A 3-D Geo-database Virtual Reality Map for Southern University's Campus

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Abstract

When you plan to visit a new place you could look for maps and directions, but maps are often two-dimensional. Since we live in a three-dimensional world, we made a navigable 3-D map for Southern University's campus, where we work. This virtual campus map gives web-visitors a user-friendly, web-enabled, interface to fly-through over a 3-D model of campus online. Keeping the virtual reality map (VRM) up-to-date should help users to locate places more easily and much faster than before in 2-D. The VRM should also help public authorities to prepare emergency response plans for natural disasters, hazardous materials, homeland security, and related problems. The virtual campus map was created as a classroom project using CAD files, high resolution aerial Ortho photography, GIS data, and digital images as texture draped on building facades. The virtual reality model of campus is rendered in an immersive computer aided environment for 3-D visualization.

Index Terms—GIS, GPS, CAD, LiDAR, DOQQ, DEM, TIN.

1. Purpose of the project

The purpose of this project is to develop a virtual campus map of Southern University that gives visitors a user-friendly, web-enabled, interface of a 3-D model fly-through online. There are many software packages are available to Geographical Information Systems (GIS) data and Geo-spatial photo imagery display. In this application we use Sketch-Up software to extrude 3-D models of buildings as a plug-in to Google Earth for navigation.

A previous paper (Shams, 2006) studied the extrusion of 3-D model of buildings from 2-D imagery and GIS data sets at another campus. Elevation data extracted from the Light Detection And Ranging data (LiDAR) was used to extrude the height of the buildings by subtracting the Data Elevation Model (DEM) elevations from the raw global positioning system (GPS) points. The DEM provided a terrain that allows one to drape an aerial photograph or Digital Ortho-photo Quarter Quadrangle (DOQQ) above it, thereby creating a virtual reality image of the study area viewed in our 3D Virtual Reality Model (VRML).

The DOQQ, is a color photograph of a section of topographic map made from an airplane; however, the film records in infrared light instead of the visible light. Each photograph covers an area that is approximately four (4) miles by four and a half (4.5) miles dimension. The photographs are detailed in that each pixel or block of light on the photograph represents one (1) meter or about three (3) feet square on the ground. The photographs are digital as they have been scanned to create electronic files that are somewhat like web images. An image on the web is small - usually 3 Kilobytes (Kb) to 100Kb in size. In contrast, each DOQQ is normally 150 Megabytes (Mb) in size, which is approximately 1,500 times larger than most web images. To make the DOQQs manageable and downloadable, the DOQQs have to be compressed into MultiResolution Seamless Image Database (MrSid) image format. MrSid format files allow the DOQQs to be compressed from 150Mb to about 3Mb - about 50 times smaller, making the images available through standard modem Internet connections. These MrSID files are georeferenced, matching true coordinates of the earth's surface so that one can measure distances and positions on an image using GIS software. One can measure distances along features such as roads and buildings on the photographs. One could even combine the photographs with other digital maps to print scaled maps. [4]

LiDAR data can be represented in many forms. These data are available in the contour form (as shapefiles), the DEM form, the raw point form, and the edited point form of the LiIDAR data. [4]

2. Project procedures

Using our existing 2-D campus map as a baseline, we planned to develop a 3-D model of campus with a virtual reality fly-through capability. We previously cataloged and collected geo-database - using GPS technology - many map features, such as streets, buildings, trees, and fire hydrants (for emergency response). In this application, we used Sketch-Up software, an application approved by the American Institute of Architecture (AIA) for modeling buildings. We had the footprint for all of the buildings on campus, but we wanted to extrude the 3-D features for realism and drape the digital imagery as a texture to the facade of the buildings.

Our procedures were as follows:

1. We developed expertise and skills in Sketch-Up. Using a train-the-trainer approach, two members of the project team took basic and intermediate courses on the architectural design software. They became a training resource for the other members of the project design team at Southern University.
2. ArcGIS and Sketch-Up was introduced both in the GIS laboratory on campus and to an engineering class on CAD design.
3. Students were recruited onto the project team for 3-D modeling. In particular we asked students from architecture, urban forestry and engineering programs to participate in development.
4. Students were tasked with photographing buildings on campus.
5. Building structures were extruded from 2-D to 3-D using Sketch-Up software.

6. Photographic images were draped on facades to simulate the real-world environment.

7. Students entered a design competition for 3-D modeling of a virtual campus and this project was developed.

8. The final product is due at the time of presenting this paper to ESRI.

These are the data processing steps we used in our project:

a) Gathered all the available data for the study area from LiDAR, DEM, Contour, CAD, DOQQ, Aerial photography, High resolution digital imagery, GIS and GPS points.

b) Studied each data package and see what process can by applied on each data set that can be helpful in the study, if converted to the right format. For example one can get the elevation from the DEM and the building height from the GPS raw points.

c) Built a 3-D model of the Southern Campus by applying extrude-function on the geo-referenced CAD file.

d) Inserted the 3D model in the real world coordinates and with realistic texture draped on the sides of the buildings.

e) Created a fly-through of Southern campus, and are trying to automate this process for larger areas of interest.

All the available data were gathered and categorized in groups for further processing and transformation to the right format. Below is the list of the data package and the original format with the extension:

2.1. DOQQ:
   a) 1998 MrSid format
   b) 2004 2000 jpeg format
   c) 2005 DOQQ jp2 format
   d) 2005 High resolution aerial photography TIF format

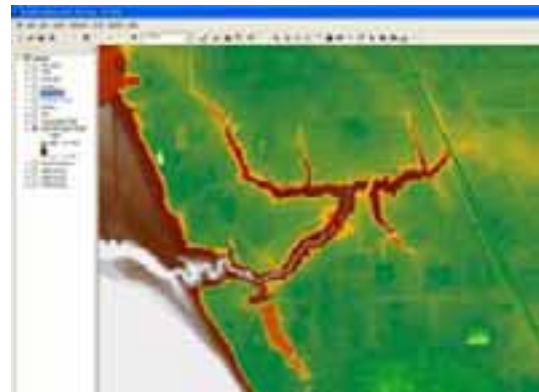(a) 1998 MrSID (.Sid)   (b) 2004 2000 jpeg (.jp2)

(c) 2005 DOQQ

(d) 2005 High resolution (.tif)

2.2. LiDAR:

a) Contour ESRI shapefiles (.shp)
b) Data Elevation Models DEMs (.dem)
c) Triangular Irregular Networks TINs

(a) Contour (.shp)

(b) DEM (.dem)

(c) TIN (.tin)

2.3. CAD and GIS

− AutoCAD files (.dwg) converted to Shapefile (points, lines and polygons).
− Tabular data (excel, CSV, dbf, etc.)

AutoCAD files (.dwg)

Topographic Map

2.4. Images
– Jpg, tiff

Agriculture Center

SU Museum of Arts

F.G. Clark Mini Dome

A. W. Mumford Stadium

2.5. 3D Model

3D Model

3. Data Processing and Transformation

After gathering the data, some processes were applied on each data set to convert and massage it from raw form to a dataset that can be helpful to create the 3D fly through model. Here is the list of the data sets and the processes.

3.1. *Aerial photos or DOQQ*:

The DOQQ from Louisiana State University Atlas website [3] which are in MrSid and JP2 format, were processed in image processing software (Global-Mapper) to convert them to GeoTIff format and a world file (.tfw) created for the correct projection and specific coordinate system. The gaps in the data were interpolated when needed. Sometime the pixel size needed to be altered to fit the 3D environment by calculating the pixel size or import the pixel size from an already known grid raster file. Also we used ArcGIS mosaic tool to attach the tiles to each other rather than having separate individual tile.

3.2. LiDAR:

a) DEM:
The Data Elevation Model was used in The Virtual Global Explorer and Observatory (vGeo) software. It was also used to determine the elevation range [5]. Since Louisiana is flat or below sea level, an exaggeration was applied to the elevation so it can be noticed in the 3D model.

DEM (.dem) files cannot be opened directly in ArcMap, and had be converted first from Dem to GRID using conversion tool in the Arctool box, but one had to pay attention

to the pixel size and the floating/integer value of output file. The result was saved in dos convention naming system folder under the hard drive other wise the function would not have worked correctly. The color or elevation was changed from integer to floating based on the height color schema.

b) Contours:

Contours came in simple line shapefiles hence there was no need to convert them and were used as is to import to GIS or the 3D model.

c) Raw and Edited Points:

The raw and edited GPS points were available in (.csv) format. They were edited in MS-Access database software, and then exported to .dbf format. It was important to use an integer format for the Z value column. It should be noted however that Excel^{TM} can hold no more than 65,536 records. The (.dbf) format was then inserted in Arcmap^{TM} as an X, Y event then exported to shapefile. This shapefile would then be converted to a raster image using the conversion tool feature and raster by the value of Z.

We subtracted the DEM elevations from the Raw Grid to get the heights of the buildings using ArcGIS ArcEditor or a higher license and reclassify the new output to get rid of all the unnecessary points such as the negative values, zero values, unrealistic points such as too much high elevation and No Data values. This method allowed us to get a shapefile with attribute table for all the building heights.

3.3. CAD:

CAD files were gathered from Southern University's Office of Technology and Networking Services as an AutoCAD (.dwg) format. They were viewed, cleaned and updated in AutoCAD software then exported to ArcMap. The most important step was to Geo-Rectify the CAD file to be in the right projecting and coordinate system by creating world file (.wld) file and presented into GIS line shape file type. We applied a coordinate transformation to a CAD layer [3], then Imported into Sketchup to extrude and drape the texture on the surfaces of the buildings.

3.4. 3D model

A CAD polyline file was imported into Sketch-Up by Google then extruded to the height of the buildings based on the raster subtraction the DEM data from the raw data. The surface texture images were draped onto the sides of the buildings [9]. To determine the center of the building we analyzed the data in ArcGIS to get the correct insertion point, scale and rotation of the object from the world file, and then exported the file to Google earth

4. Results and systems implementation

The aerial photography images and the DOQQs, in either MrSid or JP2, formats were converted to GeoTiff format and world (.tfw) files created. CAD files were exported to ArcMap and geo-rectified (.wld) then imported as a shapefile (.shp) files with right

projection and exact coordinate system in the (.jpr) format.

CAD files were imported into SketchUp Software and extruded to the correct height as mentioned before, texture images were draped onto the side surfaces of the 3 D buildings; the files were then exported to Google Earth (.KML).

DEM data was used to create the coordinate configuration file and decreased by about fifty percent (to retrieve the data faster) to create the terrain to drape the ortho- photos, CAD, shape files, contour, and 3D models on top of it. Also the DEM, Raw data, were imported into GIS ArcMap software. The raster math option from the 3D analyst tool in the Toolbox was used to subtract the DEM from the raw data to get the height of the buildings. Then the raster was reclassified to determine the correct buildings heights and positions.

5. Conclusions

This project, designed to develop a 3-D Geo-database virtual reality map for campus, was useful for educational purposes in general, and for learning geographic information systems in particular, as involved students with faculty in research environment they relate to i.e '*they all work and/or live on campus*". It also provides a service to for virtual visitors to campus, because they can use the web-enabled fly-through application to learn about their university from their desktop. The application can inform emergency responders should there be a fire or disaster, helping them to be prepared to assist the academic community.

Although the 3D model was created and implemented with all the dataset packages from Aerial photography, DEM, LiDar, CAD, TIN and 3D models in SketchUp; the building heights could also be approximately determined subtraction by means of the DEM from the raw GPS point and can be used for larger areas too by comparing to the aerial photography and CAD files with the DEM data. The buildings can hence be divided into groups or can be studied individually to increase the precision against the productivity.

6. Future endeavors

This project is just a startup on the 3D modeling using the web; this model is going to be reduced in file size so it can be easily hosted on the web so people with low speed internet access can view the campus. Project will require more work on the reclassification of the subtraction of the raster data set to decrease the noise and the clutter. Also we will try to convert the raster of z values to polygons of the same values. On the other hand these points should be exported directly into Google earth or ArcExplorer, and databases created for all the buildings and the surrounded surfaces to automatically drape the right images to the right building. Our goal is to make the whole system automated to increase the speed of the process, by reducing the translation and conversion of the imagery or by writing simple algorithms that can be efficient for a large scales urban areas.

Acknowledgements

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