CSC420 Winter 2018 Assignment 3

**Name:** Akhil Gupta
**SN:** 1000357071
**Utorid:** guptaak2

**Q1.** (a)

```
% read image
im = imread('data/door.jpg');

imshow(im);
disp('click on the four corners of the luggage. Double click the last
    point');
[x,y] = getpts();
close all;
imshow(im);

% dimensions of luggage in px
x2 = [1, 175, 175, 1]';
y2 = [1, 1, 280, 280]';

% compute homography
tform = maketform('projective',[x,y],[x2,y2]);
[imrec] = imtransform(im, tform, 'bicubic','XYScale',1);

% get height and width
imshow(imrec);
disp('Click on the length of the door. Double click the second point')
    ;
[x_height, y_height] = getpts();
disp('Click on the width of the door. Double click the second point');
[x_width, y_width] = getpts();

height = sqrt((x_height(1) - x_height(2))^2 + (y_height(1) - y_height
    (2))^2)/100;
width = sqrt((x_width(1) - x_width(2))^2 + (y_width(1) - y_width(2))
    ^2)/100;

disp (height); % in cms
disp (width); % in cms
```

```
>> door_script
click on the four corners of the luggage. Double click the last point
Click on the length of the door. Double click the second point
Click on the width of the door. Double click the second point
```

60.9856

200.7282

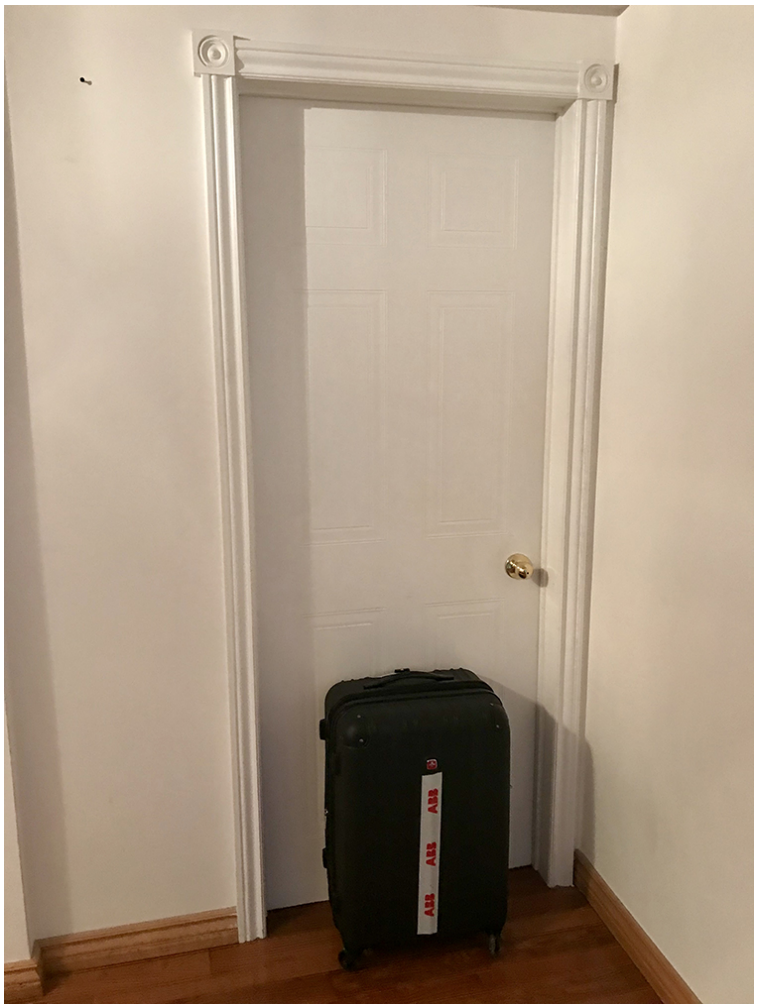


Figure 1: Luggage to scale outside my door

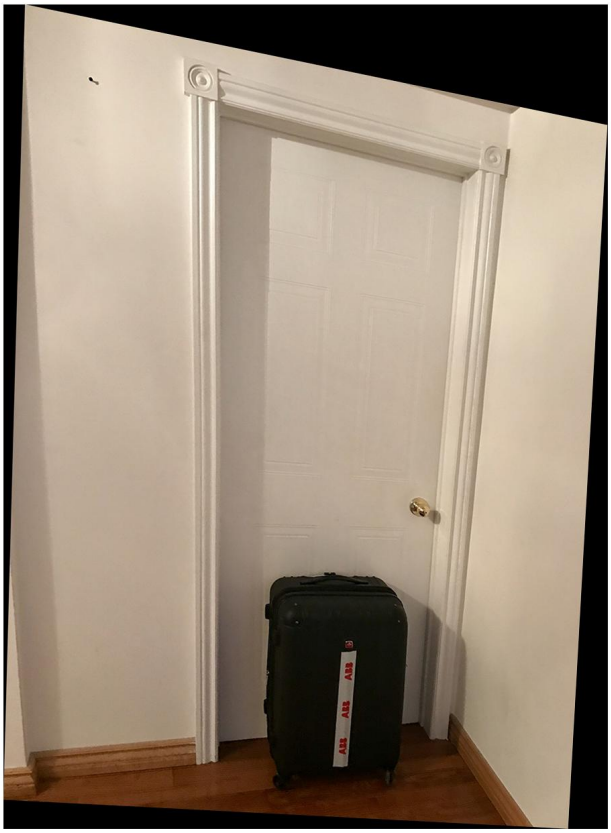

Figure 2: Output after computing homography

Q2. Stitch 2 Images:

```
import cv2
import numpy as np

# Read input images
img1 = cv2.imread('data/landscape_1.jpg')
img2 = cv2.imread('data/landscape_2.jpg')

# Use SIFT to find keypoints and compute homography matrix
M =  compute_sift(img1, img2)

# Stitch the images together using homography matrix
result_image = stitch_images(img2, img1, M)

# Show stitched image
cv2.imshow ('Stitched Image', result_image)
cv2.waitKey()
```

```
def compute_sift(img1, img2):
        # Initialize SIFT
        sift = cv2.xfeatures2d.SIFT_create()

        # Extract keypoints and descriptors
        k1, d1 = sift.detectAndCompute(img1, None)
        k2, d2 = sift.detectAndCompute(img2, None)

        # Bruteforce matcher to be run on descriptors
        bf = cv2.BFMatcher()
        matches = bf.knnMatch(d1,d2, k=2)

        threshold = 0.8
        final_matches = []
        for m1, m2 in matches:
                if m1.distance < threshold * m2.distance:
                        final_matches.append(m1)

        min_matches = 8
        if len(final_matches) > min_matches:
                img1_pts = []
                img2_pts = []

                for match in final_matches:
                        img1_pts.append(k1[match.queryIdx].pt)
                        img2_pts.append(k2[match.trainIdx].pt)

                img1_pts = np.float32(img1_pts).reshape(-1,1,2)
                img2_pts = np.float32(img2_pts).reshape(-1,1,2)

                # Compute homography
                M, mask = cv2.findHomography(img1_pts, img2_pts, cv2.
                    RANSAC, 5.0)
                return M

def stitch_images(img1, img2, M):
        # get size of input images
        w1, h1 = img1.shape[:2]
        w2, h2 = img2.shape[:2]

        img1_dims = np.float32([ [0,0], [0,w1], [h1, w1], [h1,0] ]).
            reshape(-1,1,2)
        img2_dims_temp = np.float32([ [0,0], [0,w2], [h2, w2], [h2,0]
```

```
        ]).reshape(-1,1,2)

    # Get perspective of second image
    img2_dims = cv2.perspectiveTransform(img2_dims_temp, M)

    result_dims = np.concatenate((img1_dims, img2_dims), axis = 0)

    # Calculate dimensions of match points
    [x_min, y_min] = np.int32(result_dims.min(axis=0).ravel() -
        0.5)
    [x_max, y_max] = np.int32(result_dims.max(axis=0).ravel() +
        0.5)

    # Create output array after affine transformation
    transform_dist = [-x_min,-y_min]
    transform_array = np.array([[1, 0, transform_dist[0]], [0, 1,
        transform_dist[1]], [0,0,1]])

    # Warp images
    result_img = cv2.warpPerspective(img2, transform_array.dot(M),
         (x_max-x_min, y_max-y_min))
    result_img[transform_dist[1]:w1+transform_dist[1],
        transform_dist[0]:h1+transform_dist[0]] = img1

    return result_img
```

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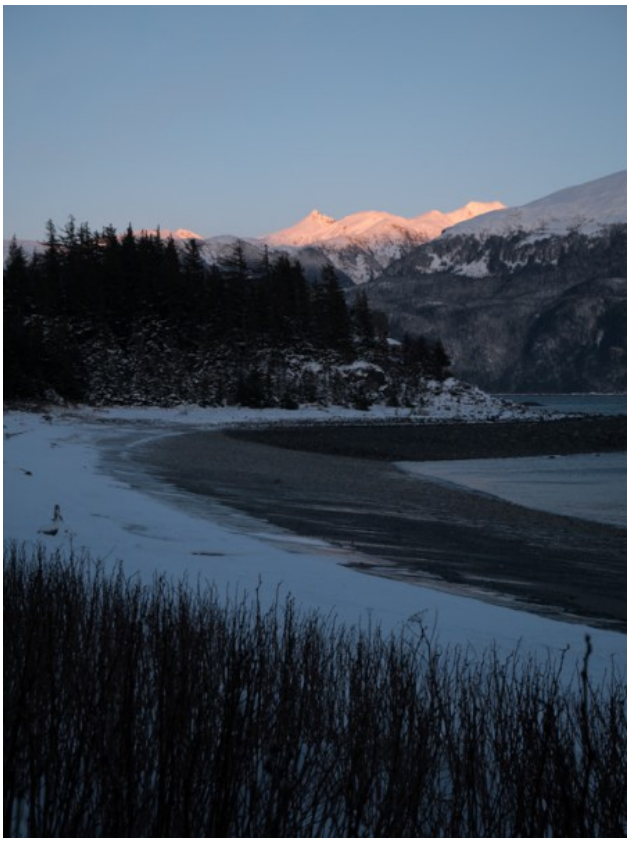

(a) landscape 1.jpg provided to us

(b) landscape 2.jpg provided to us

Figure 4: Stitched 2 images to create mini-panorama

Q3.
```
K =   [[725,     0, 620.5],
       [  0,   725, 187.0],
       [  0,     0,     1]];

baseline = 1.0;

img = imread('data/rgb.png');
disparity = double(imread('data/disparity.png'))/256;

Z = (725*baseline)./(disparity);

i = 1;
for r = 1:size(Z, 1)
    for c = 1:size(Z, 2)
        xyz(i, :) = (K \ [c-1 ; r-1; 1])' * Z(r,c);
        i = i + 1;
    end
end
```

```
X = xyz(:,1);
Y = xyz(:,2);
Z = xyz(:,3);

surf(xyz, img, 'FaceColor', 'texturemap', 'EdgeColor', 'none')
view(0, 1200)
axis manual
```

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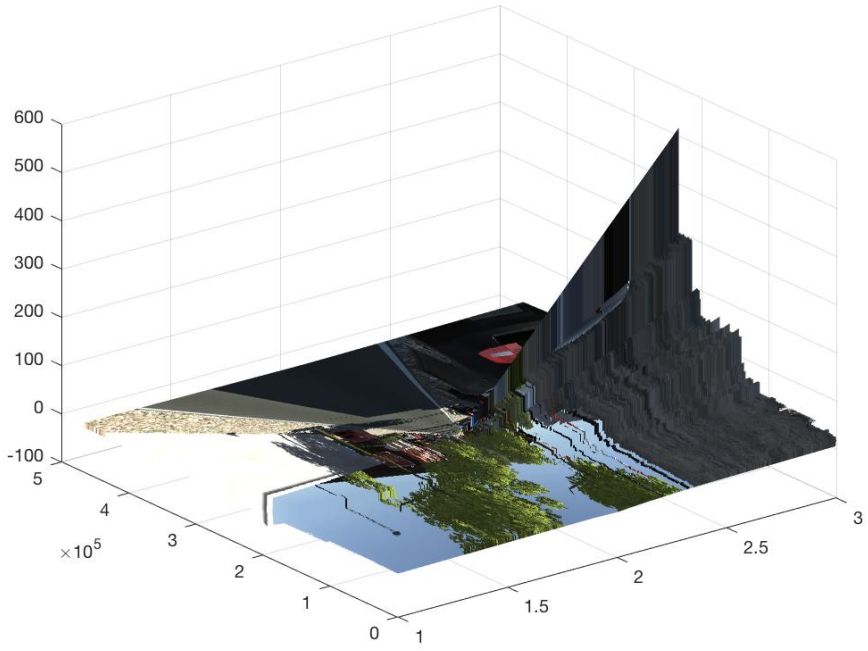
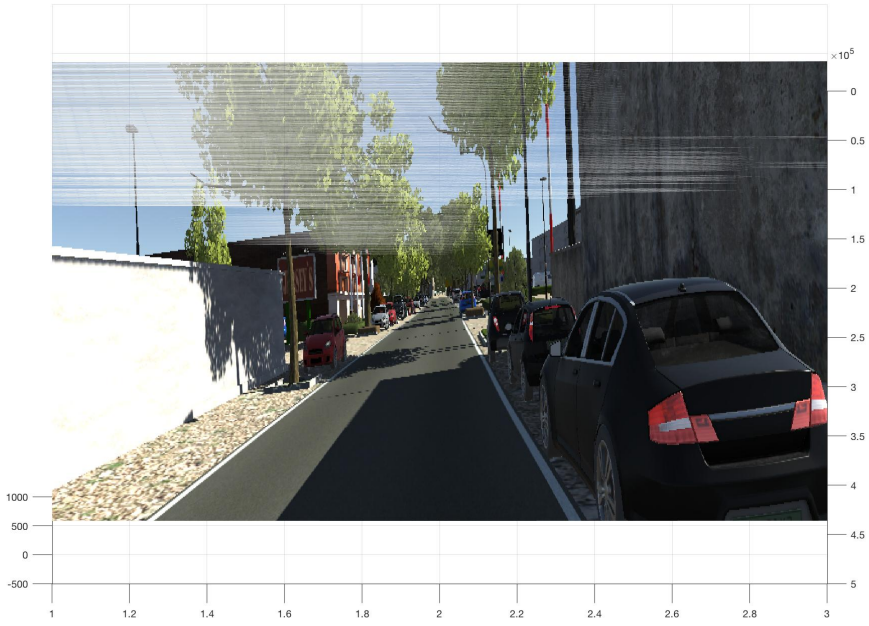



(a) Output 3D scene (approved by Professor via Piazza Post @76)




(b) Visualized 3D scene

Q4. (a) Internal Camera Parameters Matrix

$$K = \begin{bmatrix} 721.5 & 0 & 609.6 \\ 0 & 721.5 & 172.9 \\ 0 & 0 & 1 \end{bmatrix}$$

(b) Equation of the ground plane in camera coordinate system

$$\vec{m}\left(\begin{bmatrix} x \\ y \\ z \end{bmatrix} - p\right) = 0$$

where $\vec{m} = \begin{bmatrix} 0, 1, 0 \end{bmatrix}$ and $p = \begin{bmatrix} 0, -1.7, 0 \end{bmatrix}$

(c) To compute the 3D location of a 2D point $(x, y)$ given the camera matrix $K$ and disparity map; first we compute $Z = \frac{f.T}{x_l - x_r}$ where $f$ is the focal length, $T$ is the baseline value and $x_l - x_r$ is the from the disparity map. Now, since we now $(x, y)$, we can write $x = \frac{f.X}{Z} + p_x$ and $y = \frac{f.Y}{Z} + p_y$ where $p_x$ and $p_y$ are the principle points from $K$. We can rearrange the equations and solve for $X$ and $Y$. Hence, now we have our 3D location $(X, Y, Z)$ from a 2D point $(x, y)$.

**Q5.** Extra Credit: I added the below code to Q2. in order to try to create a panorama!
(P.S. I tried really hard to combine the 2 pieces but my application kept running out of memory :P)

```
# Read input images
img1 = cv2.imread('data/landscape_1.jpg')
img2 = cv2.imread('data/landscape_2.jpg')
img3 = cv2.imread('data/landscape_3.jpg')
img4 = cv2.imread('data/landscape_4.jpg')
img5 = cv2.imread('data/landscape_5.jpg')
img6 = cv2.imread('data/landscape_6.jpg')
img7 = cv2.imread('data/landscape_7.jpg')
img8 = cv2.imread('data/landscape_8.jpg')
img9 = cv2.imread('data/landscape_9.jpg')

# Use SIFT to find keypoints and compute homography matrix
# and Stitch the images together using homography matrix
M_1 =  compute_sift(img1, img2)
result_image_1 = stitch_images(img2, img1, M_1)

M_2 =  compute_sift(img3, img4)
result_image_2 = stitch_images(img4, img3, M_2)

M_3 =  compute_sift(img5, img6)
result_image_3 = stitch_images(img6, img5, M_3)

M_4 =  compute_sift(img7, img8)
result_image_4 = stitch_images(img8, img7, M_4)
```

```
M_5 = compute_sift(result_image_1, result_image_2)
result_image_5 = stitch_images(result_image_2, result_image_1, M_5)

M_6 = compute_sift(result_image_3, result_image_4)
result_image_6 = stitch_images(result_image_4, result_image_3, M_6)

M_7 = compute_sift(result_image_6, img9)
result_image_7 = stitch_images(img9, result_image_6, M_7)
```

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(a) Panorama created from image landscapes 1 - 4

(b) Panorama created from image landscapes 5 - 9