

# MODELING OUR ENVIRONMENT: FROM CARTOGRAPHIC TO PHOTO-REALISTIC

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**KEY WORDS:** Modeling, Cartographic Maps, Photo-realistic, Visualization, 3D

## ABSTRACT:

Combining science, art, and technology, cartography builds on the premise that reality can be modeled in ways that communicate spatial information effectively. Cartographic **models** such as points, lines, and polygons are often used to represent the spatial features on the earth surface. With the advancement of mapping techniques such as GIS and geovisualization tools, it is possible to model the earth environment into a photorealistic, virtual reality in which a point feature to represent a building can be replaced by a virtual building. This paper discusses an approach to developing a photorealistic, virtual village located in Glen Carbon, Illinois. Cartographic maps of the village are first generated, including features such as buildings, roads, cars, a power substation, overhead electrical power lines, a water tower, underground water mains, water sewer lines, lawns, manholes, hydrants, and trees. Those cartographic features are then transformed into 3D symbols to develop the virtual village in which the user can explore and visualize not only the 3D scenes above the ground (e.g., buildings, hydrants, power lines, trees) but also the 3D scenes under the ground (e.g., water mains, sewer lines). In conjunction with the geometric network modeling, the user can experience the geometric networking among water tower, water mains, hydrants, and buildings (i.e., water flow). For example, the user can turn on the water supply from the water tower to see how the water flows in the water mains and into each building; the user can also disable a T-valve to turn off the water supply to a particular building. It is anticipated that such an innovative approach provides a new insight how spatial information about our environment can be effectively perceived through the use of photorealistic modeling technique.

## 1. INTRODUCTION

Combining science, art, and technology, cartography builds on the premise that reality can be modeled in ways that communicate spatial information effectively. Cartographic models such as points, lines, and polygons are often used to represent the spatial features on the earth surface. As the direct consequence of advancement in digital technology, there has been increasing interests in utilizing multimedia mapping techniques and 3D geovisualization tools to provide interactive, multimedia digital maps and even 3D virtual worlds of the spatial environment under investigation and to enhance user interactions (Hu, 1999; Hu et al., 2003; Hu, 2009; Kamel Boulos and Burden, 2007; Wu et al., 2010). As a result, multimedia mapping and 3D visualization can enhance the 2D cartographic representation of geographic features and allows for visualization of spatial data from different directions and angles or from above.

The launch of Google Earth in 2005 has brought excitement to the mapping community. Google Earth is a virtual globe that brings a 3D model of the Earth to users by integrating satellite imagery, aerial photography and digital maps through 3D technologies. Google Earth has the capability to show 3D buildings and structures (such as bridges) using SketchUp, a 3D modeling program software. Microsoft's equivalent to Google's development is their

Virtual Earth mirror world with 3DVIA (<http://www.bing.com/maps/Help/VE3DVIAInstall/VE3DVIADownload.aspx>). World Wind, as a 3D visualization virtual globe software, can present images from NASA, U.S. Geological Survey (USGS), USDA NAIP and Web Map Service (WMS) suppliers on a 3D Earth model ([worldwind.arc.nasa.gov](http://worldwind.arc.nasa.gov)).

This paper discusses an approach to developing a 3D photo-realistic, virtual environment that not only models the features above the ground but also the features under the ground. The townhome complex located in Park Hamilton, Illinois is selected as the study site. Cartographic maps in points, lines and polygons of the village were first generated, which include features such as buildings, roads, cars, an electrical power substation, overhead electrical power lines, a water supply tower, underground water mains, water sewer lines, lawns, manholes, hydrants, and trees. Those cartographic features are then transformed into 3D symbols to develop the virtual village in which the user can explore and visualize not only the 3D scenes above the ground (e.g., buildings, hydrants, trees) but also the 3D scenes under the ground (e.g., water mains, sewer lines). In conjunction with the geometric network modeling, the user can experience the geometric networking among water tower, water mains, hydrants, and buildings (i.e., water flow). For example, the user can turn on the water supply from the water tower to see how the water flows in the

water mains and into each building; the user can also disable a T-valve to turn off the water supply to a particular building. It is anticipated that such an innovative approach provides a new insight how spatial information about our environment can be effectively perceived through the use of photorealistic modeling technique.

## 2. METHODOLOGY

### 2.1. Study Site and Data Sets

The study site for this project was a small neighborhood located in Park Hampton of southwestern Illinois. The data sets used for this research included digital elevation models (DEM) and digital orthophoto for the study site. The DEM data was required to generate 3D scenes and was downloaded from the official web site of Mapmart, Inc. ([www.mapmart.com](http://www.mapmart.com)). The spatial resolution was 10-meter and the data was in USGS Spatial Data Transfer Standard (SDTS) format. The digital orthophoto had a spatial resolution of 1-foot (0.33-meter) and was obtained from the USGS National Map Seamless Server website (<http://seamless.usgs.gov/>). Both the DEM and DOQQ are in North American Datum of 1983 (NAD83) and UTM zone 15 N. The map unit for both data sets is in meter. Figure 1 shows a portion of the digital orthophoto downloaded for the study site and the rectangle represents the area to be modeled.



Figure 1. Digital orthophoto for the study site where the townhome complex is located (boxed area)

### 2.2. Data Processing

The data processing was done in ESRI's ArcMap and ArcScene. The first step was to generate a series of thematic maps (layers) using the digitizing tools in ArcMap, which included features such as buildings, sidewalks, cars, an electrical power substation, overhead electrical power lines, a water supply tower, underground water mains and sewer lines, lawns, manholes, hydrants, and trees. They were all digitized off the digital orthophoto and saved as

ArcGIS feature classes in point, line or polygon feature format.

The second step was to create geometric networks in the form of geodatabase for the utility systems, which include four feature datasets: power line system, sewer system, storm drain system, and water supply system (i.e., water mains). Each of these feature datasets has four feature classes, including sources, sinks, T-valves and line features. The purpose of this step was to model the flow of electricity, clean water, and waste water in the neighborhood.

The third step was to apply the DEM as elevation base in ArcScene for all the cartographic features and to assign appropriate 3D symbols to those features. For all the features above the ground such as buildings, trees, and hydrants, a positive intrusion was applied. On the other hand, for all the underground features such as water mains, and sewer lines, a negative intrusion was applied.

## 3. RESULTS

Figure 2 shows the cartographic features captured in ArcMap, including U-shaped driveway, parking lots, grass, trees, houses, and sidewalks. Figure 3 is a photo-realistic view of the townhome complex for above-the-ground features.

Geometric network allows to model the flow of water, waste water and electrical power. In Figure 3, main waterlines run under the Arsenal Street and two lateral lines run down the center of the complex. The connector lines feed into each townhome. There are also two fire hydrants and the swimming pool connected to the lateral lines. The water tower is located in the northeast of the study area.

Figure 4 demonstrates that sewer lines come out from the back of the houses and connect up under the parking lots, to a larger line under the driveway, and to the mainline under Arsenal Street.

Figure 5 displays above-the-ground power lines feeding into the complex. At the edge of the complex, there is a transformer pole where the lines go underground. Power lines (in red) are under-the-ground throughout the complex. There are four transformers (one in each parking area) supporting nine houses plus street & sidewalk lights creating this radial look.

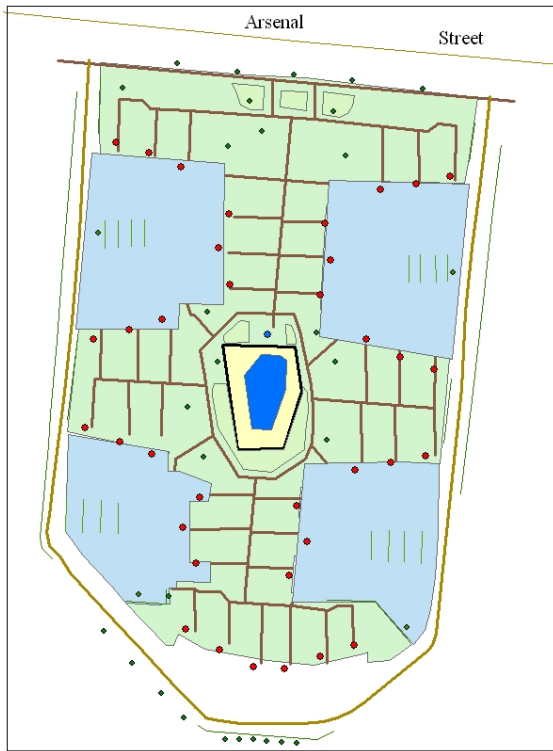


Figure 2. Cartographic features of the mapped area: U-shaped driveway, parking lots (in blue), grass (in green), trees (green dots), houses (red dots) and sidewalks (brown lines)

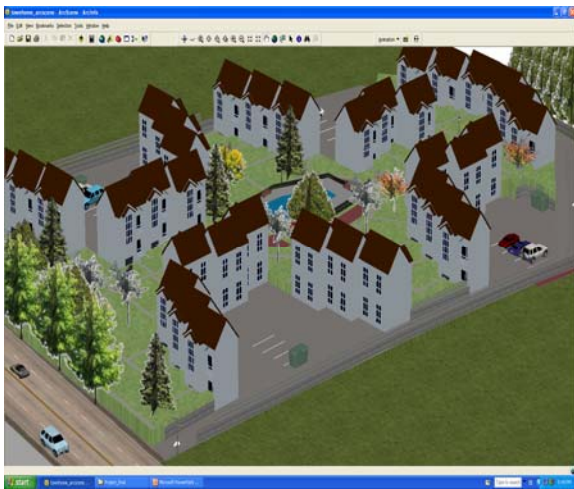


Figure 3. Photo-realistic view of the townhome complex (above the ground)

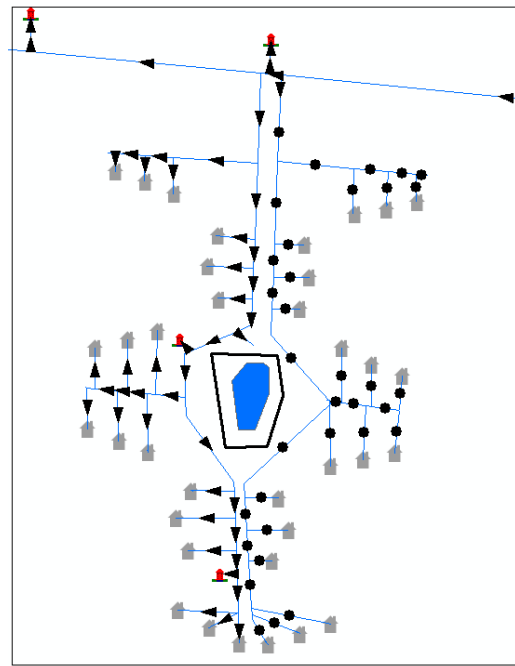


Figure 4. Modeling the water supply system. The map shows the water supply with water-flow (arrows) on the left and with no water-flow (black dots) on the right. The latter is caused by a turned-off T-Valve.

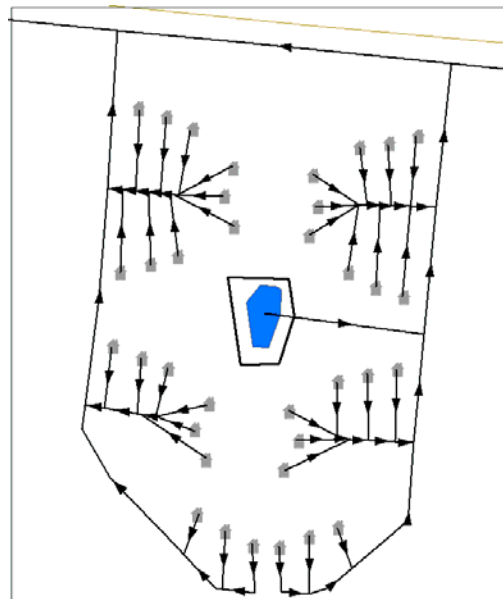


Figure 5. Modeling the sewer system. The arrows indicate the waste water flowing out of each townhome into the sewer lines. The waste water treatment plant is located in the northwest of the study area.

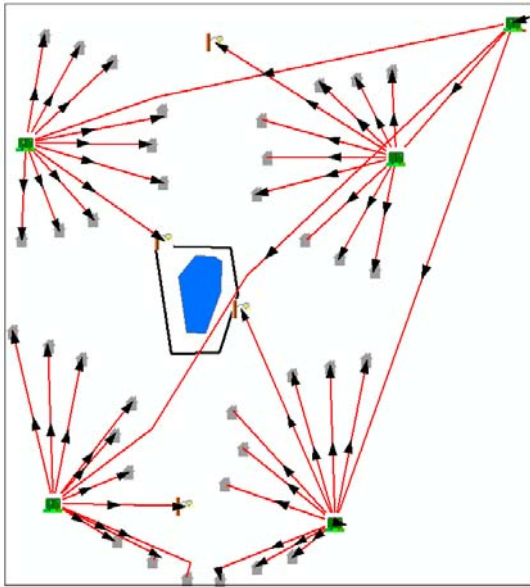


Figure 6. Modeling the electrical system. The arrows indicate the flow of electricity from a major power supply (power substation) to the four transformers and from each transformer to each individual townhomes.

Figure 7 and Figure 8 show combined displays of above-the-ground 3D features as well as under-the-ground 3D features so all the features are well represented in relation to each other in a virtual environment.

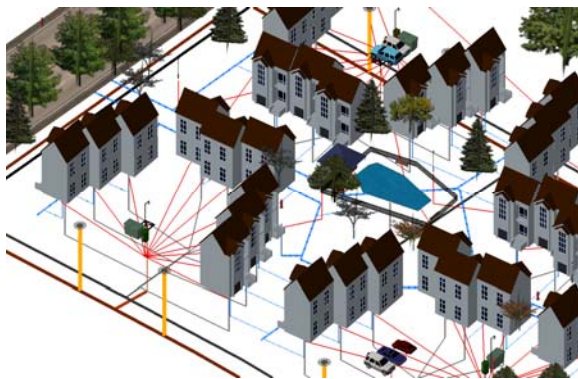


Figure 7. Photo-realistic view of the townhome complex with underground power lines (from each transformer) (in red), sewer lines (in brown) and water lines (in blue)

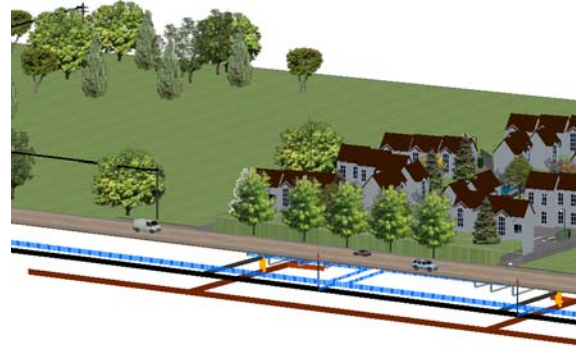


Figure 8. Photo-realistic view of the area next to the townhome complex showing above-the-ground features such as overhead power lines, electrical poles, trees, cars and fire hydrants, and under-the-ground water mains and sewer lines.

#### 4. CONCLUSIONS

It is beneficial to model 2D cartographic features into 3D photo-realistic, virtual display. The latter provides the viewer a better understanding of the environment and helps visualize the complex world. This paper, through the development of a photo-realistic and 3D village, could shed light on a new approach to modeling our environment, which can review the complex spatial relationships (e.g., the flow of resources, above-the-ground features and under-the-ground-features).

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