Project 1

3D model generation using single view metrology

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Problem Description: -

We try to generate a 3D model from a single image, through the concepts of vanishing points and vanishing lines to compute the camera matrix.

The steps followed during implementation of this process are as follows

1. **Image Acquisition**

   An image of a box on top the table is captured using a mobile camera as shown above. It is taking keeping in view of the perspective geometry.

2. **Calculation of Vanishing Points**
   To calculate vanishing points, a user is given options to mark the edges of the boxes along X, Y and Z direction. User is expected to select set of points on the image plane to draw lines.
   Image gives an example of the process. The lines marked along (or parallel) the axes X (blue), Y (green) and Z (red) on the box are shown.

   The points of selection are represented in Homogenous coordinates system ex {x,y,1}

Once these lines are drawn, the vanishing points (V_x, V_y, and V_z) are calculated by estimating the point of intersection of these parallel lines. For example the X-direction vanishing point (V_x) is calculated by estimating the point of intersection of the red lines.

Two end-points are chosen on each of the red lines and from these points two line equations are derived. The equation of line joining them is obtained by taking the cross product of the points (P1 x P2), which gives us output in a,b,c corresponding to ax+by+c = 0

Once the line equations are known they are simultaneously solved for a solution. Let L1 & L2 represent the line equations, the point of intersection in homogeneous system is given by a cross product L1xL2

The same process is used to calculate V_y and V_z.

3. **Computing the Projection and Homograph matrix**

Once the vanishing points in each of the directions is obtained. It is possible to compute the Camera Projection matrix from it.

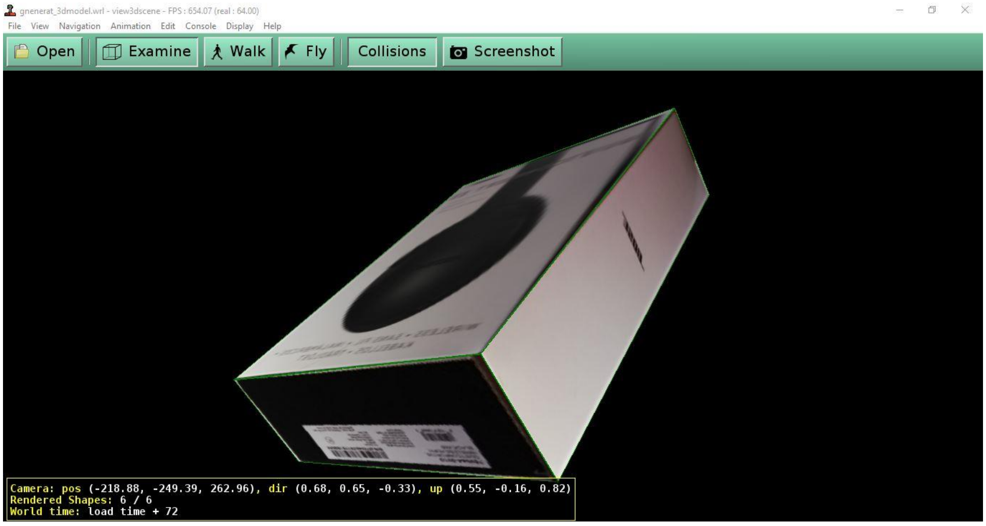
Vanishing point in the x direction corresponds to the point at infinity in the 3d world. Representing it in as homogeneous point Vx gives us (1,0,0,0) . which corresponds to P1 in the projection matrix. Similarly with Vy,Vz being P2,P3.
The origin point selected on the image acts as P4 which is subjects to scaling
Thus , The projection matrix $P = [C_1.V_x \;\; C2.Vy \;\; C3.Vz \;\; 0]$, where C_1, C_2 and C_3 are constants.
These constants are evaluated by comparing the measurements to the real world values
Scaling constant = lease sqr sol (Vx,R1-Origin) / physical distance between R1 & O
Where R1 is the point on x axis

4. **Computing the texture maps**

The homograph matrices H_{xy}, H_{yz} and H_{zx} are obtained from the projection matrix itself by considering the 1st, 2nd and 4th columns of P for H_{xy}, 2nd, 3rd and 4th columns for H_{yz} and 1st 3rd and 4th matrix for H_{zx}.
Perspective warping is done on the image with each of the Homography matrices with the inverse warping flag set. The output image appears as if take from a different view.
Cropping out the surfaces we get

5. **Visualizing the 3D reconstructed model**

For the 3D model, the coordinates for each face of the box is defined and the corresponding images to be mapped on to it is specified. For the model generation we have assumed the opposite sides to be similar.
Image of the 3D model is shown below:


gnenerat_3dmodel.wrl - view3dscene - FPS : 654.07 (real : 64.00)
File View Navigation Animation Edit Console Display Help
Open
Examine
Walk
Fly
Collisions
Screenshot
Camera: pos (-218.88, -249.39, 262.96), dir (0.68, 0.65, -0.33), up (0.55, -0.16, 0.82)
Rendered Shapes: 6 / 6
World time: load time + 72