HW 2: Advanced Topics in Computer Vision (580.464)

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Due 03/02/05 beginning of the class

1. (a) Implement a function `[Ix,Iy,It] = partials(I1,I2)` that computes the spatio-temporal partial derivatives of an image. Use the MATLAB function `filter` with five tap filters (Fig. 4.13).
   (b) Implement the Harris corner detector `x = corners(I,w,kappa,tau)`, where `x` is a $2 \times P$ set of points in the image `I` $\in \mathbb{R}^{nx \times ny}$, as described in Exercise 4.8 of MASKS. The function should have no for loops. Instead, you can use the functions `partials, filter, find`. Test your code on the images on the course webpage for different values of the window size w, the Harris corner parameter κ and the Harris corner threshold τ. Propose a strategy to choose τ and κ.

2. (a) Solve exercise 4.5 of MASKS.
   (b) Implement a function `[u,v] = optflow(I1,I2,method)` that computes the optical flow between two images using `method =` $\{$`2Dtranslational,2Daffine`$\}$. No for loops if possible. Test your code on the video sequence on the course webpage.
   (c) Implement a function `x = KLTtracker(I,x1,method)` that given an image sequence `I` $\in \mathbb{R}^{nx \times ny \times F}$ and a set of points `x1` $\in \mathbb{R}^{2 \times P}$ in frame 1, returns a set of point tracks `x` $\in \mathbb{R}^{2 \times P \times F}$ using the methods `method =` $\{$`2Dtranslational,2Daffine`$\}$. Choose the initial set of points `x1` in a subset of frame 1 to avoid having to deal with points leaving the field of view. No for loops if possible. Test your code on the video sequence on the course webpage.

3. Implement a function `I = mosaic(I1,I2)` that given two images `I1,I2` generates a mosaic `I` of the two images. This should be done by computing an affine model relating the overlap of the two images, warping `I2` onto `I1` using the computed affine model, generating a new image that contains both `I1` and the warped `I2`. Note that computing the affine transformation from two disparate views was not described in class, and so part of the problem is to propose a way of doing it that combines corner extraction, affine model computation possibly via normalized crosscorrelation, or else using a MATLAB function that does it. This procedure should be repeated to obtain subpixel accuracy, as described in problem 4.10 of MASKS.

4. Given a set of P point correspondences in two calibrated paracatadioptric views, propose an algorithm to recover the camera motion (R, T). Hint: Show that given an image point (x, y) the backprojection ray on the paraboloid is $\mathbf{b} = (x, y, (x^2 + y^2 - 1)/2)^T$. Then find an "epipolar constraint" relating two corresponding backprojection rays $\mathbf{b}_1$ and $\mathbf{b}_2$.

5. The essential matrix is computed by solving a linear system $A(\mathbf{x}_1, \mathbf{x}_2)e = 0$. In general the rank of A is 8. What is the rank of A when the points in 3D space live in a plane?

6. (a) Implement a function `X = points(P,fov,d1,d2)` that generates P points in a truncated pyramid in 3D space defined by the field of view (fov) and two depths `d1` and `d2`.
   (b) Implement a function `F = fundamental(x1,x2)` that computes the fundamental matrix `F` associated to a set of point correspondences in two perspective views `x1,x2` $\in \mathbb{P}^{2 \times P}$.
   (c) Implement a function `[R,T,X] = twoviewSFM(x1,x2)` that reconstructs camera motion `(R,T)` $\in SE(3)$ and 3D structure $X \in \mathbb{R}^{3 \times P}$ from a set of point correspondences `x1,x2` $\in \mathbb{P}^{2 \times P}$ using the 8-point algorithm (Alg. 5.1 of MASKS). Test the algorithm on the datasets $(\mathbf{x}_1, \mathbf{x}_2)$ and $(\mathbf{y}_1, \mathbf{y}_2)$ in the course webpage. What is the error in rotation and translation between the two estimates. Test your algorithm on the point tracks in the first and last view from 2(c).