A System for Virtual Reality Applications on 3D Geological Models and Mine Designs

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ABSTRACT: Determination of location and extensions of an ore body is crucial as well as estimation of quantities numerical values like reserve, thickness, grade distribution, etc. That is why recently virtual reality applications have been widely used for visual interaction and simulation on models of topography, ore body, and 3D mine designs. In this study, a very simple and practical approach to visualize underground assets and application of virtual reality on them is presented. The visual simulation includes walking or flying effects on, around or through physical surfaces and volumes. In the developed system, 3D terrain models, ore body and open pit models are generated initially by using drill holes data. Inverse distance interpolation or geostatistics are employed for modeling. The system produces 3D models in the form of Data exchange Format (DXF) which can also be converted into virtual reality format WRL. WRL form is processed by virtual reality processors like OpenGL or GLView. The final step is to load WRL formatted views and interact with them. These processors provide walking or flying utilities on 3D models. The developed system has been applied to a hypothetical 3D structure and ore body cases and revealed that it can easily be used for interactive virtual reality applications.

1 INTRODUCTION

Ore bodies are hidden economical assets to be discovered and determined. Drill holes give the most concrete information about them. This information is further used to estimate reserve and waste to be stripped as well as to determine and model the shape, extensions, thickness and quality of ore body. Various computer techniques serve to estimate these quantities and model mining site in three dimensions. Also, there are various commercial software systems employing this approach (Surpac, 2003; MineSight, 2003; Gemcom, 2003; GDM, 2003; Techbase, 2003; Datamine 2003; Lynx Mining, 2003; Minex, 2003). The aim is to determine physical appearance of ore body, as real as, it exists underground. This is crucial since all further mining activities are based on these estimations.

Virtual reality has brought a new aspect to geological modeling and mine design. It can be thought as the next step of modeling and visualization because the geological structures and designed mines are not only visualized but also can be visited virtually. This also provides an interactive visual simulation on developed models. As in many other improvements in computer techniques, virtual reality has found an application field in computerized mining systems (Denby and Schofield, 1999; Arnold et.al. 2001). Commercial software systems have also added this utility to their products.

This study presents an easy and practical approach for any mining researcher to develop this own virtual reality system. It is also shown that, the approach reduces modeling and visualization processes to geometrical calculations. In other words, the approach provides researchers a state of art for development of their own modeling systems and virtual applications on them with no need of computer graphics and visual simulation techniques.

2 THE SYSTEM APPROACH

Computer graphics is a great deal. However, it is a unique part of visualization and virtual reality systems.

The approach used in this study aims at providing an easy and practical methodology and state of art to build the visualization andrirtual reality system. It reduces the work to geometrical calculations while eliminating complicated computations of computer

graphics. Determination of geometric coordinates of a physical body is enough in the system. This is achieved by employing a distinctive format called Data eXchange Format (DXF) which is a special one to determine drawing vectors, 3D objects and entities in ASCII code. It can be visualized in several software like AutoCAD, 3D Studio Max, Bryce, etc. (AutoCAD, 1987). In other terms, the format is a way of stating geometric coordinates and can directly be introduced to many drafting software. Hence, the use of DXF format reduces many graphical computations (Erarslan, 2001).

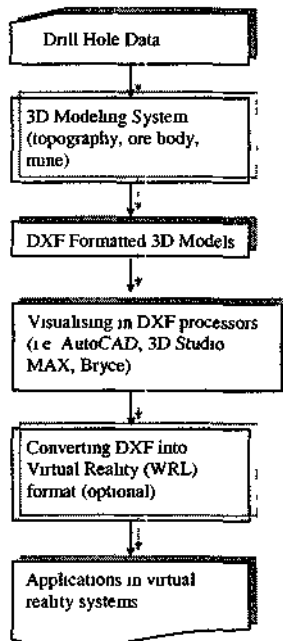The system approach is given as a flowchart in Figure 1.

Figure 1. Flowchart of the system approach.

Accordingly, initially physical models are generated and then they are stated in DXF format. Thereafter, models can be both visualized and applied virtual reality.

2.1 Three Dimensional Modeling

Drill holes constitute the database of the system. Several interpolation techniques may utilize the database and make estimations at nodes of a grid

system superimposed onto mine field. Grid nodes are estimated from surrounding drill holes by several methods such as inverse distance interpolation and geostatistics. Topographical, strata and assay data are major information needed for geological models and pit design.

A topographical model can be easily generated after assigning *z-coordinate* (elevation) to each node in addition to *x-coordinate* and *y-coordinate* (easting and northing relatively). In a three dimensional space, grid ceils can be displayed as rectangular or square surfaces (Fig. 2).
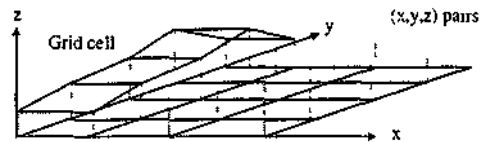

Figure 2. A part from three-dimensional terrain construction.

Similarly, parallel cross-sections or block models are used to generate 3 dimensional ore body models (Fig. 3).

Figure 3. Three-dimensional ore body block model.

Open pit mines can also be designed using pit base polygon, bench height, width, and slope angle (Fig. 4 and Fig. 5).

Figure 4. Pit base polygon (Erarslan, 2000).

Figure 5 Expanded pit on the base polygon (Erarslan, 2000)

Geometrical coordinates of grid cells, faces of blocks and faces in pit design can be calculated by the aid of computer programs These programs can be coded by researchers, too However, visualization is another aspect and requires computer graphics background and long time to realize In the study, DXF is used to state these coordinates and models can be visualized in drafting packages such as AutoCAD, 3D Studio Max, Bryce

2.2. DXF **Format and Visualization**

It is an ASCII format for determining any entity and objects in drawing (AutoCAD, 1987) A DXF formatted file includes several parts Drawing subjects (entities) are a part m the complete DXF form and take place m ENTITIES section Although DXF format has evolved during last decade, Figure 6 represents the simplest form of the general format (Erarslan, 2000)
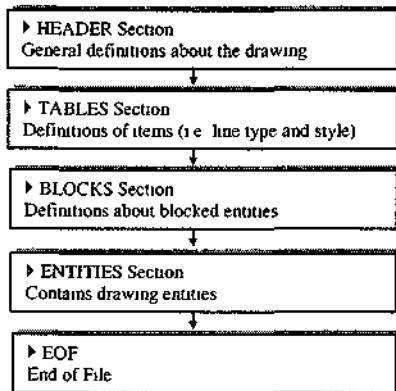

Figure 6 General structure of DXF format

Physical objects of mine field which have been stated in DXF format could be introduced to drafting packages and virtual reality systems

There are many software packages supporting DXF format Mam systems are AutoCAD, 3D Studio MAX and Bryce Especially, Bryce has powerful geological textures for rendering

2.2. **Virtual Reality**

Virtual reality applications enable visual simulation on three-dimensional models It can be thought as the further step of modeling and visualization Many drafting software provide rotating, rendering utilities However, virtual reality does not only provide visualization of models but also entering into them by walking or flying on them

Data exchange Format (DXF) can also be used for virtual reality purposes Software such as OpenGL and GLView enable import of DXF drawings Another way is to convert DXF drawings into WRL (virtual reality) format in drafting packages ı e AutoCAD, 3D Studio MAX

The virtual reality systems provide walking or flying utilities as well as rotating, zooming, turning, etc By the help of mouse or direction keys of keyboard <—, \, —», and J,, it is possible to have a trip on or around the models virtually Virtual reality applications enable observation of physical bodies from different directions Topography, ore body model and open pit can be visited virtually

3 APPLICATION OF THE SYSTEM

The approach has been coded m C++ programming language to generate a system having topographical modeling, 3D ore body modeling and open pit design utilities The system is applied to the hypothetical data including 200 drill holes After superimposing the grid system and inverse distance interpolation, the topographical model is generated Block model of the ore body is also produced as well as the pit design

The coordinates of drawing vertices are stated in DXF and imported to GLView virtual reality program (Grahn, 1998) GLView is a software package including walking and flying utilities, which enable having a virtual trip in 3D models It has ability to import DXF files or load WRL formatted files WRL format is the extension of virtual reality modeling languages (VRML)

Successive views of the virtual trip on the models are given m the Figures 7 to 9, where topographical model, ore body model and open pit model are visited In Figure 7, few squares from a virtual trip on the topographical model are given Flying or walking ability provides controlling the direction of movement
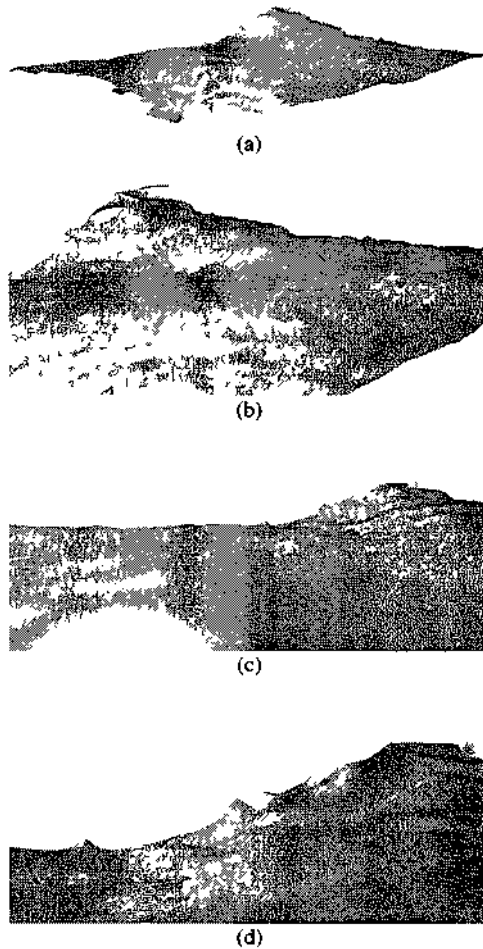
301

(a)

(b)

(c)

(d)

Figure 7 Virtual trip on the topographical model

(a)

(b)

(c)

Figure 8 Flying on and around 3D block model

Direction can be manipulated by arrow (direction) keys on the board or mouse Speed of action can also be adjusted by the software system Background color or figure determination, shading, rendering, rotating, turning, texture covering, camera controls are other utilities of GLView system

A virtual leality application on 3 dimensional ore body block model is given in Figure 8 Camera is positioned to fly around the model Extensions of the ore body could be observed easily

Figure 9 represents a trip m the open pit mine that is designed for the ore body It is possible to either walking on the benches or flying over the pit
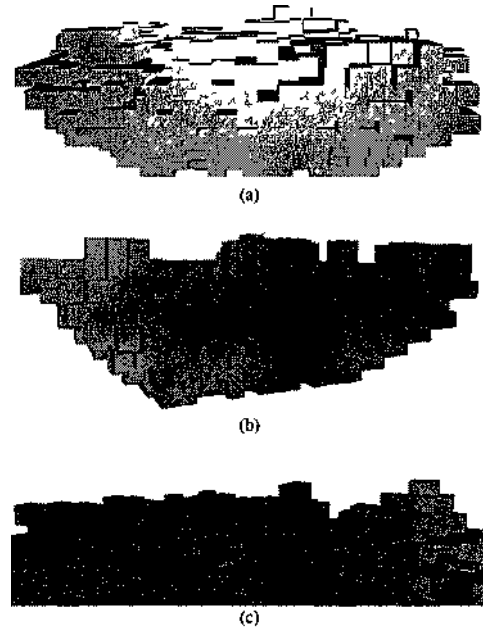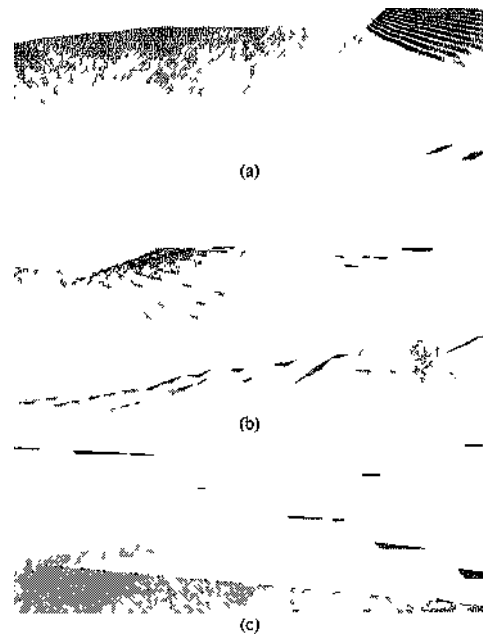

(a)

(b)

(c)

Figure 9 Virtual reality application at the pit

302

4 CONCLUSION

In this research, virtual reality applications on mine fields are studied. Difficulty of generation of a computer graphics system is overcome by Data exchange Format (DXF) A system is coded in C++ to model topography, ore body block model and open pit design The system outputs model drawings in which could be processed by many drafting and virtual reality software packages Generated 3D models are introduced to GLView virtual reality system and objective is reached The methodology used m the approach reduces the works to coordinate calculation of vertices

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