STEREO-VIEWING OF SCANNERS VIDEO IMAGES

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Frame scanners scan the ground object in two dimensions in a pixel by pixel mode and generate a video signal whose intensity is proportional to the amount of radiation emitted by the ground pixel. This video signal may be stored on magnetic tapes or used to build up a video image on the monitor screen. The use of this type of images has been until very recently restricted to the usual 2D video image. This paper investigates the possible restitution of a 3D model using the anaglyphic criteria by overlaying two digitally rectified video images of a stereopair on a GEMS image processing system.

أجهزة المسح التصويرى الحديثة تقوم بمسح الأرض في إتجاهين متعامدين وتنتج إشارة فيديو يمكنا تسجيلها علي شريط ممغنطة أو مشاهدتها على شاشة عرض. ولقد ظل هذا النوع من الصور يستخدم لمشاهدة الأرض فى إتجاهين فقط (س،ص) حتى ظهرت أجهزة حديثة يمكنها المسح الإستريوسكوبي لإنتاج نماذج ثلاثية الأبعاد والتى يمكن بها إستنتاج إرتفاع النقط على سطح الأرض.
وقد تطرق هذا البحث إلى أسلوب جديد لعمل نموذج ثلاثي الأبعاد من صور أجهزة المسح التصويرى بإستخدام طريقة الأناجلفيك المعروفة. وتوصل البحث الى إمكانية عمل تلك النماذج بدقة مقبولة إذا تم إجراء التصحيح الرقمي على الصور لتصبح الأخطاء والتشوهات الناتجه عن طريقة التصوير بحيث يمكن تحويل الصورة إلى صورة أخري مشابهة من الناحية الهندسية للصور المأخوذة بالكاميرات المستخدمة في المساحة التصويرية.
ومع هذا فإن هذا الأسلوب يتطلب تطوير وسيلة لقياس الإرتفاع من النموذج الثلاثي الأبعاد على شاشة العرض بطريقة دقيقة ولكن على الأقل فإن هذا الأسلوب يمكن تطبيقة في أغراض تفسير الخرائط.

Keywords: Scanners, Video, 3D, Mapping, Rectification

INTRODUCTION

The creation of a 3-D video model has for a long time been an attractive area of research by photogrammetric scientists but the limitations imposed by the capabilities of the systems manipulating digital images with its huge amount of data has always slowed down any progress in this aspect. Nowadays with the presence of powerful and cheap PC systems, and the great developments in the field of electronics and microprocessors, this aspect has been initiated again particularly with the availability of space digital images. It is will known that the idea of viewing 3-D models is based on separating the two overlapping images so that each eye view one image only. Petrie [1] summarized six possible alternatives of separating the two images for stereo- viewing. One of these methods is the Anaglyphic creteria which will be adopted in the current investigation. This method is based on the use of complementary red and green images and requires the use of a single colour video monitor in which the red gun displays the left hand image and the green gun displays the right hand image with the operator views the screen with anaglyphic glasses as shown in Figure 1. However before any attempt is made to view the images stereoscopically, it is necessary to remove any existing distortion by a digital rectification process.

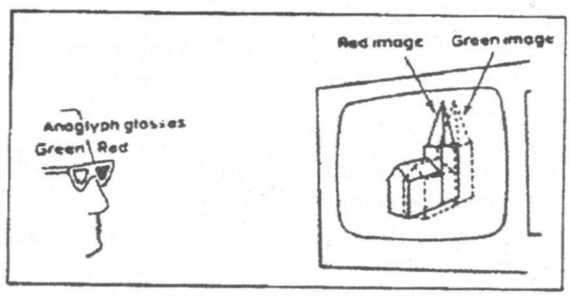

Figure 1 Anaglyphic system with single screen

DIGITAL RECTIFICATION OF VIDEO LMAGES

The acquired video images must first be digitized by sampling the grey levels in an image at constant intervals to produce an M x N matrix of pixels and quantising the grey level at each sampled pixel. This process of digitization is carried out by an analogue to digital conversion device (A/D) which provides a two dimensional array of integer values called digital numbers (DN) which represent the average brightness in the image within the pixel area.

The purpose of the digital rectification is to remove different types of distortion introduced to the image during the imaging process such as optical elements distortion, image geometry distortion, tilts and electronic distortion. In other words, the digitized video image which is called the input-image will be reduced to an equivalent distortion free vertical image taken with the scanner vertical axis pointing exactly downwards which will be called the output image. It will be noted that this image would then be identical to that produced by a photographic frame camera. If the terrain was perfectly flat, the output image will have the geometry of the map, if the terrain was not perfectly flat, the output image will still contain the relief displacements caused by the terrain elevations above or below the datum. These will not be rectified since their retention is a necessity if a stereoscopic video model of the terrain is to be produced. This rectification is carried out in two stages: (a) Analytical rectification in which each pixel position in the digital image is corrected for the geometric distortion inherent in the image, and (b) For each corrected pixel location a modified DN is assigned.

Analytical rectification requires a mathematical model to remove geometric distortion. A suitable model for rectification can only be decided upon after geometrical analysis so that the chosen mathematical model takes into consideration the geometric characteristics of the imaging sensor. Since the frame scanner scans the ground in two dimensions, the resultant image is expected to take the form of a spherical surface with a radius equals the focal length of the scanners system, this technique will cause the size of the ground resolution element to vary with respect to the scan angles while each element is recorded on the image with a constant pixel size. To remove the spherical effect, the size of each pixel image must be made to correspond to a constant resolution element on the ground. In other words, transforming the spherical image surface into an equivalent flat image surface tangent at the centre point of the spherical surface. Referring to Figure 2,

$$W = 2H \tan \frac{\beta}{2} \qquad (1)$$

where: W is the width of the frame
H is the flying height
β is the scan angle in the width direction

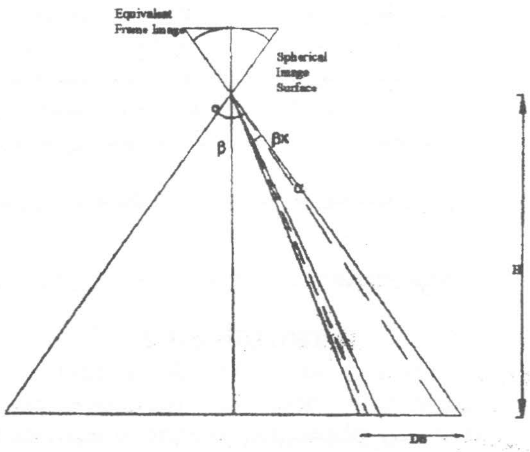

Figure 2 Digital correction for the spherical surface

Thus, the dimension of each pixel on the ground in this direction will be:

$$Y \frac{W}{M} \qquad (2)$$

Where Y is the ground pixel dimension
M is the number of lines/image.

In Figure 2, if DS is the distance on the ground from the beginning of the frame scan to the position corresponding to line x' in the image, then:

$$DS = x'\left(\frac{W}{N}\right) - \frac{1}{2}\left(\frac{W}{M}\right) \qquad (3)$$

$$= \frac{(2x'-1)}{2} \cdot \left(\frac{W}{M}\right) \qquad (4)$$

This distance may also be expressed in terms of the scan angle as follows:

$$DS = H\tan\frac{\beta}{2} - \left[H\tan\left(\frac{\beta}{2} - \beta x'\right)\right] \quad (5)$$

Then:

$$\beta x' = \frac{\beta}{2} + \tan^{-1}\left[\frac{(2x-1)}{2H}\cdot\left(\frac{W}{N}\right) - \tan\frac{\beta}{2}\right] \quad (6)$$

Substituting for W and for where is the scanner's instantaneous field of view (IFOV):

$$x = \frac{M}{2} + \left(\frac{1}{\alpha}\right)\tan^{-1}\left[\frac{(2x'-1)}{M}\tan\frac{\beta}{2} - \tan\frac{\beta}{2}\right] \quad (7)$$

In the same manner, the position of pixel y' in line x' of the output image can be found in the input image considering that the width of the line on the ground (W) will be a function of the two scanning angles and thus;

$$W = 2\ H\ \mathrm{Sec}\ \beta\ \tan\frac{\theta}{2} \quad (8)$$

and:

$$y = \frac{N}{2} + \left(\frac{1}{\alpha}\right)\tan^{-1}\left[\frac{(2y'-1)}{N}\sec\frac{\beta}{2}\tan\frac{\theta}{2} - \tan\frac{\theta}{2}\right] \quad (9)$$

DIGITAL CORRECTION OF SCANNER ATTITUDE AND CHANGE IN ATTITUDE DURING THE UKAGE SCAN TIME

The purpose of this correction is to remove the effect of tilts from the input image so that it conforms to that of instantaneously recorded image taken with the optical axis of the scanner pointing vertically downwards. In this way, each pixel location was corrected for the initial tilts which occurred during the recording of the image's geometric centre. This was achieved by rotating each pixel in three dimensions. The initial tilt values have been solved for during the space resection phase. The general three dimensional transformation has the form:

$$\begin{vmatrix} x' \\ y' \\ z' \end{vmatrix} = \lambda A \begin{vmatrix} x \\ y \\ z \end{vmatrix} + \begin{vmatrix} dx \\ dy \\ dz \end{vmatrix} \quad (10)$$

where:

x, y and z	are the coordinates in the input image
x',y' and z'	are the coordinates in the output image
dx, dy and dz	represent the shifts or translations between the two coordinate systems
A	is a 3x3 rotation matrix. Its elements are function of the three rotations about x, y and z
λ	is a scale factor

However, in the present situation it is required to rotate the input image so that the reproduced image (output image) will have the same scale and it is also necessary to ensure that its coordinate system's origin coincides with that of the input image origin. In other words, the scale factor in the above equation will be set to unity, while the translation elements will be set to zero. applying these conditions in the above equations and solving for the input image coordinates yields the following equations:

$$\begin{vmatrix} x \\ y \\ z \end{vmatrix} = A^{-1} \begin{vmatrix} x' \\ y' \\ -f \end{vmatrix} \quad (11)$$

Assignment of Digital Brightness Values

So far, the method of correcting each pixel location for the various types of geometric distortion has been discussed. Now each corrected pixel position must be assigned a new digital brightness value. This can be achieved by two different ways. In the first, the actual locations in the picture elements (pixels) are changed but each element retains its brightness value. This situation is shown in Figure 3 where the distorted input image is considered to have a regular pixel size relative to the output image which will then be represented by a series of pixels of irregular shape and size. Because of its limited accuracy this method may be used only for the simple geometric corrections as those concerned with the aspect ratio of the image.

In the second approach the input image may be considered to have an irregular pixel size relative to an output image consisting of a series of pixels of regular size as shown in Figure 4. The brightness values to be assigned to each pixel is obtained by interpolation in the input image as shown in Figure 5. This method is known as resampling. Different resampling methods are will quoted in the literature such as nearest neighbour, bilinear and biqubic resampling.

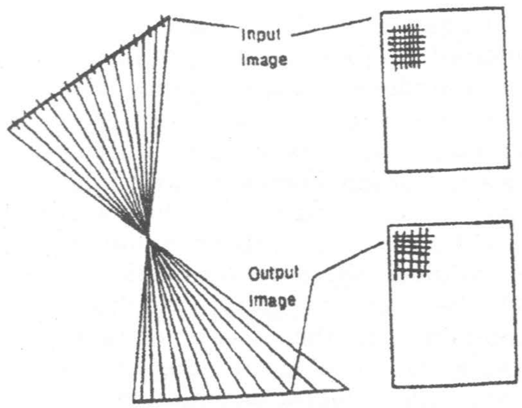

Figure 3 Regular input pixel size and irregular output pixel size.

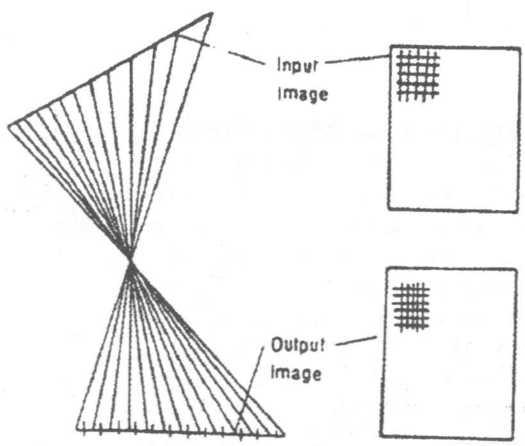

Figure 4 Irregular shaped input image and regular shape output image.

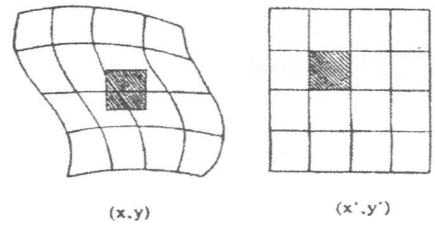

Figure 5 Corresponding locations of pixels in the input and output images.

STEREO VIDEO VIEWING USING THE GEMS SYSTEM

GEMS is a general purpose processing system on which a software package (GEMSTONE) has been specially developed for remote sensing applications.

The two digitally rectified images of the stereomodel were downloaded into the prime computer attached to the GEMS System and displayed separately on the video monitor. The process was carried out in the following way:

(i) An extract was taken from each image which is the area of overlap between the two images.

(ii) The two extracted images were overlayed by identifying two common points in each image and registering the two images at these two points,

(iii) The LH image was then projected on the colour video monitor screen using the green gun while the RH image was similarly projected using the red gun. By viewing the model using anaglyphic spectacles, the model appeared in three dimensions.

The three dimensional effect appeared very clearly particularly if the observer position himself at an appropriate distance (about 0.4 m) from the video monitor screen in order to be able to get the best impression of the 3D video viewing. Several attempts were made to improve the model by shifting the RH image relative to the LH image by intervals of 3, 6 and 12 pixels which is a similar procedure to that employed when a mirror stereoscope is used to observe two overlapping photographs by changing the base under the mirror stereoscope. The best position was obtained at 6 pixels separation, but this should not be taken as a standard value since it is related to the geometry of the overlapping photographs.

However, it was not possible to make sure that the stereo model was free from distortion since the system is not equipped with stereoscopic measuring facilities. Nevertheless, the model appeared in three dimensions which proved that the actual implemented procedure is successful and quite practical and extremely useful at least for interpreting frame scanner images for topographic mapping.

CONCLUSION

The possibility exists to create three dimensional models from frame scanner imagery after applying appropriate digital image rectification based on a careful study of the geometric properties of the imaging sensor. The use of anaglyphic technique on the GEMS image processing system showed to be a successful criteria with the only drawback is the lack of appropriate stereoscopic measuring facilities which is a must if three dimensional observations are to be extracted from the created model. However the system in its current shape provides a good tool for image interpretation applications.

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