A Visualization Application for the Mining Industry Using Standard Tools

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ABSTRACT
3-D or pseudo 3-D visualization of orebodies and mining related processes such as loading and tramming, are now commonly used by the mining industry. An approach is presented that can aid the engineer in creating the visualizations necessary for accurate presentations for use in public relations, safety training, production projections, reclamation plans, etc. It is shown that the creation of such digital representations of mining environments are independent of the mining package used to create the original mine design. Once a proper model has been created, any view of the areas is possible. These views can be taken from any number of stationary points or entered into an animation showing the progress of a mining construction. The paper focuses on the presentation of the steps used to accomplish the visualization and an example is for a quarry fill placement project.

INTRODUCTION
With the advent of distributed computing environments and the low cost of desktop computing power, it is now common for small engineering groups to use visualization tools for modeling an orebody, or a mining process such as loading and tramming. This is usually accomplished using commercial tools, such as mine design packages, process simulators, etc., that have a custom user interface which allows management of the respective databases.

There are cases, however, when a visualization application needs to be developed for one or more particulars areas in the mining property which must include data not readily included in the mining package database, such as equipment projections, underground facilities, landscaping data, surface structures, water bodies, etc (Brooks et al., 1999). This paper presents the steps needed to integrate such information with information exported from a mine package in order to create a digital visualization application that can be ported to different presentation environments.

The basic steps to be addressed are:

- Determine the type of data required for such an application (i.e. surface contours, structure frames, etc); assemble such data in the proper format (including extraction of the mining information from the mining database or package and accumulation of other data)

- Combine all entities in the same reference grid and create an integrated data set
- Apply realism on the integrated data set
- Create the final presentation package

The discussion below will be focused on a visualization application of a surface mining operation, where external data such as surface structures, water bodies, trees, and other landscaping information may be needed.

DATA COLLECTION

Data that are needed for such visualization applications fall into three major categories:

- Mine geometry related data such as mining/scheduling plans, topographic maps, access roads, location of boreholes, etc.).
- Non-mine geometry related data that describe in three dimensions the external add-ons to the base map of the area, such as 3D representations of surface structures, equipment, landscape features, etc.
- The appearance and the texture of mining and non-mining related data, such as the look of the exposed orebody, the overburden material, the reclaimed area, the landscape, etc.

Today, most mine related information is kept in CAD packages and can be extracted in a universal format, e.g. in Document Exchange Format (DXF). This provides the quality needed for depicting the terrain and locations of surface structures and features. However, data that depict equipment, surface structures, etc., should be collected in a digital format that would be appropriate for a 3D or pseudo 3D visualization. In other words, if the visualization involves moving or stationary vehicles on a surface, then these vehicles should be represented as 3D entities that allow rotations and projections from any viewing angle. If such data are not available, they should be created separately. In such cases, extreme accuracy in these representations are not needed, since in the virtual world, accurate depth perception on the part of the viewer is difficult to achieve for many of the objects. Figure 1 compares the accurate and rough 3D representations of a mining vehicle.

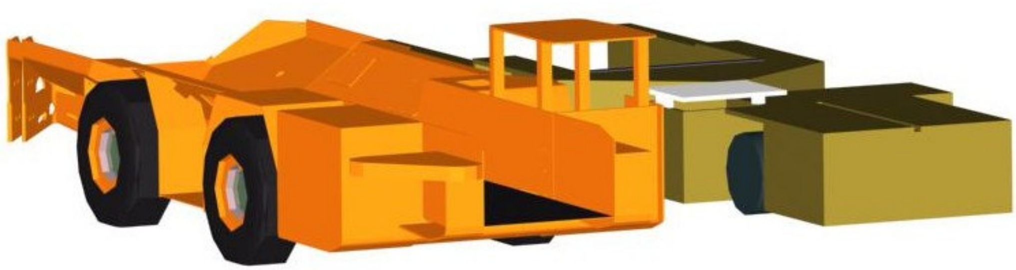

Figure 1: Accurate (courtesy Joy Manufacturing) and Approximate 3D Representation of a Vehicle

DATA INTEGRATION

To create a visualization of a landscape terrain, a Digital Terrain Model (DTM) is required. In essence a DTM is a collection of 3D polygonal surfaces, usually triangles, that represent the modeled surface. A DTM can be created in several different ways. The package administering the mining database may be capable of exporting a DTM file, otherwise the landscape model should be exported in another format and subsequently imported into a DTM generator package. As an example, commercial packages that can generate DTMs include Carlson Software's SurvCADD, Land Developer Desktop, Eagle Point Landworks, Surfer, etc. On many occasions, a DTM may not be based on real data. For example, if the model focuses on the construction of a new clearing then the DTM can be created directly to represent a flat plane. Figure 2 shows an example of a DTM file.

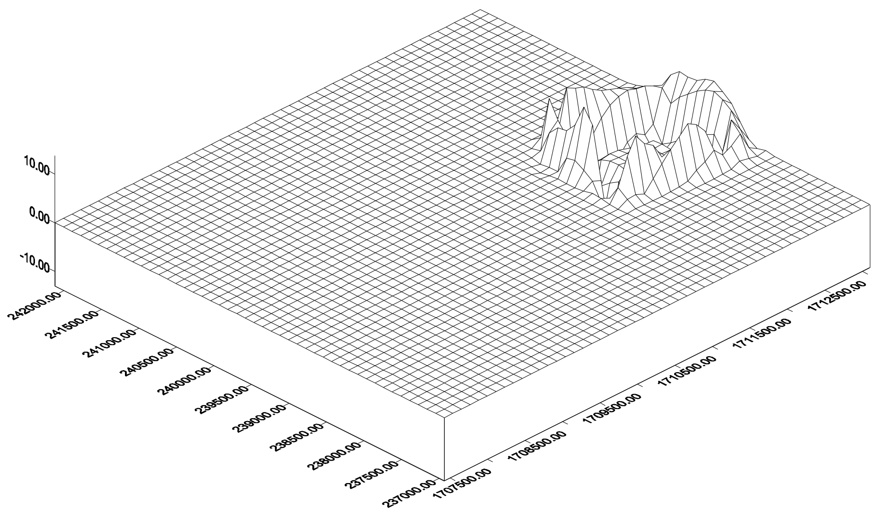

Figure 2: Example of DTM file

The level of accuracy depends directly on the area that is being modeled. It is important to note that the larger the area and detail, it will take more time and effort to load and process the model. Most desktop computers will start under-performing if the total number of polygons approaches 0.75 million. Establishing the level of detail at the beginning is critical to creating a good model.

To increase the detail and realism of the final model usage of already created models and textures is helpful (Vince, 1995). There are many resources for these libraries available, both commercially and complementary (3D Café, 2001). Using these libraries to create a personal library will increase the speed that an excellent model can be created (Lee and Owens, 2000). For instance, while creating a model that requires a house, instead of creating a house from scratch, one can be used from a library of houses. The same is true for texture maps and various bitmaps. These can be used most commonly for ground textures, skies, ore textures, roads, etc. Figure 3 presents a flow chart of the data assembly procedure.

APPLICATION OF REALISM

Once the visualization objects have been collected, they can be imported in the visualization package. The latter allows for XYZ positioning of each object as well as the specification of motion paths for each moving part. For example, the user can specify the path of a truck moving along a ramp. Examples of such packages are Kinetix's 3D Studio Max, Caligari trueSpace, Alias|Wavefront Maya, and Robert McNeel & Associates' Rhino. This can be easily accomplished in a wireframe mode. Then the textures for each surface should be applied, a light source and location should be designated, and finally the rendering procedure is invoked. Rendering is the process where virtual objects and their properties are processed for display. This process is accomplished using several different techniques (ray tracing, ray casting, volume rendering, image-based rendering, etc.) that account for varying properties (diffuse color, glossiness, opacity, reflection, refraction, etc.). Since rendering is a very time consuming process, sophisticated rendering packages can exploit the computing power of other computers in a network by using a rendering manager which coordinates the process in a number of networked computers (Pawasauskas, 2001).

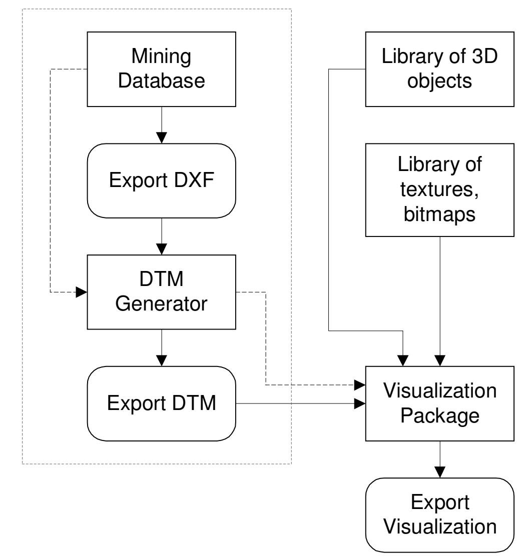

Figure 3: Flowchart of the Integration Procedure

Panoramic pictures generally are not helpful. This is because the panorama and the model will not map well to objects. Panoramas are extremely useful if, in the final output, the viewpoint will be constrained to the point from which the pictures are taken. For both panoramas and flat pictures, it is necessary to take several rows of pictures. This aids the final output because it can be used for comparison.

The last information needed is based on the level of detail for the output, the power of the computers creating the model, and the personal library of the modelers. Usually trees are the weakest part of modeling outside environments. This is due to their randomness and high complexity. There is no shortage of tree models available. Creating custom tree models can be the best way to accomplish specific goals.

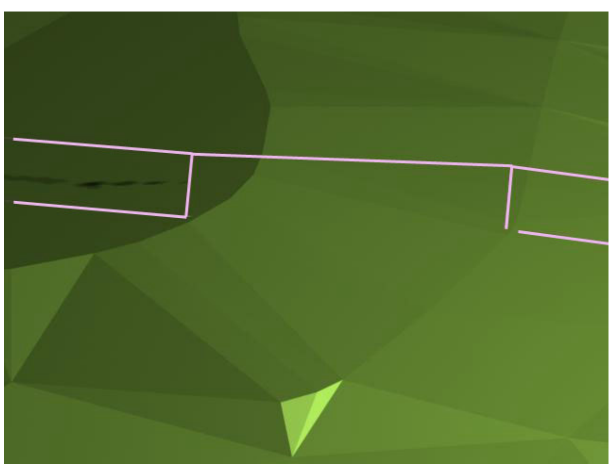

Figure 4: Wire frame fence line over a DTM

It is very unlikely that the animation or rendering just created will exactly fit the needs of the project. In this case, more information (or less in some cases) must be generated. Certain things such as fence lines, when imported into MAX, can be extruded. For most items like this it is important to locate all the points in 3D. If the modeler attempts to use the 3D snap to trace a new line over the 2D one, then it will extrude oddly at points as shown in Figure 4.

PRESENTATION METHODS
A wide and ever changing variety of distribution and presentation methods are available for models, animations, or renderings. They vary in complexity, expense, and portability. The following is a listing of a selection of such methods that will be further discussed below:

Figure 5: Volvo's Safety Simulator Mockup (Vince 1995)

Mockups – Mockups (Figure 5) are real controls that are tied into a simulation system. The simulation system dictates what is shown both on the control panel and in the user's vision. Some work has been done creating fully virtual mockups in a CAVE (discussed below). Mockups are very successful training tools in fact most pilots are trained in mockups. Mockups are extremely expensive to create because they require a simulator that controls the user's vision and controls. In general, mockups are not portable (Chakraborty and Bise, 2000).

CAVE –Figure 6 is a diagram of a Cave Automatic Virtual Environment (CAVE). A CAVE is a collection of screens on which images are projected from behind. The user stands inside the screens and wears special glasses that give the user the illusion of total emersion in the 3D world. CAVEs are excellent for projects that require the user to have no knowledge of the real world. They also require that the user not need to interface with the environment, mainly because the actual method of interfacing is unwieldy. The CAVE has excellent applications in virtual tours (for a single person). However, the CAVE is expensive to set up, requires high levels of detail, and is not portable (Benokraitis et al., 1998).

Distributed Environment (DE) – DEs are single screen CAVE displays that can connect to several locations over the internet (Figure 7 and Figure 8). DEs allow many people in many different locations to view the same 3D information synchronously. These environments are typically used for engineering projects (low level realism). They allow for a local design to be shared, presented, or reviewed by staff in other locations without any travel expenses. DEs can be expensive to set up and require good networks between locations (Lee and Owens, 2000).

Digital Videos (DVs) – DVs are used extensively, especially over the Internet. News organizations post coverage of top stories on their web sites for viewing by web browsers. DVs can be incorporated into any type of multimedia presentation from PowerPoint to Macromedia Director. DVs can be easily distributed over the Internet (either streaming or for download), by CD, or other digital media (DVD, Zip Disk,

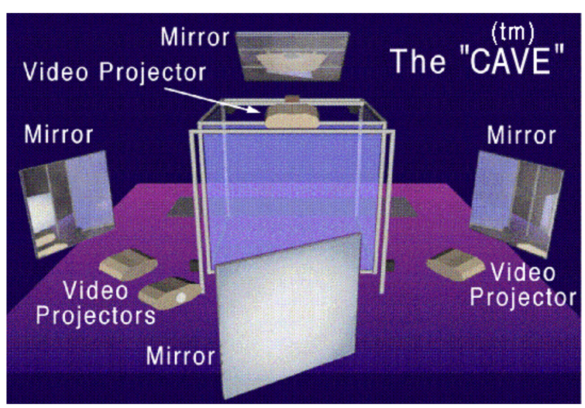

Figure 6: Diagram of the typical CAVE (Benokraitis,

etc.). Once a model has been developed a DV is inexpensive to create. However, they can be time-consuming to create and render and allow no on-the-fly interaction (Lee and Owens, 2000).

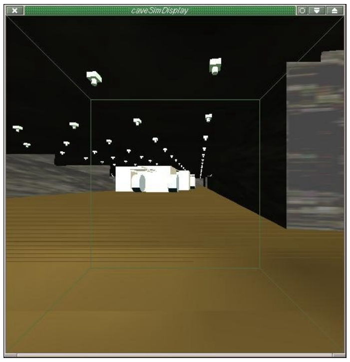

Figure 7: DE Desktop Client

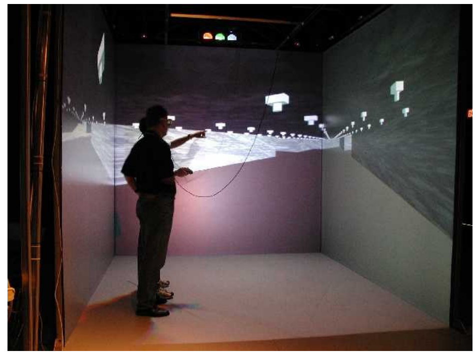

Figure 8: DE CAVE Client

VISUALIZATION OF A SURFACE SITE

Surface mining site visualizations using VR is growing as the costs fall (Williams et al., 1999). In this example, a quarry's fill placement project is presented using specific commercial packages. The steps involved are presented in flow chart form in Figure 9. The mine model in this exercise is drawn in AutoCAD.

In this section, one way of building the model is specifically detailed, using AutoCAD and Carlson Software's SurvCADD. Commands given are to be typed directly into the AutoCAD command line. Depending on the specific output this process can take as little as 20 minutes or can become practically lengthy.

The first step is to load the contours drawing into AutoCAD (Figure 10). Create a new layer named "move_point". On this layer draw a point. This point represents the new origin. If there are several drawings it is worthwhile to use the Write Block [wblock] to block that point out so it can be "xreferenced" (xrefed) into the other drawings. There are various ways of doing this. Use the Move command to move the contours to the origin using the new origin point as the reference point. From the Triangulate & Contour menu in the DTM module of SurvCADD select the Triangulate & Contour [tri] command. Simply draw the triangulation faces and do not run the function with smoothing. The result is the first pass DTM.

The modeler must review this DTM for areas that are either too coarse or too fine. Use Reduce Polyline Vertices [reduce] on the overly detailed areas and the Refine Polyline [refine] on the overly coarse areas. This process must be done with care or the model will take excessive time to load and process (too many polygons) or be too blocky (too few polygons). Once the DTM has been refined, Isolate it and Write Block it to a file.

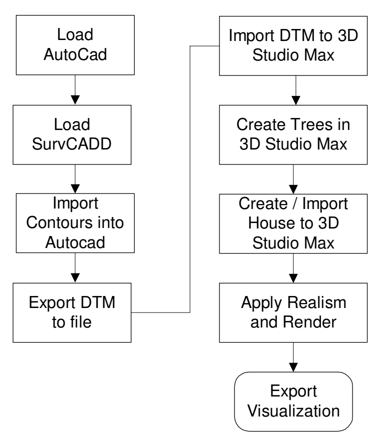

Figure 9: Flowchart of Specific Application

Create a new scene in 3D Studio MAX (for the purposes of this paper there is no difference between 3D Studio Max and 3D Studio VIZ). Import the DTM, being careful not to unify normals, weld (with an exceptionally low tolerance), and smooth (using 20 to 45 degrees tolerance). Make a few preliminary renderings of the top and perspective viewpoints to be certain that the DTM looks right for the purpose.

Using MAX, hide all objects except for the pit boundary lines (Figure 11) and the DTM. Select the DTM and then the sub-object points. Select all the points inside and on the boundary line. Detach these points to a new object named "disturbed". Follow this same procedure for all other boundaries where the ground will be a different texture. Set up the textures for each item. Use the UVW Map modifier to tweak the appearance of the materials. Insert models and trees using the imported information for guidance. It is normally better to xref these objects from other scenes. Create a sphere that encompasses the entire scene and change it to a hemisphere. Create a sky texture material and apply it to the sphere. Use the normal modifier to flip the normals in the sphere so the sphere will be visible from the inside. After adding a camera, any style animation/rendering can be created.

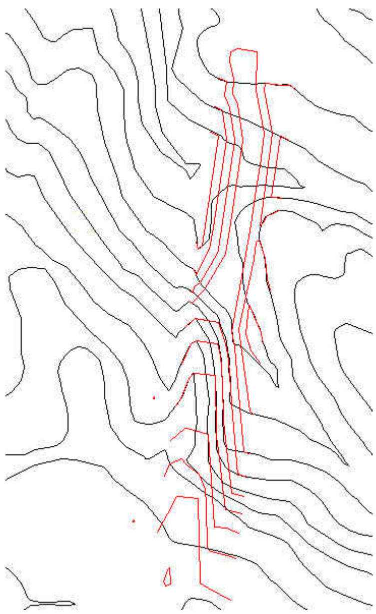

Figure 10 Beginning Topography

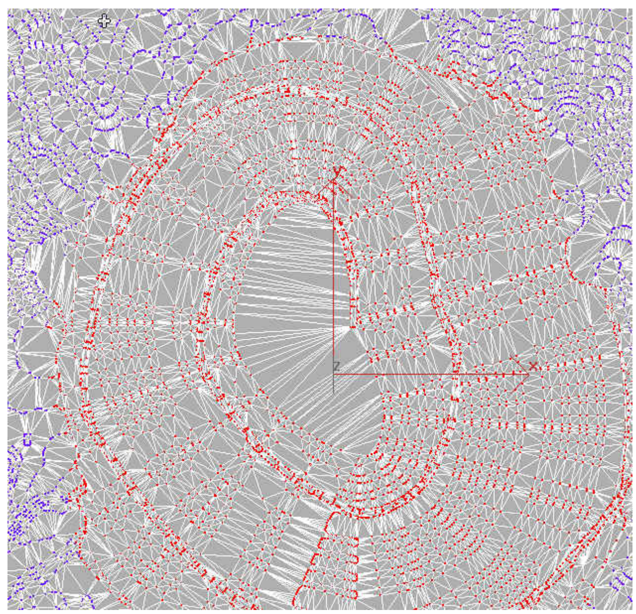

Figure 11 Selecting the DTM

In order to show the effects of a new berm construction at a quarry the above steps were followed. Starting with an AutoCAD drawing that includes surface contours, new berm contours, and locations of houses, several signs, power poles, etc. a model was created. The purpose of this model was to show how the construction of the berm would affect the view from several different houses. Figure 12 and Figure 13 are examples of the output from the model that shows the berm in about ten years after the construction. This particular model uses three different styles of tree models, a high quality tree (in the foreground), a middle quality tree (in the middle ground), and a low quality tree (in the background). The ground texture was created from pictures taken on site. The houses, signs and power poles were all taken from 3D model libraries.

CONCLUSIONS

This paper presented an approach that can aid the engineer in creating the visualizations necessary for accurate presentations for use in public relations, safety training, production projections, reclamation plans, etc. It is shown that the creation of such digital representations of mining environments are independent of the mining package used to create the original mine design.

In developing the step-by-step example presented in this paper that identifies the basic steps needed to create a custom visualization, using standard off-the shelf commercial animation packages. It was found that the most time consuming aspect of such endeavors is the artistic input such as selecting an animation sequence, a camera angle, library or custom ancillary objects (e.g. trees). Rendering the final sequences is time takes much computer processing time. However this can be done using several computers and does not require supervision.

Figure12 Initial View from Inside House

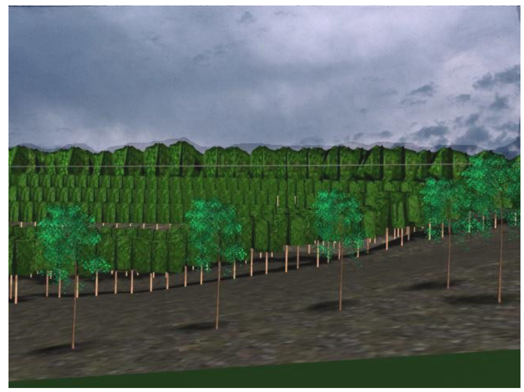

Figure 13 Ten-year view of new berm construction

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