ECE 417/598: Depth from stereo
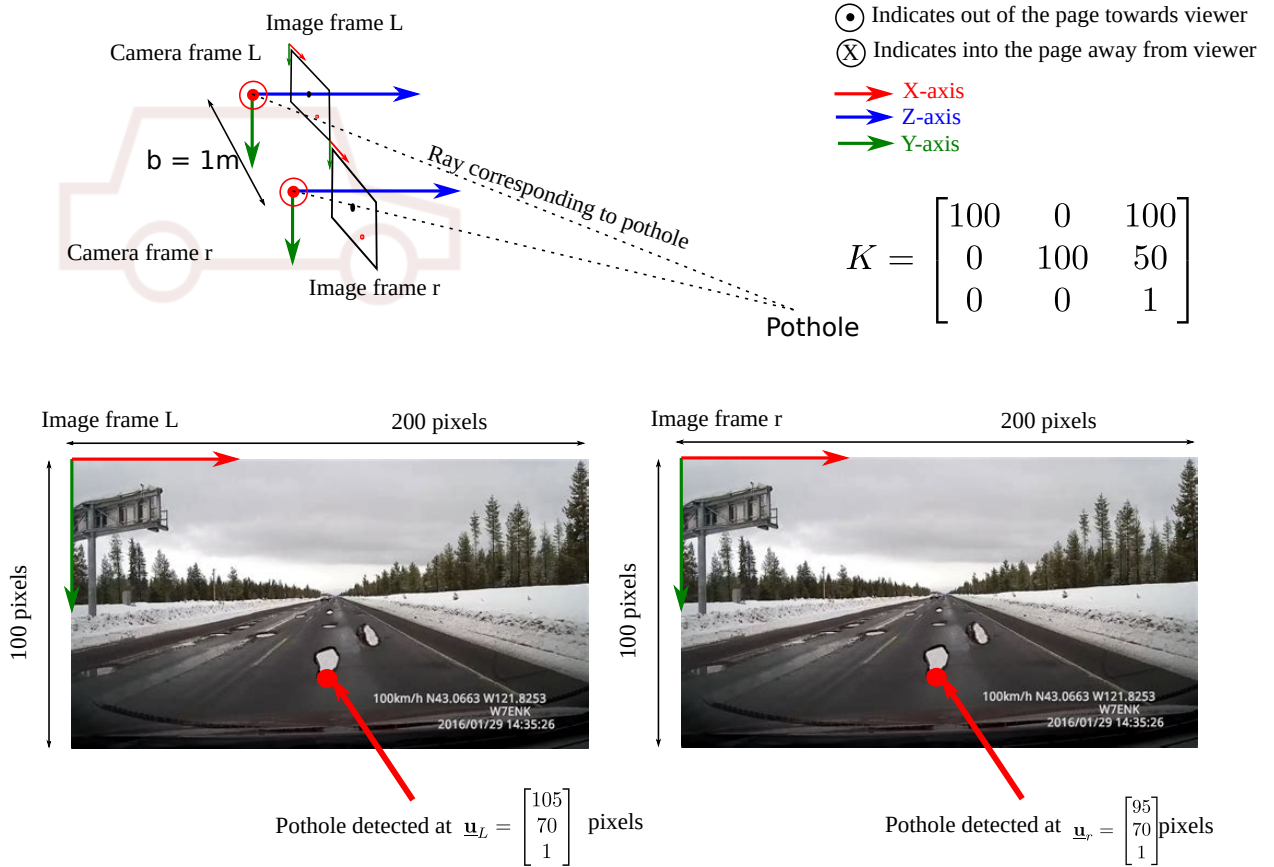
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April 8, 2022

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Problem 1 *Find the 3D position of the pothole give that the right camera r is moved along X-axis by $b = 1m$ with respect to the left camera L.*

Image frame L

Camera frame L

b = 1m

Camera frame r

Image frame r

Ray corresponding to pothole

Pothole

$\bullet$ Indicates out of the page towards viewer
$\times$ Indicates into the page away from viewer

X-axis
Z-axis
Y-axis

$$K = \begin{bmatrix} 100 & 0 & 100 \\ 0 & 100 & 50 \\ 0 & 0 & 1 \end{bmatrix}$$

Image frame L   200 pixels

100 pixels

Pothole detected at $\underline{\mathbf{u}}_L = \begin{bmatrix} 105 \\ 70 \\ 1 \end{bmatrix}$ pixels

Image frame r   200 pixels

100 pixels

Pothole detected at $\underline{\mathbf{u}}_r = \begin{bmatrix} 95 \\ 70 \\ 1 \end{bmatrix}$ pixels

1. Find the equation of ray corresponding to the pothole in the left image. In other words, write the equation of the ray corresponding to the point $\underline{\mathbf{u}}_L$, in camera frame L.

2. Find the rotation matrix ^rR_L and translation vector $^r\mathbf{t}_L$, so that they transform any point in the coordinate frame L to a point in the coordinate frame r. $(\mathbf{X}_r = {}^rR_L\mathbf{X}_L + {}^r\mathbf{t}_L)$.

3. Transform the equation of ray from coordinate frame L to coordinate frame r.

4. Find the equation of ray corresponding to the pothole in the right image. In other words, write the equation of the ray corresponding to the point $\underline{\mathbf{u}}_r$, in camera frame r.

5. Find the intersection of rays (lines) 4 and 3.

Problem 2 *When the depth corresponding to the point* $\mathbf{x}$ *is unknown, the possible pixels* $(\mathbf{x}')$ *on the right image that can correspond to the point form a line. What is the equation of that line?*
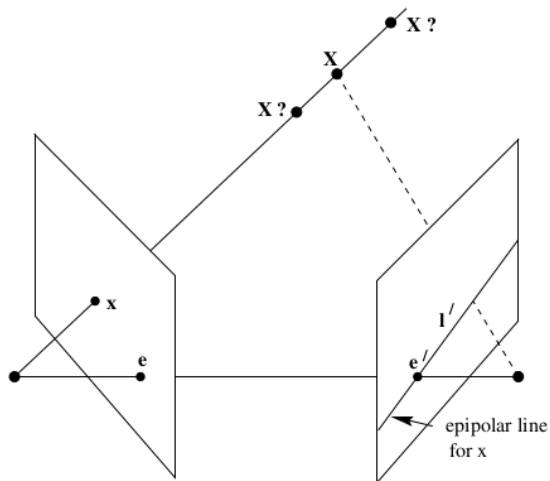
1. Find the equation of ray corresponding to the pothole in the left image. In other words, write the equation of the ray corresponding to the point $\mathbf{x}$, in the first camera frame.

2. Assume the rotation matrix R and translation vector $\mathbf{t}$, so that they transform any point in the left coordinate frame to a point in the right coordinate frame. $(\mathbf{X}' = R\mathbf{X} + \mathbf{t})$. Transform the equation of ray from the left coordinate frame to the right coordinate frame.

3. Project any 3D point on the right camera, call it $\mathbf{x}'$.

4. Find the point $\mathbf{e}'$ on the right camera.

5. Find a line $\mathbf{l}'$ that passes through both $\mathbf{x}'$ and $\mathbf{e}'$.