University of Central Florida

Assignment 4
CAP 6419 - 3D Computer Vision
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This assignment has two parts.

Part 1 – Stereo Reconstruction: You are required to use the above two stereo image pairs to reconstruct 3D models.
The following describes the steps that you need to take in order to complete this assignment.

1. Download all the associated files, including the image pairs, the point correspondences files, the camera projection matrices, and the support Matlab code.
2. Use the code provided to load the image pairs and the point correspondences in the Matlab environment.
3. Use the normalized 8-point algorithm implemented by Peter Kovesi (http://www.peterkovesi.com/matlabfns/) to find the fundamental matrix. The sample code will help you display the results. Report the residual error, and the mean squared distance in pixels between points in both images and the corresponding epipolar lines.
4. Load the camera matrices for the two images using the `load` command, i.e.
   ```
   P1 = load('house1_camera.txt');
   ```

   Implement the linear triangulation method and the optimal triangulation method (sections 12.2 and 12.5 of your book) to obtain the 3D reconstructions. Find the two camera centers, and display and compare the reconstructed 3D points from the two algorithms (including the camera centers in a different color). See the sample code for displaying using `plot3`.
5. Project the 3D points back into the images and calculate and report the mean square errors for each algorithm and the two image pairs.

Some tips to help:

- As a reminder, the camera centers are given by the null spaces of the camera matrices, and can be found by using SVD, where the solution is the last column of V (P=SDV^T).
- For triangulation, there is no need to use data normalization (For the data provided, the impact is negligible).
- Use the command `axis equal` when plotting in 3D to avoid Matlab's display distortions. Include multiple snapshots from several viewpoints of your 3D points in your report.
- You can also submit a video of the reconstructed points (provided that the video is not too large in size).

Part 2 – Affine Structure from Motion: You are required to use the tracked points provided for the following video frames to recover both structure and the motion of the camera using the method described in the paper (included in the assignment files):

C. Tomasi and T. Kanade. Shape and motion from image streams under orthography: A factorization method. *IJCV*, 9(2):137-154, November 1992.

The following describes the steps that you need to take in order to complete this assignment.

1. Download all the files: 101 video frames, and a measurement matrix of 215 tracked points.
2. Load the data matrix and normalize the point coordinates by translating them to the mean of the points in each view (see the paper).
3. Apply SVD to the 202 `x` 215 data matrix to express it as `D = U * W * V'` where U is a 202 `x` 3 matrix, W is a 3 `x` 3 matrix of the largest three singular values, and V is a 215 `x` 3 matrix. Derive structure and motion matrices from the SVD as explained in the paper.
4. Use `plot3` to display the 3D structure from several different angles. Discuss in your report whether the reconstruction has any ambiguities.
5. Project the 3D points back into the images and calculate and report the total mean square error (sum of squared Euclidean distances, in pixels, between the observed and the reprojected features) over all the frames, and plot the per-frame residual error as a function of the frame number.

As usual the whole assignment should be submitted as a single zipped file via webcourses. Your assignment should include all the codes, the report (including the results for each part and your reflection and analysis of the methods and results). No need to resubmit the input data.