MIT CSAIL

6.869 Advances in Computer Vision

Fall 2017

Problem Set 1

Posted: Thursday, September 7, 2017 **Due:** Thursday 23:59, September 14, 2017

Please submit **two files:** 1) a report named ⟨your_kerberos⟩.pdf, including your answers to all required questions with images and/or plots showing your results, and 2) a file named ⟨your_kerberos⟩.zip, containing relevant source code.

Late Submission Policy: We do not accept late submissions. The submission deadline has a 50-minute soft cut-off; after midnight Thursday, submissions are penalized 2% per minute late.

Readings: lecture 1 notes and chapter_01_simplesystem.pdf

Problem 1 *A simple image formation model*

The goal of this first exercise is to take images with different settings of a camera to create pictures with perspective projection and with orthographic projection. Both pictures should cover the same piece of the scene. You can take pictures of real places (e.g., the street, a living room, ...) or you can also create your own simple world (e.g., you can print *simpleWorld.pdf* and create your own scenes. I recommend printing on mate paper).

To create pictures with orthographic projection you can do two things: 1) use the zoom of the camera, 2) crop the central part of a picture. You will have to play with the distance between the camera and the scene, and with the zoom (or amount of cropping) so that both images look as similar as possible only differing in the type of projection (similar to figure 1.4, in the lecture 1 notes).

Submit the two pictures and label out clearly which parts of the images reveal their projection types.

Problem 2 *Orthographic projection*

Prove the projection equations (Eq. 1.2 and 1.3 of chapter_01_simplesystem.pdf) that relate the coordinates of one point in the 3D world and the image coordinates of the projection of the point in the camera plane.

In the code, we assume $\alpha = 1$.

Problem 3 *Constraints*

In the lecture 1 notes, we have written all the derivative constraints for $Y(x, y)$. Write the constraints for $Z(x, y)$.

The code of the problem set will use constraints on Y.

Problem 4 *Approximation of derivatives*

Fill the missing kernels (lines 166 and 180) in the script: *simpleworldY.m*.

Please make sure to also include your answers in the report.

Problem 5 *Run the code*

Select some of the images included with the code and show some new view points for them.

Optional: You can also try with new images taken by you if you decide to create your own simple world.

Problem 6 *Violating simple world assumptions*

Find one example from the four images provided with the problem set (img1.jpg, . . . , img4.jpg) when the recovery of 3D information fails. Include the image and the reconstruction in your writeup, and explain why it fails.

Research problem [optional] *The real world*

A research problem is a question for which we do not know the answer. In fact, there might not even be an answer. This question is optional and could be extended into a larger course project.

The goal of this problem is to test the 3D reconstruction code with real images. A number of the assumptions we have made will not work when the input are real images of more complex scence. For instance, the simple strategy of differentiating between foreground and background segmentation will not work with other scenes.

Try taking pictures of real world scenes (not the cubes) and propose modifications to the scheme proposed in this lecture so that you can get some better 3D reconstructions. The goal is not to build a general system, but to be able to handle a few more situations.