Introduction to Computer Vision

RBE 1001

Overview

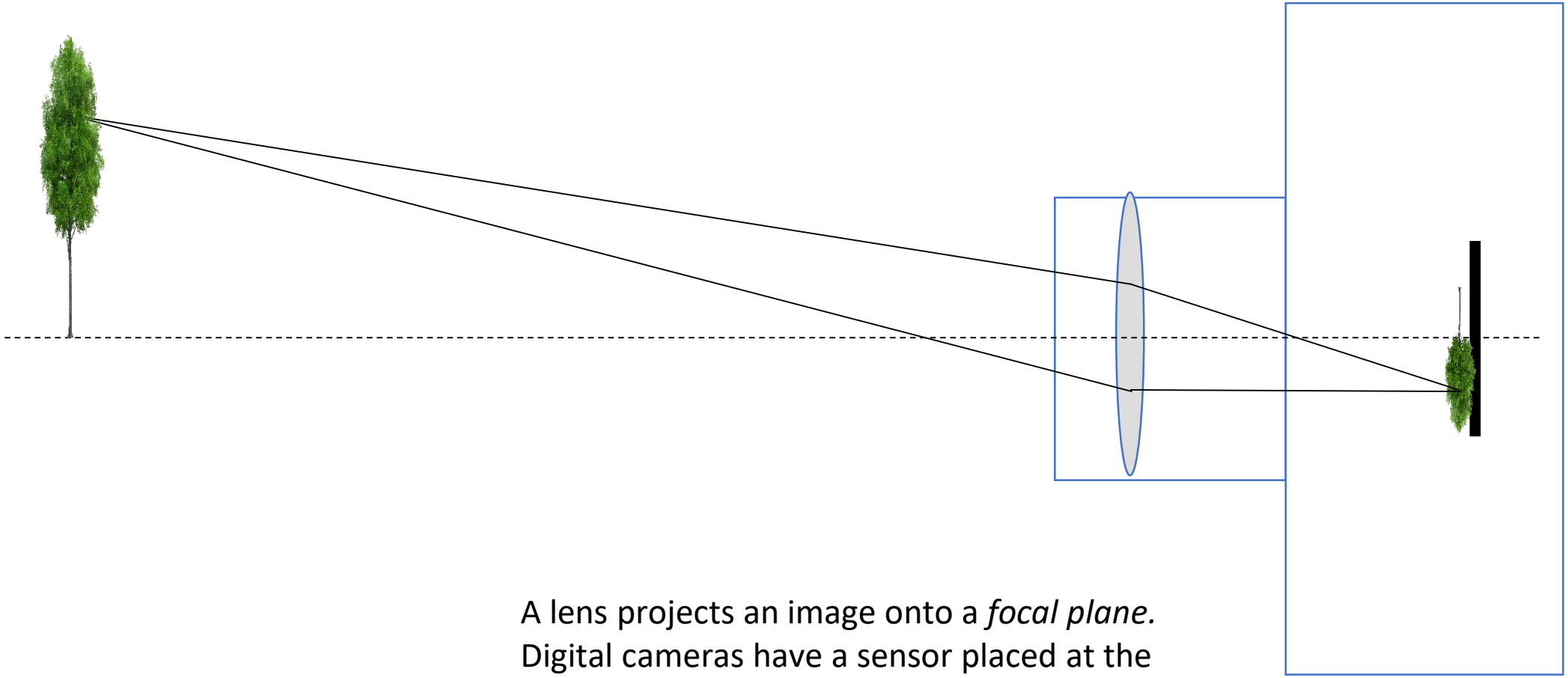
- Demos
- Camera basics
- VEX image sensor

Examples of the things you can do with a camera

Examples of the things you can do with a camera

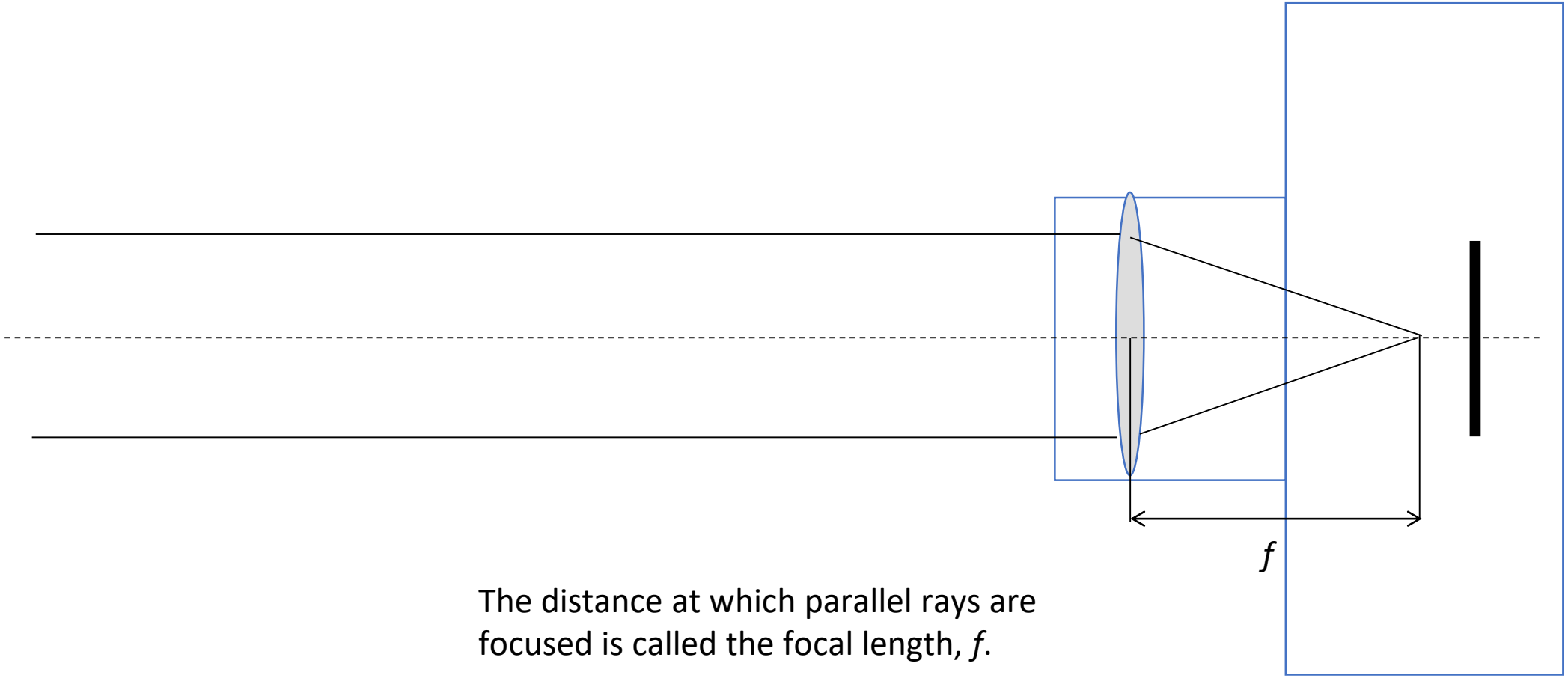
- Object detection
- Object recognition
- Face detection/recognition; eye tracking
- Motion detection
- Orientation
- AR/VR

Camera fundamentals



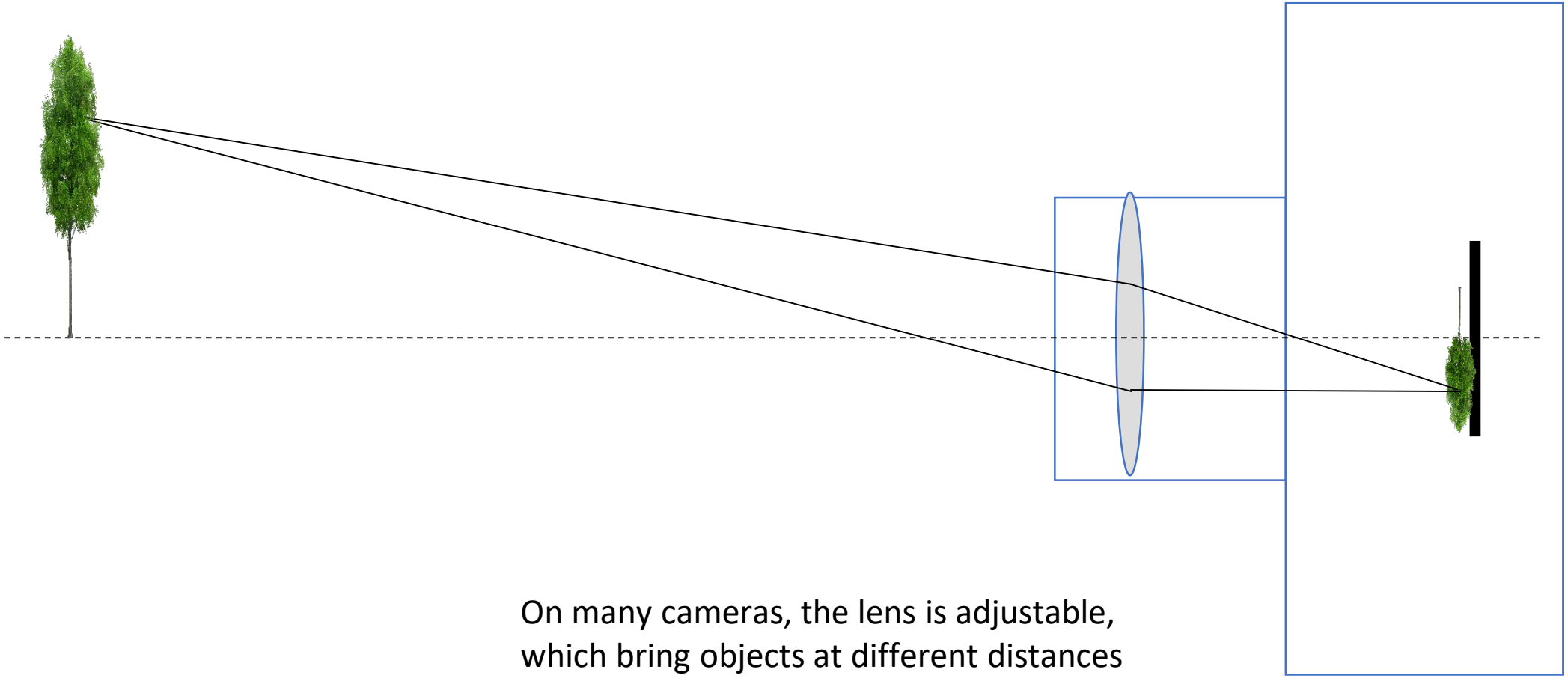
A lens projects an image onto a *focal plane.* Digital cameras have a sensor placed at the focal plane to record images.

Focal length



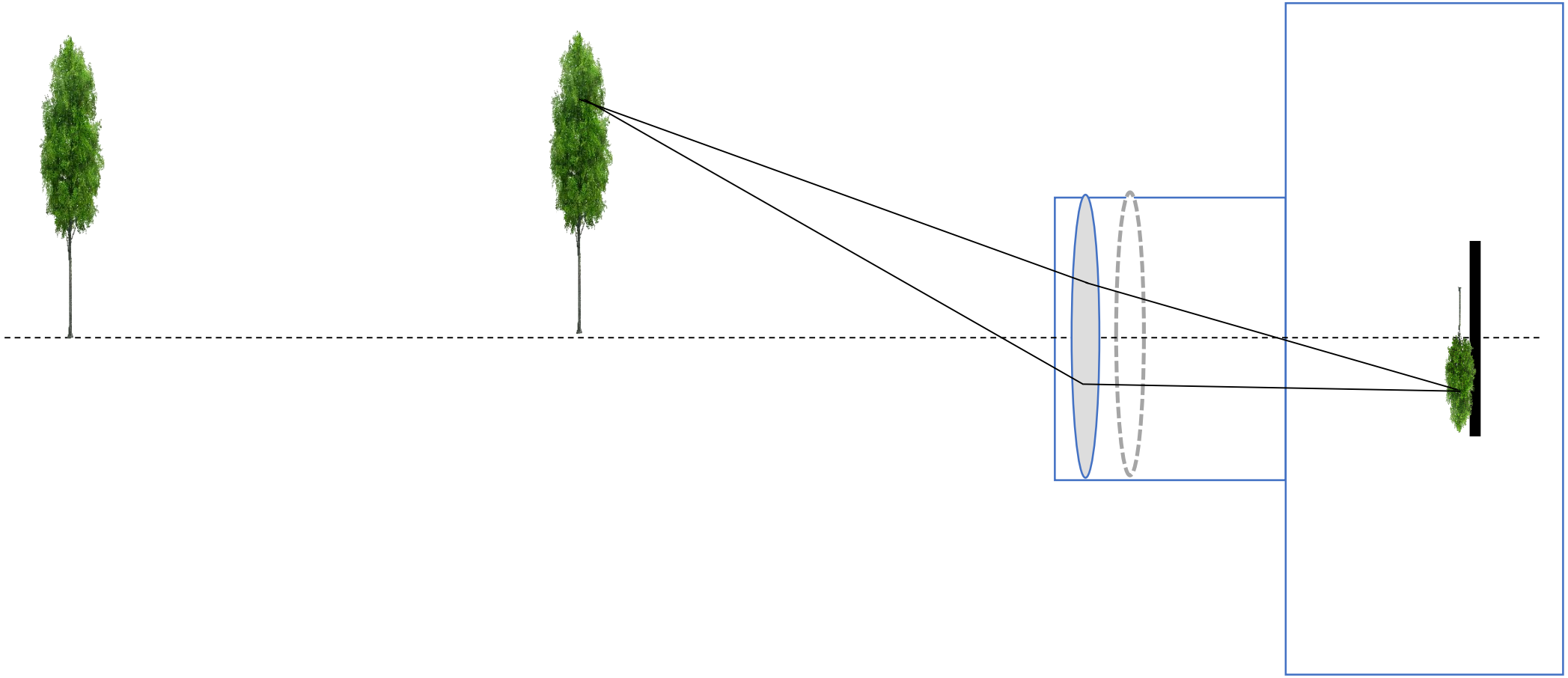
The distance at which parallel rays are focused is called the focal length, *f*.

Camera fundamentals

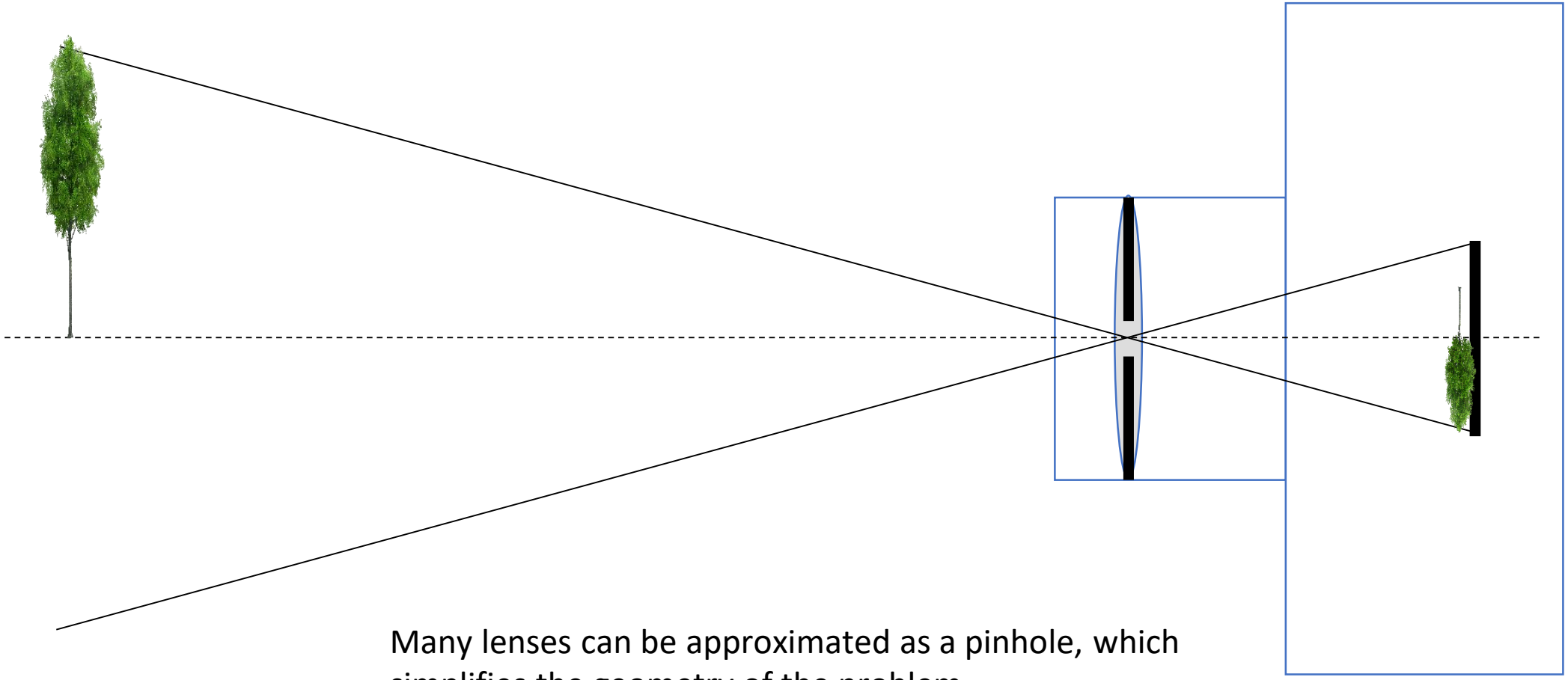


On many cameras, the lens is adjustable, which bring objects at different distances into focus on a fixed plane.

Focusing



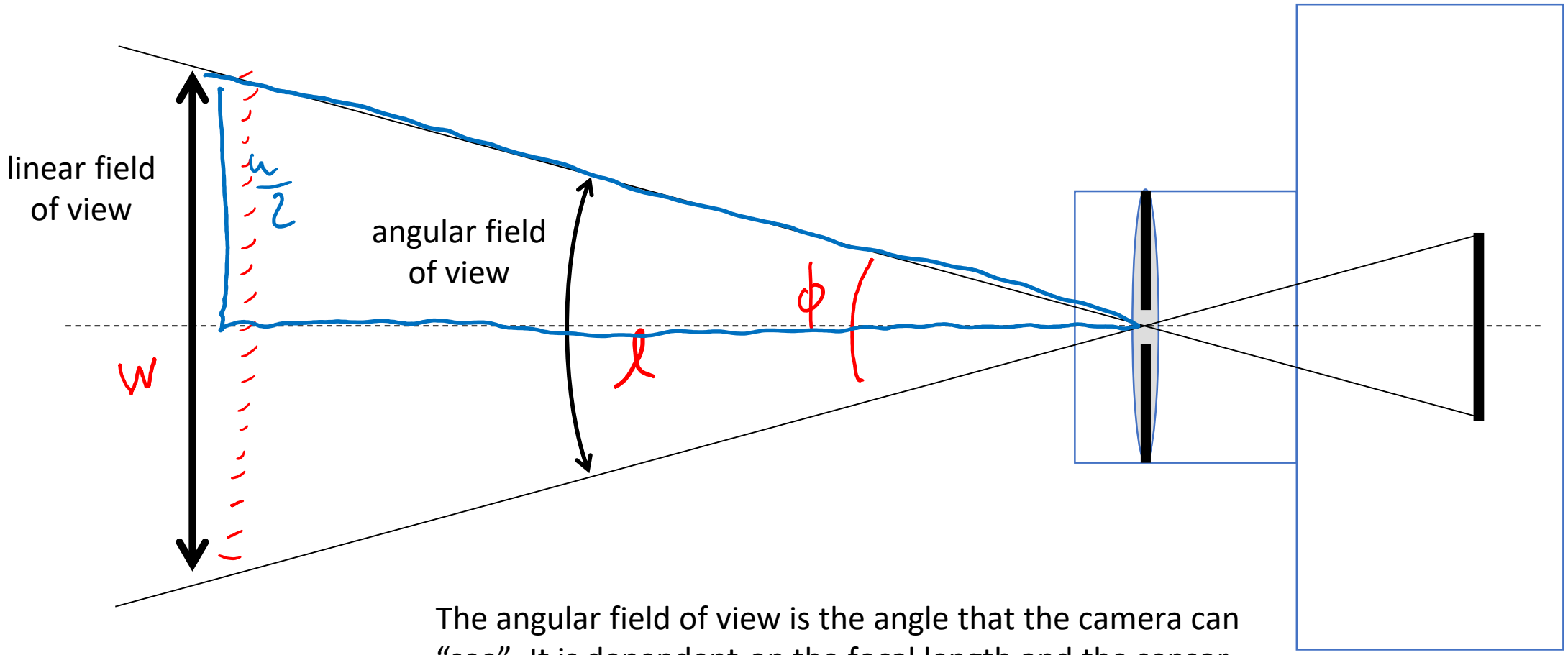
Pinhole approximation



Many lenses can be approximated as a pinhole, which simplifies the geometry of the problem

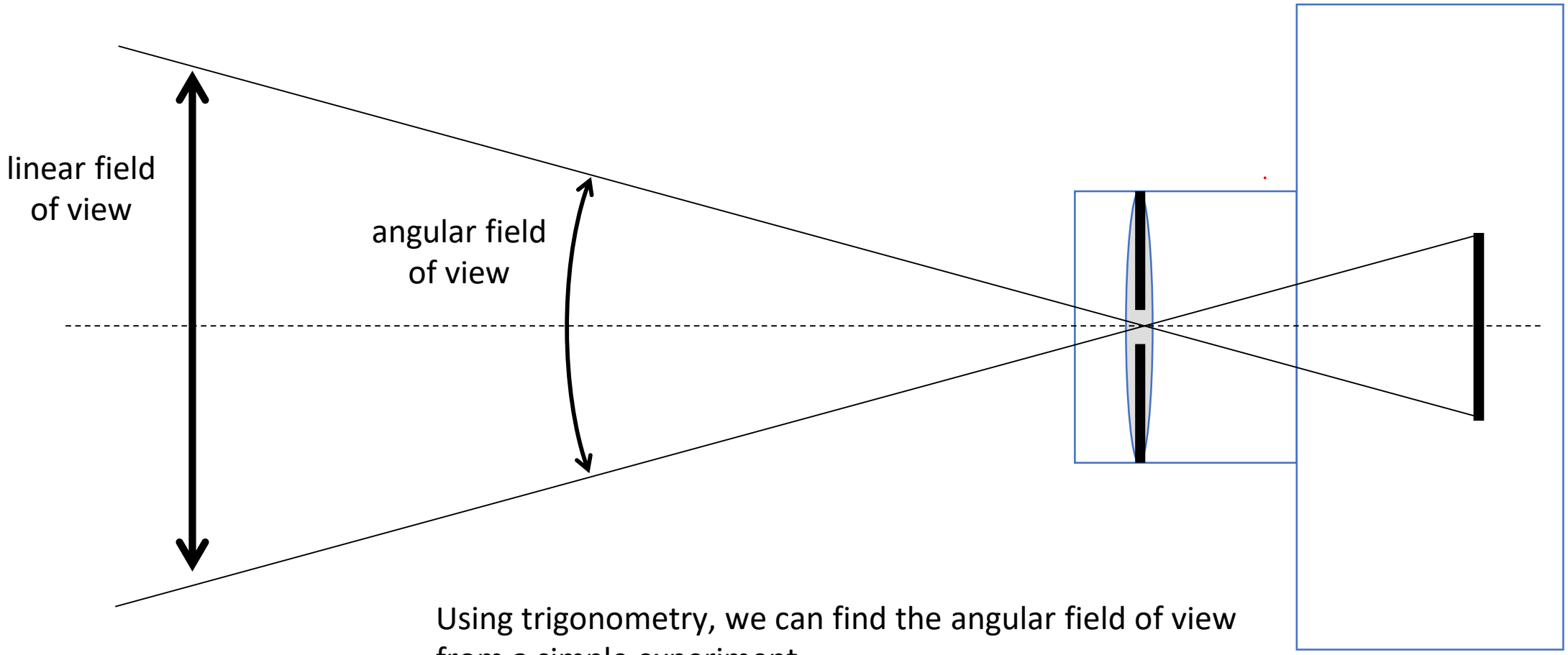
Field of View

$$\tan\left(\frac{\phi}{2}\right) = \frac{\left(\frac{w}{2}\right)}{\ell}$$



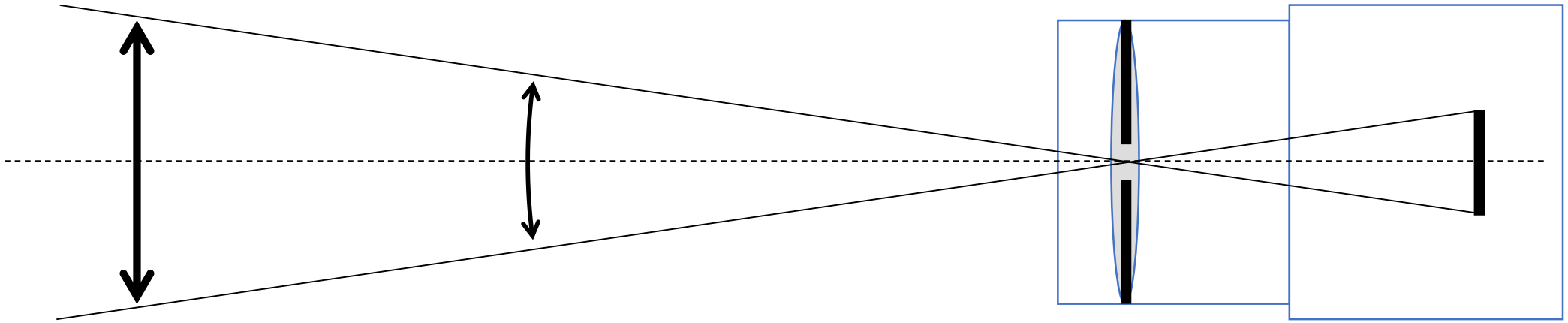
The angular field of view is the angle that the camera can "see". It is dependent on the focal length and the sensor size. The linear field of view is also dependent on the distance from the camera lens.

Field of View



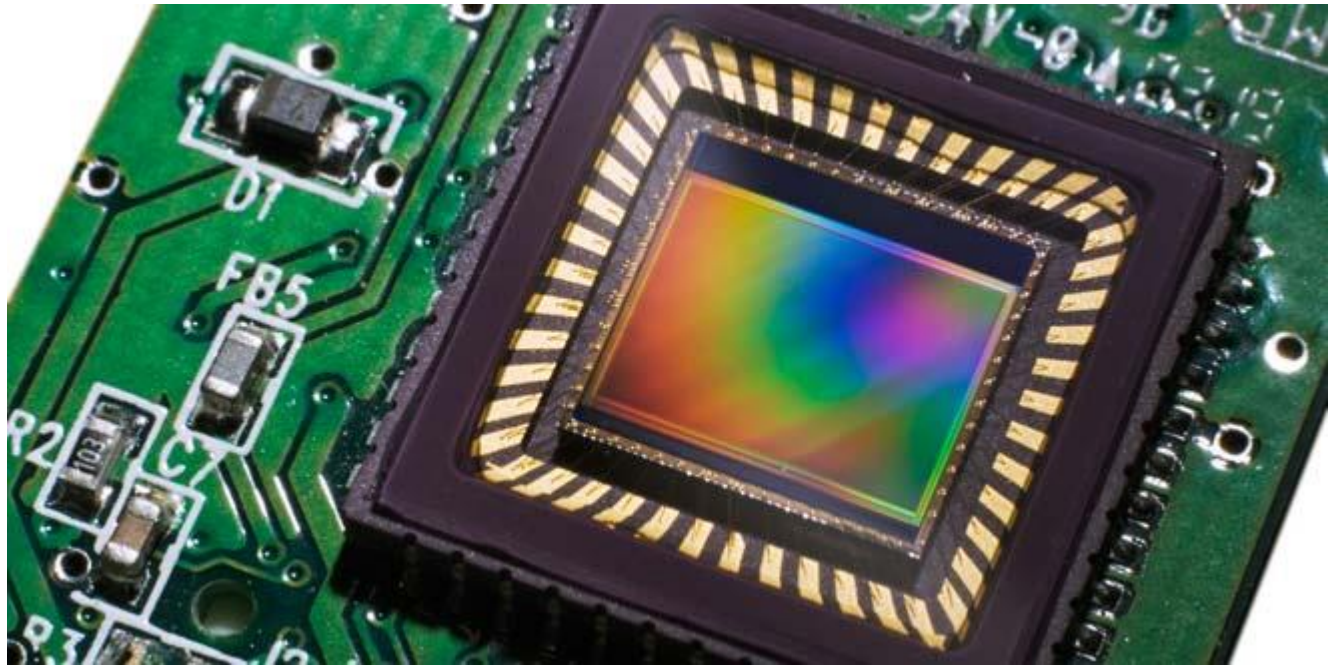
Using trigonometry, we can find the angular field of view from a simple experiment.

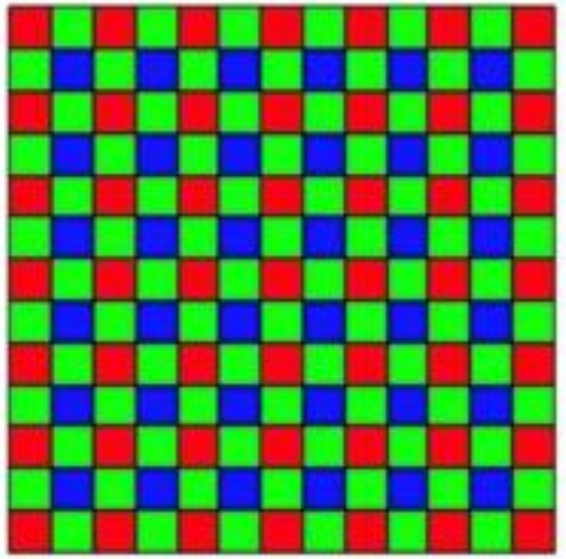
Field of View



The horizontal and vertical fields of view are typically different.

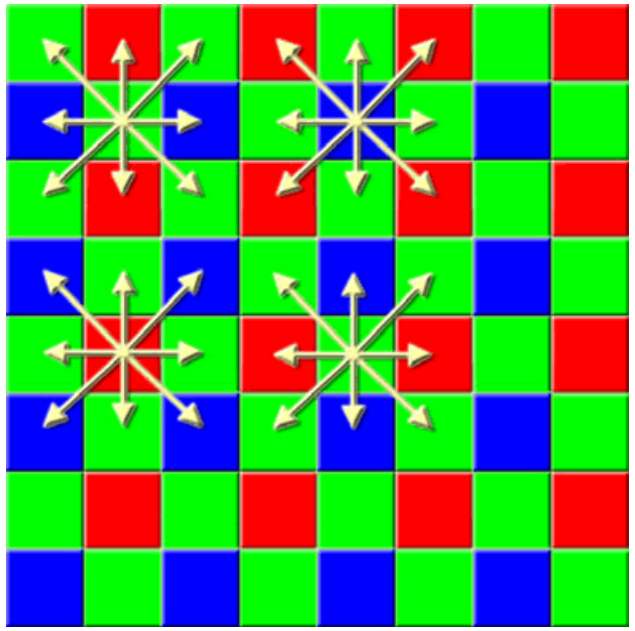
The sensor

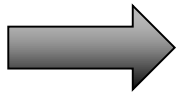


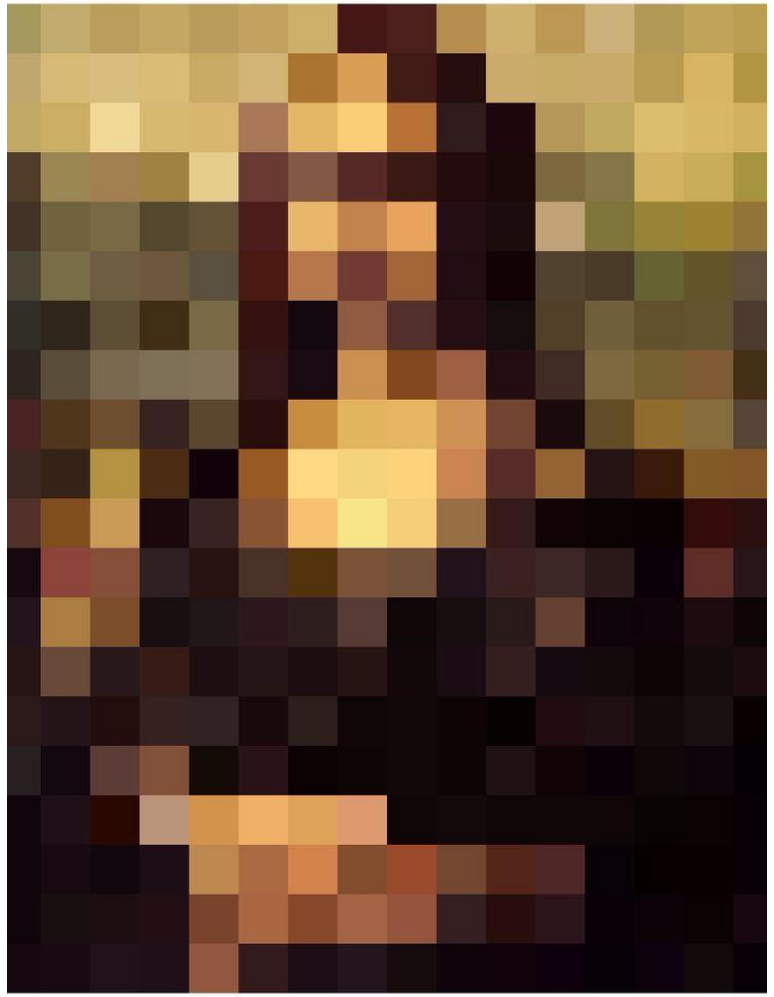


The sensor is made of a number of pixels, which are light sensitive electronic elements. Typically, filters are used to separate out the RGB colors. More green pixels are used to make a more “true” color to the human eye.

Representing color

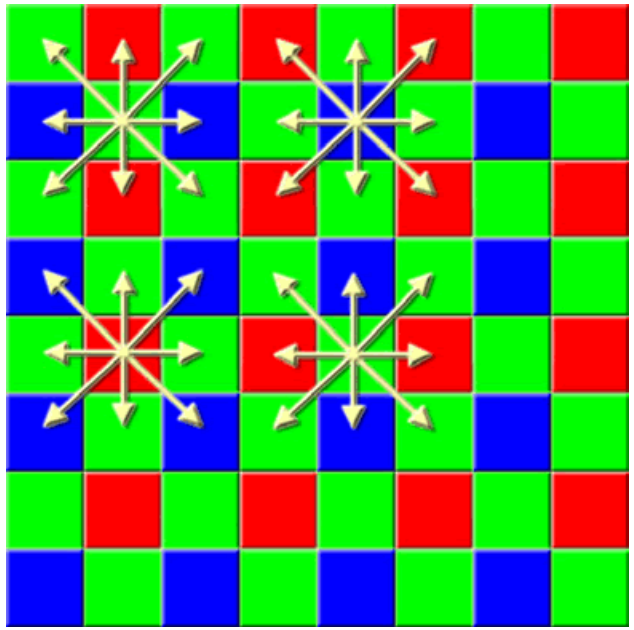


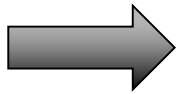




Interpolation is used to estimate the RGB signature at each pixel. The end result is an RGB signature for a rectangular region of pixels.

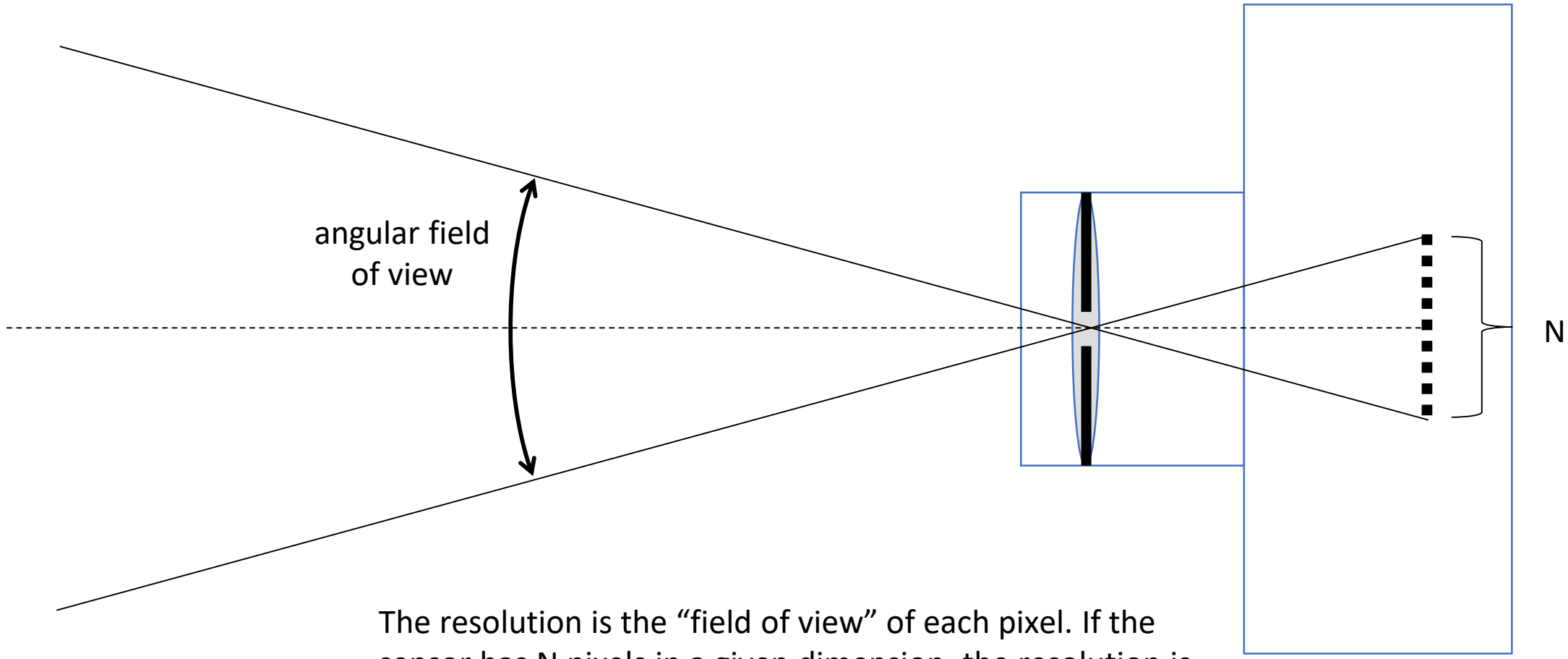
RGB formats





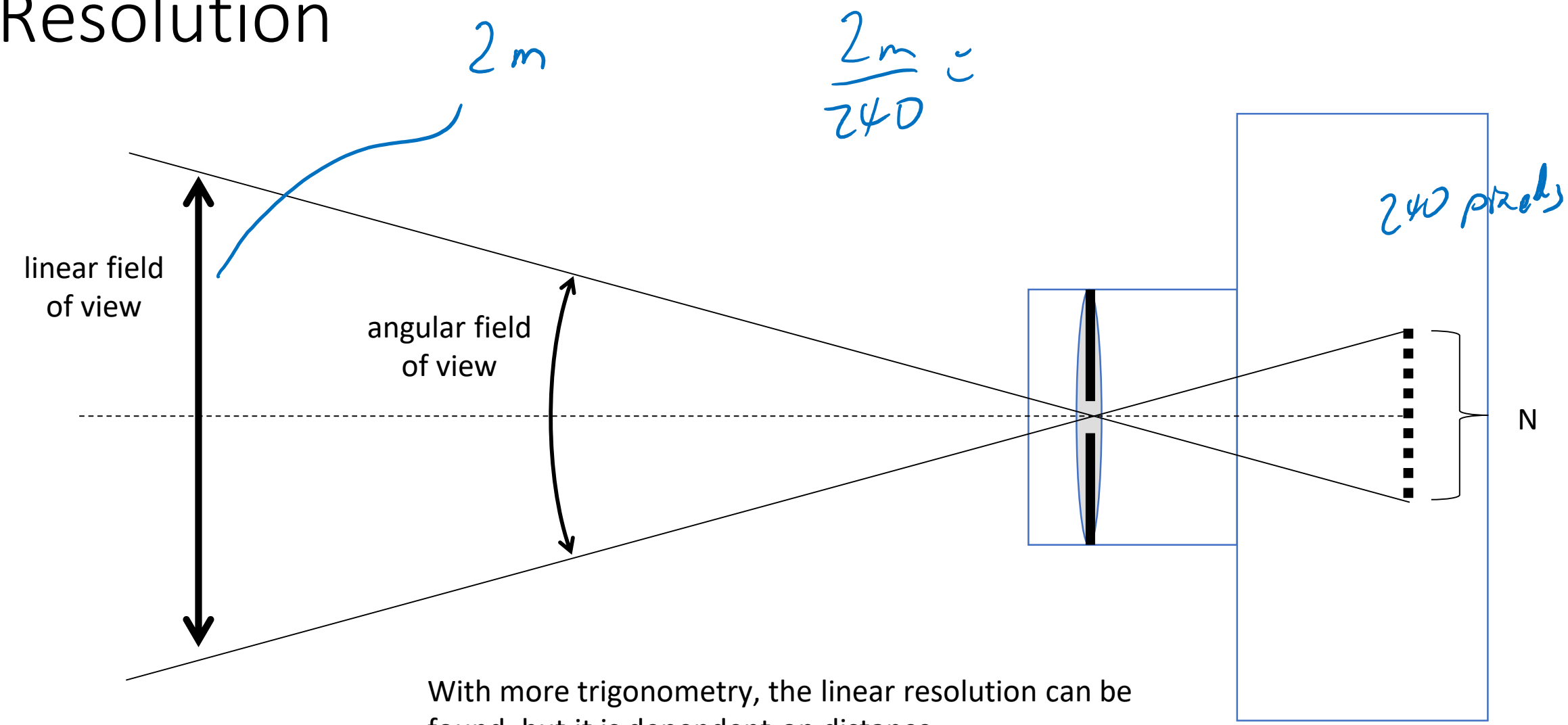
The color resolution is determined by the number of bits that are used to represent each color. Fewer bits means fewer colors can be represented, so there are bigger “jumps” between colors. The “RGB-565” format is a popular, low-memory format.

Resolution



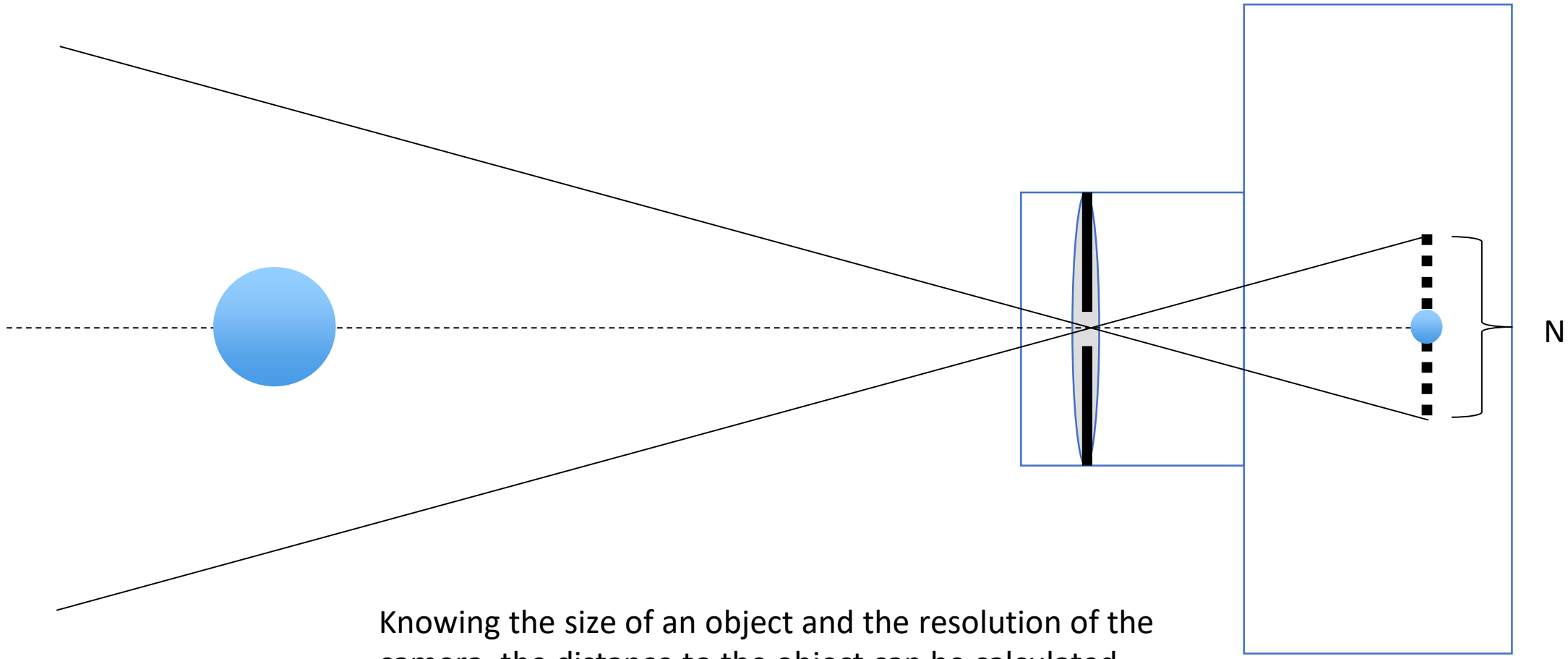
The resolution is the “field of view” of each pixel. If the sensor has N pixels in a given dimension, the resolution is the angular field of view divided by N, which is in degrees per pixel.

Resolution



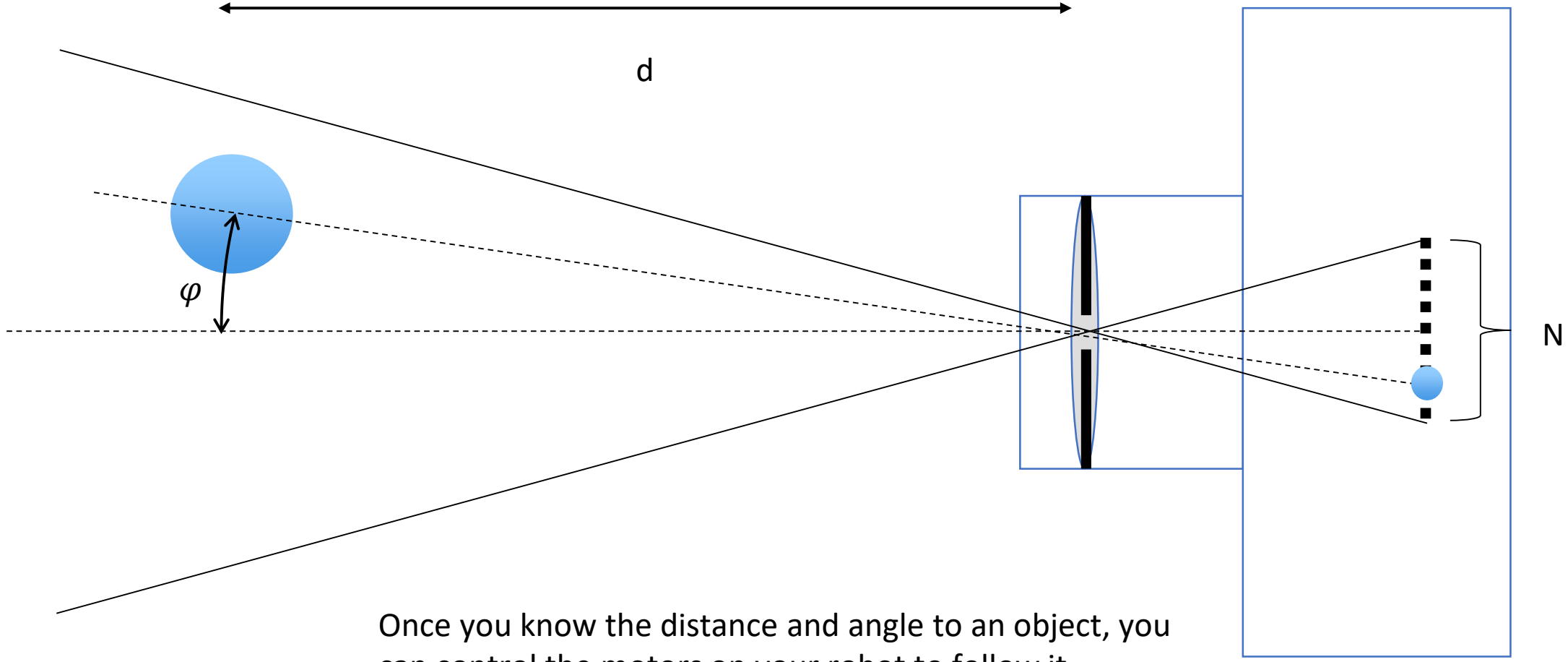
With more trigonometry, the linear resolution can be found, but it is dependent on distance.

Resolution

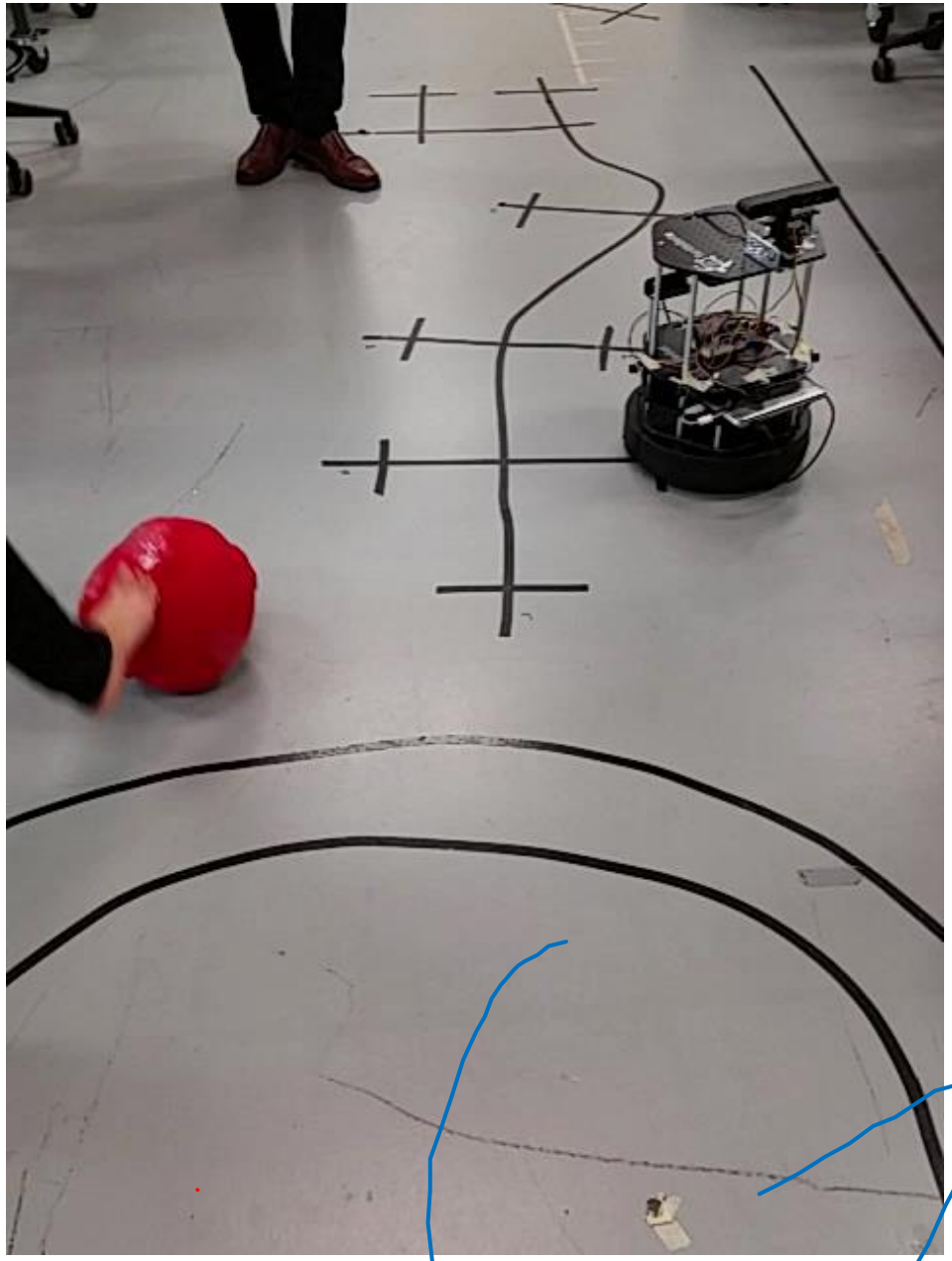


Knowing the size of an object and the resolution of the camera, the distance to the object can be calculated.

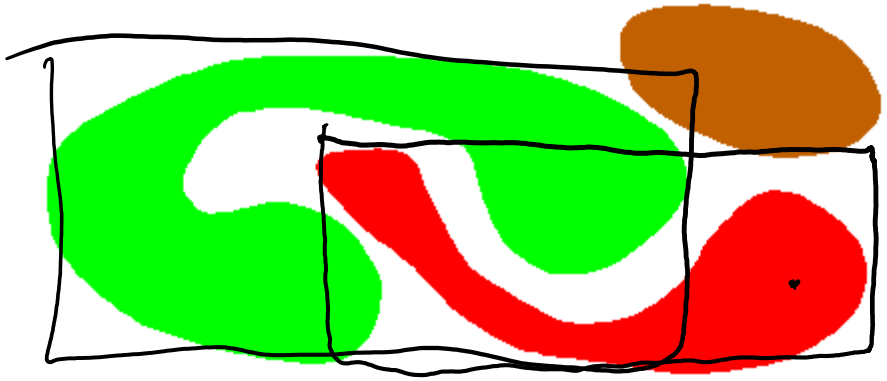
Object following



Once you know the distance and angle to an object, you can control the motors on your robot to follow it.



VEX camera



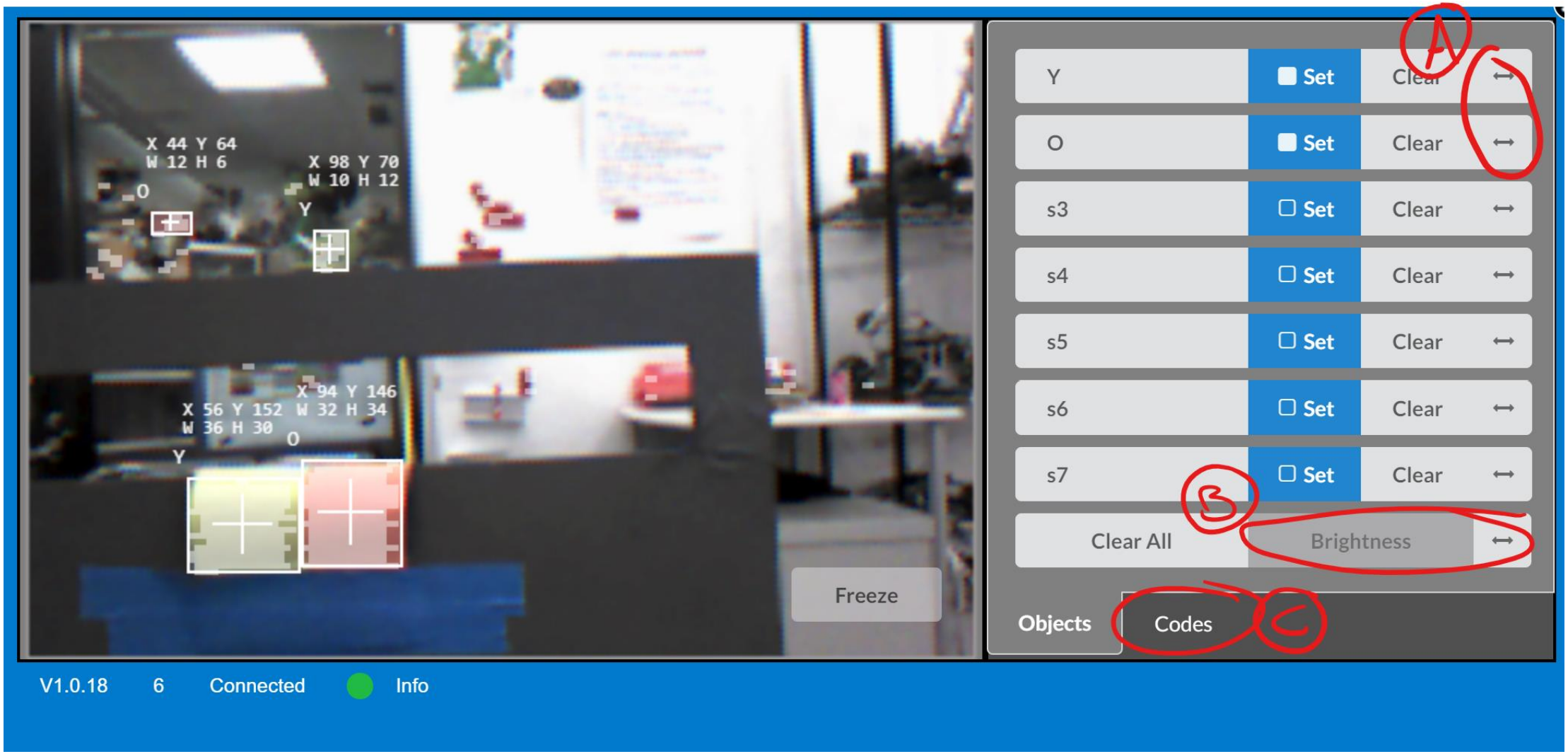
The VEX camera uses the *Color Connected Components* algorithm to detect (and track!) blobs.

VEX camera

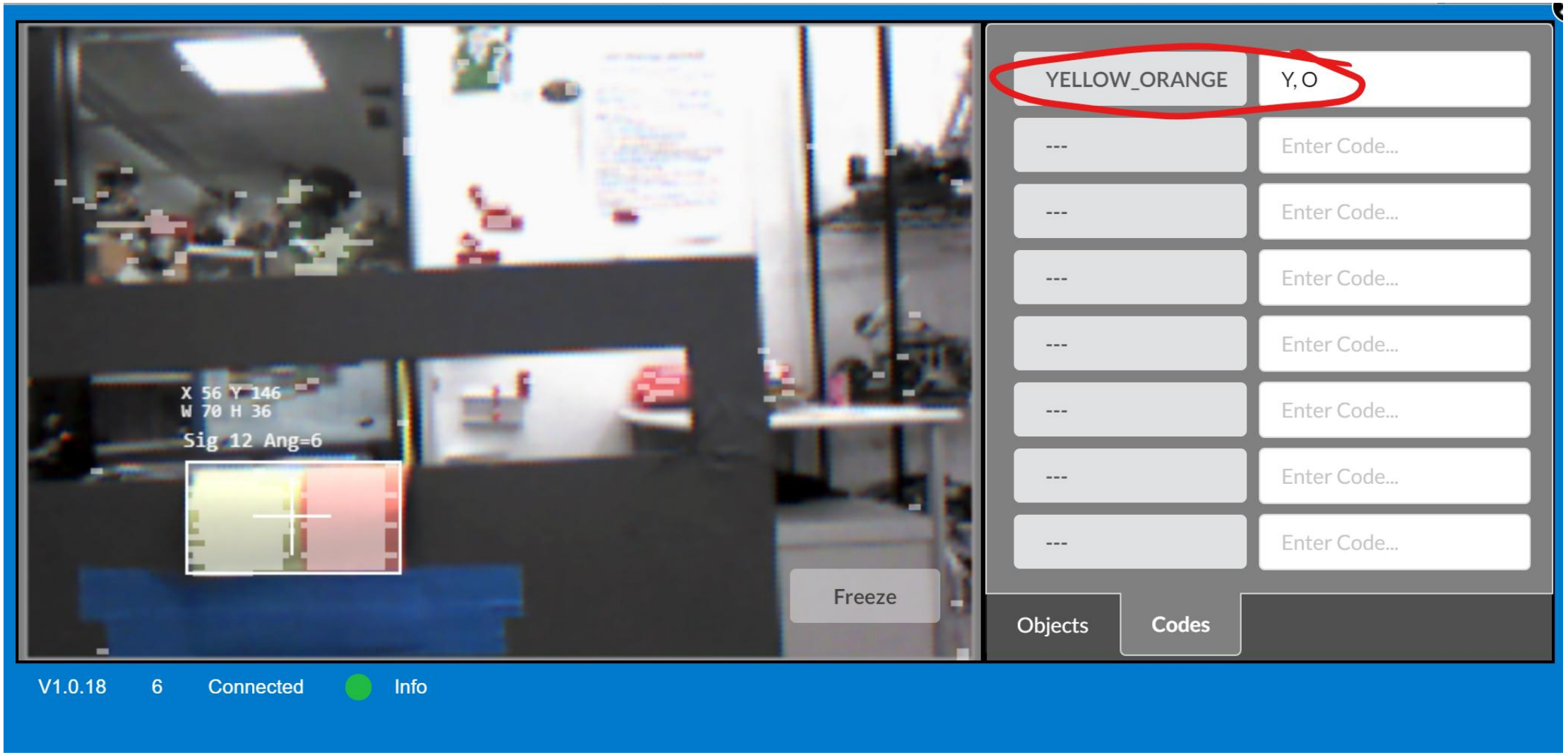
DEMO

The VEX camera identifies objects for up to seven color signatures and returns a list of detected objects with their color signature ID, size, and location. You will need to do some experiments (or online research) to find the resolution of the camera and the orientation of the pixel axes.

Be careful when you're navigating with color!



Color codes can be used for greater specificity



There are other ways to represent color