Master Computer Vision

Visual Perception

Fundamental Matrix Estimation

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1 Introduction:

Estimation of Fundamental Matrix with accuracy is most important task in most of VIsual Perception Techniques. In this session our task was to estimate the Fundamental Matrix of two vies of same scene. After words we will also analyse the performance of these various estimating techniques.

2 Estimation of Fundamental Matrix using LLS:

In this section we will estimate the fundamental matrix for three different image pairs using Linear Least square solution with constraint on one Entry of F. The equation for finding estimated value is given below,

$$f' = (A^t A)^{-1} A^t B$$

First of all we used provided Matlab function selectpoints to manually select the corresponding points in two images. Then we used these points to estimate Fundamental Matrix for all image pairs given Labo, Kebel and Chabel. Then we find out the rank of matrix and it comes out to be 3 which is not a property of Fundamental Matrix so we forced rank of estimated matrix using svd to 2. The estimated Fundamental Matrices for all of them are given below respectively.

$$EstimatedFundamentallabo = \begin{bmatrix} 0.0000 & 0.0002 & -0.0243 \\ -0.0002 & -0.0000 & 0.0404 \\ 0.0220 & -0.0463 & 1.0000 \end{bmatrix}$$

$$EstimatedFundamentalKebel = \begin{bmatrix} -0.0000 & -0.0001 & 0.0083 \\ 0.0001 & -0.0000 & -0.0111 \\ -0.0096 & 0.0060 & 1.0000 \end{bmatrix}$$

$$EstimatedFundamentalchabel = \begin{bmatrix} -0.0000 & -0.0001 & 0.0293 \\ 0.0002 & -0.0000 & -0.0150 \\ -0.0294 & 0.0095 & 1.0000 \end{bmatrix}$$

We also estimated the fundamental matrices for same images using SVD. WHich is basically same LLS technique. The results obtained were again forces to rank 2 and estimated fundamental matrices are given below.

$$EstimatedFundamentallabo = \begin{bmatrix} 0.0000 & 0.0002 & -0.0332 \\ -0.0002 & -0.0000 & 0.0293 \\ 0.0346 & -0.0199 & -0.9982 \end{bmatrix}$$

$$EstimatedFundamentalKebel = \begin{bmatrix} -0.0000 & -0.0001 & 0.0083 \\ 0.0001 & -0.0000 & -0.0111 \\ -0.0096 & 0.0060 & -0.9998 \end{bmatrix}$$

$$EstimatedFundamentalchabel = \begin{bmatrix} -0.0000 & -0.0001 & 0.0293 \\ 0.0002 & -0.0000 & -0.0150 \\ -0.0294 & 0.0095 & 0.9990 \end{bmatrix}$$

2.0.1 Epipolar Lines:

Now by using the computed fundamental matrices we will show the epipolar lines associated with the 12 corresponding points in the image pairs.

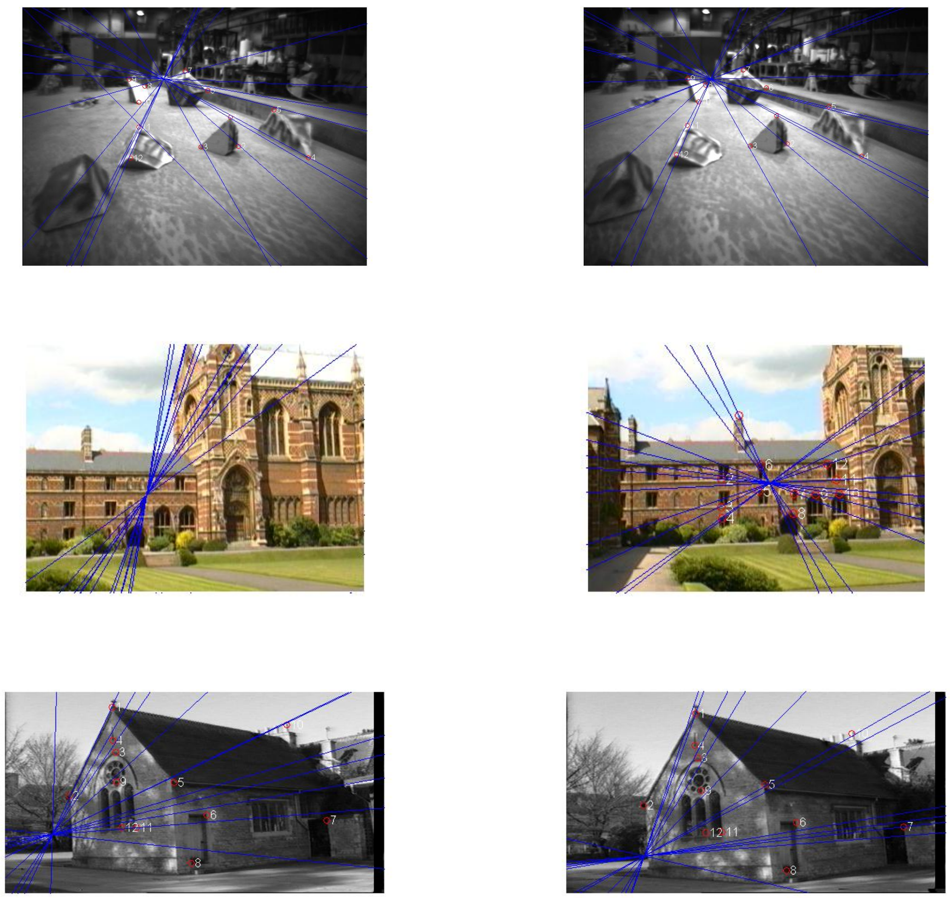

Figure 1: Showing Epipolar Lines on Image Pairs:

2.0.2 Estimation Error:

After computing the estimated fundamental matrices its of great importance to look at the error of estimation as we are estimating our fundamental matrices.

Image Pair	Labo	Kebel	Chappel
Estimation Error using LLS	0.3246	0.0161	2.94
Estimation Error using SVD	0.3223	0.0161	2.95

2.1 Normalization:

In this section we will implement the normalization procedure for our corresponding points and then we will again estimate our fundamental matrix. The Matlab code to implement normalization procedure is given below.

```
 %% Normalization New
% normalization for Image one corresponsing points
 meanans = mean(cores_points1);
 meanans2 = mean(cores_points2);
 xvals = cores_points1(:,1) - meanans(1);
 yvals = cores_points1(:,2) - meanans(2);
 meandistancetoroigin = sqrt((xvals).^2 + (yvals).^2);
  xvals = cores_points2(:,1) - meanans2(1);
 yvals = cores_points2(:,2) - meanans2(2);
  meandistancetoroigin2 = sqrt((xvals).^2 + (yvals).^2);
 s = sqrt(2) / mean(meandistancetoroigin);
 H = [s 0 -s*meanans(1);0 s -s*meanans(2);0 0 1];
 % H Dash
  s_2 = sqrt(2) / mean(meandistancetoroigin2);
   H_dash = [s_2 0 -s_2*meanans2(1);0 s_2 -s_2*meanans2(2);0 0 1];

   % Now lets transform our corresponding coordinates
   for jj = 1:12
   cores1_normalized(jj,:) = H*cores_points1(jj,:)';
   end
    for jj = 1:12
   cores2_normalized(jj,:) = H_dash*cores_points2(jj,:)';
    end
 n = 12;
 A = ones(n,8);
% corrresponding points achieveed
for ii = 1:1:n
    A(ii,:) = [(cores1_normalized(ii,1)*cores2_normalized(ii,1)) ...
        (cores1_normalized(ii,1)*cores2_normalized(ii,2)) cores1_normalized(ii,1) ...
            ...
        (cores1_normalized(ii,2)*cores2_normalized(ii,1))...
        (cores1_normalized(ii,2)*cores2_normalized(ii,2)) ...
        cores1_normalized(ii,2) cores2_normalized(ii,1) cores2_normalized(ii,2)];
end
A2 = [A,ones(n,1)];
[u,s,v] = svd(A2);
fjd = v(:,end);
% finding fundamental matrix
F_new = ones(3,3);
F_new(1,:) = [fjd(1,1) fjd(2,1) fjd(3,1)];
F_new(2,:) = [fjd(4,1) fjd(5,1) fjd(6,1)];
F_new(3,:) = [fjd(7,1) fjd(8,1) 1];
  % now we have estimated our Fundamental Matrix Now lets express it in
  % original Cordinates again


 % it is rank three so we force its rank to 2
```

```
 [u2,s2,v2] = svd(F_new);
s2(end,end) = 0;
F_normalized_fin = u2 * s2 * v2';
det(F_normalized_fin)
rank(F_normalized_fin)
F_normalized_fin = H_dash'*F_normalized_fin*H;
```

The new fundamental matrices estimates are given below.

$$EstimatedFundamentalLabo = \begin{bmatrix} 0.0000 & 0.0001 & -0.0207 \\ -0.0001 & -0.0000 & 0.0063 \\ 0.0214 & -0.00022 & -0.5850 \end{bmatrix}$$

$$EstimatedFundamentalKebel = \begin{bmatrix} -0.0000 & -0.0001 & 0.0041 \\ 0.0001 & 0.0000 & -0.0214 \\ -0.0072 & 0.0112 & 2.9317 \end{bmatrix}$$

$$EstimatedFundamentalChappel = \begin{bmatrix} 0.0000 & 0.0000 & -0.0114 \\ -0.0000 & -0.0000 & 0.0006 \\ -0.0099 & -0.0002 & 1.1390 \end{bmatrix}$$

As it can be seen that my estimates are not correct probably thee is some bug inside normalization implementation. I tried best to remove that bug but i wasn't able to remove and error are going up to 12. When i try to show epipolar lines they were kid of offset from where they should be.

2.2 Question: 3

When corresponding points in image pairs have to be identified automatically then there will always be some miss matches in correspondence. It will be very difficult to remove such miss matches. One possible solution can be cross validation. There are lot of other issues as well such as scale problem and sometimes our images are rotated so in that case we have to use such feature detectors which detect rotation and scale invariant features. In the next section we will try to examine the effect of incorrect correspondences between image pairs.

2.2.1 Effect of Incorrect Correspondences

We try to examine the effect of incorrect correspondences and below is the change in error we obtain.

Image Pair	Labo	Kebel	Chappel
Estimation Error using LLS	0.4276 (0.3246)	0.2640 (0.0161)	2.547 (2.94)
Estimation Error using SVD	0.4258 (0.3223)	0.2640 (0.0161)	2.054 (2.95)

In Brackets previous errors are enlisted. If we see the epipolar lines changes in there orientation was observed. SO it can be seen that it effects the estimation of fundamental Matrix and that's why it is crucial task in automatic features and correspondences detection.

References

[1] http://www.vision.caltech.edu/bouguetj/calib_doc/htmls/example.html, Camera Calibration Toolbox for Matlab