Homework 1 of CSE 473/573

Due Time: 3:00PM Oct. 08, 2018 at Norton 112

1 Camera Parameters [50%]

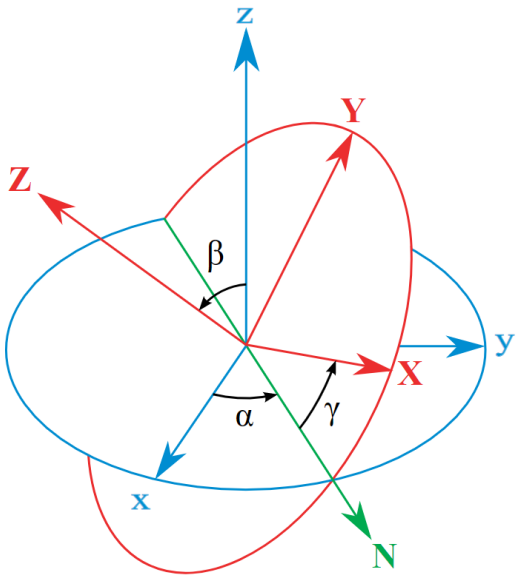

Figure 1: Illustration of Euler angles.

1. Rotation matrix [10%]
As shown in Fig. 1, the Euler angle α, β and γ is $30°, 50°$ and $70°$, respectively. Calculate the camera rotation matrix R, which is part of the camera's extrinsic parameter matrix.

2. Translation vector [10%]
The position of the origin of the camera-centered coordinate system is $[600, 300, 200]$ in the world coordinate system. Calculate the camera translation vector t, which is also part of the camera's extrinsic parameter matrix.

3. Suppose the coordinate of a point is $[600, 300, 200]$ in the world coordinate system. Using the extrinsic parameters you have obtained, calculate the coordinate of the point in the camera-centered coordinate system. [10%]

4. Intrinsic parameters [10%]
For a camera, suppose its focal length $f = 100$, skew parameter $s = 0.5$, the coordinate of the principal point on the image plane $[x_0, y_0] = [200, 150]$. Calculate the camera's intrinsic parameter matrix.

5. Using the intrinsic parameters you have obtained to project a point whose coordinate is $[60, 80, 100]$ in the camera-centered coordinate system onto the image plane. What is its coordinate in the image plane? [10%]

2 Template Matching [20%]

As shown in Fig. 3, we have an image (left) and a template (right). We would like to determine which one of the three positions in the image indicated by the three shaded pixels best matches the template.

1. Sum of squared difference [10%]
Compute the sum of squared difference (SSD) at the three positions indicated by the shaded pixels. Explain

26	3	184	75	80	128	72	0	84
89	65	0	200	224	18	170	26	54
47	75	127	52	94	26	68	43	199
81	87	86	0	97	3	9	208	218
23	12	188	176	180	1	2	6	3
0	80	54	39	31	22	40	9	2
5	21	9	12	98	176	211	105	9

3	10	20
18	1	5
2	30	3

Figure 2: Left: gray scale values of a 7×9 image; right: gray scale values of a 3×3 template.

which position is the best match.

2. Normalized cross correlation [10%]
Compute the normalized cross correlation (NCC) at the three positions indicated by the shaded pixels. Explain which position is the best match.

3 Fourier Series [30%]

Consider the following three continuous-time signals:

$$\begin{aligned} f(t) &= 2sin(3\pi t) \\ g(t) &= cos(2\pi t) \\ h(t) &= f(t)g(t) \end{aligned}$$

1. What are the Fourier series coefficients of $f(t)$ and $g(t)$? [10%]

2. Using results of the question 1 (the previous question) and the relationship between convolution in the temporal domain and multiplication in the frequency domain, compute the Fourier series coefficients of $h(t)$. [10%]

3. Compute the Fourier series coefficients of $h(t)$ through direct expansion of $h(t)$ in trigonometric form, and compare the results with that of question 2 (the previous question). [10%]

Late Submission Policy

- Homework should be submitted by the deadline.
- Late submissions are allowed for one day and will result in a 20% penalty (20% of the maximum possible score will be deducted from your score.). A day is defined as 24 hours after the day/time the assignment is due (excluding weekends or school holidays). No help will be available from the TAs or from the instructor for an assignment after its scheduled due date.
- After one day, submissions will not be accepted.