Robotics:Perception Assignment 1
Dolly Zoom

1 Introduction

In this programming assignment, we will implement Dolly Zoom effect used by film-makers to create a sensation of vertigo, a "falling-away-from-oneself feeling". This assignment is fairly simple and is meant to introduce you to the concepts of projection and focal length; later assignments will start to get trickier. It keeps the size of an object of interests constant in the image, while making the foreground and background objects appear larger or smaller by adjusting focal length and moving the camera. You will simulate the Dolly Zoom effect with a synthetic scene as shown in Figure 1, which illustrates two cubes and one pyramid seen from the top view. Please find an example of the Dolly Zoom simulation from this link:

http://cis.upenn.edu/ cis580/Spring2016/Projects/output.avi

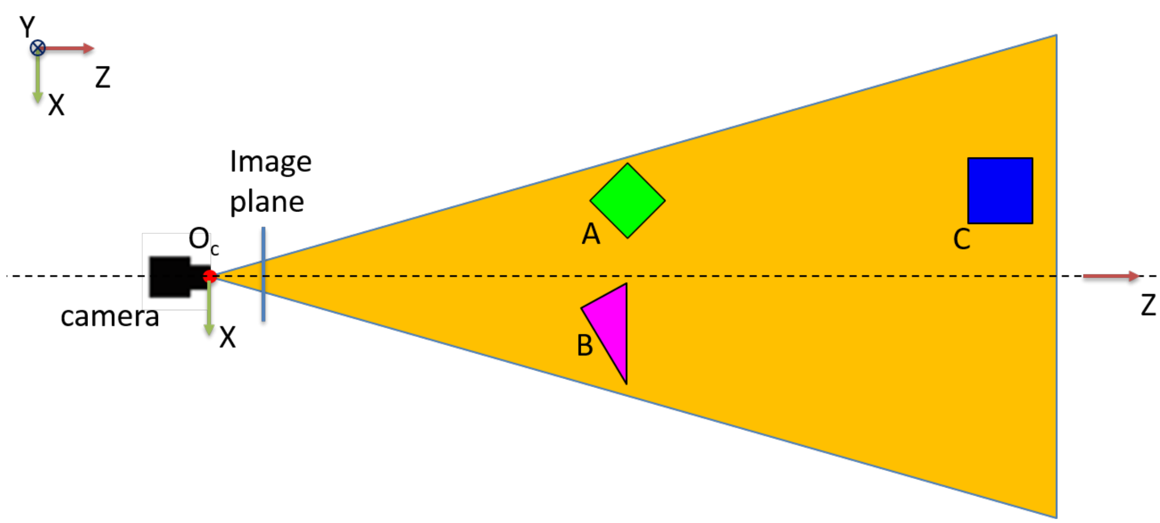

Figure 1: Top view of the synthetic scene.

2 Technical Details

The MATLAB script **run_dolly_zoom.m** will be the main script to run this assignment. Given 3D coordinates of vertices, we will complete a function, compute focal length that finds focal length such that the height of the object A remains constant while the camera moves along with Z axis. The reference depth, reference focal length and height of the object A and the camera movement will be given. We will use this function to visualize the Dolly Zoom effect using project objects. The main files you must fill out.

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Dolly Zoom

3 Dolly Zoom

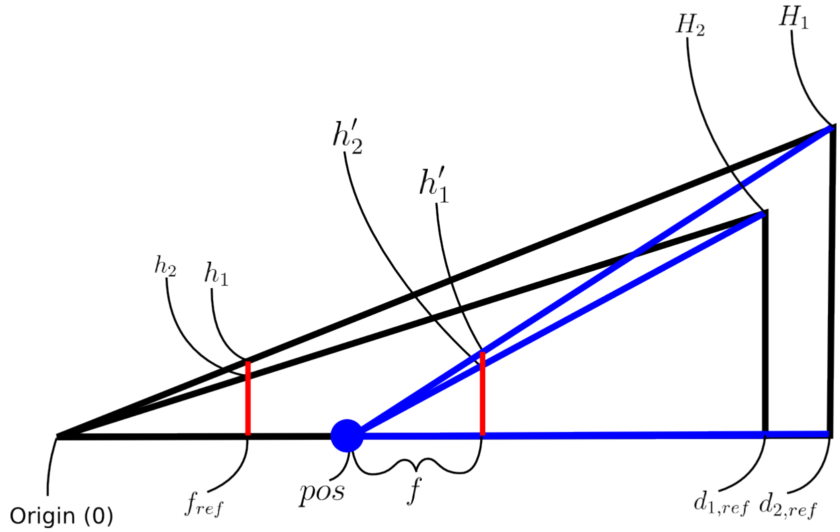

Figure 2: Relationships of all the variables.

A point in 3D is projected onto the image plane through the pinhole (center of projection, COP):

$$u = f\frac{X}{Z}, \qquad v = f\frac{Y}{Z} \tag{1}$$

where (u, v) is the image coordinate of the projection, (X, Y, Z) is the 3D point, and f is the focal length of the camera. When the camera moves along with its Z-axis, the depth, Z, changes and therefore, the projection, (u, v), changes. In our paticular case the Z of interest is d_{ref}, the depth of the objects in the scene. In the following discussion we will only mention the u coordinate to simplify the equations, as we are focused mainly on height for the dolly zoom. This projection change produced by the depth change can be compensated by adjusting focal length:

$$u = f_{ref}\frac{X}{Z_{ref}} = f'\frac{X}{Z_{ref} - pos} \tag{2}$$

where *pos* is the movement of the camera along its Z axis (+ direction indicates approaching to objects) and f' is the modified focal length. f_{ref} and Z_{ref} are the focal length and depth of an object in the original image, respectively. Dolly zoom effect exploits the compensation between depth and focal length, which produces depth sensation. The relationship between all the variable names as given in the code is described, and when implementing the description in the code you should reference that figure.

Figure 3 illustrates the focal length/depth compensation: the camera moves away from the object while changing its focal length such that the height of the object A, $h_1 = 400$, in both original and moved images remains constant. Note that the heights of the other background objects are changed due to this effect.

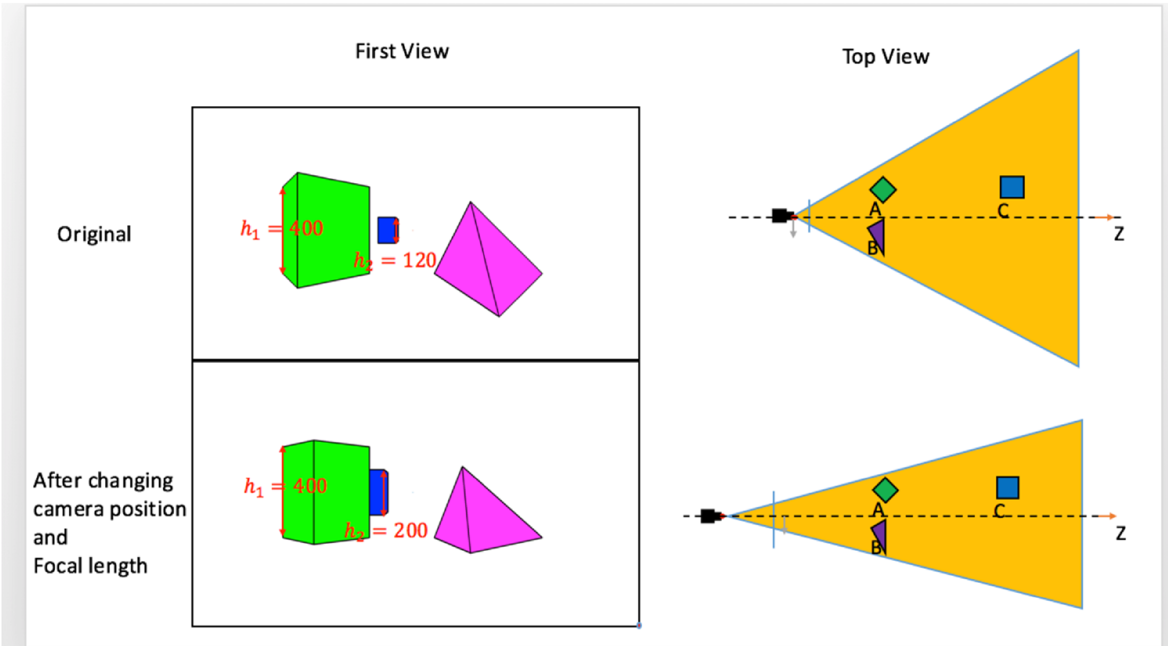

Figure 3: Dolly zoom effect.

4 Visualizing Results

We can visualize the Dolly zoom effect using **project_objects(point3D)**.

5 Submitting

To submit your results, run the **submit** script, which will test your compute focal length function by passing the depth and the camera translation. This script will generate a mat file called RoboticsPerceptionWeek1Submission.mat. Upload this file onto the assignment page, and you should receive your score immediately.