Computer Vision

Shape from Silhouettes

Name: hanxue Liang

Student ID: 16-912-156

In this exercise, I implemented a silhouette extraction algorithm to reconstruct a 3D object from multiple calibrated images.

1. Silhouette extraction

In this part, a simple thresholding technique is used. The pixels whose intensity value is greater than the threshold are set to 1, the others to 0. For this part, I gradually changing silhouette Threshold until the result silhouettes got clear and continues. I reached 110 as the optimal value for silhouette Threshold parameter.

Figure1: Extracted silhouette

2. Volume of interest

After trying several values, I chose the bounding box to be minx = 0.25; miny = −0.2; minz = −1.8; maxx = 2.1; maxy = 1.1; maxz = 2.5, which is (or very close to) the smallest bounding box.
I chose the volume resolution to be 64x64x128

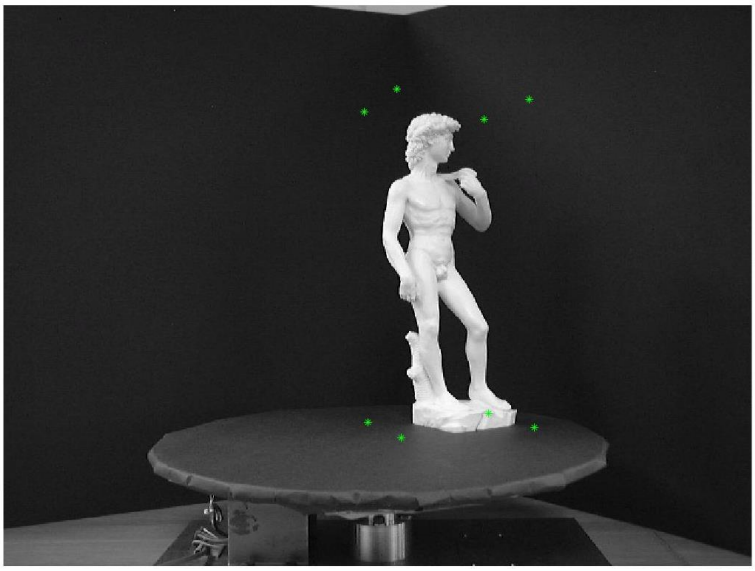

Figure2: Image of the statue with the corners of the bounding box displayed

3. Visual hull

On first step, I project the center of the voxel to the image. To do that, for each voxel (x,y,z), I transform it to world coordinates using the transformation matrix. Then I multiply it with the projection matrix of the image. On second step, I update score according to silhouette. If the projected point in the image falls within in the silhouette, add 1 to the score.
The constructed 3D model is shown in the figure below:

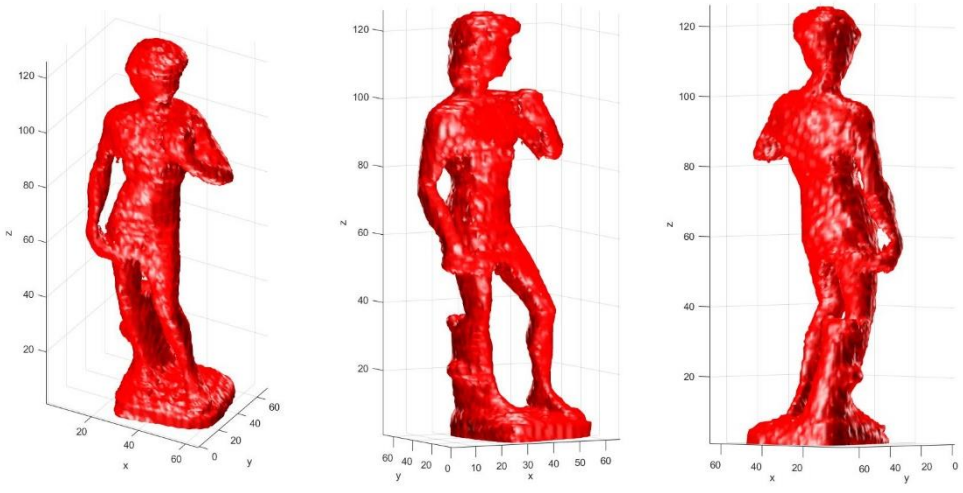

Figure3: Constructed 3D models in different views

4. Improvements

The Voxel-based Method

In this method, firstly, the object space is split up into a 3D grid of voxels. Then Each voxel is intersected with each silhouette volume. Only voxels that lie inside all silhouette volumes remain part of the final shape. And the 3D model is constructed using the isosurface() method from the resulting volume.

The first limitation of this method is that it has no concavities and the reconstruction is not photo-consistent. Another limitation is that since this method needs the extraction of silhouettes. So the quality of reconstruction is dependent on the quality of silhouette extraction. In addition, the number of cameras and their placement can dramatically influence final results. During our project, we didn't encounter this constraint because we had lots of pictures with the statue rotating around so we always had it in sight and from lots of angles. However, when the number of point of view becomes a constrain, the results can become much worse.

Possible improvement

One way to extract cavity on the thorax of the statue would be to use more information of the image, like the color of pixels, shading, texture or light sources. We could also use stereo algorithms to extract disparity map and depth from neighbor images.

After extract shape using Shape from Silhouettes, we could refine the result by using pairwise stereo matching between neighbor images to constrain the visual hull more accurately.

Apart from the voxel-based method, we can also use more efficient shape-from-silhouette techniques such as the marching intersections method, exact polyhedral methods and the image-based visual hull algorithm.