Computer Generation of Panorama Maps

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Figure 1: *Computer generated panorama map.*

Abstract

Obliquely viewed panoramic maps depict terrain realistically from a human perspective and appeal to a wide range of map-readers. Traditional artists painstakingly created most panoramas in the past. Seeking a more efficient solution, this paper introduces a software system for creating panoramic maps interactively. Using an interactive terrain editor, users can manipulate digital elevation models to alter vertical exaggeration and rotation in selected areas. The software permits aerial photographs and satellite images draped on terrain surfaces to be colored and painted. Users can control lighting, vegetation, snow cover, and other environmental factors prior to rendering panoramic map images.

1 Introduction

Panoramas, especially those depicting mountains, are a unique variety of map that spans the disciplines of art and cartography [1, 3]. They are a very good pictorial device for portraying landscapes and enjoy widespread popularity among users. Three-dimensional landscapes are easier to visualize than two-dimensional landscapes, especially for people who have limited map-reading skills. Obliquely viewed panoramic maps depict terrain realistically from a low-elevation human perspective, in addition to containing geographical information. Creation of panoramic maps has largely been the domain of specialized artists who painstakingly paint each map. This paper introduces tools and methods for creating panoramic maps interactively, acknowledging that it is impossible to achieve the artistic quality and precision of panoramas created by traditional masters like Heinrich Berann-for now. To be discussed are an interactive editor for the manipulation of digital elevation models, including selective exaggeration, rotation, and other transformations that emulate the special effects employed by traditional panoramists; tools for coloring and painting augmented terrain surfaces; and, several tools and techniques for producing computer-generated panoramic maps.

2 Panorama Maps of Heinrich Berann

Heinrich Berann, considered to be the father of the modern panoramic map, is known worldwide for his unique products that combine traditional European painting with modern cartographic styles. Figure 2 shows several panoramic maps painted by Berann.

In a comprehensive article, Patterson described many of Berann's panoramic mapping techniques. For more details refer to the paper by Patterson [6].

2.1 Berann's Methods and Landscape Manipulation

Berann utilized many different methods to paint panoramic maps, many of which are considered unorthodox by mainstream cartographic standards. For better or for worse, Berann often used considerable artistic license to manipulate a landscape to produce desired aesthetic effects and composition. His methods addressed:

- **Viewpoint and Projection**
- **Orientation**
- **Vertical Exaggeration**
- **Generalization**

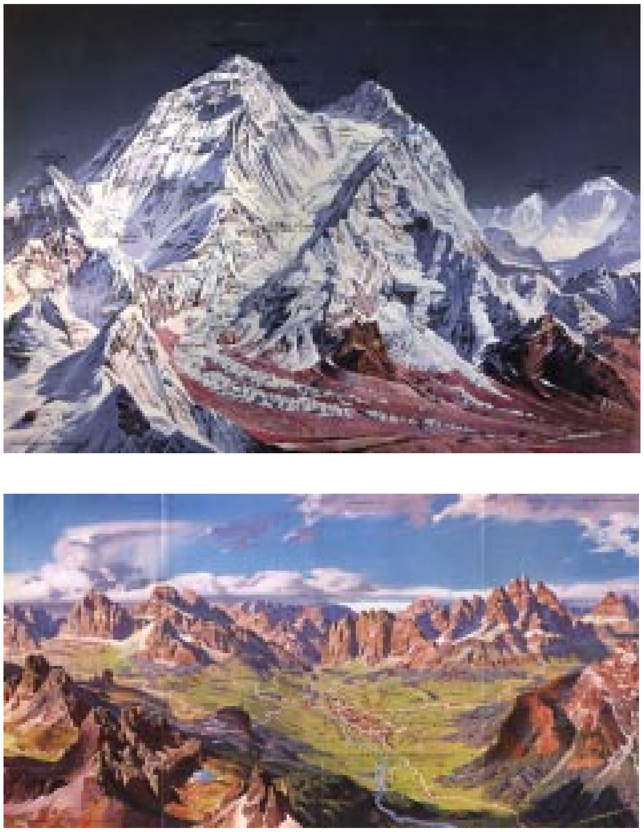

Figure 2: *Panorama Maps painted by Heinrich Berann. The top map is a panorama map of Mount Everest, and the bottom map shows Cortina, Italy.*

- **Environment**
- **Color**
- **Illumination**
- **Atmosphere**

3 Interactive Editor and Results

To create panoramic maps automatically and interactively, I developed an interactive editor and several related tools. The editor provides a 3D view of the terrain drawn from a user-selected viewpoint. The terrain data also can be viewed in 2D as a contour map or a grayscale image. Editing operations can be performed in either view. However, some editing operations such as 3D painting are restricted to one view only. The interactive editor provides the following operations:

- **Selective vertical exaggeration** A portion of the terrain selected using a rectangular selection can be arbitrarily scaled upwards or downwards.
- **Selective terrain rotation** A portion of the terrain selected using a rectangular selection can be rotated around the vertical axis calculated to be in the center of the selection. Rotations around an arbitrarily selected axis are currently not supported.
- **Perspective transformation**

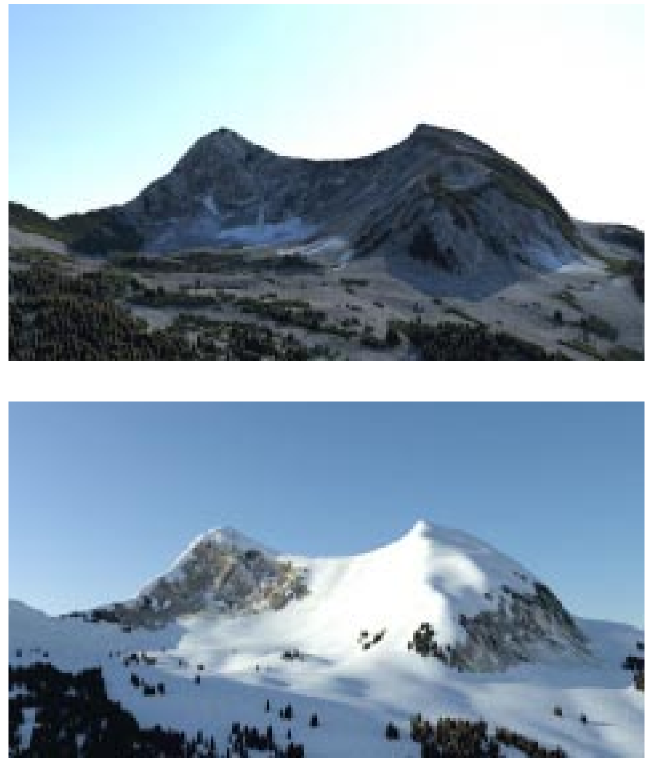

Figure 3: *Hogum Cirque in the Wasatch Range near Salt Lake City, Utah.*

- **Viewpoint selection** Viewpoint can be arbitrarily specified on the 2D contour map or interactively in 3D view.
- **Orthoimage texture mapping** A georeferenced orthoimage can be overlaid on terrain and interactively displayed.
- **3D texture painting** Users can interactively paint directly on the terrain surface in 3D view to create a completely new texture or augment an existing texture derived from a photograph or a georeferenced orthoimage. Standard painting tools such as airbrush, paintbrush, cloning, etc. are supported.
- **Sky and Atmosphere** Sky color can be specified according to time of day, time of year, and geographic location. Atmospheric effects are simulated using a physically based model of attenuation based on exponential particle distribution.

Figure 3 shows an example of a panoramic map created with the modeling and rendering system and methods described above. In addition to the terrain manipulation methods described above, the system allows manipulation of orthographic images that can be texture-mapped onto the terrain surface. The inclusion of a physically based snow cover simulator allows snow cover to be added to existing texture maps [8]. Similarly, an ecosystem simulator enables vegetation, such as trees and brush, to be simulated based on simple ecological rules [2]. The physically based simulations of snow and vegetation can be driven with a variety of real-world data (precipitation, temperature, etc.). The manipulated elevation model and the enhanced texture map are then combined to form a terrain covered by a colored texture map and a set of geospecific vegetation models. Therefore, maps may be generated for any time of the day or year, including seasonal effects such as snow. Figure 4 shows the same area in the Wasatch Mountains near Salt Lake City from different viewpoints. The final images were rendered with a physically

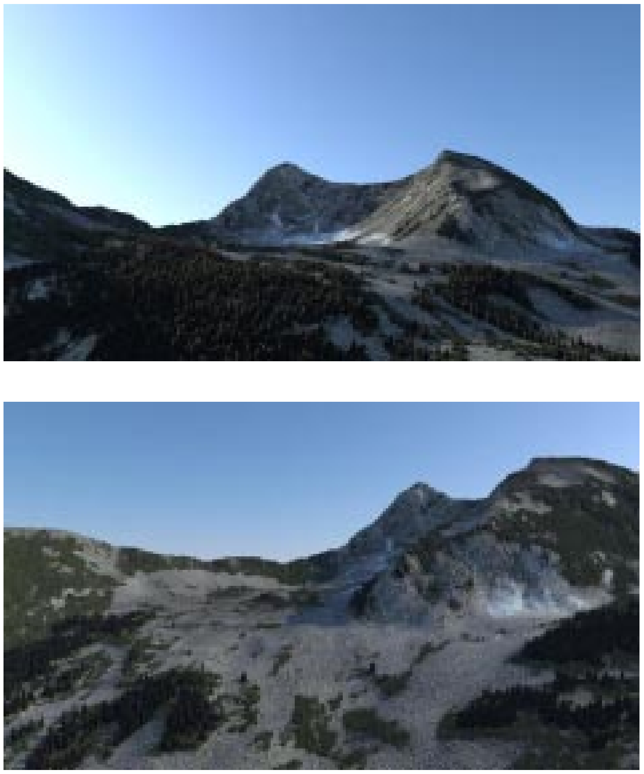

Figure 4: *Hogum Cirque in the Wasatch Range near Salt Lake City, Utah. The area roughly covers 2 km by 2 km.*

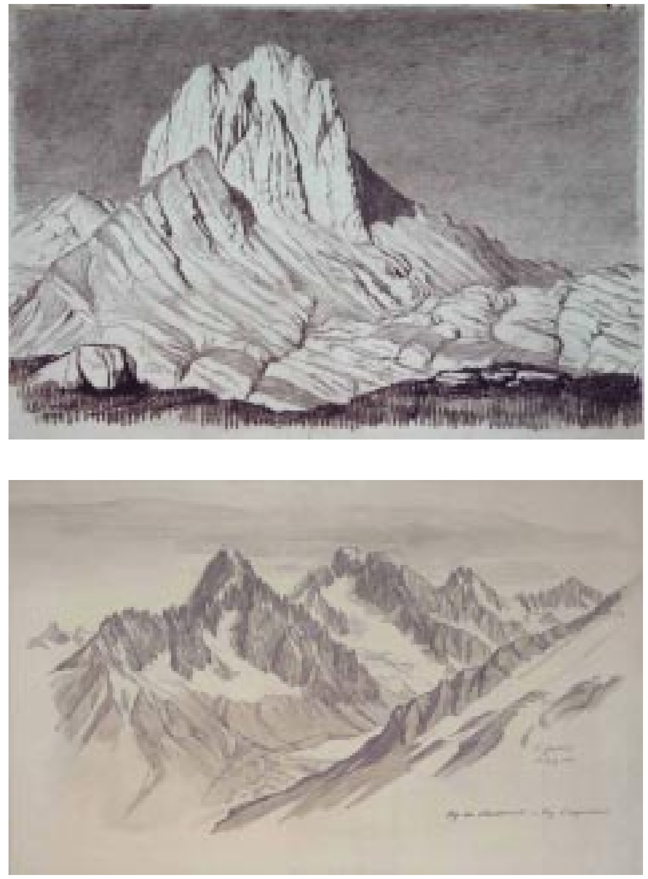

Figure 5: *Hand-drawn panoramas of Eduard Imhof. Geological and geomorphological features depicted in these drawings are very clear and striking.*

based renderer that accounts for sun illumination and inter-reflected light in the environment. The physically based sky model also enables different atmospheric conditions (perfectly clear to hazy) to be added to panoramas according to the time of day [7].

4 Future Work

This work is only a first step in the automatic generation of panoramic maps. There are many issues that still must be addressed and improvements to be made to increase the quality of panoramic maps. Improvements under consideration include:

- **Adding detail to geometry.** The resolution of existing DEM data are often very coarse, lacking sufficient detail to resolve small terrain features common in an alpine environment, such as scree. Procedural enhancements of coarse DEM data would add a hint of artificial detail yielding a panorama that looks more realistic.

- **Geometry sharpening.** Sharp alpine ridgelines and rocky faces often appear too smooth due to coarse-resolution data. An alternative method of representing terrain surfaces that allows interactive editing and sharpening of features, perhaps by using surface curves, is being investigated.

- **Large Scale Area.** The existing system works only for terrains of small spatial extent, a limitation that needs to be increased to cover small-scale areas (e.g. an entire mountain range). There is no inherent difficulty in implementing this other than the amount of data being edited and processed. With better software engineering and data structures, the interactive editing of larger areas should be possible.

- **Geological and geomorphological information.** Geological maps provide valuable insights into small-scale terrain features (e.g. a mountain range) as well as small microforms (e.g. rock faces composed of limestone look different than sandstone).

- **Automatic Viewpoint Creation.** Viewpoint is currently selected by hand, sometimes a time consuming task. Heuristics is being explored for the automatic selection of viewpoints based on user-defined objectives (e.g. photographers often use rules of thirds and fifths for composition).

- **Editing tools.** Additional interactive editing and sculpting tools would be helpful. Patterson describes several innovative terrain-deformation techniques used by Berann that can be included in the digital editor [6, 5].

Besides panoramas, I am exploring the use of semi-automated interactive procedures for generating other related categories of maps. Geological maps, geological profiles, and Imhof's beautiful relief maps and his documented methods for rock hachuring and rock drawing are worthy goals–and a considerable challenge. Figure 5 shows examples of Imhof's work. Although Visvalingam has done very promising work in this direction [9, 10], much more work will be necessary, and perhaps a technological breakthrough, before digitally generated rock drawings match those produced by the hand of Imhof [4].

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