3D Image Extraction from 2D Aerial Image

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Abstract- **A 2D image can be thought of as a surface in 3D, with the third dimension being the gray-level intensity at each image point. The image appears as a mountainous landscape, with each structure in the image represented as a series of mountains and valley. This method usually used in order to model the object in 3D-game and object surface. We tried to use this method to calculate the z-coordinate of each pixel in an aerial image. In this paper we purposed a solution to the problem of calculating the z-coordinate of each pixel in an aerial image according to gray-level intensity at each image point.**

Keywords: 3D image, image extraction, aerial image, and gray-level intensity

I. Introduction

The evolution of science and technology has turned remote sensing and satellite as a common tool for earth's environment management and study. Although current technologies suggest a better solution for information retrieval, in fact we cannot retrieve an information from the past. Aerial photography is used for information retrieval (road, bridges, buildings, terrain, height, and ect.) before remote sensing and satellite technology becomes an established tool.

Aerial photography has two main users that are of interest: (1) Cartographers and planners that take detailed measurements from aerial photos in the preparation of maps. (2) Trained interpreters utilize aerial photos to determine land-use and environmental conditions. Although both maps and aerial photos present a "bird's-eye" view of the earth, aerial photographs are not maps. Maps are orthogonal representations of the earth's surface, meaning that they are directionally and geometrically accurate (at least within the limitations imposed by projecting a 3-dimensional object onto 2 dimensions)[1]. Aerial photos, on the other hand, display a high degree of radial distortion. That is, the topography is distorted, and until corrections are made for the distortion, measurements made from a photograph are not accurate. Nevertheless, aerial photographs are the powerful tools for studying the earth's environment.

II. Related Work

Several researchers used ray casting approach to render the terrain [2][3]. They assume that a Digital Elevation Map (DEM) and Digital Color Map (DCM) are used to model the terrain [2][3]. The DEM associates an elevation to each position (x,y) in the terrain and the DCM associates a color value to each position in the terrain. A column of the terrain raised with a height and color taken from the DEM and DCM, respectively, is called a voxel. Each voxel has a height value (z-coordinate), taken from the height field, and color value taken from digital photograph. The presented approaches exploit the coherence between the pixels of a column to find linear cost incremental changes from one pixel to another.

In this paper, we propose and analyze the extension of as well as known gray-scale digital aerial image. Digital aerial images are scanned from aerial photograph (gray-scale image). In all cases, we assume that a regularly spaced grid of column voxels represents the terrain. Each voxel has a height value, take from the gray-level intensity at each image point.

III. Digital Aerial Image

Aerial photographs are taken using an airplane to photograph a series of images using a large roll of special photographic film. The film is then processed and cut into negatives. The most common size for negatives is 9"x 9" (23cm x 23cm)[5]. The final scale of the aerial photograph depends on the height of the aircraft when the photo was taken.

The first step involves selecting the aerial photographs for the area we interested in and scanning them from printed photos into digital image files. Two factors affect what resolution can be detected in the digital image of the aerial photograph. These factors are:

1. The scale at which the aerial photographs was flown. This is based on aircraft altitude above ground and focal length of the camera when taking the aerial photograph.

2. The Dots Per Inch (DPI) used to scan the aerial photo.

The final pixel size is the size on the ground, in meters, of one pixel on the digital aerial photograph, and approximately corresponds to the size of the smallest feature that can be detected.

A scanned gray-scale aerial photo can be used to define a z-coordinate. A 2D image can be thought of as surface in 3D, with the third dimension being the gray-level intensity at each image point. The image appears as a mountainous landscape, with each structure in the image represented as a series of mountains and valleys. In order to model a structure, we need these 3D attributes (i.e. z-coordinate)

IV. Segmentation

The segmentation of given images is one of the most important techniques for image analysis, understanding and interpretation.

The purpose of image segmentation is to partition the image into a number of homogeneous region [8]. There are three group of scene features can be distinguished for segmentation: area, linear and point features [9]. In the context of aerial images, woods and grassland represent area, roads and rivers represent linear, and buildings and trees represent as point features.

Segmentation of linear features employs edge detection, and segmentation of area features uses region growing based on statistical texture model.

The goal of image segmentation is to partition the image regions and thus to distinguish difference object before extracting their height value.

V. Height Field Extracting

A height field is essentially a one unit wide by one unit long square with a mountainous surface on the top. Figure 1 illustrates the height field model. The height of the mountain at each point taken from color number or palette index of the pixels in a graphic image file. The maximum height is one, which corresponds to the maximum possible color or palette index value in image file.

The extracting technique involves the following step: (1) Input of digital 2D aerial photo from a scanned aerial photograph. (2) Adjusting the gray-level of scanned aerial photographs. (3) Modification of basic voxel algorithm to define a height value from each pixel on the image.

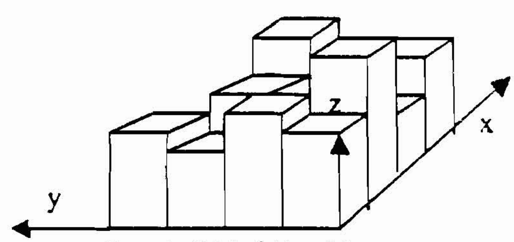

Figure 1 : Height field model

The resolution of the height field is influenced by two factors: the resolution of the image and the resolution of the color/index values. The size of the image determines the resolution in the x- and z-direction. The resolution of the color or index value determines the resolution along the y-axis. A height field made from an 8 bit image can have 256 different height levels while one made from a 16 bit image can have up to 65536 different height levels.

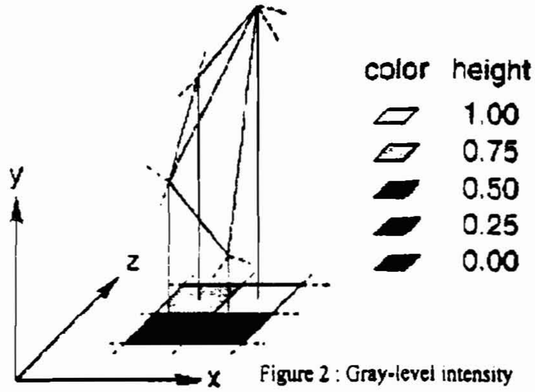

Figure 2 : Gray-level intensity

The height value at each point can be determined from the gray-level of the image (Figure 2). White color value is a higher point and black color value is a lower point in the image.

We can get a real height (z-coordinate) from the digital aerial image by calculating the height based on aircraft altitude above ground and focal length of the camera when taking the aerial photograph. Let H be the ground height to be calculated and Ph be the pixel height of the digital aerial image. Ah is the aircraft height and Hmax is the maximum height of all peaks. Then we have one pixel height computed as:

$$ph = \frac{Ah - Hmax}{Ph}$$

For N Pixel Height, we have

$$Nph = N \cdot \frac{Ah - Hmax}{Ph}$$

$$\therefore H = Nph$$

VI. Conclusion

While advanced techniques from 3D-feature extraction from intensity images are available, fewer ones use range images. Better techniques are needed, especially for extracting features from combined intensity and range images. It is important to take advantage of range information when available. Otherwise, significant errors can be introduced by computing them from 2D intensity data.

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