spatial relationships are visible immediately. Thanks to augmented reality it is no longer necessary to explain the difference between the reconstruction represented by objects in the 3D model and the already existing environment. It also helps to overcome language barriers because the model is for the most part self-explanatory. The possibility to view the object from all directions and to move freely within the model is especially seen as an improvement in contrast to traditional renderings presented on paper. In traditional renderings on paper the perspective which is chosen is usually the most attractive. By using an augmented-reality app where you can navigate freely, the possibilities for manipulating perspectives are reduced. The augmented reality app can also provide a better indication of the height of buildings or different ground levels. The option to view objections from a child's perspective was a very interesting feature for most people. In the child's perspective mode the height of all objects inside the 3D model is doubled and by activating this feature the user can put himself into a child's perspective in order to better understand which visual barriers a young child (between seven and ten years old) has to deal with every day. Additionally, the use of iPads was a strong magnet for many teenagers and young adults who otherwise usually are not represented in participatory processes. This younger group reported that the use of new technologies was definitely a motivation for their participation.

6.2 Accuracy of positioning

Urban street canyoning in particular causes a higher inaccuracy of the GPS signal, which influenced the positioning of the 3D object decisively. Metallic elements such as tram tracks, window frames or passing cars influenced the accuracy of the compass which in turn influcenced the orientation of the 3D model. When it comes to projects in already built environments it is especially important that the model fits very well into the existing reality otherwise it may lead to misunderstandings among the users.

The implementation of LLA codes – QR (Quick Response) codes containing the latitude and longitude of the current position was tested in order to improve the accuracy of the device's postion. By using LLA codes the device's location can be determined within one-meter accuracy. However, due to the usage of QR codes, the key advantage of the augmented reality app – moving freely within the model – is lost because the user is tied to the location of the QR code.

[2] To evaluate the ways2gether app, a comparison of means (t-test) was applied. One group used analog plans, the other the AR app. Part of the results of this evaluation is documented in another CORP paper by Martin Berger, Mario Platzer, Christoph Schwarz, Thomas Pilz (2013) Neue Instrumente der Partizipation: Vergleich von Augmented Reality und Perspektiveskizzen im Rahmen des Shared Space Projektes Alleegasse in Hartberg.

A manual control unity was also integrated into the app during the development process so the user could manually modify the three axes of the model, whereby the model could be located more precisely. This workaround still allows the flexibility to freely move within the model. The disadvantage is that a strong three-dimensional imagination is required and the functions of the augmented reality app need to be known in detail. In the test cases for the project therefore guided tours were conducted in small groups with a maximum number of five participants. During these tours a trained person calibrated the model exactly by hand and afterwards the iPad was handed over to the participants.

When it comes to decision-making processes in particular a high accuracy of models and a precise positioning are necessary. It is expected that the usage of special digital video process algorithms, such as edge detection, will prove to be an improvement since the accuracy of GPS systems cannot be greatly increased in the foreseeable future,. Metaio is currently working on a semi-automatic snap-in (snapping) mechanism presented on the insideAR2012 (c.f. Metaio snap-in 2012) that could help to fit the model to its designated location. This feature works with object recognition using the camera of the mobile device. Once a manual setup of the 3D model is done by a user, the model will be automatically located in the correct position and this manual set up can be stored permanently so it is only necessary once.

6.3 Accuracy of the model

Due to current technical limitations, only a low level of immersion – how "real" the virtual world feels – is possible. Some participants in the test groups were a little bit disappointed about the low-detailed objects inside the 3D model because they were already used to the photorealistic renderings used for 3D movies or in computer games. The restriction of the used augmented reality framework regarding the amount of displayed faces and the absence of shadows inside the model reduces the immersion. However, test cases have also shown that the disappointment regarding the quality of representation is, in most cases, only experienced by people who already work in the planning sector.

It is also important to mention that for presenting first drafts – which is often necessary in participation processes – a more reduced schematic representation is necessary to give the impression that changes are still possible and suggestions and feedback are valued and will be taken into account.

6.4 Workflow

As mentioned in 5 there are a number of steps necessary to go from conventional plans or 3D models to the final augmented reality test case. It has been shown that the basics for an augmented reality model can be developed with existing and popular programs. The earlier in the planning process the decision to use an augmented reality model is made, the more easily it can be integrated into regular planning and participation processes. Augmented reality instruments can be used in many phases of the planning process, from the presentation of the first drafts up to the visualization of results.

The Austria-wide (and probably European-wide) first concretely applied test of an augmented reality app in the field of planning tested under real conditions has shown that these tools have great potential to increase the quality of participatory processes. Moreover, the augmented reality app is a helpful tool set and could help to expand the visualization and the presentation of results in planning. The app can also be used as an additional tool to extend the visualization and result presentation in planning.

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