Exercise 10 for MA-INF 2201 Computer Vision WS18/19
14.12.2018
Submission deadline: 05.01.2019
Optical Flow

Given are two consecutive frames and their corresponding optical flow ground truth in the `data` directory. Use these frames to evaluate your solution for the following tasks. Additionally, we provide the function `load_FLO_file()` that you may use for loading optical flow data. For visualizing your results, you need to write a function that converts optical flow data to a BGR image.

1. **Lucas-Kanade Flow**:

   (a) Write your own implementation of the Lucas-Kanade optical flow as presented in the lecture. Use a 15×15 window in the algorithm. Display the ground truth and your estimated flow on the two frames.
   (9 Points)

   (b) Report the average angular error of your estimated flow.
   (1 Point)

2. **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

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

   Use your implementation to estimate the optical flow on the two given frames. 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

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

   Report the average angular error and display the estimated flow.
   (10 Points)

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