HW3

New Attempt

Due May 17 by 10am **Points** 100 **Submitting** a file upload

Submit your HW3 on Canvas by 10am May 17!

This homework is about stereo geometry. For this assignment, you will use the following five stereo pairs of images: Stereo_images.zip (https://canvas.oregonstate.edu/courses/1811612/files/85435494/download?download_frd=1)

For each stereo pair of images, perform the following tasks:

- Detect 100 strongest SIFT keypoints in image 1 and image 2, $\mathbf{p}_i = [x_i, y_i, 1]^\top$ and $\mathbf{q}_{i'} = [x_{i'}, y_{i'}, 1]^\top$, and compute their deep features. For keypoint detection, you may use either your own code or our solution for HW1.
- Find one-to-one matching pairs of SIFT keypoints in image 1 and image 2, and from the matched pairs select the top 50 best matches with the smallest distance between their respective deep features, $M^{(0)} = \{(\mathbf{p}_i, \mathbf{q}_{i'}) : \ i = 1, \dots, 50, \ \ i' = 1, \dots, 50\}$. For matching, you may use either your own code or our solution for HW2.
- Estimate the fundamental matrix $F^{(0)}$ based on $M^{(0)}$ using all 50 pairs of best matched keypoints in image 1 and image 2. For this, you may use the OpenCV Python (https://docs.opencv.org/2.4/modules/calib3d/doc/camera_calibration_and_3d_reconstruction.html) library -- specifically, the function "*cv2.findFundamentalMat(points1, points2[, method[, param1[, param2[, mask]]]])*", where the arguments *points1* and *points2* are coordinates of the best matched 50 keypoints in image 1 and image 2, respectively, and *method* = CV_FM_8POINT for the 8-point algorithm when the number of pairs of points is greater than 8 (as is our case).
- Estimate the fundamental matrix $F^{(1)}$ by implementing the RANSAC algorithm on $M^{(0)}$. For this, you may use the OpenCV Python (https://docs.opencv.org/2.4/modules/calib3d/doc/camera_calibration_and_3d_reconstruction.html) library -- specifically, the function "*cv2.findFundamentalMat(points1, points2[, method[, param1[, param2[, mask]]]])*", where the arguments *points1* and *points2* are coordinates of the best matched 50 keypoints in image 1 and image 2, respectively, and *method* = CV_FM_RANSAC for the RANSAC algorithm. Depending on your implementation of RANSAC, you may need to manually specify the following input parameters: number of RANSAC iterations, number of sampled data points per iteration, number of inliers required to assert that your model fits well to data. If you use the OpenCV Python function "*cv2.findFundamentalMat()*", you may use the default parameters for RANSAC.
- Starting from the original 100 SIFT keypoint detections in image 1 and image 2, find another set of one-to-one matching pairs by combining both appearance and epipolar cues in matching, as formulated in slide 24 of lecture CS537_13.pdf: $\text{minimize } \text{Trace}[(A + \lambda B)^\top Y]$, subject to one-to-one constraints. For computing matrix B, as specified in slide 21 of lecture CS537_13.pdf, use $F^{(1)}$ (remark: do not forget to use absolute values in B, and normalize values of matrices A and B to fall in a similar range). Experimentally find a good value for the weighting parameter $\lambda > 0$. From the matched pairs select the top 50 best matches $M^{(1)} = \{(\mathbf{p}_i, \mathbf{q}_{i'}) : \ i = 1, \dots, 50, \ \ i' = 1, \dots, 50\}$. For matching, you may use either your own code or our solution for HW2.
- Estimate the fundamental matrix $F^{(2)}$ by implementing the RANSAC algorithm on $M^{(1)}$, as suggested for $F^{(1)}$.

Turn in three files with the following information:

1. (60 points) "fundamental.pth": 5 x 3 x 3 x 3 tensor consisting of your estimates of five 3x3 fundamental matrices $F^{(0)}$, $F^{(1)}$, $F^{(2)}$ for the five stereo image pairs.
2. (15 points) "epipoles.pth": 5 x 3 x 2 x 3 tensor consisting of your estimates of five pairs of epipoles in image 1 and image 2 for $F^{(0)}$, $F^{(1)}$, $F^{(2)}$.
3. (25 points) "figures.pdf": Five figures for the five stereo image pairs depicting the following:
   - Clearly mark one example point selected in image 1, and the three corresponding epipolar lines in image 2 -- first for $F^{(0)}$, second for $F^{(1)}$, and third for $F^{(2)}$ (use different colors for depicting the three epipolar lines), as illustrated in the figure below.
   - Clearly mark the epipoles of image 1 and image 2 for $F^{(0)}$, $F^{(1)}$, $F^{(2)}$ (use different colors for depicting the three epipoles) if they fall inside the image boundaries.
   - In the figure caption specify: (a) the row and column of the point you selected in image 1; (b) comment if the three epipolar lines (closely) pass through the right corresponding point in image 2; and (c) comment, based on your observation of the three epipolar lines in image 2, which estimate $F^{(0)}$, $F^{(1)}$, $F^{(2)}$ is the best.