Visualization of Change from Mining and Land Disturbance
Computer-aided Photographic Simulations, Site Selection, Reclamation, Impact Assessment

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This paper discusses landscape visualization research and applications with special attention given to valid and reliable processes of visual data capture, locational accuracy, and display for mining and drastic land disturbances. In order to conduct studies informed by both the natural and cultural phenomena of projects, the authors pursue a paradigm that integrates the most useful aspects of geographic information systems, image processing, computer-aided graphic design, and photography for visualization of changes to the landscape.

Early on, it was postulated that in order to be responsive to the greatly disparate needs of most projects, the authors must be able to focus on both macro-scale and micro-scale landscape phenomena. Thus, it becomes essential to be able to move relatively freely between vector and raster GIS functionality as well as computer imaging and photography in the establishment of physical data, water, terrain, and land cover modeling, and visualization of results and alternative scenarios. Recent projects have ranged from simulation of mine and tailings disposal areas, to buildings, railroads, transmission line structures, and roads. Application of advanced computer technology in conjunction with wide ranging personal experience and delineation skills has resulted in highly cost effective capabilities.

INTRODUCTION

Sir Humphrey Repton, circa 1690, established original methods for portraying "before" and "after" visualizations/drawings of landscape prescriptions. These life-like drawings, generated for landscapes in Great Britain, enabled Mr. Repton to portray landscape reclamation ideas and concepts for the benefit of clients.

With the invention of the first true computer in Germany in the 1930s, and the first electronic digital computer, the Electronic Numerical Integrator and Calculator (ENIAC), at Princeton University in 1946 (Golden, 1983), humans have utilized machine assistance with computational problems. The establishment of computer mapping software, SYMAP - for Synagraphic Mapping System (Fischer, 1961) in the early 1960s and GRID (Sinton, 1969) at Harvard University enabled landscape planners to make gridded maps of statistical values representing thematic information and manipulate them according to desired analysis specifications. The early 1960s also saw the use of computers to create and manipulate drawings on a screen. These computer-aided design (CAD) systems were developed for product design at General Motors and Lockheed. By the early 1970s, computer-aided design and drafting software such as that developed at several large

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architectural/engineering firms provided automation in the design and drafting process. Today, computer programs provide greatly improved utility for addressing visualization problems.

The impediments to widespread adoption of computers have changed since the mid-1980s. The potential of computers for reclamation visualization has been linked to the costs of both hardware and software. Hardware capabilities of computers have also limited their utility. In the past, slow processing speed, restricted memory capacity, lack of statistical, spatial analysis, and image processing algorithms, and poor quality graphics have all played a role in keeping the computer from being a dominant force in the decision making and production processes. Also, much of the software was of meager utility for addressing the needs of the visualization professional.

It is fortunate that costs for microcomputer hardware have continued to spiral down while capabilities have greatly improved. Microcomputers can now perform mapping and visualization tasks that only a few years ago required mainframe computers. Although hardware development usually outpaces software development, computer software for use in reclamation visualization are significantly improved. This is due in part to improved capacities of computers and in part to the efforts of major users in the architectural/engineering professions who have finally become convinced of the reality of the computer in drawing and designing. Consequently, the use of microcomputers is continually expanding in reclamation generally and in visualization/portrayal specifically.

Geographic Information Systems (GIS)

A contemporary GIS such as ARC/INFO (Dangermond, 1992), highly useful for inventory and analysis of mine site resources, is comprised of raster (Sinton, 1969) and vector (or polygon, White, 1977) data structures, capabilities for data input, storage, and output, digital terrain models, functions for spatial analysis modeling, functions for classification and interpolation, and methods of importing remote sensitive information. The major difference between GIS and systems for computer-assisted cartography is the provision of capabilities for transforming the original spatial data in order to be able to answer particular queries (Burroughs, 1986). For mining visualization projects, geographical information systems provide a significantly larger range of analysis capabilities that will conduct analysis on the spatial aspects for resource information, on the non-spatial attributes of resources, or on the non-spatial and spatial attributes combined.

With regard to reclamation visualization, the major differences between GIS and systems for computer-aided design and drafting (CADD) are the much greater volume and diversity of the data input to GIS systems and the spatial analysis functions critical to informed decision-making within the programming/analysis phase.

Geographical information systems differ from computer graphics because the latter are largely concerned with display and manipulation of visual material. Computer graphics systems do not acknowledge important non-graphic attributes that are essential for landscape analysis. Good computer graphics are essential for a modern GIS but a graphics package is by itself not sufficient for performing the tasks expected, nor are such drawing packages necessarily a good basis for developing a GIS (Burroughs, 1986).

Visualization/simulation applications

An important technique to improve communication between developer, consultant, and the public is embodied in the methods and products of computer-aided visualization/simulation. A simulation is a model of a physical system that operates with clearly defined rules. Using a computer based model of the physical system, practitioners can conduct studies that help them to understand the behaviors of mining and post-mining landscape systems. Behaviors are modeled as they would be experienced from human vantage points. Typically, the vantage points chosen for simulation correspond to locations identified by field investigation and geographic information system (GIS) visibility software as having potential visibility to the proposed actions, significant quantities of viewers, and potential for high viewer sensitivity.

Some of the most exciting advances in computer technology for mining reclamation have been in the area of computer-aided generation data, analysis information, and landscape reclamation alternatives. Several inexpensive microcomputer applications hardware and software, which have become available in the past five years, finally make practical the application of two and three dimensional display to computers. As a consequence, the practitioner's ability to provide direct communication in three dimensions (perspective), as humans would see it, has vastly improved. These capabilities are particularly significant for the fields of landscape reclamation and visualization since they make it possible for people with limited artistic abilities to communicate visually and, thus, permit some type of evaluation of alternatives.

Many hardware and software systems are available for visualization/simulation. These systems differ greatly in cost, ease of use, validity, and reliability. Typically, higher end systems do more for the practitioner and require less artistic ability, while lower end systems require more effort and expertise on the part of the user.

1. Photographic scanner & paintbrush program: The least expensive means to accomplish computer-aided visual simulation is through video or raster scanned capture of a photograph and painting, with a mouse or trackball, proposed changes to the image on the computer screen. Since this process occurs without the benefit of a 3D, hidden line algorithm, results cannot be tested for validity or reliability except by the human eye. Several vendors supply image capture software for microcomputers connected to home or professional video cameras or raster scanners. Among these is Hewlett-Packard's DeskScan and DeskPaint programs, TIPS for IBM and compatible microcomputers Photoshop for MacIntosh microcomputers, and Computer-Eyes and Degas.Elite for Atari MEGA microcomputers.

2. Photographic scanner, 3D algorithm, and paintbrush program: A moderately expensive system for simulation may include an image capture capability, a 2D to 3D conversion algorithm in wire-frame or solids graphics, and an object oriented paint program that allows the user to pick up and move images, textures, and colors within the photograph. Since this process occurs with the aid of a 3D, hidden line algorithm, the final image can be verified with regard to validity and reliability. One such system is the Landscape Information System (LIS) (Paulson, 1987) which permits the user to scan in a single photograph or video image, overlay a 3D wire frame image generated from a map of topography and surface features, paint the changes on the scanned photograph, and render "by hand" changes onto the original photograph with digitizer, mouse, or trackball.

3. Computer generated simulation of a single image: The most successful, single image, simulation systems are those that display scenes in colored, solid surfaces (in contrast to wireframe vectors). Most of these systems are relatively disadvantaged in that every item must be located in plan view (2D) and then calculated and displayed in 3D. Most of these systems do not permit capture of the image and subsequent use of a paintbrush for enhancing character, i.e., adding people, trees, cars, shadows, atmospheric affects, etc. to the scene. However, with significant amounts of computer storage space and computing time, these systems generate highly appealing and accurate simulations. One

such system is available from Dynamic Graphics, Denver, Colorado. Another popular system is Auto Desk's AutoCad/AutoShade program running on IBM and compatible microcomputers.

4. Computer generated simulation of multiple "real time" images: Relatively few computer systems exist in the landscape reclamation field that are capable of generating 3D images in real time. One such system is a 32-bit, 16 million-color Silicon Graphics IRIS Indigo series workstation that allows 3D image generation in real time and PC386 and 486 equipped with AT&T's TARGA board. Practitioners can overlay the IRIS generated 3D images onto video camera or scanned site photos on the TARGA system, composite them and output the images onto slides via a film recorder or inkjet printer for hard copy color output. The visualization system permits flying in real time on the IRIS and performing site matching in an easy, straightforward manner.

The Woodward-Clyde-MPI Visualization/ Simulation Process: The process of using a computer simulation system as a tool to visualize/simulate a proposed plan involves seven steps as follows:

1) Using a computerized digitizing system, existing landscape conditions are entered into a geographic information system database.

2) The proposed project plan, and/or landscape reclamation plan, are digitized into the same database as a separate map coverage.

3) Using the computer software, elements of the plan, such as buildings, roads, or tailings dams, can be located, and viewed from different locations both within and adjacent to the site.

4) The computer system allows the viewer to look at a proposed project or project alternatives from selected viewpoints as established in the field.

5) Using computer plots from the database, perspective renderings are created to illustrate the project.

6) Overlaying the computer image with site photos from the same viewpoint.

7) Utilizing photographic dyes, water colors, and other art media, "paint-by-number" to realistically delineate/render the project as it would appear on the landscape.

PROJECT APPLICATION

The following is a brief description of mining and energy projects requiring visualization/ simulation applications. A number of these projects not only contain visibility issues regarding facilities and activities at the project site, but the related issues of linear activities and corridors such as electric transmission lines pipelines, access roads and other ancillary facilities.

Montanore Mine, Montana - Located in northwestern Montana and adjacent to the Cabinet Mountain Wilderness, the Montanore Mining Project triggered a series of major visual concerns regarding the visual sensitivity of the wilderness, the heavily used recreation area of Howard Lake and the gold panning historic district of Libby Creek. Early issues were identified by the U.S. Forest Service and Montana Department of State Lands included siting of the tailing facility, 230-kV transmission line to the mill site and visibility of the mill site and other facilities from the nearby Cabinet Mountains Wilderness. Visual studies were conducted to document the visibility of the major project facilities from thirteen observation points (e.g., recreation sites, roads, trails) including four areas in the wilderness. Study results showed that most of the project components would not be as visible as first indicated. With the exception of the tailing disposal site, all other facilities including the 230-kV transmission were strategically located to minimize their is presently being revised to integrate visual resource concerns to reduce overall visibility. Visual simulations of the tailing site showed how the impoundment would be located on previous timbered landscape and the visual effectiveness of reclamation procedures. Another simulation showed how the mitigation technique of feathering the edges of the utility row and topping of trees under the corridor itself would minimize visual change and lessen the visual input of as view from a campground.

Craig-Bonanza Transmission Line - Colorado/Utah

The Woodward-Clyde-MPI Visualization/ Simulation Process was instrumental in gaining National Park Service approval for a transmission line that would pass near Dinosaur National Monument in western Colorado. Park Service officials were concerned that transmission towers would block the view from the Monument and be an aesthetic eyesore.

The line, which was proposed by the Western Area Power Administration, would connect two power plants -- Craig Station and Bonanza Plant -- via a 345-kV line carried on 120-ft steel-lattice towers. The Craig-Bonanza line would parallel an existing 115-kV line constructed on 60-ft wooden H-frame poles and pass within a couple of miles of the park headquarters. Park officials, concerned that the proposed towers would adversely impact the view from the park, threatened to veto the project. Detailed computer visibility studies convinced the park officials that strategic location of the transmission towers and lines and use of dulled color, non-reflective materials would minimize visibility to acceptable levels.

The graphic analysis, generated by computer and based on park topography and tower construction specifications, convinced officials there would be virtually no adverse visual impact from the new line and led to Park Service approval for the project.

New World Gold Mine, Montana

Located in southwestern Montana and adjacent to Yellowstone National Park, Beartooth Absaroka Wilderness, North Absaroka Wilderness, the New World Gold Mine Project triggered a series of major visual concerns regarding the visual sensitivity of the wilderness, and visual effects to Yellowstone National Park. A series of meetings were held with visual resources and recreation specialists from the Park Service and Gallatin National Forest. A total of 27 Key Observation Points (KOPs) were evaluated of which 12 carried forward and assessed. Computer visibility models were run to document seen and unseen areas of the mine site and 115-kV transmission line including two KOPs from Yellowstone Park and 6 KOPs from the 2 wilderness areas. Study results showed that by strategically maneuvering certain mine facilities the overall visibility of the mining project would be significantly reduced.

Basque High Speed Railroad, Northern Spain

The Spanish ministry of transportation has planned to correct a portion of northern Spain to Southern France with a high speed railroad system. The mountainous terrain would require extensive tunnelling, numerous bridges and would pass very close rural villages, towns and churches. Concern was raised by the Basque people about the visual change of their rural mountainous landscape into a major transportation corridor.

For the specific route selected, environmental impacts were analyzed in detail and recommendations were developed for mitigation measures. A total of 10 color photographic simulations were completed for the assessment which displayed representative but varying landscape character types and conditions. Bridges, tunnels, cuts and fills, portals and alternative mitigation measures and reclamation were simulated and presented to the local people for review.

Davis Canyon High Level Nuclear Waste Site, Utah

Due to the controversial nature of the high level nuclear waste repository project proposed near Canyonlands National Park, public reaction was considerable, particularly on visual impacts. Canyonlands is a primitive park; its appeal is solitude and pristine landscape. The BLM, the lead review agency, strongly recommended that the DOE employ visual simulation for displaying effects of visual change for the exploratory shaft, railroad access and transmission routes, and repository. As a result a study was conducted to address the concern for scenic values and the potential visual change within and surrounding the lands of Canyonlands National Park. Products of the study included computer graphic perspective plots and visual simulations identifying areas of potentially significant visual contrast and mitigation recommendations to reduce or minimize visual change.

The study displayed though the use of color rendered photographs, the visibility of segments of the alternative railroad and transmission line corridors and portions of the proposed Paradox Basin Repository site from ten selected viewpoints. The purpose of using color rendered photographs was to illustrate in advance how the proposed project would appear after it was constructed and after reclamation.

The study showed that although the transmission line corridor and the nuclear waste repository site would not create significant visual impacts, the auxiliary facilities of the railroad corridor and water and gas pipeline would create significant adverse effects to visual resources.

CONCLUSION

With valid and reliable means for linking capabilities from portrayal techniques of the past with GIS and image processing methods of today, visualization will become an essential part of surface mine reclamation in the next decade. There have been convincing recent demonstrations of the benefit and the cost effectiveness of GIS as an aid to information capture, analysis and decision making, and visualization output. Although, methods for utilizing data and models from a variety of GISs and imaging systems remains cumbersome, computer applications in visualization research and practice have become too pervasive, their promise too enticing, and their cost too irresistible to ignore. As scientists, educators, managers, and students are increasingly exposed to contemporary methods, more useful applications will be generated and used throughout the professions directly responsible for surface mine reclamation.

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3C. WETLANDS

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