Vision 2 - Stereo + Triangulation + Epipolar Geometry

1. What are the two main steps in the stereopsis process?
2. What is the correspondence problem?
3. What is the reconstruction problem?
4. What two general types of stereo did we talk about? What are the advantages disadvantages of both?
5. What do we know about the location of a 3D point when we have the image location where we see the point? (You can assume you know P.)
6. What is the epipole? How can you construct it?
7. What is an epipolar line? In which part, and how, can it help speed up the stereopsis process?
8. How can you construct the epipolar line (not only a direction)?
9. Compute ray:
   9.1. How do you compute the ray on which a 3D point corresponding to a location in the image (m) will lie (given P or K, A and H)? Represent the ray as point + direction or as a Plücker line.
   9.2. Compute point on line + direction or Plücker line given:

$$K * A = \begin{pmatrix} 1000 & 0 & 500 & 0 \\ 0 & 1000 & 500 & 0 \\ 0 & 0 & 1 & 0 \end{pmatrix}; H = \begin{pmatrix} 0 & 0 & -1 & -40 \\ 1 & 0 & 0 & 30 \\ 0 & -1 & 0 & -300 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$P = \begin{pmatrix} 0 & -500 & -1000 & -190000 \\ 1000 & -500 & 0 & -120000 \\ 0 & -1 & 0 & -300 \end{pmatrix}; m = \begin{bmatrix} 767 \\ 650 \end{bmatrix}$$

10. Compute the two endpoints of the epipolar line (they do not need to be inside the image boundaries)

$$(K * A)_{left} = (K * A)_{right} = \begin{pmatrix} 1000 & 0 & 500 & 0 \\ 0 & 1000 & 500 & 0 \\ 0 & 0 & 1 & 0 \end{pmatrix};$$

$$H_{left} = \begin{pmatrix} 0 & 0 & -1 & -40 \\ 1 & 0 & 0 & 30 \\ 0 & -1 & 0 & -300 \\ 0 & 0 & 0 & 1 \end{pmatrix};$$

$$P_{left} = \begin{pmatrix} 0 & -500 & -1000 & -190000 \\ 1000 & -500 & 0 & -120000 \\ 0 & 0 & 0 & -300 \end{pmatrix};$$

$$H_{right} = \begin{pmatrix} 0 & 0.052336 & -0.99863 & -80 \\ 1 & 0 & 0 & 30 \\ 0 & -0.99863 & -0.052336 & -300 \\ 0 & 0 & 0 & 1 \end{pmatrix};$$

$$P_{left} = \begin{pmatrix} 0 & -446.98 & -1024.8 & -230000 \\ 1000 & -499.31 & -26.168 & -120000 \\ 0 & -0.99863 & -0.052336 & -300 \end{pmatrix};$$

$$m = \begin{bmatrix} 767 \\ 650 \end{bmatrix}$$

11. Draw a non-rectified stereo camera system. [SCANNING] Highlight:

- The epipole
- A 2D location in the left image of your choice
- The corresponding generated ray
- The corresponding epipolar line

12. Point reconstruction:
    12.1. How does the geometric method for point reconstruction work? What problem do we have to deal with here (influence of noise)?
    12.2. How does the algebraic method (linear alternative) work?
    12.3. In which situation is the algebraic method the better choice?
    12.4. Compute the 3D position of the point M causing m_left and m_right (using the method of your choice):

$$(K * A)_{left} = (K * A)_{right} = \begin{pmatrix} 1000 & 0 & 500 & 0 \\ 0 & 1000 & 500 & 0 \\ 0 & 0 & 1 & 0 \end{pmatrix};$$

$$H_{left} = \begin{pmatrix} 0 & 0 & -1 & -40 \\ 1 & 0 & 0 & 30 \\ 0 & -1 & 0 & -300 \\ 0 & 0 & 0 & 1 \end{pmatrix};$$

$$P_{left} = \begin{pmatrix} 0 & -500 & -1000 & -190000 \\ 1000 & -500 & 0 & -120000 \\ 0 & 0 & 0 & -300 \end{pmatrix};$$

$$H_{right} = \begin{pmatrix} 0 & 0.052336 & -0.99863 & -80 \\ 1 & 0 & 0 & 30 \\ 0 & -0.99863 & -0.052336 & -300 \\ 0 & 0 & 0 & 1 \end{pmatrix};$$

$$P_{left} = \begin{pmatrix} 0 & -446.98 & -1024.8 & -230000 \\ 1000 & -499.31 & -26.168 & -120000 \\ 0 & -0.99863 & -0.052336 & -300 \end{pmatrix};$$

$$m_{left} = \begin{bmatrix} 767 \\ 650 \end{bmatrix};\ m_{right} = \begin{bmatrix} 620 \\ 648 \end{bmatrix}$$

13. Fundamental matrix
    13.1. What does the fundamental matrix tell us about the relationship of a point in the left and one in the right image? How does the corresponding equation look?
    13.2. How can we estimate the fundamental matrix from image correspondences?
    13.3. If the correspondences are noisy what approach can we use to filter out the good correspondences? How does the process look if we use that algorithm (steps)?
14. What is rectification?