3D Vision
Homework 1

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Exercise 1

Used transformation matrix is as follows: $\begin{pmatrix} 0.5 & 0 & 0 & 1.5 \\ 0 & 0.5 & 0 & -2.5 \\ 0 & 0 & 0.5 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$. So the object is scaled with 0.5 and translated with 1.5, -2.5. Result can be seen in Figure 1.

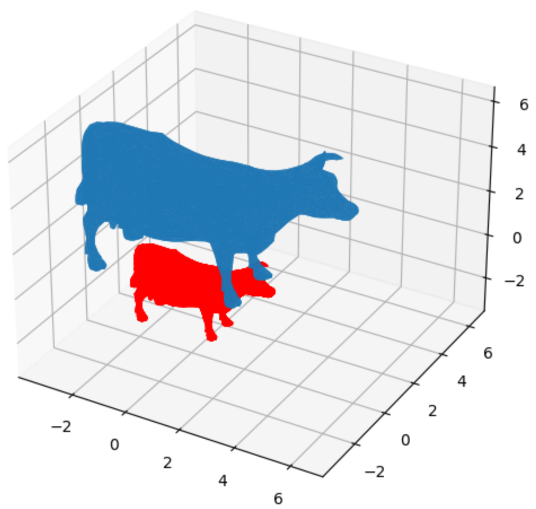

Figure 1: The cow and the calf.

Exercise 2

Result can be seen in Figure 2.

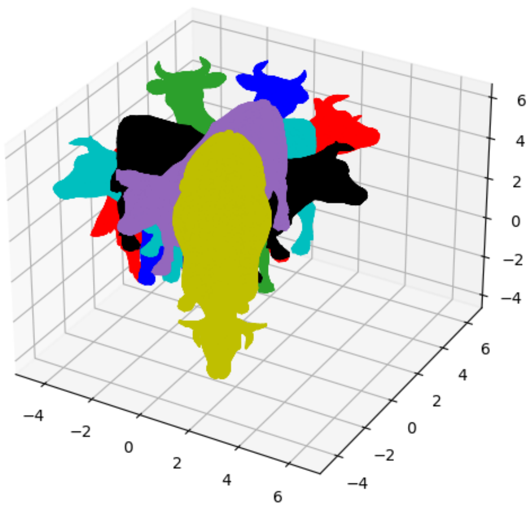

Figure 2: Rotated Cows.

Exercise 3

We do not obtain the same position after (i) and (ii) because exponential mapping in Rodrigues formula is not commutative as expected. Formulation is shown in Equation 3.1 and plot is shown in Figure 3

$$e^{w1} \cdot e^{w2} \neq e^{w2} \cdot e^{w1} \tag{3.1}$$

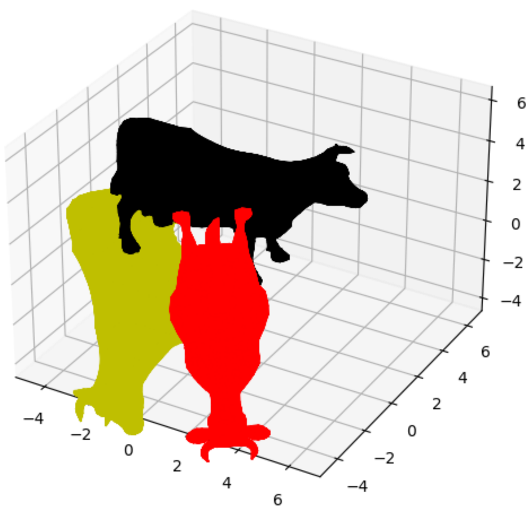

Figure 3: Tańcząca Polska Krowa.

Exercise 4

Result can be seen in Figure 4.

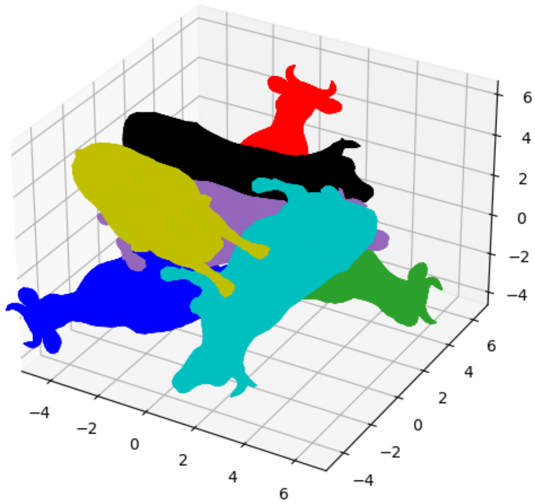

Figure 4: Perturbed Rotations.

Exercise 5

As we can see from the Figure 5, quaternion rotations are also not commutative.

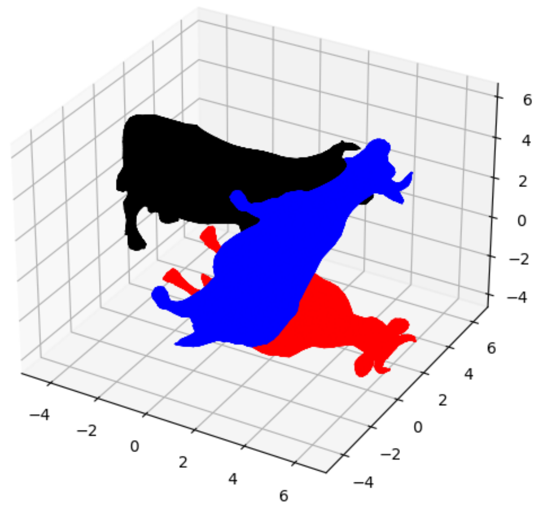

Figure 5: Quaternion Representation of 3D Rotations.

Exercise 6

I) Is there a singularity in the Exponential Coordinates? If yes, can it be overcome?

If the rotation matrix is identity matrix which means rotation angle is 0, we can not define the rotation axis from the rotation matrix. For theta = 0, there is a singularity.

II) Is there a singularity in Quaternions?

No, There is no singularity in Quaternions.

III) Why is the quaternion representation preferred over Euler angle representation for 3D rotations?

In Euler angle representation, we lose 1 degree of freedom and that is defined as gimbal lock. In addition, rotation pattern does not change continuously. These are the reasons why we use quaternion over Euler angle.

Exercise 7

Calculated 2 rotation matrices are as follows: $\begin{pmatrix} 0.84 & -0.52 & -0.16 \\ 0.22 & 0.59 & -0.77 \\ 0.5 & 0.61 & 0.61 \end{pmatrix}$, $\begin{pmatrix} 0.84 & -0.52 & -0.16 \\ 0.22 & 0.59 & -0.77 \\ 0.5 & 0.61 & 0.61 \end{pmatrix}$
Values in these 2 matrices differs from each other on the order of 10^{-7}. Result can be seen in Figure 6.

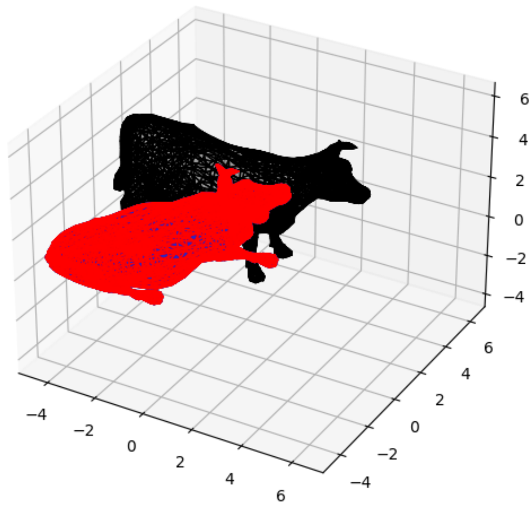

Figure 6: Computing angles.

Exercise 8

Starting from an affine matrix A = $\begin{pmatrix} a11 & a12 & a13 \\ a21 & a22 & a23 \\ 0 & 0 & 0 \end{pmatrix}$, we need minimum of 3 point correspondences. Since we are given 4 points of the planes, we use all of them to calculate A matrix. We first re-scale the album cover to background size and match the corner points of the image to the corner points of the plane. After we warp the album cover, we should know if the cover is behind the cat or not. This information can be obtained by simply comparing the top left of the plane versus top right of the plane. If the difference of x coordinates of top left point and top right point is positive, it should be behind the center cat object. First frame of the created video is shown in Figure 7. We may apply Gaussian filter to the edges to get rid of the pixelation effects.

Figure 7: The cat is wishing to get rid of the album, but it is impossible.

Exercise 9

In order to utilize Normalized Direct Linear Transform, we need to choose minimum 4 corresponding points in images. I chose 6 points in each images and calculated 2 homography matrix. At first, I warped the first image and blended it with the second one. Then, I applied the same procedure between the third image and second image. Finally, I blended these 2 blended images. Result can be seen in Figure 8. While blending the image, I just simply multiply each of the images by 0.5, if there is an overlap between images.

Figure 8: Panoramic view of pier 69.

Exercise 10

Feature extraction using SIFT made stitched image quality worse. Result can be seen in Figure 9. This is caused probably a wrong match between selected points. In other words, we used outlier points while calculating the homography matrix.

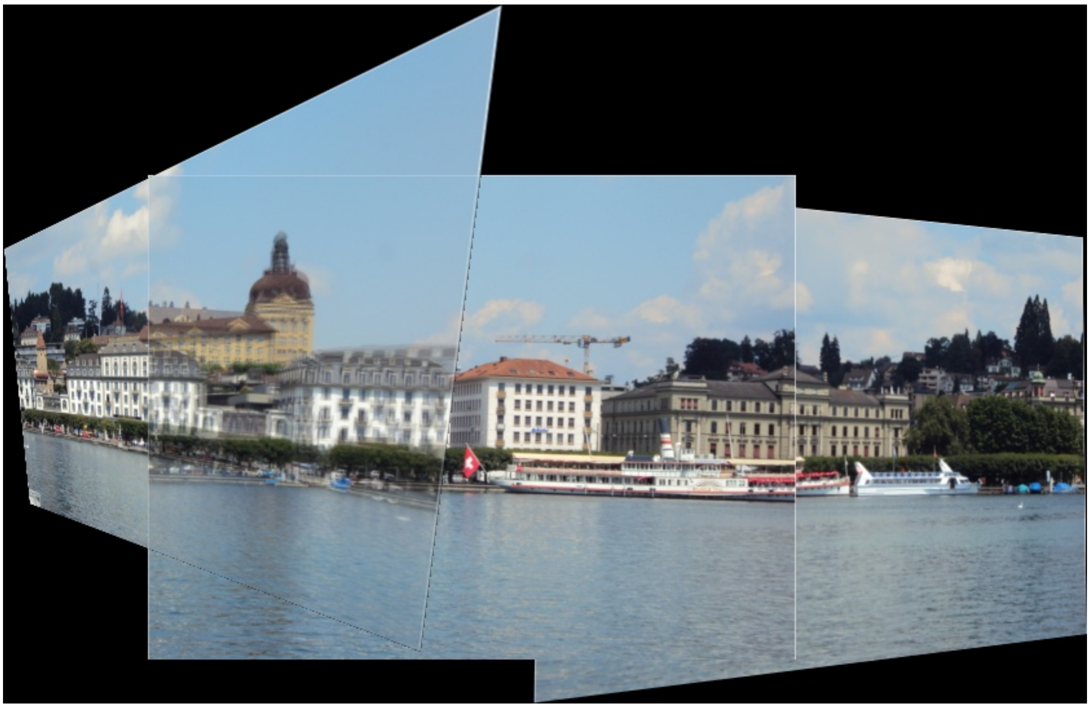

Figure 9: Panoramic view of pier 69 by utilizing SIFT.

When we apply RANSAC algorithm, we get rid of the outlier points. Furthermore, as we decrease the support distance, we obtain more robust results with RANSAC algorithm. Merged images with different support distances can be seen in Figure 10-12.

Figure 10: Panoramic view of pier 69 by utilizing SIFT and RANSAC with support distance of 25.

Exercise 11

I chose 2 different photograph taken in Grand-Place, Brussels from CVPR Image Challenge. These images are scaled in the report to appeal to the eye and can be seen in Figure 13 and Figure 14. Results of the stitching operation are shown in Figure 15-18. Obtained results seem worse than previous results. We can improve the result by masking the images to the certain areas while finding feature points. For example, we may extract the features only from the

Figure 11: Panoramic view of pier 69 by utilizing SIFT and RANSAC with support distance of 5.

Figure 12: Panoramic view of pier 69 by utilizing SIFT and RANSAC with support distance of 1.

building.

Figure 13: First image in Grand-Place, Brussels.

Figure 14: Second image in Grand-Place, Brussels.

Figure 15: Panoramic view of Grand-Place by utilizing SIFT.

Figure 16: Panoramic view of Grand-Place by utilizing SIFT and RANSAC with support distance of 25.

Figure 17: Panoramic view of Grand-Place by utilizing SIFT and RANSAC with support distance of 5.

Figure 18: Panoramic view of Grand-Place by utilizing SIFT and RANSAC with support distance of 1.