CARTOGRAPHIC ANIMATION OF MINING PROGRESSION

Garry A. Underwood
Argyle Diamonds
Kununurra, Western Australia
Dr Zhilin Li
School of Surveying and Land Information
Curtin University, Bentley, Western Australia

Abstract

Visualising mining progression using traditional cartographic techniques requires a high degree of map reading skill to perceive and understand the spatial and chronological changes of the mining operation. Typically, the progress is represented by conventional line symbolisation depicting the two-dimensional spatial position, and annotation to indicate the value of the third dimension. A mining progression generally consists of a number of large static maps, with each map depicting the spatial position of the mining operation at a set time interval throughout the progression. This paper describes an attempt to use the visualisation module of a high end CAD system to develop a time-series animation sequence based on digital terrain models, as an alternative to traditional static maps, to enhance the visual communication of the mining progression.

1 Introduction

Surface mining operations conform to a geometric design that incorporates safety and economic parameters. Material is removed in horizontal slices, the height of which, is matched to the size of the excavating equipment. Catch berms (ledges left to catch falling material from the earthworks above) are created by not excavating each slice back to the limit of the slice above. An orthogonal top view of the mining operation would give the impression of concentric breaklines, indicating the form and shape of the excavation. The volume of material excavated in a time period will occur spatially over multiple slices and positions within the operation.

Mining progress is depicted by a chronological sequence of projected future positions of the mining operation. Each sequence is represented by a large static two-dimensional line map using conventional symbolisation to depict the spatial position of the breaklines. Typically, a number of sequences will constitute a mining plan, and in the case of a 'Five Year Plan', there will be eight maps set at standard but varying time intervals. Communicating the change in spatial position of each sequence, and the overall change through time, is an important contributing factor to the safe and economic extraction of the material. Technical and non-technical supervisory personnel possessing a varied range of map reading skills are the targeted audience for these maps.

Even though the line maps are optimal in their presentation, perception of the changes between sequences - individually and overall - proved to be very difficult. Time-series animation was employed as a visualisation method to enhance the perception of these changes. Using this form of cartographic animation has been covered by many [2,3,6,7 and 9]. This use of animation to depict mining progression will be initially covered by looking at what presentation technique is currently being practised and the inherent problems in this method, followed by the evaluation and use of the visualisation

techniques available in a high end CAD system, and finally the use of time-series cartographic animation.

2 Traditional methods for Presentation

Currently the map presentation is constructed in a high-end computer aided drafting (CAD) facility using traditional cartographic methods, utilising conventional symbolisation to depict the difference between the breaklines and annotation to indicate the height of each slice. The spatial position of each slice is indicated by two breaklines which form the angled face of the wall, one at the top (crest), and one at the base (toe). Crests are symbolised with a continuous line, toes with a dashed line, and the slice height annotated with respect to a local or regional height datum. Each map is presented at a scale of 1:2500 on an A0 size sheet (see Figure 1).
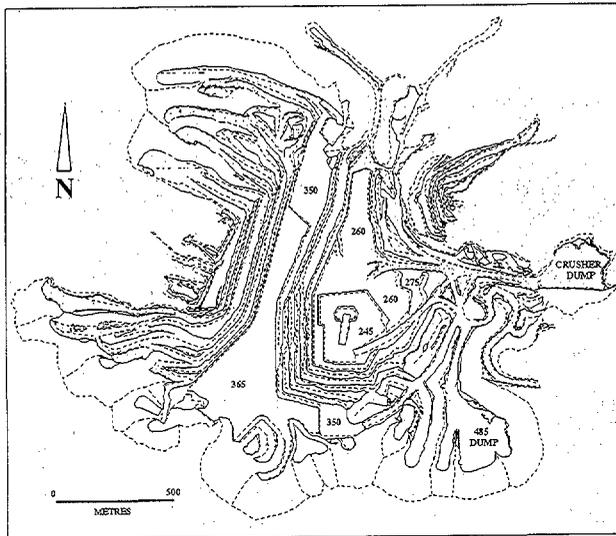

Figure 1: Line map showing the spatial position of projected Mining Operations
Note: This line map has been simplified for presentation in this paper.

Considering that there are eight A0 line maps produced for a 'Five Year plan', the task of visualising the local and regional changes within the mining operation over this five year period is enormous, requiring a very high level of map reading expertise. Usually this is carried out on a individual or group basis, where the map percipients try to commit each sequence to visual memory and then carry that to the next sequence to visualise the changes that have occurred. Methods that have been employed in trying to achieve this, range from stacking the line maps in chronological order and flipping back and forth through them, to laying each map alongside each other in chronological order and bodily moving back and forth along the sequence. Essentially what was trying to be achieved

was a form of animation, albeit very slow, by using movement (paper or body) to visualise the change through time.

Individually, each line map was optimal, as far as visual communication was concerned - using techniques traditionally employed for presenting mining progression - however, methods for visual communication of the change between each map were inadequate. Visualisation and the use of visualisation techniques, as envisaged by McCormick et al [5], created an environment that had the potential to encompass and alleviate the visual communication problems of a set of sequential static maps.

3 Visualisation and Animation

The immediate impact of using visualisation techniques can be seen in Figure 2, where by utilising shading as a depth cue, the three-dimensional attributes of the scene become very apparent.
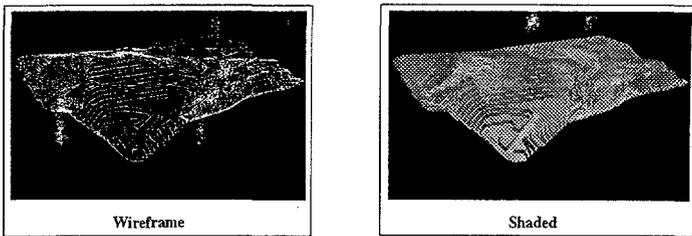

Figure 2: Visual impact of shading on surface representation

The visualisation modules in Microstation® v5 (the CAD system) provide a full range of depth cueing techniques capable of creating a realistic perspective view of the mining operation. Of these many techniques available, surface rendering using a lighting scenario based on the operation's geographical position, was the only technique employed. As the surface modelling by triangulation, produced a very detailed representation of the surface, it required only shading to produce a very realistic image of the mining operation. This technique was very effective in showing the three-dimensional attributes of the mining operation and greatly enhanced the visual communication of the spatial relationships of the mining operation.

Cartographic animation can be used to visualise spatial, chronological, and attribute change according to DiBiase et al [2]. Chronological change can be depicted using time-series animation, which involves maintaining a constant viewpoint from which the change in space through time can be visualised.

Incorporating the spatial visualisation qualities of a rendered isometric view and the ability to see chronological change through time-series animation, provided an alternative approach and/or potential enhancement to the visual communication of the mining progression. Using a realistic rendered topographic surface as a base and adding data as textures and visualising the changes in the textures through time has been employed by Bishop [1].

4 Cartographic Animation of Mining Progression

Microstation® v5 was the software used to develop the final images. This is a high-end standard configuration PC based CAD system utilising dual hi-resolution graphic screens. Microstation® v5 has a visualisation capability that enables development of Flythru's and the subsequent displaying of, through a movie facility. A comprehensive set of shading and lighting techniques is available enabling the creation of near photo-realistic images from three-dimensional surfaces and solids. The digital terrain modelling was done using an add-on application that worked within the Microstation® v5 environment.

Final spatial positions for each time interval was developed through the use of mine planning software, and then the toe and crest strings were imported into the CAD system. A digital terrain model was constructed of each sequence and then merged with a previously constructed digital terrain model of the original topographic surface to produce a final digital terrain model of the sequence and the surrounding surface.

A customised isometric view was set up to give the maximum coverage of the mining operation, and each individual sequence was referenced to this. A shaded image of each sequence was developed and then saved as an image file. The set of eight images was given a unique number in their file names to facilitate the correct sequential loading into the movie facility (see Figure: 3).
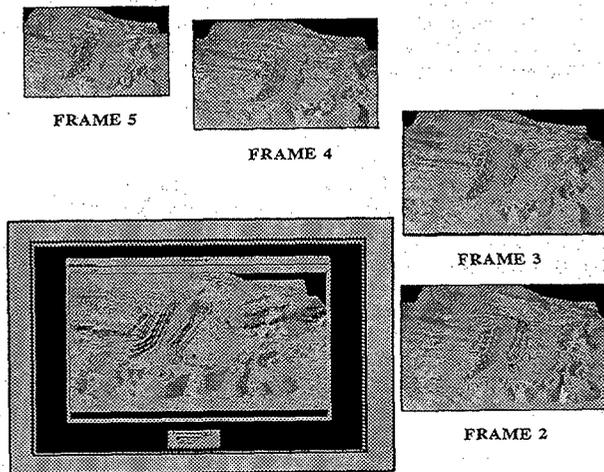

Figure 3: Mining sequences animated through movie facility in Microstation® v5

The movie facility has start/stop clickable buttons as well as a dragable sliding bar to position individual frames. A settings box allows the user to set the duration time for each frame, and whether the sequence will display as a single or continuous loop. This allows interaction with the animation sequence, enabling the user to move back and forth through the sequence, or letting the sequence run completely through the loop.

As each scene covered the same spatial dimensions and was regional in nature, the changes that occurred through time, were totally contained within each scene, giving the impression of an imploded bubble effect for the excavation, and a bubble effect for the dumping of material, as the progression ate away the terrain. This came about because only those pixels whose attribute changed in the sequence, could be seen being refreshed within the scene.

Duration between frames was set at one minute, allowing the audience to visually commit to memory the spatial dimensions of the progression, however, the change occurring was not picked up immediately, and missed completely if momentarily inattentive. Even though this was disconcerting, there was still the ability to interact with the display and rerun the animation completely, or just rerun those frames to see the change.

5 Conclusions

Using animation to facilitate the visual communication of the mining progression proved to be very beneficial to the supervisory personnel, who indicated that it improved their understanding of the changes that occurred through the period of the plan. The approach taken in this project was to let the realistic shape created by the detailed shaded surface digital terrain model be the transition from the real-world to the generated scene. Surface colour was not an issue, providing it was earthy in nature. Since this project was completed, animation software has become more sophisticated and extensive in range, as covered by Slocum [8]. The capability of using sonification variables, as suggested by Krygier [4], would enhance the visualising of the actual change between scenes.

References

[1] Bishop, I. 1994. Using Wavefront Technology's Advanced Visualiser Software to Visualise Environmental Change and Other Data. in Visualisation in Modern Cartography. A.M. MacEachren and D.R.F.Taylor (Eds.). Pergamon Press. pp. 101-103.

[2] DiBiase, D., MacEachren, A.M., Krygier, J.B. and Reeves, C. 1992. Animation and the Role of Map Design in Scientific Visualisation. Cartography and Geographic Information Systems, Vol. 19, No. 4, pp. 201-214,265-266.

[3] Dorling, D. 1991. Stretching Space and Time: From Cartographic Animation to Interactive Visualisation. Cartography and Geographic Information Systems, Vol. 19, No. 4, pp. 215-227,267-270.

[4] Krygier J.B. 1994. Sound and Geographic Visualisation. in Visualisation in Modern Cartography. A.M. MacEachren and D.R.F.Taylor (Eds.). Pergamon Press. pp. 149-166.

[5] McCormick, B.H., DeFanti, T.A. and Brown, M.D. (Eds.). 1987. Visualisation in Scientific Computing. Computer Graphics, Vol. 21, No. 6.

[6] MacEachren, A.M. and DiBiase, D. 1991. Animated Maps of Aggregate Data: Conceptual and Practical Problems. Cartography and Geographic Information Systems, Vol. 18, No. 4, pp. 221-229.

[7] Moellering, H. 1976. The Potential Uses of a Computer Animated Film in the Analysis of Geographical Patterns of Traffic Crashes. Accident Analysis & Prevention, Vol. 8, pp. 215-227.

[8] Slocum, T.A. 1994. Visualisation Software Tools. in Visualisation in Modern Cartography. A.M. MacEachren and D.R.F.Taylor (Eds.). Pergamon Press. pp. 91-122.

[9] Weber, R. and Buttenfield, B.P. 1993. A Cartographic Animation of Average Yearly Surface Temperatures for the 48 Contiguous United States: 1897-1986. Cartography and Geographic Information Systems, Vol. 20, No. 3, pp. 141-150.