A NEW METHOD TO MAKE ORTHO- IMAGES AND STEREOSCOPIC ANIMATIONS

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ABSTRACT

An ortho-image production method has been developed, which makes an ortho-image from stereoscopic images directly. The method has been realized by changing a DEM (Digital Elevation Model) extraction software a little in a digital photogrammetric system. In the method, the pixel values of the output ortho-image can be calculated using those of two input images, and 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 make an ortho-image without clouds and shades from satellite stereoscopic images. Using this system, it is very easy to make stereoscopic animations, 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. Two kinds of stereoscopic animations are proposed here. One is a stereoscopic animation of landscape, which is useful to grasp detailed topographic information of subject areas. The other one is a stereoscopic animation of rising mountains, which is useful to extract such features of the earth's surface as lineaments. These stereoscopic animations can be used effectively in many application fields.

1. INTRODUCTION

At present, three-dimensional (3-D) animations are very popular in TV programs and games. But 3-D animations of landscape are not so popular, because it is very difficult to get these two kinds of essential data of subject areas, 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 interval 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 a computer. DEMs can be extracted from stereoscopic images also by a digital photogrammetric system. 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. This is the reason why ortho-image production is cumbersome and scarcely carried out. In this paper, one method to make both a fine ortho-image and a DEM at the same time will be shown. Then, two kinds of stereoscopic animations, landscape and rising mountains, will be proposed as useful tools for designing of area development and feature extractions.

2. AN ORTHO- IMAGE PRODUCTION METHOD FROM STEREOSCOPIC IMAGES

As mentioned above, a DEM is necessary to make an ortho-image by conventional methods. But now, it is possible to make an ortho-image from stereoscopic images directly using a new method (Mori, 1997). In addition to the ability of extracting a DEM from stereoscopic images, the digital photogrammetric system with the method can produce an ortho-image also from the same stereoscopic images. Figure 1 shows the method to make an ortho-image from stereoscopic images directly. In the figure, the left image and the right image compose a pair of stereoscopic images, and are placed on the position where the images were taken. O' is the perspective center of the left image, and O" is the one of the right image. These positions of the left image, O', the right image and O" can be determined by doing orientations of both images. P is a point on an object. P' is the corresponding point of P on the left image, and P" is the one on the right image. The position of P can be determined as the cross point of two lines, O'P' and

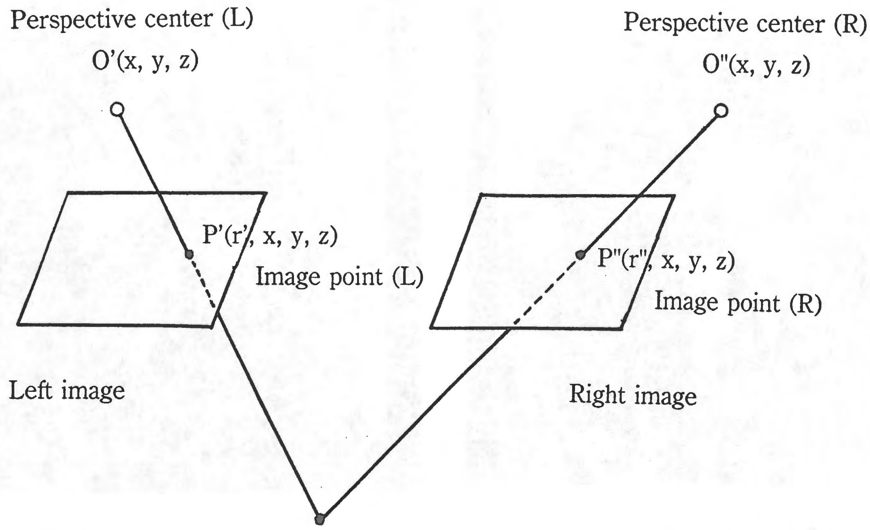

Figure 1 The method for making an ortho-image using stereoscopic images

O"P". The pixel values of P' and P" are r' and r", respectively. The radiance of P, which is represented by r, is the function of r' and r".

$$r = f(r', r'') \quad \cdots (1)$$

Many kinds of formula can be used as f, and r can be calculated from r' and r". An ortho-image of the object is obtained by calculating the values of r of all points on the object. 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 output of an ortho-image.

This method of making 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 (Mori, et al., 1992). The system already has a DEM extraction software from stereoscopic images. This ortho-image production method has been realized by changing the DEM extraction software a little, and both a DEM and an ortho-image can be produced at the same time by the system. 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 (Base/Height) 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. ORTHO-IMAGES PRODUCED BY THE SYSTEM

Some ortho-images were produced using the system mentioned above. Two SPOT panchromatic images of different dates at Mt. Minobu near Mt. Fuji in Japan were used as the input stereoscopic images. Figure 2 is the left image at Mt. Minobu (Date: 1988.3.17, Off-nadir angle: 15.4 deg. east). Figure 3 is the right image at the same place (Date: 1988.3.7, Off-nadir angle: 4.1 deg. east). Figure 4 and Figure 5 are the output ortho-images made from Figure 2 and Figure 3 respectively by the system. Figure 6 is the mixed image of Figure 4 and Figure 5, which was made by adding these two images. By adding two images, the influence of off-nadir looking, such as the shades of the opposite sides of the mountains, can be reduced, and the areas of unchangeable things on the earth's surface are enhanced. Figure 7 shows contour lines overlaid on the mixed ortho-image. Because DEMs and ortho-images are extracted at the same time, it is easy to draw contour lines of any height interval on the ortho-images.

4. A STEREOSCOPIC ANIMATION OF LANDSCAPE

An ortho-image and a DEM of the same place can be obtained easily from satellite stereoscopic images by a digital photogrammetric system with the ortho-image production software explained above. 3-D animations, such as bird's eye view animations and stereoscopic animations, can be made from these data. It is also possible to overlay or draw something on an

Figure 2 The left image at Mt. Minobu

Figure 3 The right image at Mt. Minobu

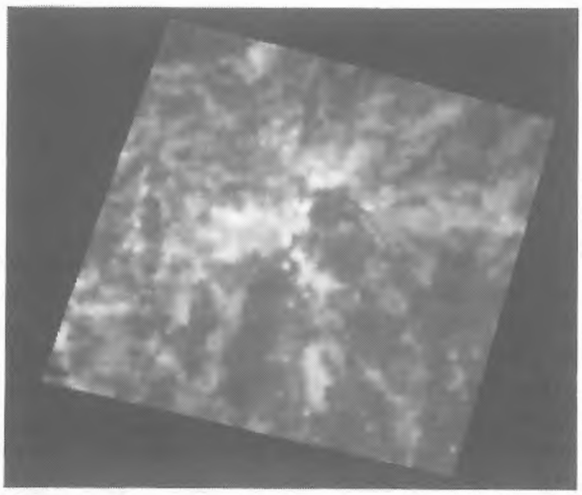

Figure 4 The ortho-image of the left image

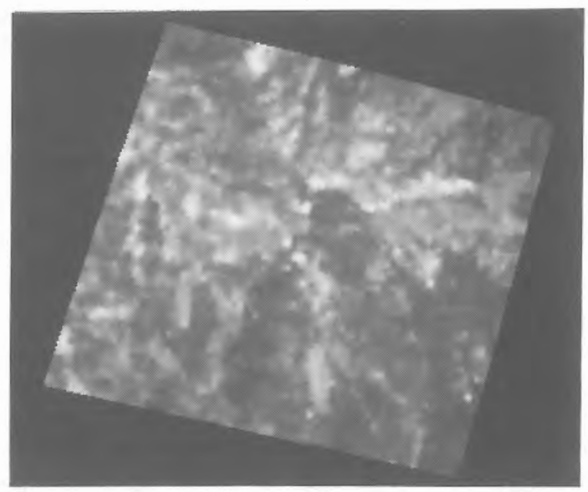

Figure 5 The ortho-image of the right image

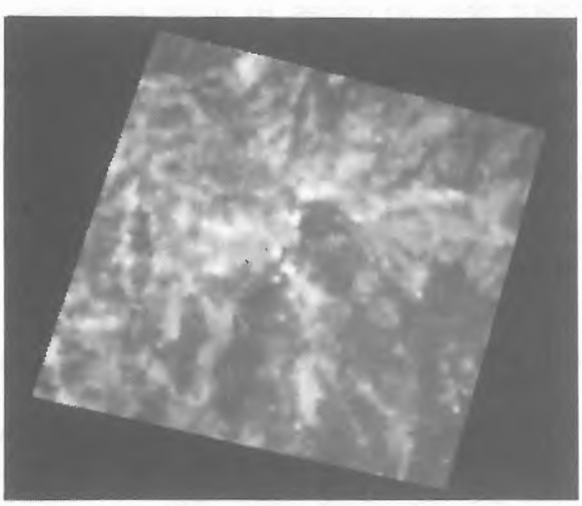

Figure 6 The mixed image of the left and right ortho-images

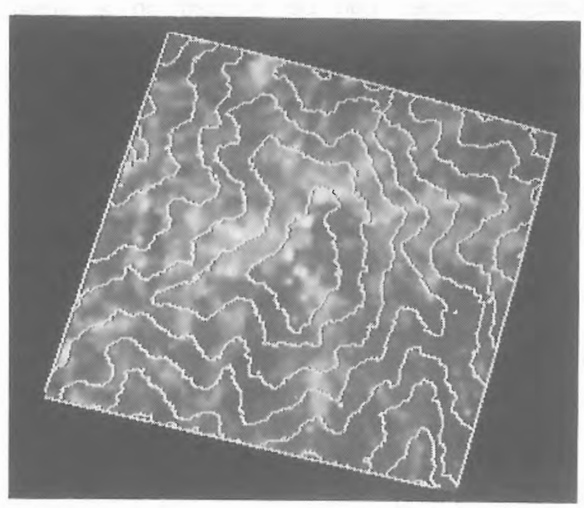

Figure 7 Contour lines overlaid on the mixed image

ortho-image before transforming it to a 3-D animation. For 3-D animations, bird's eye view animations are very often used because they require no special display devices. But stereoscopic animations are more effective for some special work which require detailed topographic information of the earth's surface, such as designing of area development or route selections of roads. In this case, a 3-D display device is necessary to see the stereoscopic animations. For some design purposes, fast motion of stereoscopic animations are not necessary. Slow motion or step motion of stereoscopic animations are sometimes more suitable. Figures 8 to 10 are one example of such a stereoscopic animation. Figure 8 are stereoscopic images taken at a start view-position. In figure 9, the view-position was moved a little left. In figure 10, the view-position was moved farther left. In these images, the view-position moved from right to left holding the B/H ratio at the same value. The stereoscopic animation can be completed by inserting many stereoscopic images of gradually different view-positions between these three images. The white rings in the images show the areas of nearly the same height. These kinds of animations are very useful to grasp detailed topographic information, and can be used effectively for much design work such as area development.

5. A STEREOSCOPIC ANIMATION OF RISING MOUNTAINS

Another proposition of a stereoscopic animation is rising mountains. In this case, the B/H ratio of stereoscopic images increases gradually one by one. So, the mountains as virtual images grow slowly. These kinds of animations are very useful in such a field as earth resource exploration. In this field, it is very important to find linear features (lineaments) on the earth's surface to find new faults. These two principles are already known from experiments (Mori, et al., 1996). One is that the most suitable B/H ratio of stereoscopic images to find many lineaments is different according to the steepness of the mountains. The other one is that different lineaments can be extracted from different B/H ratio stereoscopic images. It can be said from these principles that it is effective to extract lineaments using many different B/H ratio stereoscopic images. So, a stereoscopic animation of rising mountains is very useful in these fields. Figures 11 to 13 show one example of this kind of animations. White dot lines on these images show the positions of already confirmed faults. Figure 11 was stereoscopic images of the low mountains made using a small B/H ratio. In figure 12, the mountains were risen a little. In figure 13, the mountains were risen much more. Inserting much more stereoscopic images of different B/H ratio, this animation can be completed. This kind of animations are a new style of stereoscopic animation application, and are very effective to extract such geographic features as lineaments.

6. CONCLUSION

Using a digital photogrammetric system with the 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 those of 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 bird's eye view images or 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 there elements are completely the same. As the application of this system, two kinds of stereoscopic animations are proposed here. One is a stereoscopic animation of landscape, which is useful to grasp detailed topographic information of subject areas. The other one is a stereoscopic animation of rising mountains, which is useful to extract some kinds of geographic features. These stereoscopic animations can be used effectively in many application fields.

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An example of a stereoscopic animation of landscape

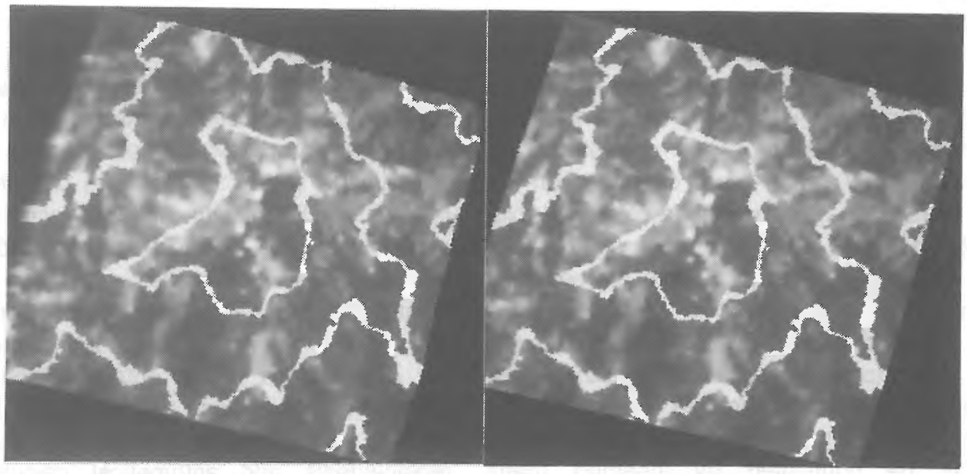

Figure 8 Stereoscopic images of a start view-position

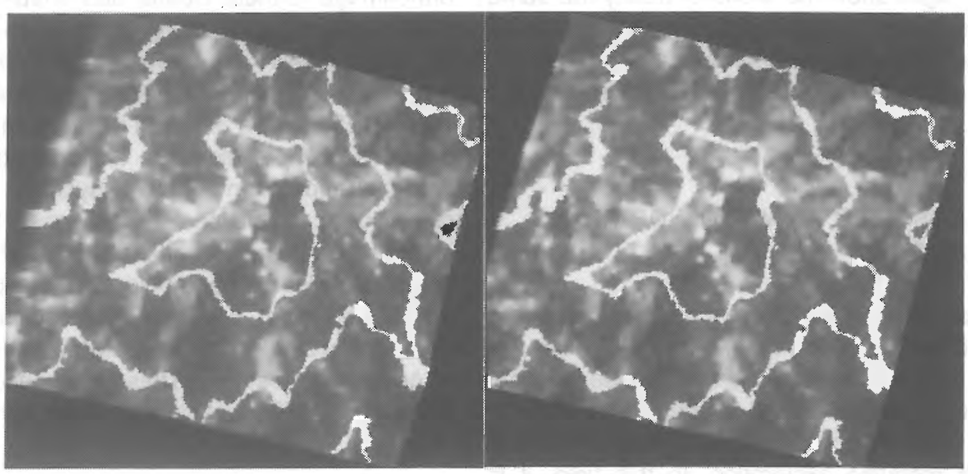

Figure 9 The view-position was moved a little left

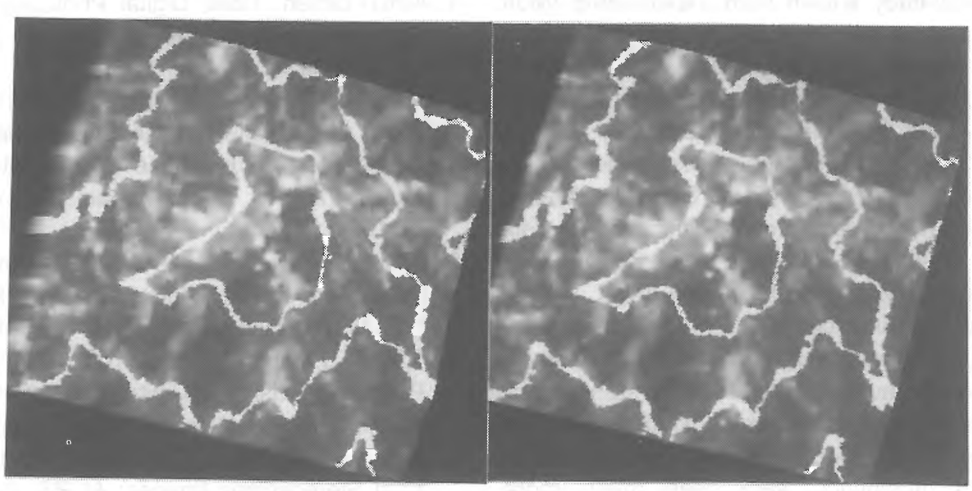

Figure 10 The view-position was moved farther left

An example of a stereoscopic animation of rising mountains

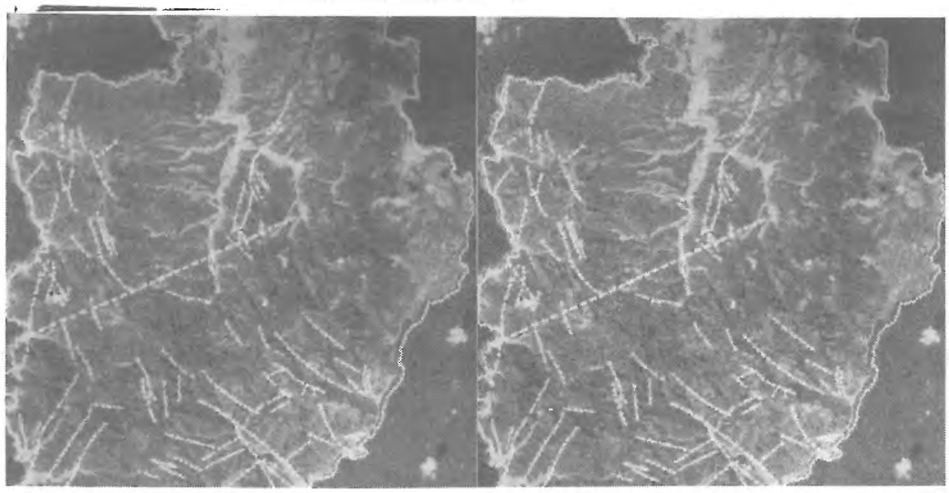

Figure 11 Stereoscopic images of low mountains

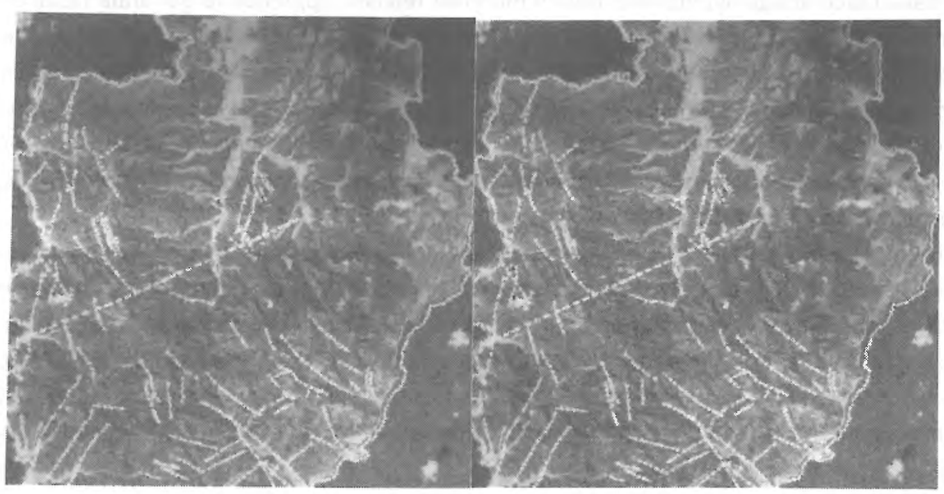

Figure 12 The mountains were risen a little

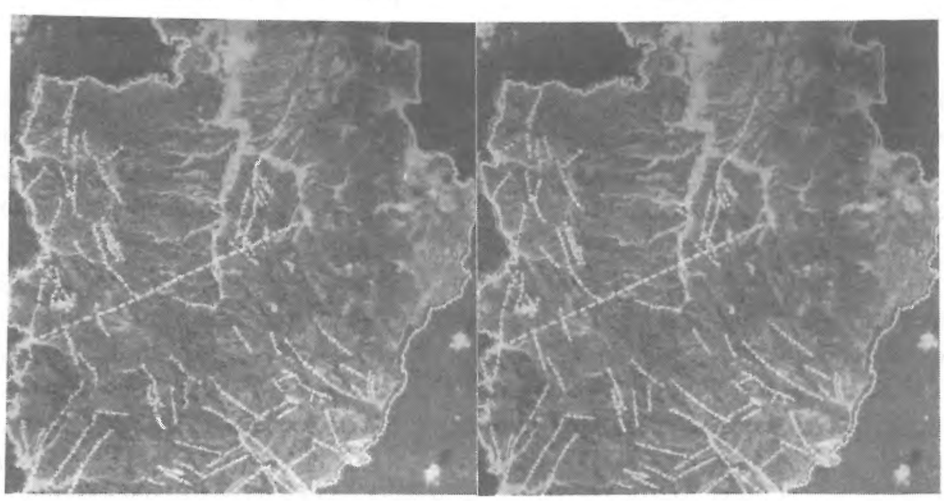

Figure 13 The mountains were risen much more