The 3-D Box Method for Recovering Shapes of 3-D Objects from Multi-Images.

Md. Jahangir ALAM*, Yoshio YANAGIHARA**, and Hiromitsu HAMA***
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Synopsis

One of important-tasks in computer vision is to determine the three-dimensional shapes of objects given different views (images) of the object scene. Here we want to propose a new method for recovering shapes of 3-D objects from multi-projected images. It is based on the concept of voting box and counting the votes for different images. Assuming a point in a scene has been correctly identified in each image, its three-dimensional position can be recovered via a simple ray tracing and counting votes which is called here as a 3-D box method. The main advantages of this method are simplicity, reliability, and less computational time. These advantages will make surely the 3-D box method of practical use for many applications.

KEYWORDS: Computer vision, Projected image, Voting box, 3-D box.

1. Introduction

The recovery of three-dimensional objects is one of the most talked about topics in the field of computer vision. For the simplicity first, we consider our system involves two image views of an object, then we extend our system for multi-cameras (more than two cameras). If the positions of two cameras are known with respect to each other, it is possible to estimate the three-dimensional position of a point using corresponding points in the two images. Given the internal geometry of the cameras, including the length of base line, the focal length for each camera, the principle distance, and the location of the principle point, rays can be constructed by connecting the points in the images to their corresponding projection centers. These rays, when extended, intersect at the point in the scene that give rise to the image point(s).

It is assumed that a pinhole camera is employed for each camera. That is, the lens is considered to be a point through which all incoming rays of light pass. In reality, a pinhole cannot be used since it does not allow enough light through to the imaging surface. One may assume that in well lighted conditions and with a proper geometrical setup, the lens aperture is small enough so that the effect of such blurring is small compared to the camera’s other distortions. Under such conditions a pinhole model can be accepted as a very close approximation to a lens’ behavior.

The objective of this research work is to recover the shape of 3-D objects from its multi-images by using 3-D voting boxes. In this case, ray tracing is employed for different projected images of the 3-D object for each camera. Votes are casting in different 3-D boxes by passing rays by connecting the image points with the projection centers. After completing this process for different cameras and for different images, the number of votes casting in the 3-D box are calculated. If any box contains two votes in the case of the two camera system, then we can conclude that this box corresponds to the location of the point of 3-D object. For every point on each image plane, same technique is employed.

* Research Student, Dept. of Information and Communication Engineering, Osaka City University
** Associate Professor, Dept. of Information and Communication Engineering, Osaka City University
*** Professor, Dept. of Information and Communication Engineering, Osaka City University
2. 3-D box method

Let us use the terms left \((L)\) and right \((R)\) to identify the two cameras. Fig. 1 shows our experimental setup. The points \(C_L\) and \(C_R\) are the focal points of the left and right cameras. \(I_L\) and \(I_R\) are two image planes for the left and right cameras, respectively. We can use the cameras with any focal lengths but here we use pinhole cameras for simplicity, therefore, their focal lengths \((F_L = F_R = 1)\) are equal to one.

![Fig. 1 Experimental setup.](image)

There are many kinds of images, for example, a point image (due to a single point in 3-D), a line image (due to a line in 3-D), and two-dimensional image (due to planes or three-dimensional objects in 3-D). Rays start from both the optical centers through their corresponding image on each image plane and are extended to superimpose them. This superimposing area contains the three-dimensional information about the object's shape and position. Our goal is to find out these information correctly and to reconstruct the shape and position of a 3-D object using by a 3-D voting box method.

For simplicity, we give some shape restrictions for our experiment. These are: point, straight line, smooth curve, planes (circle, triangle, and square), and solids of smooth surfaces. For any practical purpose, we can verify our experiment with consistent blood vessels in the brain phantom obtained by X-Ray radiation.

![Fig. 2 (a) Rays are traced for a point in 3-D. (b) Voting boxes are superimposed.](image)
In the case of a single point in 3-D (Fig. 2), it is not so difficult to find out its exact position in the scene. But the problem is that, when the intersecting point of two rays is at any corner of the voting boxes then we cannot decide which box is the location of the point. We can solve this problem by subdividing the voting boxes and superimposing them. Voting boxes drawn by the light-line and bold-line are superimposed to get the position of the point inside of a box, which is shown in Fig. 2(b).

Fig. 3 Rays traced for a line of multi-colors. (a) Single-colored line. (b) Double-colored line. (c) Multi-colored line.

In the case of a straight line, voting boxes at the corner (Fig. 3(a)) contain double votes. The line is bounded by these voting boxes, but we cannot choose any two of them. The voting box contains double votes due to the rays coming from the left end point of the line image of each image plane gives the left point of the line in the scene. Also, a voting box contains double votes due to the rays coming from the right end point of the line images gives the right end point of the line in the scene. For this case, ending points of the line are clear but shape ambiguity remains. To solve this problem we can divide the line as a combination of multi-colors (Fig. 3(b) and Fig. 3(c)). Each color image contains the information about each part.

In the case of smooth curves, we get a curved image on each image plane and rays are constructed as the same way of line image. We can solve the ambiguity problem by dividing them or taking them as a combination of multi-colors.

In the case of any plane, we get a two-dimensional image on each image plane. Rays are constructed for everypoint on each image plane with their corresponding projection centers. Comparing to the previous cases, here we get a three-dimensional region containing double votes. The position of the plane is within this region bounded by the boxes containing double votes.

In the case of a three-dimensional object, we get a two-dimensional image on each image plane as the case of a plane but here the shape of each image on each image plane is different than that of the image shape for the plane. Because each camera contains different information about each plane of the three-dimensional object. Votes are casting for each point of the image as the previous cases. Voting boxes containing double votes give the three-dimensional information for each point of the 3-D object.
3. Conclusion

We have presented an approach for recovering 3-D objects. Our method is applicable for finding the three-dimensional information of points, straight lines, curves, planes, and solid objects in the scene. We can apply this method in those fields which need to recover the three-dimensional information from their images, such as in the field of medical sciences. We can face problems in some cases, there we can use three cameras to solve these problems, which is our next goal.

References