Towards the use of a 3D virtual globe to support public participatory decision making

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Abstract

Today the utilization of 3D mock-ups is very common in GIScience. Since 2001, with the emergence of Google Earth, citizen have become used to virtual globes. However, a majority of applications using these technologies are still restricted to professional users. This is the case with urbanism and decision making where only static 3D scenes are shared with the public. In this paper, we describe the early results of a 3D virtual globe platform to support participatory decision making processes for urban planning. Our concept is built on the visualization of specific scenes. Context, content and design are crucial elements that need to be considered for the development of any participatory decision making tool. Our goal is the development of a web-based platform that focuses on collecting feedback from real-world citizen. The next step of this project is to utilize the platform in a real-world scenario and to evaluate the feedback from real-world citizen.

Keywords: 3D virtual environment, public participatory GIS, decision making, 3D mock-up

1 Introduction

The establishment and utilization of 3D mock-ups is a common task in the fields of architecture, urbanism and GIScience. In recent years, large quantities of 3D mock-ups have been created using (semi-) automated methods. Virtual web-based globes and BIM (Building Information Modeling) seem to accelerate this trend with the abundance of new solutions. However, the utilization and the visualization of 3D mock-ups are today mostly restricted to expert users. Especially within the context of spatial planning, 3D mock-ups are clearly underused for decision making. The goal of this project is the democratization and the utilization of 3D mock-ups in the context of decision making processes.

The utilization of spatial technologies for participatory decision making is a concept that has existed since the late 1990'ies. Since then Public Participatory GIS (PPGIS) have enabled citizens to participate in decision making processes. Today web-based web-globes are emerging systems. These systems offer an interactive visualization of 3D objects such as terrain models or buildings in a web-browser.

The goal of this paper is to present the first stage of a 3D virtual globe to support public participatory decision making in Switzerland. Foremost, a review of related work will be presented. Then, we will describe our approach to apprehend the subject. Finally, we will describe the prototype derived from our considerations.

2 Related work

According to Marzouki, Mellouli, & al. (2017), challenges regarding the participation of citizen can be classified into six categories: ethical, efficiency and cost-effectiveness, political, quality, citizens and technology. Technology, and more precisely spatial technologies for urban planning have been used since several years. Benefits of 2D maps are engraved in public participation processes (Al-Kodmany, 1999; Rinner, 1999). The issue of citizen empowerment in participatory decision making dates back to Arnstein (1969), who suggests the “ladder of citizen participation”, where 8 rungs are divided into 3 degrees: non-participation, tokenism, citizen power. He demonstrates that depending on the participation process, the public gets more or less weight in the decision-making process. In 2014 the international association for public participation (iap2) describes a modern public participation spectrum which involves five stages: inform, consult, involve, collaborate, empower. Every step marks a forward leap regarding citizen influence on the project. At first authorities intend to notify citizen about the relevant parameters of the project; at the last rung it is the public who defines the strategy and makes all the decisions regarding project.

The transition to the third dimension started in 2001 with the emergence of Google Earth. In their state of the art, Biljecki, Stoter, & al. (2015) identify 29 different categories of scenarios for using 3D city models. Urban planning is one of them, with various outputs such as park design or traffic simulation. However, participatory decision making is not mentioned as a category.

Notwithstanding, few implementations of 3D tools for public participation have been created. For instance, a European program, IpCity has brought together researchers from several Universities to work on a mixed reality (MR) concept. A MR tent, a ColorTable and a CityWall were developed within this project (Wagner, Broll, & al., 2009). Some web platforms use 3D as a visual support for information and public consultation (Alatalo, Pouke, & al. 2017). Others focus on collaboration by adding real-time meeting functionality for authorities/experts and citizen (Hu, Lv, & al. 2015).

3 Research questions and approach

We were influenced by two studies which aimed at describing guidelines for participatory processes. Lovett, Appleton, & al., (2015) recommend answering three concerns, 1) when? 2) what? 3) how? The first point is about the general context and history of the area as the definition of the participants, the resources, and the purpose. The second aims at defining the contents such as the realism (verism vs sketch) and the features. The last issue intents to clarify the visualization and methods used for implementing interactivity. In their research, Bryson, Quick, & al., (2012) provide an akin approach split in three axes. The starting phase established the purpose and the context (when?). The next stage describes the resources and the participation handling (what? how?). The last step computes the results and enhances the process. The overall concept is to continuously improve public participation.

3.1 Concept

The utilization of 3D mock-ups on the Internet in the context of decision making processes for spatial planning is a sensitive subject and several points need to be considered.

what? - A mock-up needs to be understandable. This point suggests that the visualization of a virtual mock-up needs to be as objective as possible in order to allow the user to understand the impact of a future building or neighborhood. This implies research in the domain regarding the spatial cognition of 3D-mock-ups and visualization aspects such as the level of detail (LOD), the objects to be visualized (existing objects and new objects), the choice of colors and textures and navigation tools in the mock-up (e.g. authorized points of view). Some clues about contents and their representation as objects or as surroundings have been described by Brasebin, Christophe, & al. (2016).

how? - The 3D mock-up needs to be utilized within a decision-making process. This implies that alternatives need to be evaluated and compared based on criteria that indicate the consequences for each alternative. A system that includes a mock-up needs to offer possibilities to give feedback. Therefore, different means for a citizen to give feedback regarding a project within the context of spatial planning need to be identified and discussed. The word e-planning is increasingly used for describing this kind of tools, which collect a tremendous amount of functionality borrowed from the web 2.0 such as evaluation, modification, sketching, sharing, tagging etc (Steiniger, Poorazizi, & al. 2016).

when? - A 3D spatial decision making system needs to be part of a political process. In Switzerland for instance decision making processes are well-structured and well-defined. A challenge is therefore to identify the best moments and channels to utilize a 3D spatial decision making system within a decision making process. A part from political processes, the citizen's background related to the surroundings often represents tacit (unsaid) knowledge that needs to be taken into account for the development of a 3D participatory platform.

3.2 Hypotheses

The utilization of Web 2.0 functionalities focuses on the exchange between users and the 3D mock-up as a tangible visual support for argumentation, hence we can establish the hypothesis that such a tool will enhance the communication and the debate between citizens (**H1**). Moreover, the planning of a project will be discussed ahead using such tools and the citizens will be engaged in the decision making process. We therefore assume that a project's acceptance rate will increase and the proportion of opposition will decrease (**H2**).

New media to advertise public participation processes such as social networks reach many people, however one of the main drawbacks of this kind of media is to transform citizens' enthusiasm into action (Evans-Cowley, 2010). The utilization of a 3D web tool will ease the current process complexity (public meetings) and boost public society participation (**H3**). Besides the esthetic rendering and the use of social networks will further increase the ratio of younger people in such discussions, currently rarely present at public events. Older people are already involved in participatory processes and should adopt such tools smoothly using appropriate communication channels (**H4**).

4 Prototype

Our development process is based on an iterative improvement loop. Figure 1 highlights two distinct phases. The first phase is the "action" stage in blue where we implement our solution in real-world city projects. Its two substages are the implementation of real-world use cases in the tool and the use of the tool with the users. The second phase is the "improvement phase" where we first analyze feedback from the use case, then we develop functionality or improve elements that what do not meet the users' expectations.

Figure 1: Iterative development process.

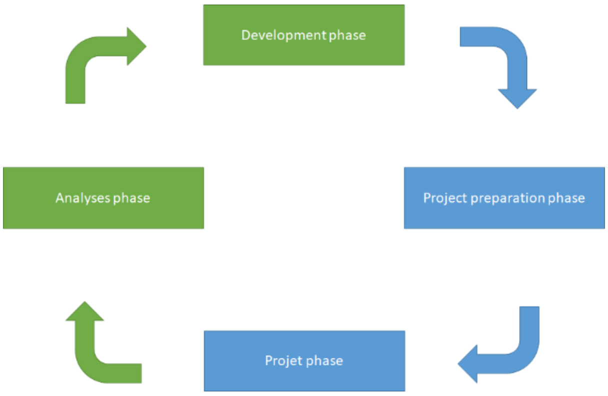
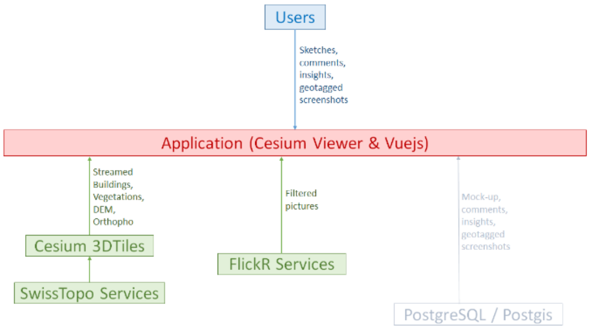


Figure 2: Data Flow.



Currently, we are in the first phase of development. Thus, this section will present our choices regarding the technical implementation and what drove them, then in a second part we will present some early results.

4.1 Technical Implementation

4.1.1 Technical choices

Cesium (cesiumjs.org) was chosen for the 3D rendering. This high level API is quoted many times in the literature, (Schaik, 2010; Blut, Blut, & al. 2017), and described as an efficient solution which can stream a considerable load of data (Cesium 3D Tiles), natively supports OGC services and handles all coordinate systems in real-time (Krämer & Gutbell, 2015). Furthermore, this virtual globe technology allows to develop a simple to use, client-side tool which meets our two main goals.

We have combined this 3D rendering engine with a form efficient framework, Vuejs. The application runs on a nodejs server and is linked to a geographical relational database, PostgreSQL/PostGIS (postgresql.org).

4.1.2 Data sets

Data sets are mainly provided by SwissTopo (swisstopo.admin.ch) through web services: DEM, orthophotos and 3D models (buildings and trees). These layers are streamed in real-time via Cesium 3DTiles (Fig.2). The application is based on context pictures from flickR services (flickr.com), loaded only in a 2 kilometers perimeter from the user's camera. These data sets ease the creation of surroundings of the scene, aiming to integrate all landmarks needed by the users to relate the model to the real world.

Users can contribute with data as well and manually add objects such as screenshots, sketches and insights.

4.2 Web User interface

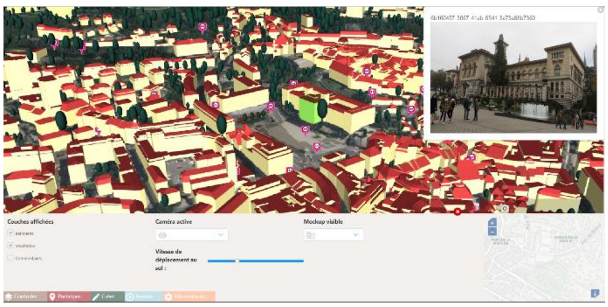
One challenge is the question, how to place the user in the center of the discussion. Currently, a majority of participatory decision making initiatives appear to consider citizen as observers. In this case, we can talk of communication or information processes. Our goal on the other hand is to create a debate between public society and authorities.

In the following section we will describe the implementation of our 3D platform.

4.2.1 Interface

GIS solutions are often regarded as professional tools, and can repel shareholders. Therefore, we aim at developing a user friendly interface. When a user logs in, the only visible features are the bottom left menu, and the 2D bottom right maps with some useful action shortcuts.

Figure 3: Example of the bottom menu and the tacit knowledge.



The bottom panel is activated in the menu. This layout has been inspired by modern city building simulation games such as City Skyline or SimCity. It has two benefits, at first, the bottom panel breaks with common GIS solutions such as ArcGIS (esri.com) or QGIS (qgis.org). Secondly, screens are horizontally larger than vertically and therefore offer more space for the interface's features. (Fig.3).

In the bottom right corner, 2D maps enable to pinpoint the user camera position; the maps are oriented to match the camera's direction. Three shortcuts, "take a screenshot", "add a comment", "answer the survey" are situated above the map.

4.2.2 Navigation

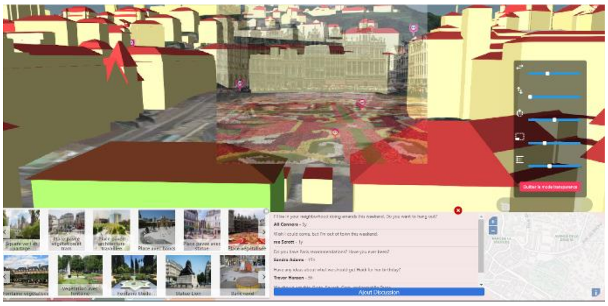
According to Montello (1993) the perception of surroundings is strongly affected by scale; in his study, four scale categories are suggested, Figural, Vista, Environmental and Geographical. Urban planning stands between the Vista space (an object that is the same size or slightly bigger than a human body such as a building or a square), and the Environmental space (a place that cannot be apprehended from a standing position such as a district). To enable users to understand the 3D virtual environment, we have developed four distinct cameras or navigation possibilities. Jankowski & Hachet (2015), describe in an article resuming different studies, an entire bundle of 3D interactions. From this review, we choose to implement two cameras allowing to handle the Vista space. One is derived from the *specified coordinate movement* (Jankowski & Hachet, 2015), where some coordinates are pre-computed in the application. Users can choose different positions and look around from this point of view. Two degrees of freedom (DOF) are allowed. Movements are vertically blocked between -60° and 60° to mimic the human head. The other, the *specified trajectory movement* is an automatic displacement of the camera between points of interests without user interaction. The environment scale is managed via a walking and a flying camera. The user has a full control of his movement, the walking camera (first person perspective) is clamped to the ground with four DOFs. The three DOF flying movements are handled via rotations.

4.2.3 Features

Control: In this tab, classic GIS functionality is regrouped. Users can display or hide context layers (buildings, trees, FlickR pictures) and points of interest defined by other users. Camera preferences are settable from this tab, speed of movement and type. If different proposals are provided by the stakeholders, users can choose to visualize these proposals via mock-ups in the 3D virtual environment, as shown in Figure 5. This component allows citizens to step inside a scaled environment without any perspective bias induced by static pictures created by opponents or supporters of a specific proposal.

Participation: This tab aims at gathering functionality related to participation such as real-time discussions or the establishment of georeferenced screenshots. Our goal is to promote discussion and exchange between users. Each comment can be answered, tagged and rated. At any moment, users can take a georeferenced screenshot of their current view and add a description. Once finished, their picture is published as a pin on the map. Other users are allowed to comment and rate the screenshot. One contribution to decision making is the insight component. Urban planning professional such as architects prefer having inspirational pictures at hand during the prototyping phase of a project. We decided to implement the same functionality. A bucket of pictures is selected and added as a layer to the 3D scene. A user is able to translate, rotate, enlarge or choose the degree of transparency of a photo (Fig.4). A tag system allows for ordering, classifying and rating the usefulness of the pictures.

Figure 4: Semi-transparent insights integrated in the 3D scene.



Creation: This tab aims at encouraging citizen to create sketches. A tool allows for drawing 2D points, lines and polygons directly in the scene. Predefined 3D components such as a house, a bench or a tree can be added to the scene.

Animation: In this tab, two sets of functionality are put together. First, two sliders allow any user to control the position of the sun (date, hour) and to identify areas affected by shadows. Moreover, an animation launcher starts a specified trajectory movement of the camera with a simulation of the sun's position moving over time.

5 Conclusions and perspectives

In this article we have introduced the establishment of a 3D platform to support public participation. This platform focuses on citizen's contributions such as comments, insights and screenshots. Another key element of this tool is the ability to add and represent tacit knowledge in 3D through pin's. Our method for the implementation of this tool is an iterative process involving two phases: project testing and improvement.

Our next steps are to complete the development of the application in order to quickly use it in the context of a real-world scenario in Switzerland. Furthermore, we want to utilize this experience to validate our hypotheses that address H1: *The acceptance of our platform*, H2 *The participation of citizen*, H3 *The utilization of our platform to ease the complexity of current participatory processes* and H4 *The utilization of the platform by other population groups.*

During the development process we aim at following the *when - what - how* guidelines and to stay focused on the context, the content and the design.

As a perspective of this study, we are considering the concept of *urban promenade* where a group of citizen is guided by a mentor along a path of interest. In this concept each stop is marked by descriptions, pictures and explanations of a future project. Another perspective is to use augmented reality technologies during these promenades to allow the participants to discover the scene by themselves.

Figure 5: Interactive comparison between two mock-ups.

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