Employing Open Simulator as an Immersive and Collaborative GeoDesign Tool

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Abstract

The goal of this research is to develop an interactive and collaborative geodesign tool utilizing existing immersive virtual environments. The geodesign tool will enable the design of landscapes in a simulated virtual environment using interactive modeling tools that incorporate data from existing GIS databases. In his keynote address FLAXMAN (2009) defines *geodesign* as 'a design and planning method which tightly couples the creation of design proposals with impact simulations informed by geographic contexts.' This points out the potential importance of its possible guidance function for planners and designers. However, he also suggests that geodesign has thus far fallen short in a number of critical areas. These include:

- **visualization**: Although the existing geodesign tools provide rich visualization opportunities, they fall short in the representation of computable and sharable information.
- **evaluation/guidance**: Parameters for evaluating the proposal and guiding the design participants with these parameters and evaluations during the design process is lacking.
- **collaboration**: Design proposals developed by planners and designers are not publicly accessible and therefore their impacts are limited to individual clients.

FLAXMAN suggests using a tool that can visualize critical parameters related to the geological characteristics of the project site to shape the design process, and provide feedback to the participants. He argues that the proposed tool should be accessible for increasing public awareness by representing the design proposal and the underlying parameters of the idea. Our research proposes creating an immersive virtual environment by employing the Open Simulator software (Opensimulator.com 2014) that will respond to the shortcomings identified by FLAXMAN. Additionally, this research presents a plug-in that was developed using the Grasshopper plug-in (Grasshopper.com 2014) for Rhinoceros (Rhino3D.com 2014) modeling software, the most popular parametric design tool in design disciplines, for developing a contour map from a digital elevation model (DEM) image. The developed geodesign tool allows users to:

- act as virtual characters, also known as *avatars*, and experience the realistic three-dimensional virtual environment in walkthrough;
- communicate and share information with other users with built-in communication tools;
- create geo-referenced three-dimensional virtual landscapes through the use of digital elevation model (DEM) image files, and to shape the portrayed landscape in collaboration with other design actors such as clients, planners, and designers;
- gather outsourced data from online databases, and use the collected information as parameters in geodesign in order to assist users in making decisions;

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- create a contour line map from a DEM image by using a grasshopper plug-in that we have developed specifically for this research.

1 Introduction

During a GeoDesign Summit keynote address, Fundamentals of Geodesign, FLAXMAN (2009) defined *geodesign* as 'a design and planning method which tightly couples the creation of a design proposal with impact simulations informed by geographic context.' While he identified great potential for geodesign he went on to add that 'In an ideal case, a planner or designer receives real-time guidance on performance at every phase of design from early site visit or conceptual sketch to final detail' pointing out the imperfections of the existing geodesign tools. In his address, he further elaborates on the shortcomings of the existing slate of geodesign tools and his three main concerns related to this:

His first concern is the lack of the visualization of computable and sharable information by existing geodesign tools. Although the existing geodesign tools are able to portray the design with a high level of fidelity using advanced rendering engines, they are not able to visualize the information, which constitutes the design. This information is, however, essential for the development of responsive design. Furthermore, predictive simulations could be demonstrated through evaluating this information and providing feedback to the design actors to optimize the design.

The next concern refers to the accessibility of developed design proposals. Planners and designers and the public would greatly benefit from increased accessibility. The visibility of the design takes on an important role for increasing public awareness about how design can influence the site. Therefore the drawings and image of design proposals should be accessible and sharable for everyone in order to inform professionals and the public about the effects of design.

The last concern outlined by FLAXMAN was the limited tools for the evaluation of spatial data that could provide real-time guidance to the design actors. This is the most critical shortcoming amongst the rest in terms of the geodesign process. As FLAXMAN states, most Building Information Modeling (BIM) is focused on evaluating individual buildings with shallow ecological information and Geographical Information System (GIS) information limited to spatial data. However, as a city planning simulation game, *SimCity* evaluates the planning and management decisions of players and provides real-time feedback for assisting them to build a better city (SHAFFER 2006). In this game, players can observe the effects of their decisions on complex city dynamics while they are planning.

This research proposes that the existing immersive virtual environment technologies could respond to most of these concerns. Immersive virtual environments, often referred to as *virtual worlds*, allow users to create graphics-oriented virtual places and experience these places through Internet or local network connections. Although virtual worlds are equipped with advanced communication and immersion features, these features are mostly used for entertainment and educational purposes (ÖRNEK & ÖZER 2014). This research aims to develop an interactive and collaborative geodesign tool by adopting the affordances of the existing immersive virtual environments and supporting them by developing third-party applications. Furthermore, this research aims to exploit online databases for visualizing them to guide designers for designing in a simulated virtual environment.

2 Research

This research presents the opportunities of Open Simulator software and suggests developing an online and participatory geodesign tool through exploiting these opportunities. Addressing the concerns of FLAXMAN, the proposed system aims to:

- portray the design proposal in a virtual environment with a high level of fidelity,
- allow multiple users to discuss and design the same project in synchronization,
- visualize the crucial parameters regarding the geological characteristics of the project site and the evolution of the design process,
- evaluate the design parameters and provide real-time feedback to the designers for developing the design,
- enable designers to manipulate the portray landscape with interactive modeling tools,
- extract the manipulated topography data and generate a contour map through employing a specified plug-in.

2.1 Immersion

A key goal of the proposed software tool is an immersive experience. In this research, *immersion* refers to the method and level of fidelity in the representation of design and the underlying parameters of the design actors. Immersion is mostly related to the representation of the quality of design, the control the user has on the interface, the interactions between the user and the representation of the design, and therefore takes an important role on the user's perceptual experience and understanding. Hence the enhancement of the immersion may leverage the understanding of design and the underlying parameters and ideas. This proposal system enables users to navigate through the design by controlling virtual characters, also known as *avatars*, in walkthrough or aerial-view options. Moreover, it allows designers to brainstorm, discuss, and model in a photo- realistic three-dimensional virtual environment through the built-in tools.

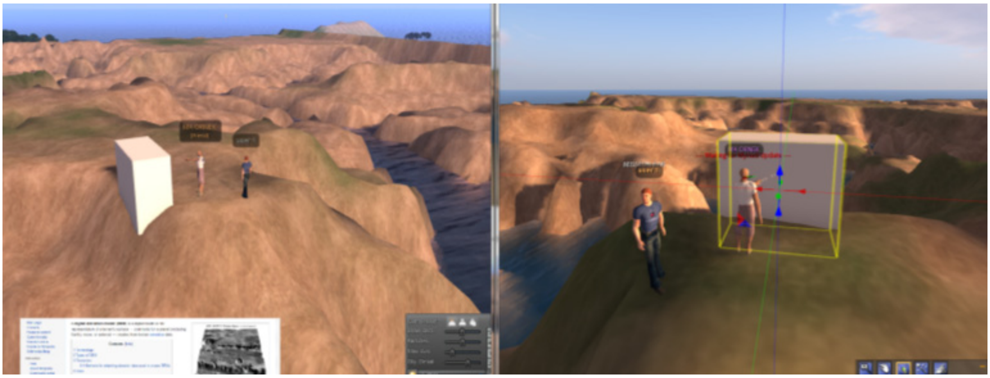

Fig. 1: The built-in solid and terrain modeling tools allow users to shape the virtual environment in collaboration

2.2 Participation and Accessibility

The propose software tool aims to enable numerous users to work on the same project and communicate and work in collaboration with other design actors by using Singularity (2014) client software. For that purpose, each design actor has their own avatar which can be assigned different design roles (decision maker, client, etc.) through various settings available to the users. These roles can be defined as: (1) client/observer: can only participate through communicating with design actors by using textual and audio-visual communication methods, (2) cadastral/planner: can allot the virtual landscape and assign these land lots to users, (3) architect: can build/import existing three-dimensional models into the virtual environment, (4) landscape architect: can shape the virtual landscape by importing DEM images and built-in landscape modeling tools.

Furthermore, the proposed system can be accessible by using viewer software on any personal computer with Linux, Windows, MacOS operating systems and mobile devices (smartphone and tablets) with Android and iOS operating systems.

Fig. 2: This proposal system allows numerous users to connect and work together at the same time

2.3 Topography Integration and Modeling

The proposed system allows designers to create geo-referenced three-dimensional virtual landscapes through the use of digital elevation model (DEM) image files, and to shape the portrayed landscape in collaboration with other design actors. At last, it is able to gather the contours of manipulated landscape by using a grasshopper plug-in, which will be introduced in the next topic.

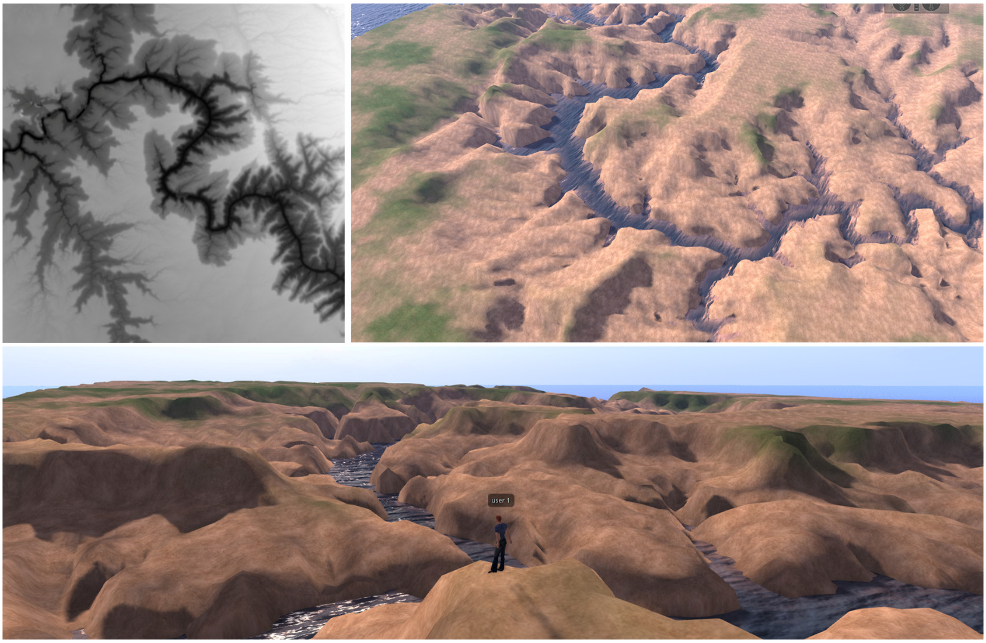

Fig. 3: DEM image of Grand Canyon (top left); an aerial view of integrated landscape from Open Simulator (top right); walkthrough view of integrated landscape (bottom)

2.4 Data Outsourcing

The utilization of external data from third-party software and databases through importation into the virtual environment is important for incorporating existing data. The outsourced data can be textual and numerical data, or three-dimensional models.

The proposed system enables the importation of three-dimensional models from GIS and modeling software into the virtual environment. For that purpose, the existing three-dimensional models should be in DAE (COLLADA) filename extension. Although the DAE filename extension is not well-known, it is an interchange file format for most three-dimensional modeling software; e.g. ArcGIS, Autodesk 3DsMax, Cinema4D, SketchUP, etc. The model can be imported into the virtual environment directly using the viewer.

This research aims to gather data through collecting outsourced data from online databases and uses this information as a set of parameters in geodesign in order to evaluate or assist users in making decisions. According to FLAXMAN, this ability is critical for geodesign tools in presenting the essential information flow to the designers, visualizing them like a design dashboard. Furthermore, this ability aims to provide guidance to the designers by displaying feedback to the design actors and informing them about the process. For that purpose, we developed a multistage process for importing data from external databases into the virtual environment (Fig. 5). According to this process, any textual/numerical data can be retrieved from a database by creating a PHP page and transferring this information to an Open Simulator console with an HTML interface. Afterwards, a dashboard should be de-

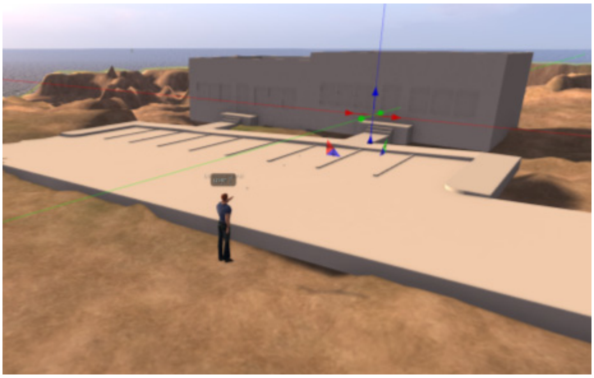

Fig. 4:
The existing three dimensional models can be imported into the virtual environment

signed in the virtual environment and it should be programmed to process the imported data through the use of the LSL programming language. Moreover, the imported information can be used as a set of parameters for the components (such as objects, buildings, vegetation, sea water level, topography, etc.) to shape the virtual environment.

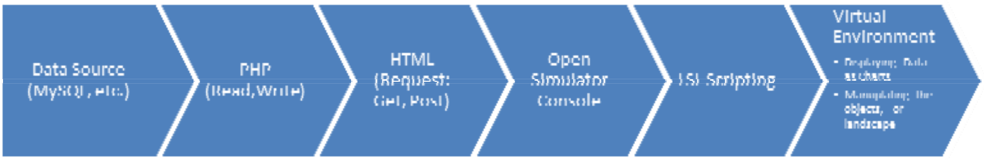

Fig. 5: Flowchart of the process of outsourcing from online databases into the virtual environment

This ability enables the creation of seamless connections between data sources and the stakeholders of the design process. For instance, it could be possible to update the portrayed water level of the virtual environment by gathering data from a database which keeps daily water level measurements for a city. Such an ability enables record-keeping of design parameters in an online or local database by gathering from the virtual environment. Afterwards, these parameters could be displayed on a web-based interface for increasing the accessibility of the information.

2.5 Topography Data Gathering

The last ability is about extracting the contour map of the manipulated virtual landscape. Despite the fact that Open Simulator software enables the exportation of the height map image of the virtual environment, this image is not accurate enough to generate contours by using existing methods. For that purpose, a plug-in was programmed specifically for this research by using Rhino modeling software and the Grasshopper plug-in. The process starts by subdividing a mesh surface, and then creates a 256 x 256 point matrix by using the coordinates of the subdivided surface. Afterwards, the plug-in reads the brightness value for each pixel of the height map image and moves the point matrix according to these values.

Finally, it creates the topographical surface using the PATCH command and generates the contours of the surface.

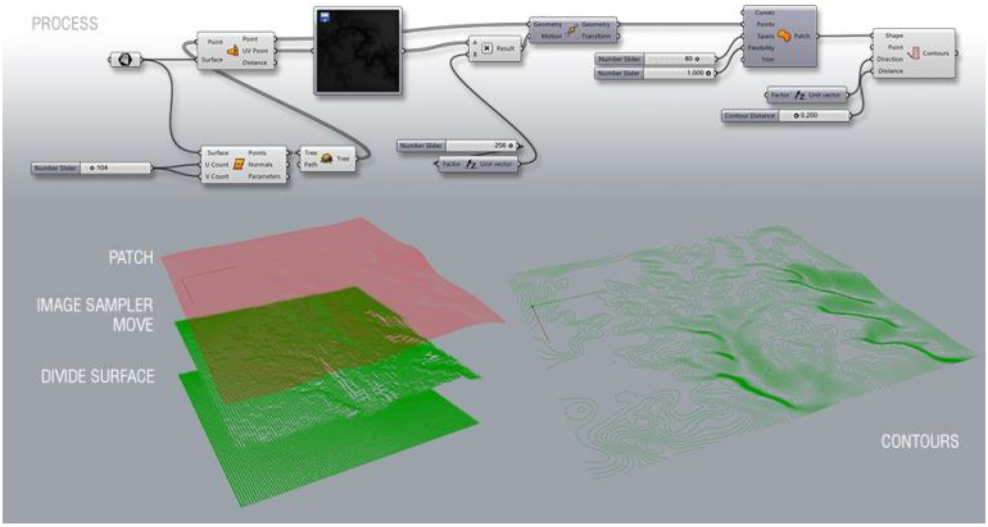

Fig. 6: The contour generator plug-in process scheme

3 Conclusions and Future Work

This research suggests using Open Simulator software as a geodesign tool that allows users to participate and work collaboratively in an immersive virtual environment. For that purpose, Open Simulator is programmed and supported with third-party software to serve as a geodesign tool. Moreover, this research aims to employ design parameters as a guidance and feedback system for the participants of the design process through visualizing them directly or using as an attribute in the design process. Although this research broadly describes the potentials and opportunities of Open Simulator software from the perspective of geodesign, the abilities of the proposed system are not limited to this research. Additional work is necessary to further develop the proposed system. In further work, the authors aim to employ the proposal system in geographically dispersed locations as a simultaneous and collaborative case study.

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