Exercise 09 for MA-INF 2201 Computer Vision WS19/20
15.12.2018
Submission deadline: 04.01.2019
Optical Flow

Given several consecutive frames and their corresponding optical flow ground truth from a video (stored in the `data` directory) Use these frames to finish the following tasks. (We provide the function `load_FLO_file()` that you may use for loading optical flow data).

1. **Optical Flow Computation**:

   (a) **Lucas-Kanade optical flow**: Write your own implementation of the Lucas-Kanade optical flow as presented in the lecture. Use a 25×25 window in the algorithm.
   (7 Points)

   (b) **Horn-Schunck Flow**: Write your own implementation of the Horn-Schunck optical flow using an iterative scheme based on the Jacobi method as originally proposed by Horn and Schunck[1]. The iterative update rule is defined by

   $$u^{(k+1)} = \bar{u}^{(k)} - \frac{I_x(I_x\bar{u}^{(k)} + I_y\bar{v}^{(k)} + I_t)}{\alpha^2 + I_x^2 + I_y^2}, \tag{1}$$

   $$v^{(k+1)} = \bar{v}^{(k)} - \frac{I_y(I_x\bar{u}^{(k)} + I_y\bar{v}^{(k)} + I_t)}{\alpha^2 + I_x^2 + I_y^2}, \tag{2}$$

   where

   $$\bar{u}^{(k)} = u^{(k)} + \Delta u^{(k)} \quad \text{and} \quad \bar{v}^{(k)} = v^{(k)} + \Delta v^{(k)}. \tag{3}$$

   You can approximate the laplacian $\Delta u^{(k)}$ and $\Delta v^{(k)}$ using the normalized Laplacian kernel

   $$K = \begin{pmatrix} 0 & \frac{1}{4} & 0 \\ \frac{1}{4} & -1 & \frac{1}{4} \\ 0 & \frac{1}{4} & 0 \end{pmatrix}. \tag{4}$$

   Set $\alpha = 1$ and initialize $u^{(0)}$ and $v^{(0)}$ with zero. Iterate until the difference of two flow fields in L_2 norm is less than 0.002, i.e. until

   $$\sum_{i,j} |u_{i,j}^{(k+1)} - u_{i,j}^{(k)}| + |v_{i,j}^{(k+1)} - v_{i,j}^{(k)}| < 0.002. \tag{5}$$

   (7 Points)

2. **Average Angular Error**:

   Compute the average angular error and per point error map (angular error at each pixel of image) for above methods.
   (3 Points)

[1] B.K.P. Horn and B.G. Schunck, *Determining optical flow.* Artificial Intelligence, vol. 17, pp. 185 – 203, 1981

3. **Visualization**:

   Write a function that converts optical flow data to a BGR image. Display ground truth optical flow, estimated optical flow and per point error map together.
   (3 Points)

4. **Large Motion**: Repeat above step for frames with large interval to see how average angular error changes.