A look at making real-imagery 3D scenes

(Texture Mapping with nadir and oblique aerial imagery)

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In the near future, the photogrammetry industry will be able to provide city and county managers the ability to visualize their cityscapes using 3D views for varying types of analysis. Pipeline managers will have the ability to see their above ground pipelines traversing the countryside for active risk assessment analysis. As some will attest, true ortho and wire-framing have been in existence for over 15 years but this involves manual to semi-automated interaction with the stereo imagery. We have seen oblique imagery in use for the last decade with trends to continue to be a very good product for city and county governments along with emergency management over the next decade. Software used for viewing and measuring oblique imagery will continue to be the norm in varying industries. Yet, our focus here is the refreshing trend toward the display and measureable use of 3D urban and infrastructure models using aerial mapping, which we are witnessing as it makes its way into the spotlight.

The concept is to use aerial imagery (nadir and oblique) as the input to producing real 3D textured surfaces. The topic of using oblique and nadir imagery to produce real 3D textures to interact with 3D mesh models has been in the research community for more than a decade. The new trend as this technology surfaces within the private photogrammetry industry is for these 3D textured surfaces draped on a mesh model to be produced as a by-product of a fully automated mapping workflow. It is predicted these 3D real imagery models of the landscape will be as common to client project deliveries over the next five to ten years, as digital orthophotography had become by the late 1990s.

In a recent discussion with Jeff Kirk, VP of Software for Icaros (Fairfax, VA), I was provided insight into how aerial photography is used to produce these real-imagery 3D scenes.

Oblique and nadir imagery are processed through the normal photogrammetric workflow to produce aero-triangulated imagery blocks. This same imagery set is then used to produce accurate surface structure through dense correspondence matching and triangulation, similar to dense DSMs, only three dimensional. With this methodology, the end product is a great view-navigation and visualization tool, and a product from which measurements may be extracted by the end user. The process goes something like this.

Corresponding image points are triangulated to 3D points on the Earth's surface (the same as for traditional DTMs). Points are then connected to make a surface. There are various methods for doing this. One method is to cast the points outward onto a huge sphere, where in the limit, the sphere becomes a flat surface. Points are then connected together on the flat surface, similar to a connect-the-dots game. The points are then transformed back to their original positions on the Earth's surface, but now they are connected to one another. This is called skinning the surface.

Now we must colorize the surface from the original images.

Texture maps are computed for the surface model as shown in figure 1 mapping images to it. A simplified description of the process is that as the algorithm parses through each triangle, it analyzes and looks for where the triangle face is most perpendicular to a given image and collects those pixels into a corresponding texture map location, based on fit.

Figure 1. Texture map produced from nadir/oblique imagery of Frederick, MD by Icaros, Inc. The texture is an index with the larger images on the left and smaller matching images on the right

When the process is finished, we end up with a 3D surface of the Earth and new images, the texture

Figure 2. 3D city view of Frederick, MD using 2cm nadir and 3cm GSD oblique imagery collected by Icaros, Inc. This imagery is converted to a texture map and then reconstructed on to the 3D model of the city through an automated process. The above image is a wireframe rendering of the model with texture applied.

maps, which map bits and pieces of the original images to the surface to form a seamless 3D image of Earth's surface.
Of course there are lots of issues to consider.

The primary one being that if you don't have stereo imagery for a particular point on the Earth's surface, you cannot hope to derive that point's structure or color. The geometry and color of that unseen point may only be approximated based on its surroundings.

However, in practice we now are able to reconstruct detailed skinned and textured models of the Earth's surface such as those shown in figure 2. The reconstructed surfaces can be directly related back to the images that were used to produce it. As such, measurements on the 3D model may be confirmed by epipolar correspondence to the original images. This provides a powerful methodology for accurate and precise measurements, using both the 3D reconstruction and the original bundle block adjusted imagery.