5 Computer Vision – Pierre Beckmann

5.1 Shape from Silhouettes

In this assignment we reconstructed a 3D object using multiple calibrated images.

We were provided with multiple images of the same object from different angles and their corresponding projection matrices Ps. We computed a matrix for every image that contains ones for every pixel that is brighter than a certain silhouette threshold and zeros otherwise: $sils$.

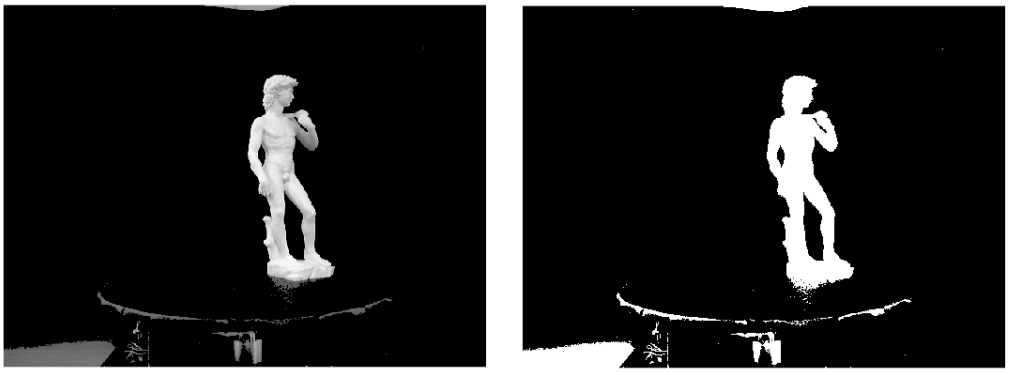

Figure 1: **Silhouette Matrix.** On the left we have one of the images andon the right the corresponding silhouette matrix using a silhouette threshold of 90.

Next we defined a volume of interest with a grid that separates the volume into voxels. Each voxel has an occupancy score.

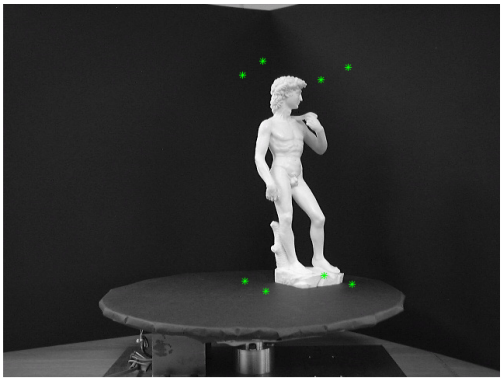

Figure 2: **Volume of interest.** The volume of interest is delimited with green stars. It is tight to improve resolution.

For every voxel, seen from each image, we computed the corresponding 3d coordinates XYZ using a provided transformation matrix and got the corresponding xy in current image: $xy = Ps[n] * XYZ$. We made sure to normalize xy. Everytime xy is a one (so a bright point which corresponds to the silhouette) in $sils[n]$ of the current image we add one to the occupancy score of the matrix.

Finally we plot every voxel that has an occupancy score higher than a certain volume threshold and obtain the desired reconstruction of the 3d object.

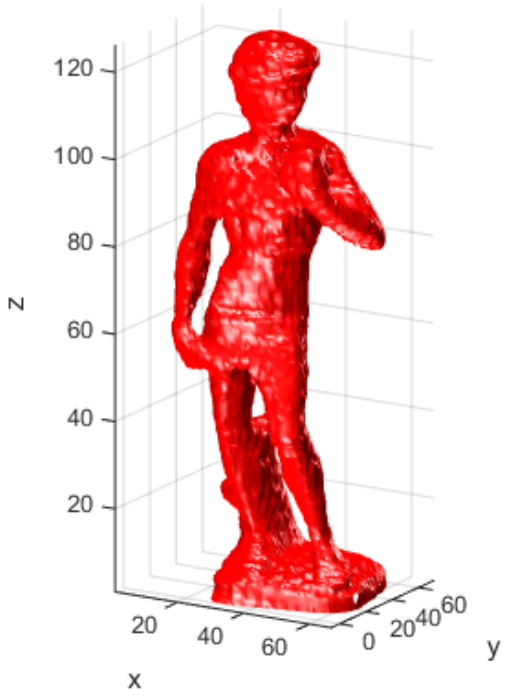

Figure 3: **3D object Reconstruction: Visual Hull.** This is the obtained reconstruction using a 64x64x128 grid in following bounding box: $min_x = 0.25, min_y = -0.11, min_z = -1.8, max_x = 2.07, max_y = 1.1, max_z = 2.5$, a silhouette threshold of 90 and a volume threshold of 17.

5.2 Main Drawbacks of this Technique

Intuitively the shape from silhouettes technique seems to be limited by the number of cameras and their configuration aswell as the quality of the input images and their silhouette extraction. While searching for other drawbacks I came accross an interesting paper where B. Michoud et al.[1] identified three principal ones. I decided to borrow their figure in this report because the illustrations are self-explanatory.

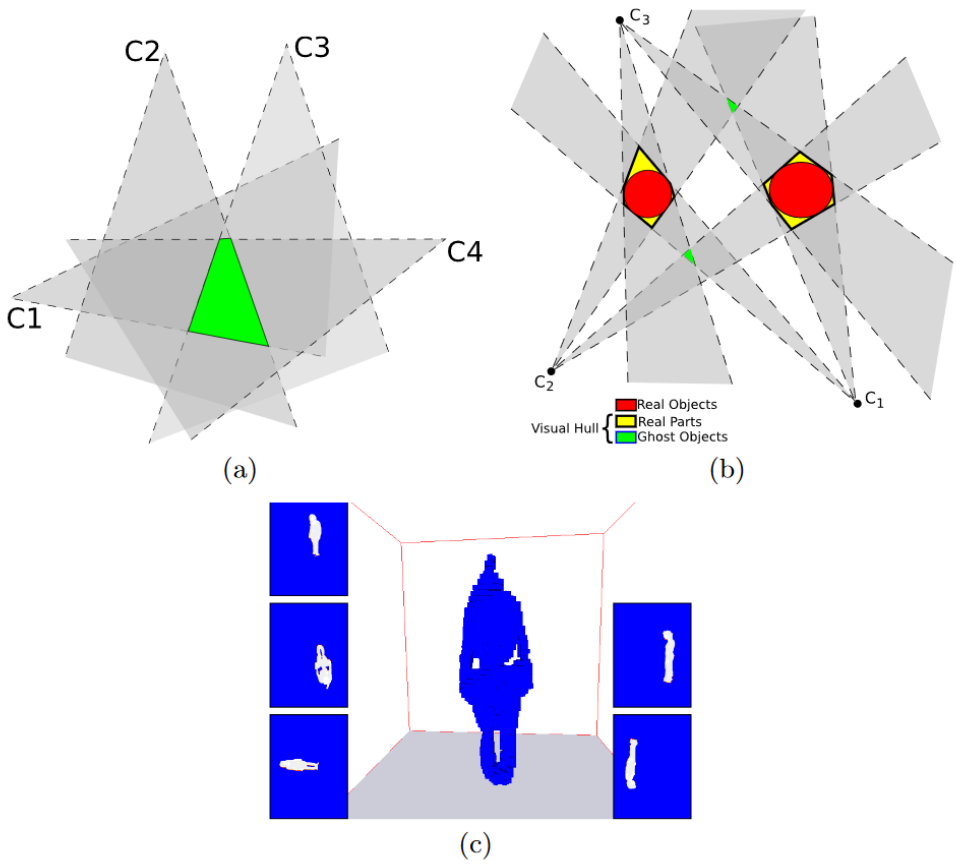

Figure 4: **The three main Drawbacks of the Shape from Silhouettes Technique.** This figure is taken from the paper of B. Michoud et al.[1]. They state the following main drawbacks: (a) the acquisition space is limited to the strict intersection of the camera's fields of view, (b) some configurations lead to ghost objects and (c) the reconstruction precision depends on the silhouette's extraction resolution and quality.

These three main drawbacks are clear and can even be observed when playing with the parameters in our example.

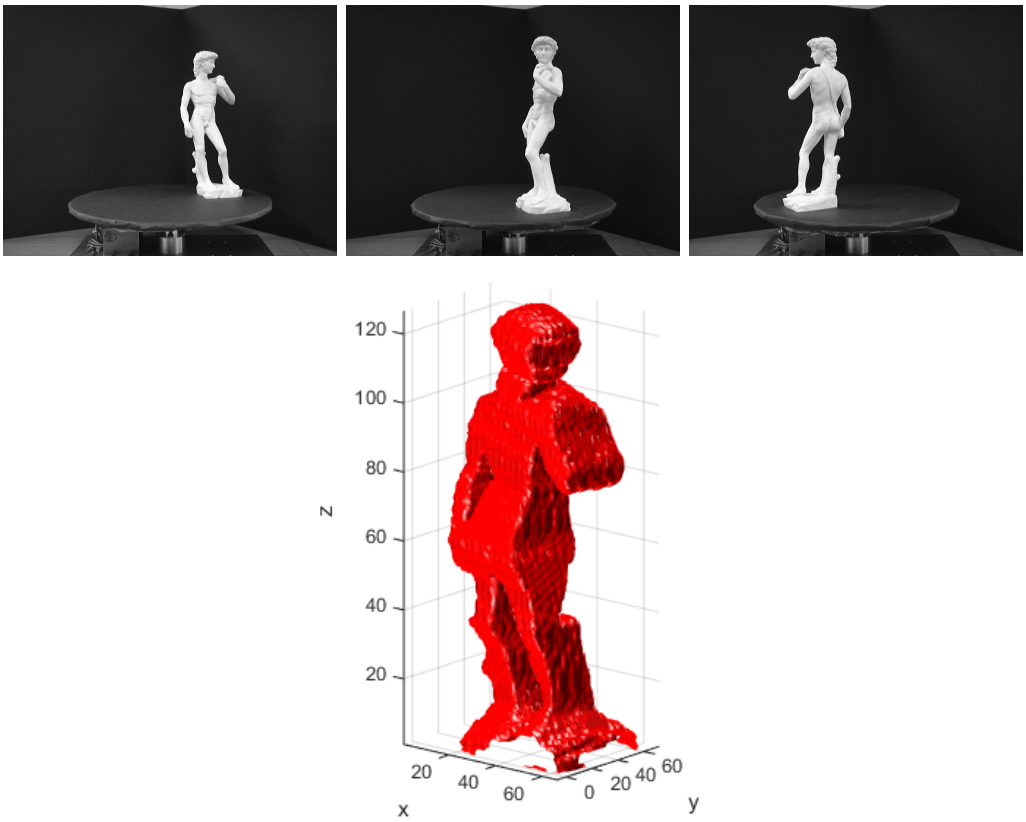

Figure 5: **Limited Acquisition space.** We computed the visual hull using the 3 images on the top. We can see that the result is limited by the number of cameras and the intersection of their viewing frustrums.

When changing the value of the silhouette threshold we can also make ghost objects appear in our example.

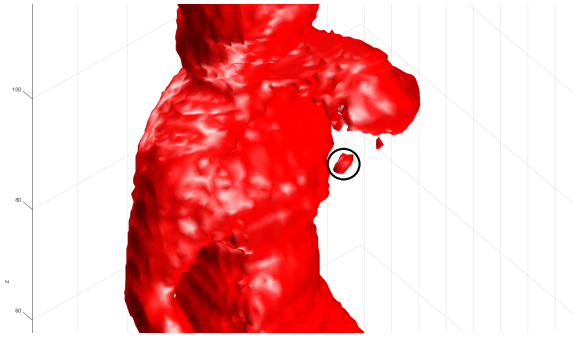

Figure 6: **Case of a ghost object.** Visual Hull with a 64x64x128 grid in following bounding box: $min_x = 0.25, min_y = -0.11, min_z = -1.8, max_x = 2.07, max_y = 1.1, max_z = 2.5$, a silhouette threshold of 80 and a volume threshold of 17. Ghost object is cricled in black.

5.3 Possible Improvements

To overcome the three main drawbacks B. Michoud et al.[1] propose a statistical mapping approach to compensate bad silhouette extraction and find an approach to identify and remove ghost objects.

We could also use additional infromation in the images such as the shading, light sources, texture, focus, specularities and shadows. In this case shading seems particularly interesting

because the different tones of grey on the statue give useful cues to its shape. Therefore computing identifyng the sources of light and computing the reflectance map for one or even each image would give additional intersting information.

Additionally, it could be intersting to extract features in a tight rectangle around the statue in the image in order to get a precise contour of the silhouette.

References

[1] Brice Michoud, Erwan Guillou, Héctor M. Briceño and Saïda Bouakaz. *Silhouettes Fusion for 3D Shapes Modeling with Ghost Object Removal*. LIRIS - CNRS UMR 5205 - Université Claude Bernard Lyon 1.