ECE 472 Robotics and Vision Prof. K. Dana

Homework 6: Motion Estimation and Deep Learning

In this assignment Part 1, you will implement coarse to fine motion estimation using a direct method and the Lucas-Kanade algorithm. In Part 2, you will experiment with CNN recognition by using a python-based machine learning library (e.g. Keras https://keras.io/ or Pytorch)

1. **Warp an image to simulate a motion frame.** Choose an image and warp by the following affine parameters. $(a = 0.02, b = 0.01, c = 10, d = 0.01, e = -0.02, f = 5)$. Show the difference between the original and warped image. Watch your datatypes in the subtraction. Use a datatype that supports the correct range as well as positive and negative values. You will likely need to map the difference values to the range 0 to 255 before displaying the image.

2. **In python, Implement the course-fine motion estimation from the LK method described in class** Use your image generated in the previous question as the simulation of the frame at $t = t_1$. Your goal is to align this frame with the one at $t = t_0$. Report your affine parameters. Show the difference between the original and warped image. **Important:** Do not use built-in python code for estimating the affine parameters!. Write a paragraph describing the algorithm. As a reference consider the matlab code *cfaffine.m* made available to you in the resources.

3. **Graduate Students** Modify the algorithm above to estimate optical flow. Choose two images from a video showing object motion. Show the optical flow field as two gray scale image (u-component and v-component). Write a paragraph describing the motion expected and the motion recovered.

4. **Optical Flow with Deep Learning** Use a pytorch implementation of a deep learning optical flow network to estimate flow between several of your own example image pairs that show motion. Use one of the following deep learning networks: Flownet, PWCnet (pyramid, warping, and cost volume network) or Spynet (spatial pyramid network) Write a paragraph describing the difference between classic motion estimations for optical flow and your chosen deep learning method.

5. **Graduate Students** In the question on **Optical Flow with Deep Learning** compare the performance of two deep learning networks and your own implementation using a table. Use the Average end point errors (EPE) metric in your table. Use a ground truth optical flow dataset for testing the network available at http://vision.middlebury.edu/flow/data/. Show 2 examples of the performance of the using colorized flow (see matlab code at the middlebury site).

6. **Back Propagation** Handwritten (submit a pdf file). Following the example discussed in class, devise 3 of your own simple networks and the corresponding computational graphs. Show the graph and the forward pass values and back propagatied gradients each step of the way. Check your work by evaluating the gradient of the function with respect to each input variable. In your examples describe and name three patterns of backward flow (add gate, max gate and mul gate). Provide one sentence describing each of these patterns.