

Review:

**Image Sensor:** similar to the retina on the back of a human eye, measured in millimeters, and is about the size of a fingernail, made up of individual color sensors (called pixels)

**Sensor Resolution:** defined by the number of pixels on the Image Sensor

**Focal Length:** how far the image sensor is from the lens of the camera

**Lens:** where the light passes through to get to the image sensor, imagine this as a simple pinhole that is centered in front of the image sensor

**Image Plane:** an imagined image in front of the pinhole that is the same focal length distance as from the pinhole to the image sensor (this allows us to use an upright image, rather than an upside down image)

**Stereo Vision:** allows the robot to calculate the distance to nearby objects by using 2 cameras that are parallel to each other and the cameras are a known distance apart

Steps:

1. Take a picture – This step produces an image (a 2-dimensional representation of the real-world)
2. Process the Image – find interesting points such as corners and edges of objects in the image – we'll call these interesting points, features
3. Calculate information – Use the features to extract information about the scene in the image such as where objects are, or distance to particular features or which objects are in view.

Line through two points:

$$z - z_c = \frac{f - z_c}{A_x - x_c} (x - x_c)$$

- $x_c, z_c$  is the center of the camera – typically one camera will be set at the origin and is 0,0, the other will typically have the x position as the offset between the two cameras.
- $A_x$  is the position in mm of the pixel of the feature in the image – find by multiplying the number of pixels from center by the ratio of sensor size to pixel count (i.e. if the sensor is 2000 px wide and 10 mm wide than the ratio would be 200 px per mm).
- For the both cameras, if the pixel of the feature in the image is to the left of center, than the value will be negative.
- You will have two equations with z and x in them. Solve by substitution, or by systems of equations.

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**Challenge Questions:**

With cameras in robots collecting all of the visual information that they see, what are physical and digital security measures that can be taken to help secure the visual data from cameras?  
How do these security measures do that?

From your list of security measures above, which would you recommend based on the criteria of: efficiency, feasibility, and ethical impacts?

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