Computer Vision I

Homework 5

Given November 28, 2017; Due December 5, 2017

Motion and Object Recognition

1. Consider an optical system with its camera coordinate system coinciding with the world coordinate system. The camera has unit focal length. At time $t = 0$, a point is located at $(X, Y, Z) = (30, 60, 10)$ and it is moving with a constant speed $(u, v, w) = (-5, -10, -1)$ towards the observer.

   (a) Determine the location of the object at the image at time $t = 0$.

   (b) Determine the image coordinates of the focus of expansion (FOE)

   (c) Determine the time of the object collision with the observer.

2. (Old exam problem) Consider an imaging system with a unit focal length with its image plane located at $z = 1$ and with view direction towards the positive Z axis (The center of projection is located at $(0, 0, 0)$) An object point is located at $(10, 20, 0)$ at time $t = 0$, and it is moving with constant acceleration. The initial velocity of the point is $(0, 0, 0)$. The point is observed at $(50, 100, 20)$ at time $t = 2$. Will the optical flow vectors corresponding to this point meet at a point (focus of expansion)? If yes, what are the coordinates of this point? If not, what is the locus of the FOE (curve on which the FOE moves over time)?

3. Consider a database of faces of 40 people, with 10 images per person. Assuming that the images are 92x112 pixels, how much memory would require to store the database:

   (a) Storing the images with no compression.

   (b) Using PCA for the "Universal" set (i.e. one eigenspace for all the images) and keeping all the eigenvectors.

   (c) Using PCA for the "Universal" set (i.e. one eigenspace for all the images) and keeping 40 eigenvectors.

   (d) Using PCAs for each of the "Individual" sets (i.e. one eigenspace for each person) and keeping all the eigenvectors.

   (e) Using PCAs for each of the "Individual" sets (i.e. one eigenspace for each person) and keeping 10 eigenvectors.

   (f) Using PCAs for each of the "Individual" sets (i.e. one eigenspace for each person) and keeping 3 eigenvectors.

4. (Old exam problem) The following three 2×1 images were used to train a recognition system using an eigenspace approach:

1	2	3
1	2	3

The eigenvectors and eigenvalues found using the above training images are: $e_1 = (\sqrt{2}/2, \sqrt{2}/2)'$, $e_2 = (-\sqrt{2}/2, \sqrt{2}/2)'$ with $\lambda_1 = 4$ and $\lambda_2 = 0$, respectively. The recognition system will be tested with the image

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(a) Find the average image of the training set.

(b) Show that e_1 and e_2 are orthonormal vectors.

(c) If only one eigenvector is going to be used to represent and recognize the data, which one would you use? Why?

(d) Find the eigenspace representation for the training images using only one eigenvector (the one chosen above).

(e) Find the eigenspace representation for the testing image using only one eigenvector (the one chosen above).

(f) Find the closest match to the test image in the compressed training database.