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# Creation of Plane-Spatiotemporal-Image Using a Selected Slit

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## Abstract

*Continuous images include a very large quantity of data. Their processing for 3D information acquisition takes too much time. As a method for decreasing the quantity of continuous image data and processing time, the transformation of 3D spatiotemporal image into 2D spatiotemporal image for 3D information acquisition has been studied. In this paper, we first discuss the creation of 2D spatiotemporal image from sequences of images with analyzing the features of objects, the camera motion and the selection of slit. Then we show that we can obtain the 3D information of objects by only extracting some straight lines from 2D spatiotemporal images with several examples.*

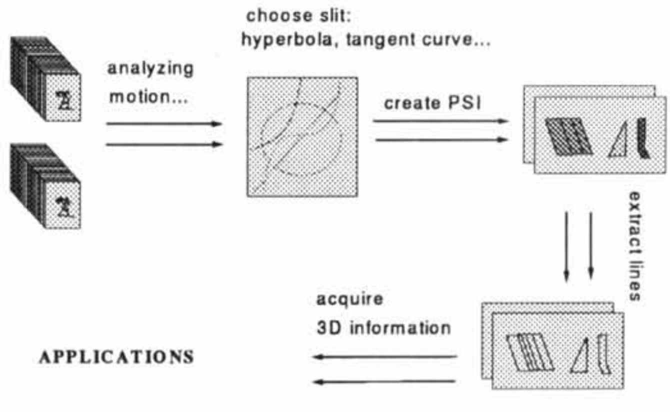


Figure 1:

## 1 Introduction

As an effective method to solve the difficulty of corresponding problem in the stereo image processing, the method to create 3D spatiotemporal images form image sequences for acquiring the 3D information of objects has been developed. A 3D spatiotemporal image is a dense sequence of images taken in such rapid succession that they form a single solid block of data in which the temporal continuity from image to image is approximately equal to the spatial continuity in an individual image.

Much work has been done to analyze three dimensional spatiotemporal image to obtain 3D information about the environment of the camera. For straight-line camera motion, tracks of object appear as linear structures on epipolar-plane images(EPIs), which are slices of the spatiotemporal image containing epipolar lines. The distance from the camera to the object is determined from the inclination of tracks. With EPIs analysis, it is much easy to compute the three dimensional positions of object features. Any corresponding problems between images can be solved by the extraction of feature-lines from the EPI[1].

Yasuno and Hamano presented an expansion of camera motion for spatiotemporal image analysis using spherical projection transformation[2]. In their approach, images are projected on a homocentric spherical surface to make a Homocentric Spherical Spatiotemporal Image(HSSI). An object feature is drawn as a curve on a plane containing the longitudinal lines of the HSSI. Then this HSSI is analyzed to acquire the 3D information of the object.

The 3D spatiotemporal image or HSSI is a very huge quantity of data. It takes plenty of time to extract lines or curves from those images. Zheng and others proposed a method to create a 2D image using only the pixels selected from each image taken by the motion camera[3]. They also showed that the 2D image includes spatial and temporal information of objects.

In our living environment, there are many artificial objects. They have many straight-line feature edges that include the 3D information of the objects. For constant speed straight-line camera motion, Li, Zen and Sakauchi proposed a method to create 2D spatiotemporal image using a hyperbolic slit for acquiring the 3D information of this kind objects[4].

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They proved that we can acquire 3D information of an object by only extracting some straight-line edges of the object from the 2D spatiotemporal image. In this paper, we extensively discuss how to create the 2D spatiotemporal images in which the straight-line feature edges of an articicial object are projected in a simple shape by analyzing the the camera motion and the selection of an appropriate slit. We will make the straight-line feature edges of objects be transformed into straight lines in the 2D spatiotemporal image. Because the straight lines are easier to be extracted for obtaining the 3D information of objects. Figure 1 shows the approach approximately.

The rest of this paper is organized as follows: Section 2 discusses the relation of camera motion and slit. Section 3 expresses the creation of 2D spatiotemporal image with a few concrete examples. And the last section makes the conclusion with discussion about future work.

## 2 2D spatiotemporal image

A 2D spatiotemporal image is created from a dense sequence of images taken by a moving camera continuously[3]. For the creation of 2D spatiotemporal image we must choose a slit first based on the camera motion. When a slit is chosen we set the slit on each frame of the continuous images and then arrange the pixels on the slit along a line with an order of an item selected(for example $x$ or $y$ coordinate)[4]. For each frame we can get such a pixel line. When arranging those pixel lines along a time item(for example time $t$), we create a 2D spatiotemporal image. There are several very important factors with the creation of the 2D spatiotemporal image. They will affect the projection of the straight-line feature edges of objects.

1. Camera Motion

   Camera motion affects the projection of object. With the difference of speed and movement of camera objects will appear with different shapes in the 2D spatiotemporal image. And we can think such two camera motion cases: one is the camera moves with a typical motion like a straight-line motion. In this case we can set the camera on the machine which moves with the motion. The second case is that we move the camera actively to create the 2D spatiotemporal image ideally.

2. Slit

   Slit is the curve which is set on the frame of the continuous images. The pixels on the curve is used to create the 2D spatiotemporal image. In order to acquire the 3D information of an object easier we have to select an appropriate slit to make the projection of the object in a simple shape. And we can also think to select a slit which is changing with time depending on demand.

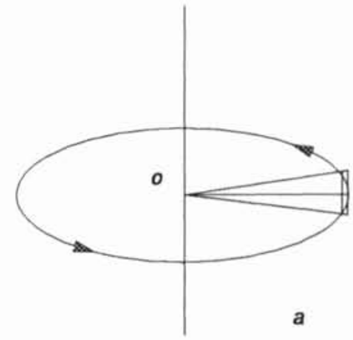


Figure 2:

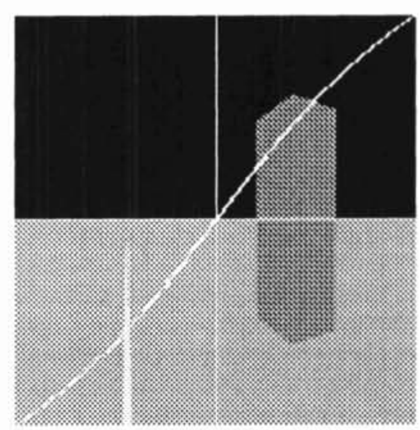

Figure 3:

When we acquire 3D information of an object from 2D spatiotemporal image, analyzing the camera motion and choosing an appropriate slit to create the 2D spatiotemporal image with suitable axes are very important, because those appropriate selections will make the projection of the object in a simple shape. This will make us easier extract the projection of the object from the 2D spatiotemporal image.

## 3 Creation of 2D Spatiotemporal Image

Here, we express the creation of 2D spatiotemporal images taken with several typical camera motions.

### 3.1 Rotary Motion

1. Tangent Slit

   Now let the camera move on a circle as shown in figure 2. The center of the circle is the view point and the lens center of the camera moves along the circle.

   we choose a tangent slit to set on each frame of the continuous images as shown in figure 3.

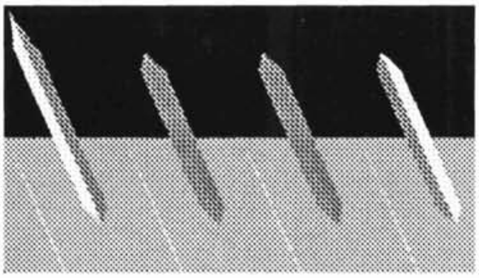

Figure 4:

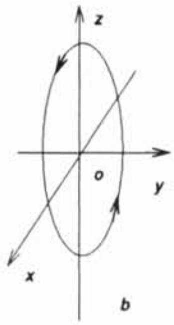


Figure 5:

There is a box in the environment. In this case, because the vertical edge lines go through the slit smoothly, as we see in the figure, the vertical edge lines of the box are projected into slanting lines when we select two appropriate axes for the 2D spatiotemporal image. And based on the relation of the straight line edges and their projections in the image, we can acquire the direction information of the straight-line edges by calculating the inclination of the projection lines. If there are many such boxes in the environment, when the camera rotates a complete circle, all of the boxes will be projected into the 2D spatiotemporal image. Then we can obtain all the direction information of them by extracting the straight lines from the 2D spatiotemporal image.

2. Straight-Line Slit

When we find an object in a direction we may want to get the position information. Here, we let the camera do such a moving that the lens center of the camera moves along a circle on a plane perpendicular to the ground as shown in figure5 and the view point is do the same way on another plane parallel to the first vertical plane. Bsed on the camera motion, we choose a straight-line slit as shown in figure6 to create the 2D spatiotemporal image. Figure7 is the 2D saptiotemporal image. Equation 1 is the slit and equation 2 shows the relation between time and coordinates. $X, Y, Z$ are world coordinates.

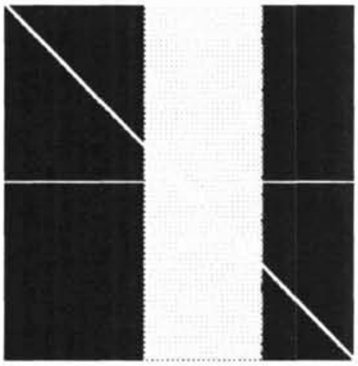

Figure 6:

Figure 7:

$x, y$ are the projection plane coordinates. $f$ is the focal length and $\omega$ is the angular speed of the rotary motion. As we see in the figure the vertical straight-line edges of the box are projected into slanting lines. In equation 2 we can know that we can acquire the 3D information of those lines in the 3D space by calculating the inclination of the lines projected.

$$ax + by + c = 0 \quad (1)$$

$$(Z + f)/f * (by + c)/(-a) = X - r\cos(\omega) \quad (2)$$

### 3.2 Straight-Line Motion

Now let us think about another typical camera motion. In this movement the camera moves along a straight line at a constant speed. There are many boxes standing beside the path which the camera moves on. We create a coordinate system as shown in figure 8. $X, Y, Z$ are the global coordinates. $f$ is the focal length. $x, y, z$ are the coordinates of the projection plane. A point $P(X, Y, Z)$ in the 3D space is projected to point $p(x, y)$ on the projection plane with the following equation:

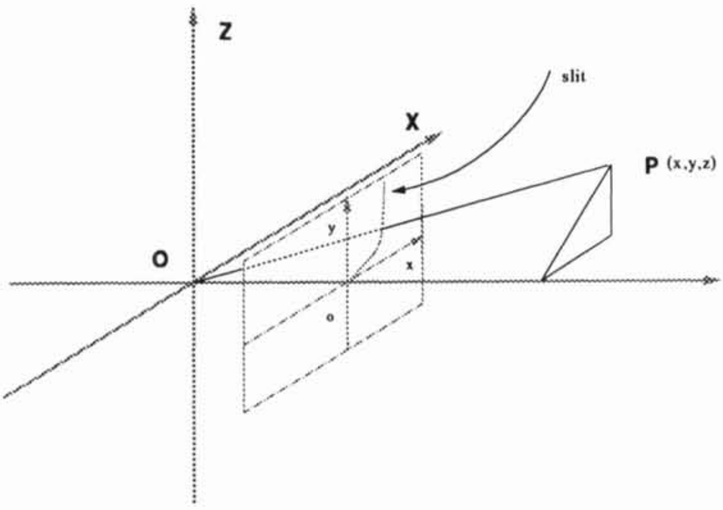


Figure 8: coordinate system

$$\frac{X}{x} = \frac{Y}{y} = \frac{Z - vt}{f} \tag{3}$$

$v$ and $t$ represent speed and time respectively.

Based on the relation of the straight line edges and their projections, we use a hyperbola described in equation (4) as slit to create the 2D spatiotemporal image.

$$x(y + a) = c \tag{4}$$

From equations (3) and (4) we have:

$$y = \frac{-vc}{Xf}t + \frac{cZ}{Xf} - a \tag{5}$$

Figure 9 and figure 10 show the slit and the 2D spatiotemporal image created with the slit respectively. From the 2D spatiotemporal image we can acquire the 3D information of the objects in the camera moving environment[4].

The transformation from 3D spatiotemporal images to 2D spatiotemporal images largely decreases the quantity of image data. It will greatly decrease the processing time of image data. In order to obtain the 3D information of object easier, Analyzing the camera motion and the relation between the straight-line edges of objects and their projection lines to choose a proper slit to make objects be transformed into a simple shape which is easier deteted is very important.

## 4 Conclusion

A 3D spatiotemporal image contains a very large amount of data, its processing and analysis take very much time. Creating 2D spatiotemporal image from a sequence of images is a very effective method for decreasing the quantity of data and processing time.

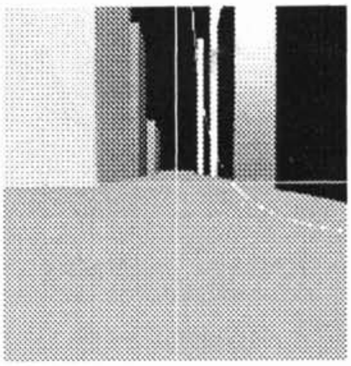

Figure 9:

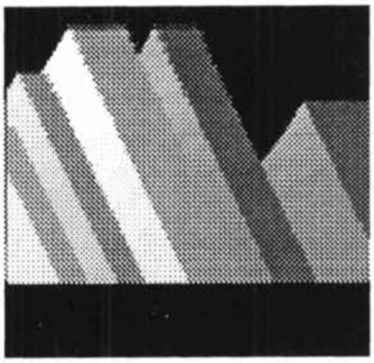

Figure 10:

Here how to create a 2D spatiotemporal image in which the objects are projected in a simple shape is a point for 3D information acquisition of objects. In this paper we discussed the creation of the 2D image with several typical camera motions. And we gave the slits for creating the 2D spatiotemporal image from the 3D spatiotemporal image taken with those typical camera motion. As future work we are going to continue our work with more applications of the proposed method .

## References


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