Master in Computer Vision *Barcelona*

Module: 3D Vision
Project: 3D recovery of urban scenes
Session 3

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Session 3

Goal: compute the fundamental matrix that relates two images

Algorithms:

- Normalized 8-point algorithm (algebraic method).
- Robust normalized 8-point algorithm.

Application: Photo-sequencing.

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Mandatory tasks:

- Function that estimates the fundamental matrix F with the normalized 8-point algorithm.
- Function that robustly estimates F using the previous function and RANSAC (you can use as a basis the provided function 'ransac_homography_adaptive_loop.m').
  The inliers are obtained with a threshold on the first order approximation of the geometric error: **Sampson distance**,

$$\sum_i \frac{(x_i'^T F x_i)^2}{(Fx_i)_1^2 + (Fx_i)_2^2 + (F^T x_i')_1^2 + (F^T x_i')_2^2}$$

- Compute the theoretical fundamental matrix that relates two images with correponding camera matrices $P = [I|0]$, and $P' = [R|t]$.
- Compute the epipolar lines of the matching points in both images.
- Apply the theoretical concepts to do photo-sequencing.

Optional task: Photo-sequencing with your own images.

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Geometric distance
(used for determining the inliers in the RANSAC function)

$$\sum_i d([x_i], [\hat{x}_i])^2 + d([x_i'], [\hat{x}_i'])^2 \text{ s. t. } \hat{x}_i'^T F \hat{x}_i = 0 \ \forall i$$

where the different matchings $x_i \longleftrightarrow x_i'$ are the data,
[.] is the projection operator to Euclidean coordinates.

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Geometric distance
A variant is (we use the distance of a point to a line $d(x, l) = |x^T l|/||l||$):

$$\sum_i d(x_i', Fx_i)^2 + d(x_i, F^T x_i')^2$$

$$= \sum_i (x_i'^T F x_i)^2 \left(\frac{1}{(Fx_i)_1^2 + (Fx_i)_2^2} + \frac{1}{(F^T x_i')_1^2 + (F^T x_i')_2^2} \right)$$

We will use the **Sampson error**
(1st order approx. of the geometric distance)

$$\sum_i \frac{(x_i'^T F x_i)^2}{(Fx_i)_1^2 + (Fx_i)_2^2 + (F^T x_i')_1^2 + (F^T x_i')_2^2}$$

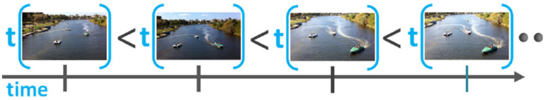
Photo Sequencing

Int J Comput Vis (2014) 110:275–289
DOI 10.1007/s11263-014-0712-x

Photo Sequencing

Tali Dekel (Basha) · Yael Moses · Shai Avidan

Given a set of images of a dynamic scene taken at different viewpoints and different time instants, the photo-sequencing algorithm establishes an ordering of the images according to the time they were taken.



There are two underlying hypothesis:

- Object trajectories can be approximated by straight lines.
- Two of the images are taken from approximately the same position.

Photo Sequencing

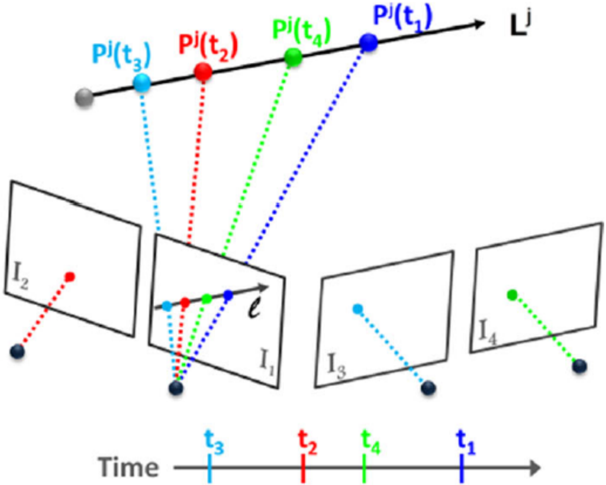


Photo Sequencing

Computing static and dynamic features (thanks to hypothesis 2)

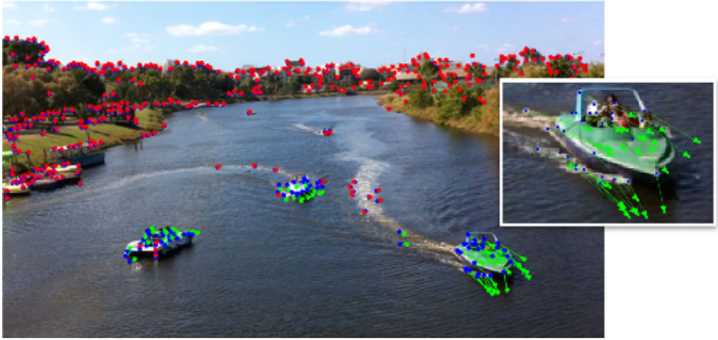
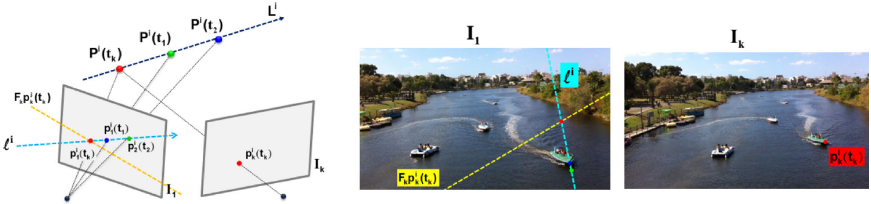


Photo Sequencing



(a) (b)

Fig. 5 (**a**) The projection of the trajectory, L^i, of the point P^i, forms the line ℓ^i on image I_1. The feature points $p_1^i(t_1)$, $p_2^i(t_2)$, in image I_1, and $p_k^i(t_k)$ in image I_k, are corresponding dynamic features. The line ℓ^i intersects the *epipolar line* (in *yellow*), which corresponds to p_k^i. The intersection point, $p_1^i(t_k)$, is the projection of P^i onto I_1 at time step t_k. The spatial order of $p_1^i(t_1)$, $p_2^i(t_2)$, and $p_1^i(t_k)$, along ℓ^i, defines the temporal order between I_1, I_2 and I_k. (**b**) The computation on real images: the projected trajectory, ℓ^i, in cyan; the *epipolar line* in *yellow*; the intersection in *red*

Photo Sequencing

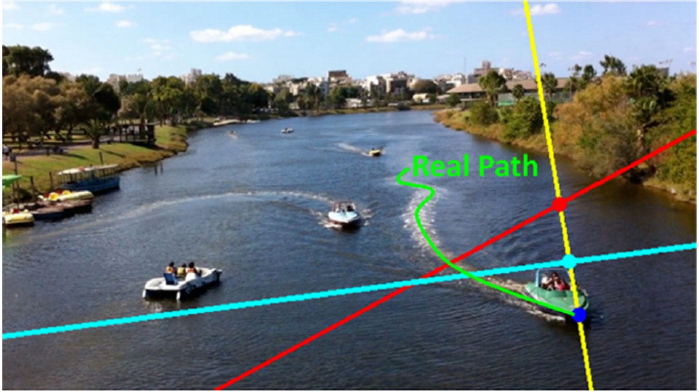


Fig. 6 Linear Motion Assumptions: In *green*, the real path of the green boat; in yellow, the approximated 2D image line. The epipolar lines intersect both the real path and the 2D image line. The spatial order of both sets of intersections is the same

Session 3

Language: MATLAB

Provided functions: lab3.m, ransac_homography_adaptive_loop.m, normalise2dpts.m, plot_homog_line.m, vgg_gui_F.m.

lab3.m is the guided file with the different steps of the lab session.

Functions ransac_homography_adaptive_loop.m, and normalise2dpts.m are part of the solution of lab 2.

To Do:

- Complete the code in lab3.m as indicated in the same file
- Write the function fundamental_matrix.m
- Write the function ransac_fundamental_matrix.m
- Complete the code on photo-sequencing, dynamic feature given
- (Photo-sequencing with your own images, determine static and dynamic features)

Evaluation

To deliver **before 9am of the day before** the next lab session:

- **Code deliverable:**
  - READY TO BE LAUNCHED on the provided images
- **Short document (10 pages):**
  - Results
  - Problems and comments, conclusions

Evaluation

Grading:

- Report: **2 points**
- Normalized 8-point algorithm: **2 points**
- F from P1 and P2: **1 point**
- Robust 8-point algorithm (RANSAC): **2 points**
- Epipolar lines: **1 point**
- Photo-sequencing: **2 points**
- Optional photo-sequencing with your own images: **+ 0.75 points**