HW1

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CS 6320 - 3D Computer Vision
Due: 11:59 PM on 01/29/2017

Please submit a zip file containing a PDF document (solutions to the problems) and a PLY file (3D model).

1. Let us consider a car moving on a highway with four lanes. Show that the three parallel lane marking lines on the road intersect at a single point on the image captured by a car mounted camera. Let the origin of the camera be given by $O(0,0,0)$. The image resolution is 640×480 and the principal point is given by $(320, 240)$. We assume the following parameters for the camera:

$$\begin{pmatrix} u \\ v \\ 1 \end{pmatrix} \sim \begin{pmatrix} 200 & 0 & 320 & 0 \\ 0 & 200 & 240 & 0 \\ 0 & 0 & 1 & 0 \end{pmatrix} \begin{pmatrix} \mathsf{I} & \mathbf{0} \\ \mathbf{0}^T & 1 \end{pmatrix} \begin{pmatrix} X^m \\ Y^m \\ Z^m \\ 1 \end{pmatrix} \tag{1}$$

where (u, v) correspond to pixel coordinates and I denotes the 3×3 identity matrix. We use two 3D points (in some units, say meters) to represent a 3D line. The three parallel 3D lines $\mathcal{L}_1, \mathcal{L}_2,$ and $\mathcal{L}_3$ are shown below:

$$\mathcal{L}_1\{ \begin{pmatrix} -10 \\ -10 \\ 10 \end{pmatrix}, \begin{pmatrix} -10 \\ -10 \\ 20 \end{pmatrix} \}, \mathcal{L}_2\{ \begin{pmatrix} 0 \\ -10 \\ 10 \end{pmatrix}, \begin{pmatrix} 0 \\ -10 \\ 20 \end{pmatrix} \}, \mathcal{L}_3\{ \begin{pmatrix} 10 \\ -10 \\ 10 \end{pmatrix}, \begin{pmatrix} 10 \\ -10 \\ 20 \end{pmatrix} \} \tag{2}$$

[25 points]

2. Let us consider the same camera model used in Question 1. Find the coordinates of two 3D points $A(X_1, Y_1, Z_1)$ and $B(X_2, Y_2, Z_2)$ that satisfy the following conditions:

   - The projections of A and B on the image are given by $\mathbf{a}(120, 240)$ and $\mathbf{b}(520, 240)$, respectively.
   - $OA = 100$ and $AB = 100\sqrt{2}$ [25 points].

3. Download the visual SFM software (http://ccwu.me/vsfm/). Create a 3D model using at least 25 images. The images can be obtained from the following sources:

   - The images can be captured using your phone or any digital camera.
   - The images can also be downloaded from the web (Flickr, Google images).

   Submit the 3D model in PLY format, which can be visualized using meshlab (http://www.meshlab.net/) [50 points].