CENG 391 Introduction to Image Understanding

December 22, 2016

Fundamental Matrix Estimation

Write a C++/Python program that operates the following tasks.

1. Read the image("horse_0.JPG")
2. Read the image("horse_20.JPG")
3. Read the correspondences from the file "corrs.txt"
4. Normalized 8-point algorithm:
   - Normalize point coordinates for each image.
   - Compute $\tilde{F}$ using DLT.
     — Construct a matrix A with normalized points as in the following:
     $$x'^T F x = 0 \tag{1}$$
     where **x**= $(x, y, 1)$ and **x'**= $(x', y', 1)$.
     — $Af = 0$ where
     $$A = \begin{bmatrix} x'_1x_1 & x'_1y_1 & x'_1 & y'_1x_1 & y'_1y_1 & y'_1 & x_1 & y_1 & 1 \\ . & . & . & . & . & . & . & . & . \\ . & . & . & . & . & . & . & . & . \\ x'_nx_n & x'_ny_n & x'_n & y'_nx_n & y'_ny_n & y'_n & x_n & y_n & 1 \end{bmatrix} \tag{2}$$
     — Select n as more than 8. Because 8 point correspondences are enough to find a unique solution for F.

- Find Fundamental matrix(F) by taking Singular Value Decomposition(SVD) of A.
- The last column of "SVD.vt" gives fundamental matrix($\tilde{F}$).
- Unnormalize: F = $T'^{-1}\tilde{F}T$
- Forcing Rank-2 Constraint
  — Matrix F is replaced by F' that minimizes the Forbenious norm $||F - F'||$ subject to the condition det(F')=0.
  — This can be done again using SVD. Let F = UDV T , where D is a diagonal matrix D=diag(r,s,t). Then, F'=Udiag(r,s,0)V T .

5. Apply RANSAC:
   (a) Choose the number of iterations N as 10000 initially.
   (b) Select 8 random correspondences.
   (c) Compute Fundamental Matrix (F) with these correspondences by applying Normalized 8-point algorithm.
   (d) Project points to epipolar lines by $l' = F * x$
   (e) Count number of inliers as follows:
   — Compute the distance between the epipolar line and corresponding point.
   — Check whether the distance is smaller than **3 pixels**. If it is, then this correspondence is inlier.
   (f) Compute the inlier ratio as follows:

$$\text{inlierRatio} = \%\frac{\text{numberOfInliers}}{\text{numberOfCorrespondences}} \tag{3}$$

   (g) Update N as follows:
      i. Calculate the probability(w) of each of the randomly selected correspondence is inlier.
      ii. $1 - (1 - w^s)^N >= 0.99$. From there, calculate N.
   (h) Repeat step[b-g] N times and save the fundamental matrix that gives the maximum inlier ratio.

6. Compute inliers with the best F that is calculated in previous step.

7. Compute final F with all of these inliers by using Normalized 8-point algorithm.

8. Optionally, you can calculate better fundamental matrix as you did in homework for the homography calculation.