Geovisualization of 3D Modeling Representation of Topographic Relief Based on Open Source GIS

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Abstract. 2-dimensional and 3-dimensional representations have been used in various physical, virtual, and geovisual surface models of the earth - to improve spatial thinking skills. Physical models such as relief maps have been shown to enhance understanding of topographic maps, helping to understand the relationship between 2D representations and 3D objects. Virtual models can support spatial learning, for example, by viewing objects at various angles, by providing an environmental context. This model makes it possible to combine physical models’ interactive benefits with virtual tools’ flexibility and diversity. The term geovisual is an overlay depiction of information scanned through a sensor, processed by a computer. Subsequently, the data obtained are presented to the media so that it is like the real world. It has been built and used in this Tangible research Landscape, which is a real-time geovisual system integrated into a computer connected to a 3D sensor, projector, and supported by GRASS GIS [1]. This geovisual system is then applied for modeling terrain 3-D terrain physically through media, scanned through sensors to a computer, and used to analyze the environment with various effects and graphical simulations. The initial model produced is topography from aerial photographs and DEM from LiDAR, which has a spatial resolution of up to 0.4 meters showing physical processes such as contour lines and water flow, and sediment transportation can be well visualized.

Keywords: geovisualization, geographic information systems (GIS), 3D modeling

1. Introduction

The depiction of the shape, position, and orientation of objects and visualization in three dimensions is currently mostly done in digital form to understand and analyze complex processes that occur on the surface of the earth [2]. Physical modeling, such as 3-dimensional relief maps, has been shown to increase understanding of digital terrain models, helping researchers understand the relationship between 2D and 3D objects. Quite a lot of research has been done on modeling the earth’s surface relief and its presentation in digital 3-dimensional form, but with the physical shape and scale of the “real” model, it is still small and necessary. Such a system will help a lot in disaster events such as the pattern of disasters (floods or landslides) in a real and interactive way. This study aims to make complex computational terrain modeling utilizing spatial data and processing using geographic information systems (GIS). The raster data such as DEM or LiDAR and their objects’ results can be formed by creating a real model of the products of a 3D printer or CNC machine (Computer Numerical Control). This system will then connect the physical model with digital models to make the modeling more intuitive and scientific representation more real. This system can be used as a design model for disaster landscapes such as flooding with geovisual technology. Geovisual techniques are tools and techniques that support the analysis of geospatial data using interactive visualizations. This research took the initiative to apply open-source GIS, Tangible
Landscape plugins, 3D sensors, and 3-D print models with spatial data from Aerial Photogrammetry/LiDAR, allowing users to create topographic models can then be simulated with system integration that will produce in real terms landscape time interactively. This geovisual system can also be used as a teaching medium in explaining the concepts of geography, geology, and hydrology, such as contour lines, watersheds, catchments, dykes, dams, and irrigation systems. On geovisual, this research has been inspired by tangible interfaces for geospatial modeling that can transform the way we use GIS by affording intuitive, hands-on modes of embodied interaction, streamlining workflows for tasks such as 3D modeling and analysis, and thus encouraging creative exploration. The following are some of the systems used in geovisual modeling.

Table 1. Augmented Sandbox Interface [1]

| System                        | Interaction | Studies          | Publication                                      |
|-------------------------------|-------------|------------------|-------------------------------------------------|
| SandScape                     | Sculpting   | Ishii et al. (2004), Ratti et al. (2004a) |
| PhoxelSpace                   | Sculpting   | Ratti et al. (2004b) |
| Elektro Marposa                | Sculpting   | Vivo (2011)      |
| SandyStation                  | Sculpting   |                  |
| Augmented Reality Sandbox     | Sculpting   | Woods et al. (2016) |
| Hakoniwa                      | Sculpting   | Kikukawa et al. (2013) |
| Sandy Station                 | Sculpting   |                  |
| Phoxel Space                  | Sculpting   |                  |
| Efecto Marposa                | Sculpting   |                  |
| Sedimachine                   | Physical simulation | Cantrell and Holzman (2014) |
| Rapid Landscape Prototyping Machine | Machining | Robinson (2014)                 |
| Tangible Landscape            | Sculpting   | Petrasova et al. (2014) |
|                              | Object detection |                  |
| The Augmented Reality Sandtable (ARES) | Sculpting | Amburn et al. (2015) |
|                              | Quantitative experiments |                  |
| Inner Garden                  | Sculpting   |                  |
|                              | Breathing    |                  |
|                              | Emotion      |                  |

Note: symbols link type of study to relevant publications

This research will build and apply one of the systems in geovisual modeling that will be used to develop and analyze disaster modeling. The initial stage of this pre-research study several sandbox research results, as shown in Table 1, and selected Tangible Landscape, which was developed by Petrasova et al., in 2014. Furthermore, this equipment will be built on the label with hardware available on the market and software obtained from. This system has been developed as an initial stage and is used to visualize a topographic model of the Aerial and LiDAR Photo data.

2. Methodology

2.1 Stages of Preparation

A theory study and the implementation of geovisual technology are carried out in some existing literature. Establish a geovisual system and case studies as and plan the equipment. The next stage is designing the dimensions of the media and instruments. At this stage, media dimensions were measured to be adjusted to the classroom/lab. As well as surveying the equipment and specifications available in the market.
Furthermore, at the installation stage, the instrument setup starts from the computer, and the settings consist of the installation of the Ubuntu Linux OS and the GRASS GIS installation and the Tangible Landscape plugin, and the installation of the Kinect Xbox One sensor. The next stage is Calibration, where the LCD Projector is set up and the sensor calibration stage. Then analyzed whether the model has been formed correctly. If the model has not been created, reset, and calibrate again. If the model has been created, a trial is carried out on topographic terrain forms from high/mountain to low/valley to modeling the shape of water bodies/lakes/rivers. At the last stage, a trial and report were made.

2.2 Equipment

Materials and tools used in this study are as follows:

2.2.1 Hardware

a. Personal computer/laptop
b. 3D sensor
c. LCD Projector
d. Aluminum Frame
e. Kinetic sand

2.2.2 Supporting data and applications

a. Windows 10 and Microsoft office 365 OS
b. Linux OS Ubuntu
c. GRASS GIS 7 + Python software
d. Tangible Landscape plugin and r.in.kinect
e. LiDAR DEM and aerial photography

2.3 Processing Stage

Data The data processing stages carried out in this study are as follows:

Figure 1. Data Processing Flowchart

The following is an explanation of the data processing flow:

1. The PC used is the ROG HURACAN type G21CN ID761T with the I7 8700 RAM 32GB SSD specifications. 256GB HDD 1TB and video graphics GTX1060 6GB.
2. The Operating System used is Linux Ubuntu.
3. GIS (Geographic Information System) is the primary program, GRASS. GRASS GIS is a general-purpose cross-platform, open-source geographic information system with raster, vector, 3D raster, and image processing capabilities [4].

4. Used Kinnect Xbox One. Next, install the Kinnect driver.

5. For visualization, the ASUS P3B DLP 800 ANSI Lumens projector is used, 1280x800

6. The next stage is the installation of the Tangible Landscape plugin application. Tangible Landscape is a projection-augmented sandbox powered by a GIS for real-time geospatial analysis and simulation. It was designed to intuitively 3D sketch landscapes — to explore ideas or test hypotheses with real-time computational feedback rapidly. The Tangible Landscape plugin connects the scanning component with GRASS GIS and automates the loop of scanning, importing scans, and geoprocessing in the GRASS GIS environment [5].

7. Install all equipment on the frame made and finally put the kinetic sand in its place.

8. The last step is to calibrate the Kinnect and calibrate the projector. If successful, output will be obtained in the form of a 3-dimensional appearance on kinetic sand.

3. Result and discussion

This system is built from a frame of equipment to place sensors and projectors (Figure 2a) and is connected to a computer equipped with GRASS GIS software. Simulations and sensors (Kinect sensors), data projectors, and kinetic sand media.

The principle of this system is that GRASS GIS with the Tangible Landscape plugin will overlay physical models with digital models in the 3D scanning cycle, geospatial modeling and simulation, and 3D projection rendering. Tangible Landscape is an impressive system for presenting topographic models. The best quality of this system is that when changing kinetic sand, the user will change virtual isolines and hypsometric coloring in real-time. Relief on kinetic sand will be recalculated based on depth data, which is scanned by the sensor and processed by the software at any time. After these steps, it is provided from the data projector on kinetic sand, which illustrates virtual assistance that is well suited to the sand landscape.

By making physical topographic models from aerial photographic data, it will be able to see how changes affect processes such as water flow, flooding, erosion, and solar irradiation. Thus we can easily and quickly test ideas while being guided by scientific feedback, exploring a much larger solution space, and making more creative and informed decisions. One of the special characteristics of this system is the simulation of topographic surface changes. The system shows what water does after falling over aid after rain. Like in nature, simulated water masses follow forms of assistance: moving
from highest to lowest elevations, moving faster through steep landscapes, and accumulating in closed form. This simulation is based on Figure 3a. Show a contour line picture and Figure 3b. Topographic terrain slopes based on aerial photographs and DEM from LiDAR data of Sekarwangi village, Walungan, Garut Regency - West Java. The rain simulation intensity can be controlled through the software menu, helping to do different disaster scenarios.

The system’s ability to simulate media is useful and essential when visual explanations of emergencies such as heavy rain, floods, or cracked dams are needed. The main idea of the creators is to develop a 3D visualization application that will be exhibited at the museum to teach the main concepts of geology, hydrogeology, and geography, using augmented reality to explain some of the terms in this discipline. From a cartographic perspective, this is also an excellent way to teach students how to read topographic maps. From the results of applying this tool, it is very interesting for disaster simulations that offer countless scenarios of emergency cases not only for floods but even for landslides.

4. Conclusion

From this study, it can be concluded as follows:

a. A set of geovisual modeling tools has been made based on the Tangible Landscape system, which is a development of 3-dimensional earth surface (TopAR) modeling learning based on Augmented Reality technology in the Geoinformatics Laboratory of the ITS Geomatics Engineering Department.

b. At this stage, it has been tested with modeling from aerial photographic data and LiDAR DEM of Sekarwangi village, Walungan Garut Regency - West Java.

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