

Introduction to HVE 3D Environments with Google SketchUp

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ABSTRACT

Creating an accurate and appealing 3D model for use in HVE is an important part of accident reconstruction simulation. Google has released software in recent years, which can be utilized to create 3D models for HVE environments. SketchUp (SU) is a 3D drawing program by Google that is supported by Google Earth's (GE) Digital Elevation Model (DEM), Aerial Photography and 3D Warehouse (3DW). DEM data can be imported from GE with overlaid aerial photography and used in SU as a starting point for 3D accident scene modeling. 3DW provides pre-made models of environmental objects and vehicles submitted by other users of SU. The accident scene model created with SU can be imported into HVE as a 3D environment. The 3D model can also be exported to a .kmz file and viewed with GE software. This paper will discuss the use of SU as a 3D environment-modeling tool and give some examples of its application.

INTRODUCTION

The purpose of this paper is to introduce the use of SU for creation of HVE-3D environments and HVE vehicle geometry. SU's integration with GE provides many advantages for modeling accident environments over other types of modeling software. Integration with Google Earth provides "geo-locating" and seamless import of aerial photographs and DEMs into SU for use with creation of accident scenes. SU utilizes open source programming code;

therefore plug-ins for the software can be developed by anyone. SU's plug-in library is updated often.

The 3DW is an online bank of 3D models that have been created by other users of SU. There are thousands of models in 3DW. 3DW models include vehicles and objects used for accident scene creation (i.e. trees, stop signs, etc).

The combination of these features offers timesavings and convenience for the HVE environment and vehicle modeler. This paper will introduce and discuss the advantages of using SU and some of the "road blocks" currently in place, which limit the software's full potential. The paper will also discuss the accuracy of Google Earth's DEM.

BACKGROUND

Some background on the development of SU and in particular the aerial photographs and DEM used by SU should be understood. As described in the abstract section, SU is 3D modeling software developed by Google. SU was originally developed for, and is typically used for creating buildings and other structures to be displayed in GE. Numerous textured buildings have been created by users of SU and uploaded to the GE database (Figure 1). For this purpose, SU was created with a "geo-locating" feature. The software has the ability to download aerial photographs with terrain models directly from GE.



Figure 1 - Google Earth with building models

Models of buildings and other 3D objects can be constructed over aerial photographs and terrain and exported back to the GE database.

The features that make SU ideal for constructing models of buildings on-site for display in GE also make it ideal for creating HVE-3D environments. Aerial photographs and DEM can be used as a driving surface in HVE, which is very useful for accident simulation, if the DEM is confirmed accurate. In addition the 3DW provides pre-made 3D models that can be used for HVE environment creation. Information beyond the roadway about the environment is included with minimal effort.

DATA SOURCES

The data sources that provide the aerial photographs and DEM in GE warrant some discussion since they will be used for accident scene recreation. The user should understand the source of data and corresponding accuracy. It should also be noted that Google makes no claim for accuracy of its aerial photographs or DEM. Information should be compared to site measurements whenever possible. The accuracy of the DEM for one area was evaluated for this paper and will be discussed later. Further studies regarding DEM accuracy validation beyond the scope of this paper should be performed.

Aerial Photographs

The aerial photographs provided by GE are taken from many different sources. Overall the qualities of the photographs improve with increasing population. Resolution can vary from 15 meters (~50 feet) per pixel or greater to 8 centimeters (~0.25 feet) per pixel. Many images taken via satellite are available in 2.5-meter (~8 feet) resolution.

Google also provides historical image data in the most current releases of the software. A time bar slider can be used to explore previous aerial photographs. The process for using historical aerial photographs from GE in SU has not been explored by the author as of the time of this paper and will not be discussed.

Digital Elevation Model

The digital elevation model used in GE and imported to SU provides a digital representation of ground surface topography. The Shuttle Radar Topography Mission (SRTM) flown by NASA in February of 2000 provides the primary source of data for the DEM. The mission was performed over 11 days and covered approximately 80 percent of the earth's surface.¹ The SRTM mission utilized Synthetic Aperture Radar (SAR). SAR utilizes phase-difference measurements from two radar images acquired with a very small base to height ratio (typically 0.0002) to acquire topography. The SRTM provided a DEM at a resolution of 30 meters (~100 feet).

GE filled gaps in the SRTM data with elevation data from other sources such as the National Elevation Data Set (NED) and stereo reduction techniques. The DEM resolution of many mountainous regions of the western half of the USA has been increased to 10-meter (~30 feet) resolution with other data sources.

¹ NASA SRTM Mission Paper

The SAR technology had some limitations, which are discussed further in the SRTM paper referenced. The technology used did not penetrate heavy vegetation canopies. According to the SRTM paper, the terrain in these areas will show to the top of the canopy rather than ground level. However the authors have not found to date any areas in GE where this was noted. Some areas with tall buildings, such as city centers, do not have accurate elevation models. This is most likely due to a similar issue caused by the city scape.

Rough surfaces are required for good satellite signal return. Therefore calm water and sand sheets do not typically scatter enough energy to yield accurate height measurements. The radar waves from SRTM can penetrate up to several meters into frozen ice/snow and very dry soil, which can yield inaccurate elevation measurements.

Aside from the shortcomings mentioned by the referenced paper, the authors have also noted other discrepancies in the DEM. The DEM does not correlate well to actual site conditions in areas with high variance of elevation. Note the inaccurate elevation representation of a road in a "hilly" area in eastern Missouri shown in Figure 2.

As discussed in the NASA SRTM paper, some elevation errors are caused by errors in "phase unwrapping". The SAR technology measures a path length difference between two radar's as an angular phase difference, which becomes ambiguous after 2π radians. A method for finding the absolute phase and actual path difference must be used, and there are several algorithms that have been invented to optimize the process. Phase wrapping errors typically show up as elevation jumps of 10's to 100's of m when estimates from one pixel to the next jump by 2π , or titling caused by poor choice of an absolute phase.



Figure 2 - DEM of "hilly" area (top) with street view at bottom of same area (bottom)

Correlation of DEM with actual site conditions improves with less elevation variance. Users should also be aware that due to the penetration effects of the SAR radar waves, DEM scans elevation to ground level and will not scan to top pavement level for bridge structures or highway over passes (Figure 3).



Figure 3 - DEM at highway overpass

The authors do not recommend that DEM be used as the sole source of elevation data for accident reconstruction where it is critical to the accident reconstruction until further validation studies can be performed. Even after validation of the DEM some areas, such as bridge overpasses will still require survey measurements. The aerial photography and DEM does provide good supplemental site data and imagery for HVE 3D environments. SU can also “drape” the aerial photograph from GE onto a user created terrain.

DEM VALIDATION STUDY

On January 23, 2011, Ronny Wahba of SEA, Ltd. performed a 3D laser scan for purposes of comparing DEM information from Google Terrain images to measured roadway slopes and elevations. A total of 11 scans were performed using a Faro Laser Scanner Photon 120 (Figure 4) in Maryland City, Maryland. The scan was taken on three connecting roadways including Cokeland S, Old Line Avenue, and Dameron Street S. Sphere targets were used between the 11 scans to ensure all of the scans were accurately aligned to one another (Figure 5 and Figure 6).



Figure 4 - Faro Laser Scanner

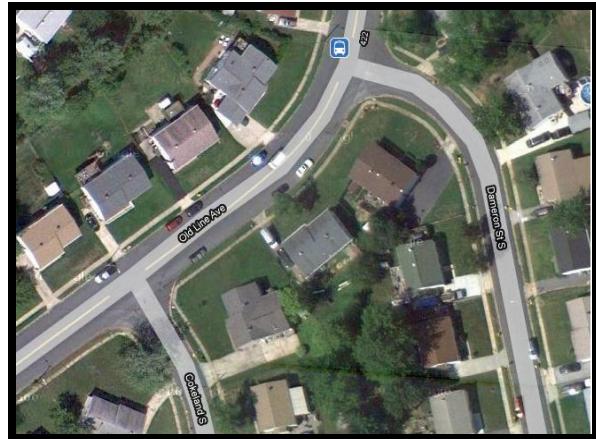


Figure 5 - Google Earth Aerial Photograph of Scan Area



Figure 6 - Plan View of Laser Scan Point Cloud

The accuracy of the DEM when compared to the laser scan of the road was studied. The DEM had very close correlation to the laser scan for the section of roadway examined. Approximately 800 linear feet of roadway was scanned and compared to the DEM. Measurements for a selected 100-foot section of the long axis of a roadway had a maximum vertical height variation of less than 2 inches (Figure 7). Excellent correlation of the DEM to site elevation measurements from the laser scan for the entire scan area was observed.

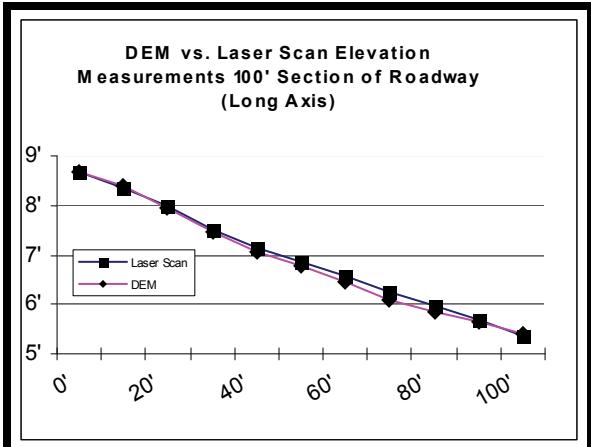


Figure 7 - DEM vs Laser Scan

Further validation studies should be performed regarding the DEM accuracy with different types of terrain. The results from one section of roadway compared to the Google Earth DEM were very promising. Figure 8 shows some of the contour lines extracted from the laser scan placed onto the DEM from Google Earth.



Figure 8 - DEM vs Laser Scan Road Surface

HVE ENVIRONMENTS

Aerial photographs and DEM can be used in concert with accident site survey information to create detailed HVE environments with SU. SU also incorporates a direct link to photograph editing software to make edits to the aerial photograph, such as removing vehicles in the photograph. The aerial photograph in SU is updated automatically after editing is complete.

In addition SU incorporates a built-in photo texture from Google Street View option. 3D buildings created in SU can be textured with images from street view with this feature (Figure 9). SU also utilizes 3DW, where commonly used items, such as light poles, stop signs, and fences can be downloaded into the accident scene.

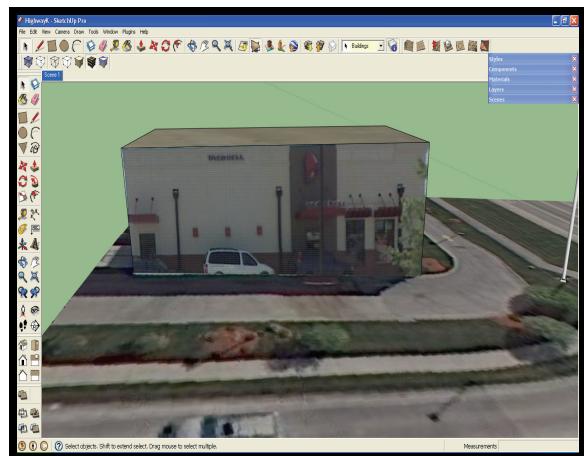


Figure 9 - Building textured with street view in SU

The authors of this paper found conversion of 3D environments from SU to HVE to be cumbersome. Although the pro version of SU exports to VRML and DXF files, HVE did not accept either format from SU without additional modifications. HVE would eventually load the VRML export from SU, however it was not functional and would overload system memory. This appeared to be due to a mesh texturing issue. It is interesting to note that the HVE Scene Viewer did not have any issues with the direct VRML export from SU.

Converting the file in SU into a .dae (collada) or .3ds format for import into 3ds Max was successful. After the file was imported into 3ds Max, some minor modifications were made and the file was exported to a VRML file from 3ds Max. The VRML file from 3ds Max was accepted by HVE without issues. The problem appeared to be due to a mesh texturing issue with the

aerial photograph and terrain model when it was exported directly from SU to HVE in the VRML file format. The VRML from SU was “exploded” into individual triangular meshes each with its own texture. Using 3ds Max solved this problem.

HVE VEHICLES AND 3D WAREHOUSE

In addition to utilizing SU for accident scenes as discussed above, the 3DW incorporated into SU is a database of thousands of 3D models. Models for vehicles can be found in the 3DW. Prior to using the models for HVE accident simulations the accuracy and copyright requirements should be confirmed.

The authors determined that conversion of the native SU file format to the accepted HVE format required the use of 3ds Max. The vehicle model was modified as required, wheels were removed and the vehicle was rotated around the “red” axis in SU. The vehicle was exported to 3ds Max as a .3ds file from SU. The surfaces were renamed in 3ds Max for purposes of editing the .h3d file as described later. The vehicle model was then exported to a VRML file. HVE Scene Viewer was used to open the VRML file and save it to a .h3d file. The .h3d file was then edited to make the body surfaces transparent in the vehicle editor.

RECOMMENDATIONS

The authors recommend that further study be performed with respect to the accuracy of DEM for use as an accident scene environment in HVE. It is recommended that further validation studies be performed.

The conversion of the .sku files to VRML within SU was not compatible with HVE. Memory overflow was caused by the surface textured with the aerial photograph. Further work should be done in this area to remove 3ds Max as a required step in the conversion process.

The authors recommend that a .dae collada file importer being included with HVE software. The SU files export to .dae format, which is open source software code.

CONCLUSIONS

The methods described in this paper can be utilized to create detailed 3D environments for HVE in less time than traditional methods. The aerial photograph and terrain data combined with the 3D Warehouse provide the user with the tools needed to quickly create HVE 3D environments.

As outlined above, validation studies of the DEM accuracy of roadway elevations would be beneficial to HVE users. If DEM could be confirmed to be accurate, it could reduce time spent measuring site elevations. At a minimum long axis road slope from DEM could be used for HVE simulations. The DEM of the roadway area studied for this paper had excellent correlation to site elevation measurements taken with a laser scanner.

The improvement of HVE environments with little extra time spent could be substantial by using SU. There are obvious benefits to the HVE environment modeler. The conversion process from SU to HVE needs further work done to streamline the process for all users. The addition of a .dae file import into HVE would be possible as the .dae file format is written in open source programming code.

REFERENCES

1. “The Shuttle Radar Topography Mission,” NASA, 2000
2. Google Earth
3. Google SketchUp
4. 3ds Max
5. HVE 3D
6. Faro Laser Scanner Photon 120