PRODUCTION AND APPLICATION OF A NEW KIND OF STEREOSCOPIC ANIMATION

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KEY WORDS: Animation, Application, DEM, Geology, Orthophoto, Photogrammetry, Resources

ABSTRACT

Usually, ortho-images are made using DEMs（Digital Elevation Models）. But a new method has been developed which has the ability to make ortho-images from stereoscopic images directly. The ortho-image production program in this case has been developed by changing a DEM generation program slightly. DEMs and ortho-images are generated at the same time from the same stereoscopic images. Stereoscopic animations can be made using these two data very easily because the positions of the elements are completely the same. A new kind of stereoscopic animation has been proposed made by changing the intervals of two looking eyes, that is, by changing the B/H （Base/Height） ratios of component stereoscopic images. In the new kind of stereoscopic animations, the mountains as virtual images rise or sink slowly by changing the B/H ratios of the component stereoscopic images gradually. Lineaments, which means linear features on the earth's surface, can be extracted from these stereoscopic animations effectively. Because they sometimes show the existence of faults, they are very useful for mineral vein finding and route selection. In tunnel construction, faults must be avoided carefully, and detailed ground inspection by boring is necessary. Using the lineament information, much of this work can be replaced by computer and the cost of ground inspection can be reduced greatly.

1. INTRODUCTION

Bird's eye view images or animations are often used, because they do not require any special display devices such as liquid crystal shutter glasses. But it is impossible to extract detailed topographic information from them. For detailed topographic information, stereoscopic images or animations are necessary. There have been some reports showing the usefulness of stereoscopic images in some fields such as earth resource exploration or route selection, but there are few reports showing the usefulness of stereoscopic animations. Stereoscopic animations indeed have an ability to be useful in many application fields.

In order to make a stereoscopic animation, two data of subject areas are necessary, fine ortho-images and DEMs of appropriate interval. Ortho-images are usually made using DEMs and images with orientation elements. Those DEMs are very often extracted at appropriate intervals from topographic maps with contour lines, because there are few kinds of available DEMs now. There are many proposed methods to extract DEMs from contour lines automatically by computer. DEMs can be extracted from stereoscopic images also by a digital photogrammetric system（N.Mori, 1996）. There are now many commercial digital photogrammetric systems in the world（Armin Gruen, 1996）. To make ortho-images, it is necessary to take two steps, a DEM extraction and then an ortho-image production. For this reason, ortho-image production is cumbersome and scarcely carried out.

In this paper, a new method will be shown which makes both a fine ortho-image and a DEM at the same time from the same stereoscopic images. Then, a new kind of stereoscopic animation will be shown which is very useful for earth resource exploration or route selection.

2.   AN ORTHO-IMAGE PRODUCTION METHOD FROM STEREOSCOPIC IMAGES

Now a DEM is necessary to make an ortho-image by conventional methods. But using a digital photogrammetric system, it is possible to make an ortho-image from stereoscopic images directly（N.Mori, 1997）. In addition to the ability to extract a DEM from stereoscopic images, the digital photogrammetric system can produce an ortho-image also from the same stereoscopic images. Following is a brief explanation of this method.

In the process of DEM extraction from stereoscopic images, stereo conjugate points are usually determined all over the stereoscopic images, and the positions of object points on the earth's surface are calculated using the positions of these stereo conjugate points on the stereoscopic images. Ortho-images can be produced modifying this DEM extraction program slightly, that is, not only pixel positions, but also pixel values of stereo conjugate points are determined, then, both positions and radiances of object points on the earth's surface are calculated. Ortho-images can be produced from these data using a resampling program. As two input images are used to make an ortho-image in this method, it is possible to make some image corrections, such as partial replacements and arithmetical calculations on images, to make a fine ortho-image. For example, it is possible to reduce the influence of off-nadir looking such as the shades of opposite sides of mountains in the output ortho-image.

The method to make an ortho-image from stereoscopic images can be realized on a digital photogrammetric system. In this research, a PC-based digital photogrammetric system with 3D display has been used（N.Mori, 1992）. The system already had DEM extraction software from stereoscopic images. This ortho-image production method has been realized by changing the DEM extraction software slightly. Figure 1 is the flow chart of the ortho-image production software developed on the system. The parts in common with the DEM extraction software are indicated in the figure.
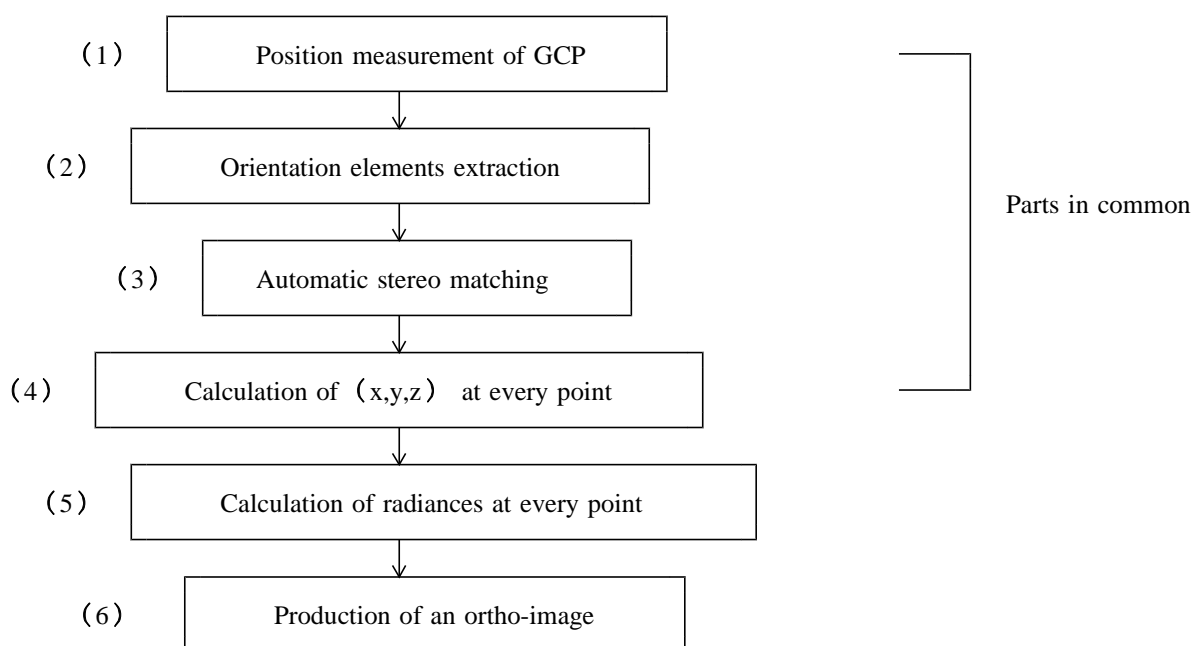

Figure 1   The flow chart of the ortho-image production software

Brief explanations of the items in the figure are given as follows.
（1） Positions of GCPs are measured in both images and maps.
（2） Orientation elements of both images are extracted.
（3） Sufficient number of stereo conjugate points are determined by stereo matching.
（4） Positions of object points are calculated from those of stereo conjugate points.
（5） The radiances of object points are calculated from the pixel values of stereo conjugate points.
（6） An ortho-image is produced using a resampling program.

Because most part of this software is the same as the DEM extraction software, it is easy to extract DEM at the same time. The merits of this system are as follows:

（1） Because the pixel positions of the ortho-image and the data positions of the DEM are completely the same, it is very easy to make bird's eye view images or stereoscopic images of any B/H ratio from these data.

（2） The accuracy of pixel positions of the ortho-image in this case is better than in the usual case using a DEM, because it is necessary in the usual case to do resampling to make an arrayed DEM from irregularly positioned height data.

3. STEREOSCOPIC ANIMATION PRODUCTION METHODS FROM STEREOSCOPIC IMAGES

Stereoscopic animations of landscape are usually made using a method as is shown in figure 2. In the figure, an ortho-image is made using an image and a DEM, overlaid by maps if required. Then, an output stereoscopic animation is made using the overlaid ortho-image and the DEM. Because the scale and projection method of input images and DEMs are usually different, it is difficult to make stereoscopic animations using this method.

But a new method for making stereoscopic animations has been developed, which is shown in figure 3. In this method, the new method for making ortho-images mentioned above is used, which extracts both an ortho-image and a DEM from the same stereoscopic images at the same time. In the figure 3, DEMs and ortho-images are extracted from stereoscopic images at the same time using the new method. Then some useful maps are overlaid on the ortho-images, and finally stereoscopic animations are made using the overlaid ortho-images and the DEMs.
With this method, stereoscopic animations can be made from stereoscopic images directly, and the work is greatly simplified.
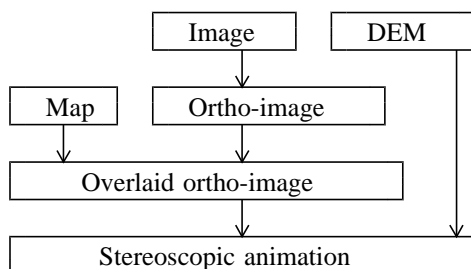
Figure 2   The usual method to make
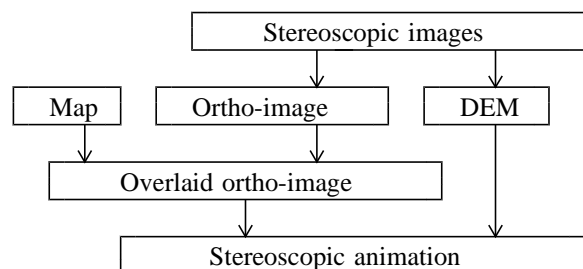stereoscopic animations

Figure 3   A new method to make
stereoscopic animations

4. A NEW KIND OF STEREOSCOPIC ANIMATION

Stereoscopic animations are usually made by moving the positions of fixed interval looking eyes. This kind of animation makes us feel as if we are flying in the sky, and is useful for grasping detailed topographic information. Such animations can be used effectively for much design work, such as area development or route selection.

Recently, a new kind of stereoscopic animations has been proposed made by changing the interval of the two looking eyes, that is, by changing the B/H ratios of the component stereoscopic images（N.Mori, 1998a）. In this case, the B/H ratio of stereoscopic images increases or decreases gradually one by one, and the mountains as virtual images grow or sink slowly. This kind of stereoscopic animation is very useful to extract geographic features on the earth's surface, lineaments or circular（N.Mori, 1988b）. Lineaments are especially important features in the field of earth resource exploration, and are usually used to find new mineral veins. Application examples of this new kind of stereoscopic animations in these fields will be shown next.

5. APPLICATION OF NEW STEREOSCOPIC ANIMATIONS TO EARTH RESOURCE EXPLORATION

A lineament, which means a linear feature on the earth's surface, is very important information for mineral vein finding because it sometimes shows the existence of a fault. In the field of earth resource exploration, lineament extraction from remote sensing images is a very important theme, and has been researched actively. The relationship between the B/H ratios of stereoscopic images and the total amount of lineaments which can be extracted from the stereoscopic images, has already been researched.

Two experiments were carried out to examine the relationship between the B/H ratios of stereoscopic images and the total amount of lineaments which can be extracted from the stereoscopic images（N.Mori, 1988）. One was made at Izu peninsula, the other at Hishikari district in Japan. The lineaments were extracted by a specialist of mineral vein finding. Table 4 shows the lineaments extracted from 4 pairs of different B/H ratio stereoscopic images of Izu peninsula. Table 5 shows the lineaments extracted from 4 pairs of stereoscopic images of Hishikari district.

B/H ratio	Total number of lineaments	Total length of lineaments（km）
0.1	135	305.86
0.3	284	594.13
0.5	330	730.10
1.0	262	610.36

Table 4   Total number and length of lineaments at Izu peninsula

B/H ratio	Total number of lineaments	Total length of lineaments（km）
0.1	78	152.18
0.3	76	189.18
0.5	103	249.43
1.0	164	309.58

Table 5   Total number and length of lineaments at Hishikari district

As a result of this research, some principles have been extracted as follows.

（1） The greatest amount of lineaments were extracted from 0.5 B/H ratio stereoscopic images at Izu peninsula where the slopes of the earth's surface were steep, but at Hishikari district where the slopes were gentle, 1.0 B/H ratio stereoscopic images were the best. It can be said from this that the most suitable B/H ratio of stereoscopic images for finding many lineaments is different according to the steepness of the earth's surface.

（2） The lineaments which were extracted from 4 different B/H ratio stereoscopic images were slightly different. So, it can be said that different lineaments can be extracted from different B/H ratio stereoscopic images.

It can be said from the results shown above that it is necessary to use many different B/H ratio stereoscopic images to extract the greatest amount of lineaments at each place. However in practice, it is very difficult to make and use many stereoscopic images. In order to resolve this problem, the new kind of stereoscopic animation is very useful. Because the new kind of stereoscopic animation consists of many different B/H ratio stereoscopic images, the most suitable B/H ratio stereoscopic images for the object area are surely contained in it, and almost all lineaments which can be extracted from many different B/H ratio stereoscopic images are easily obtained from the stereoscopic animation. The lineaments must be determined one by one carefully by moving the stereoscopic animation very slowly.

6. APPLICATION OF NEW STEREOSCOPIC ANIMATIONS TO ROUTE SELECTION

The usefulness of stereoscopic animations in the field of earth resource exploration has been shown above, but they can be used also in the field of road route selection as will now be shown.

In tunnel construction, faults must be avoided carefully. A map of already confirmed faults is surely very useful, but usually there are many other unknown faults even in fairly developed areas, and detailed ground inspection by boring is usually necessary. It has been proposed to use lineament information in the work of tunnel route selection （N.Mori, 1999）. The technique of lineament extraction from remote sensing stereoscopic images has already been developed in the field of earth resource exploration, and the usefulness of stereoscopic animations of rising mountains has already been shown. This technique and stereoscopic animations can be used effectively in the field of route selection also. Slow careful motion or step motion of the stereoscopic animations should find new lineaments across the route of a planned tunnel. Figure 6~10 show one example of these stereoscopic animations.

Figure 6 is a map of already confirmed faults at Izu peninsula. Figure 7 is a map of main roads. Figure 8 is an overlaid ortho-image of Izu peninsula, which was made by overlaying these maps on an ortho-image. A stereoscopic animation has been made using this overlaid ortho-image and a DEM. Figure 9 is one pair of component stereoscopic images of the stereoscopic animation. Figure 10 is another of larger B/H ratio. A stereoscopic animation of rising mountains is composed of such different B/H ratio stereoscopic images.

It is very expensive work to gather necessary information for route selection on the ground especially in undeveloped areas, but most can be replaced by computers using stereoscopic animations. Also the cost and time consumed in the route selection work can be reduced substantially.

Figure 6   A map of already confirmed faults   Figure 7   A map of main roads
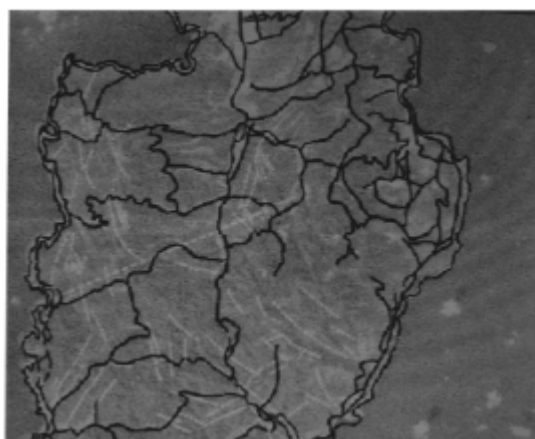

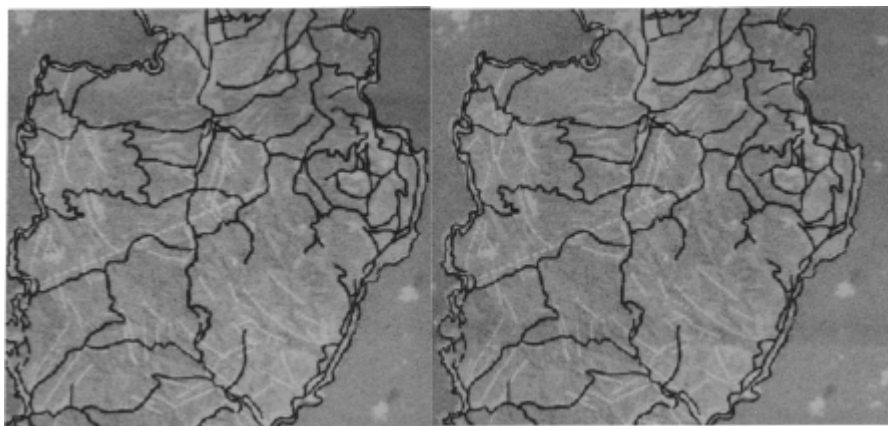Figure 8   An overlaid ortho-image of Izu peninsula

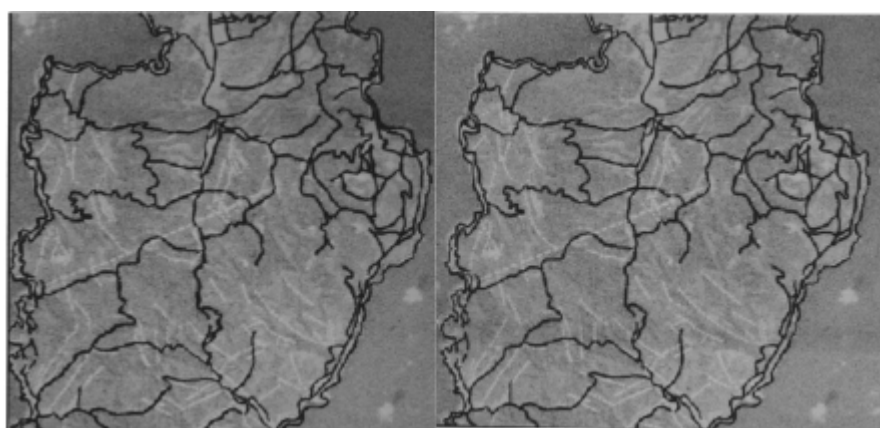Figure 9   Component stereoscopic images of the stereoscopic animation

Figure 10   Component stereoscopic images of larger B/H ratio

7. CONCLUSION

Using a digital photogrammetric system with ortho-image production software, an ortho-image can be made from stereoscopic images directly. This ortho-image production software can be developed by modifying DEM extraction software slightly. The accuracy of pixel positions of an ortho-image in this case is better than in the usual case using a DEM, because a DEM included slight error when it was arrayed by resampling. Concerning the radiance, as the pixel values of an output ortho-image can be calculated using two input images in this system, some image corrections, such as partial replacements and arithmetical calculations on two input images, can be carried out to make a fine output of an ortho-image. So, it is easy to get an ortho-image without clouds and shades from satellite stereoscopic images. Using this system, it is very easy to make stereoscopic images of any B/H ratio, because both an ortho-image and a DEM can be obtained at the same time, and the positions of their elements are completely the same. Stereoscopic animations can be made by arranging these stereoscopic images.

In the field of lineament extraction, two experiments have been carried out, and the results show that it is necessary to use many different B/H ratio stereoscopic images to extract the greatest amount of lineaments. However it is very difficult to use many different B/H ratio stereoscopic images in the same work. In order to resolve this problem, a new type of stereoscopic animation has been proposed. The animation is made by changing B/H ratios of component stereoscopic images gradually, and mountains in the animation look like they are rising or sinking.

This lineament information is very useful not only for finding new mineral veins in the field of earth resource exploration, but also in the field of route selection. In tunnel construction, faults must be avoided carefully. Usually there are many other unknown faults and detailed ground inspection by boring is necessary. Using the lineament information, some proposed tunnel routes can be omitted from consideration and the cost of ground inspection can be reduced substantially.

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