Assignment 2 - Question 5

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Question 5. Optical Flow by the Lucas-Kanade method

NOTE: See the attached folder for results Optical flow deals with the problem of estimating motion field from a sequences of images.

In the Lucas-Kanade construction, the motion field is obtained by finding, for each pixel in an image, a corresponding pixel in the next frame of the sequence of images, in such a way that it minimizes the sum of squared intensity differences computed over a window.

We have a image constant brightness assumption,

$$\Rightarrow \frac{\partial E}{\partial x}\frac{\partial x}{\partial t} + \frac{\partial E}{\partial y}\frac{\partial y}{\partial t} + \frac{\partial E}{\partial t} = 0 \tag{1}$$

We have to solve for the motion field that one gets from 2D frame to frame registration by minimizing the sum of squared intensity differences (frame to frame) but over local windows.

Implementation details:

- The images are smoothed using a Gaussian Blur. σ is a parameter and have computed some sample results for σ values of 3 and 5. The Gaussian filtering is done for a window size of 3X3.
- I have attached some folders which shows for σ values of 1.5,3 and 6 for window sizes of 15,25 and 40
- Also, a 1D Gaussian is applied to smooth the images in time
- The second moment matrix is obtained as taught
- Quiver plots are obtained to see the motion field

Results, discussions and some intuition:

$$\begin{bmatrix} \sum(\frac{\partial I^n}{\partial x})^2 & \sum(\frac{\partial I^n}{\partial x})(\frac{\partial I^n}{\partial y}) \\ \sum(\frac{\partial I^n}{\partial x})(\frac{\partial I^n}{\partial y}) & \sum(\frac{\partial I^n}{\partial y})^2 \end{bmatrix} \begin{bmatrix} v_x \\ v_y \end{bmatrix} = - \begin{bmatrix} \sum(I^n(x,y) - I^{n+1}(x,y))\frac{\partial I^n}{\partial x} \\ \sum(I^n(x,y) - I^{n+1}(x,y))\frac{\partial I^n}{\partial y} \end{bmatrix}$$

Figure 1: Least squares: Second Moment matrix for LK method

1. The σ value of the Gaussian function is a parameter. I have tried values of 1.5,3 and 6. It can be seen that at σ equals 6, the results are good and one can see the movement clearly. The Gaussian smoothing window can be selected to be either 3X3 or 5X5.
2. At small σ values, the image is not smoothed properly and gradients might not be well defined and hence we do not see good representation of the actual flow vectors. We dense vectors which have very very small values.
3. The window is chosen to of size 40X40. It essentially smooths out the flow vectors and only the dominant flow vectors remain. The flow vectors are of considerable size for aesthetic visualization.
4. At homogeneous regions, the flow vectors are small. And, also at background regions the flow vectors are small as can be clearly seen in the *Dumptruck* example.
5. Also, possible variation could be to provide a weighting function in the right part of the equation given in figure 1 which instead of weighing all pixels equally wieghts them by some window.
6. I have provided some visualizations below. Some can be found in the attached folder.