Homework 4 Questions

Instructions

- 4 questions.
- Write code where appropriate.
- Feel free to include images or equations.
- Please make this document anonymous.
- **Please use only the space provided and keep the page breaks.** Please do not make new pages, nor remove pages. The document is a template to help grading.
- If you really need extra space, please use new pages at the end of the document and refer us to it in your answers.

Questions

Q1: Imagine we were tasked with designing a feature point which could match all of the following three pairs of images. Which real world phenomena and camera effects might cause us problems? Use the MATLAB function *corner* to investigate. $corner(I, 1000)$.

RISHLibrary — Chase — LaddObservatory

A1: The image for Chase is shaken possibly due to low light conditions. Images for Ladd Observatory contain too much of different objects *e.g.* people. Images for the RISH Library have different color tones. To design a feature point that match all of the three pairs, the conditions of them should be similar. However, in this case the three pairs have different characteristics that it is difficult for a common feature point to match them. This phenomenon is common in the real world, which makes it difficult to make feature points.



Q2: In designing our feature point, what characteristics might we wish it to have? Describe the fundamental trade-off between feature point invariance and discriminative power. How should we design for this trade-off?

A2: Scale and orientation invariance would benefit the feature points. However, this could lead to cases in which a pattern-like image with patterns of different sizes are not distinguished. The patterns of different scale but of same shape would be considered as a same feature even if in fact they are not. A similar issue may arise for patterns of different orientation that are considered as the same. Parameters such as the window size and threshold could be adjusted so that the similar features are distinguished.

Q3: In the Harris corner detector, what do the eigenvalues of the 'M' second moment matrix represent? Discuss both how they relate to image intensity and how we can interpret them geometrically.

A3: The eigenvalues represent the axis lengths of the ellipse. The length of the major axis is determined by λ_{min} by the formula $\frac{1}{\sqrt{\lambda_{min}}}$. The length of the minor axis is determined by λ_{max} by the formula $\frac{1}{\sqrt{\lambda_{max}}}$. The minor axis is the direction of the fastest change in intensity, and the major axis is the direction of the slowest change in intensity.

Q4: Explain the difference between the Euclidean distance and the cosine similarity metrics between descriptors. What might their geometric interpretations reveal about when each should be used? Given a distance metric, what is a good method for feature descriptor matching and why?

A4: The cosine similarity is calculated for A and B by the formula $\frac{\sum A_i B_i}{\sqrt{\sum A_i^2}\sqrt{\sum B_i^2}}$. The Euclidean distance is calculated by the formula $\sqrt{\sum (B_i - A_i)^2}$. The cosine similarity is measured by the angle between the vectors thus the magnitudes of them are not considered. In cases the magnitude of the feature vector is important, cosine similarity should not be used. *L1 norm* or *L2 norm* is used as a distance metric for feature matching of string based descriptors such as *SIFT*, *SURF* and *KAZE*. The *Hamming distance* is used for binary descriptors such as *ORB*, *BRISK*, and *BRIEF*.