

Introduction to Computer Vision

RBE 1001

Overview

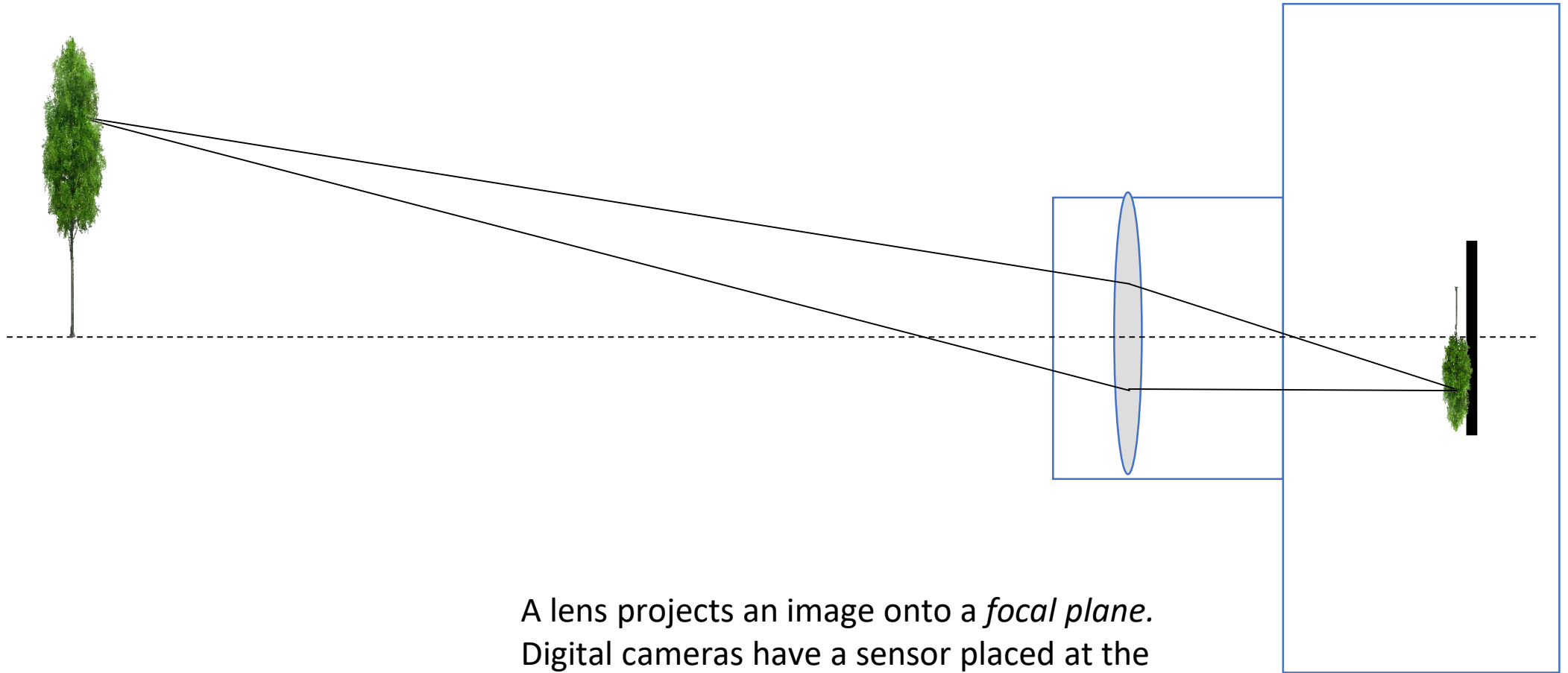
- Demos
- Camera basics
- VEX image sensor

Examples of the things you can do with a camera

Examples of the things you can do with a camera

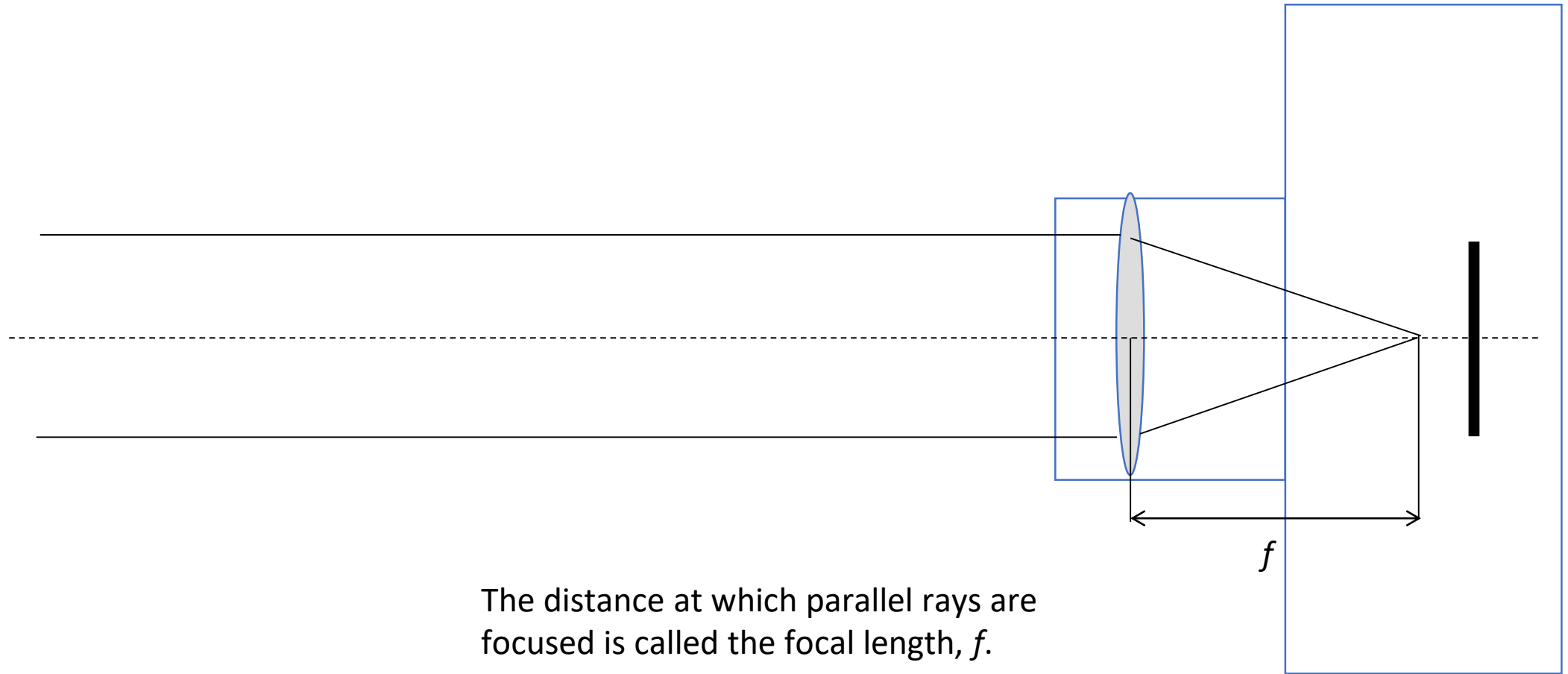
- Object detection
- Object recognition
- Face detection/recognition; eye tracking
- Motion detection
- Orientation
- AR/VR

Camera fundamentals

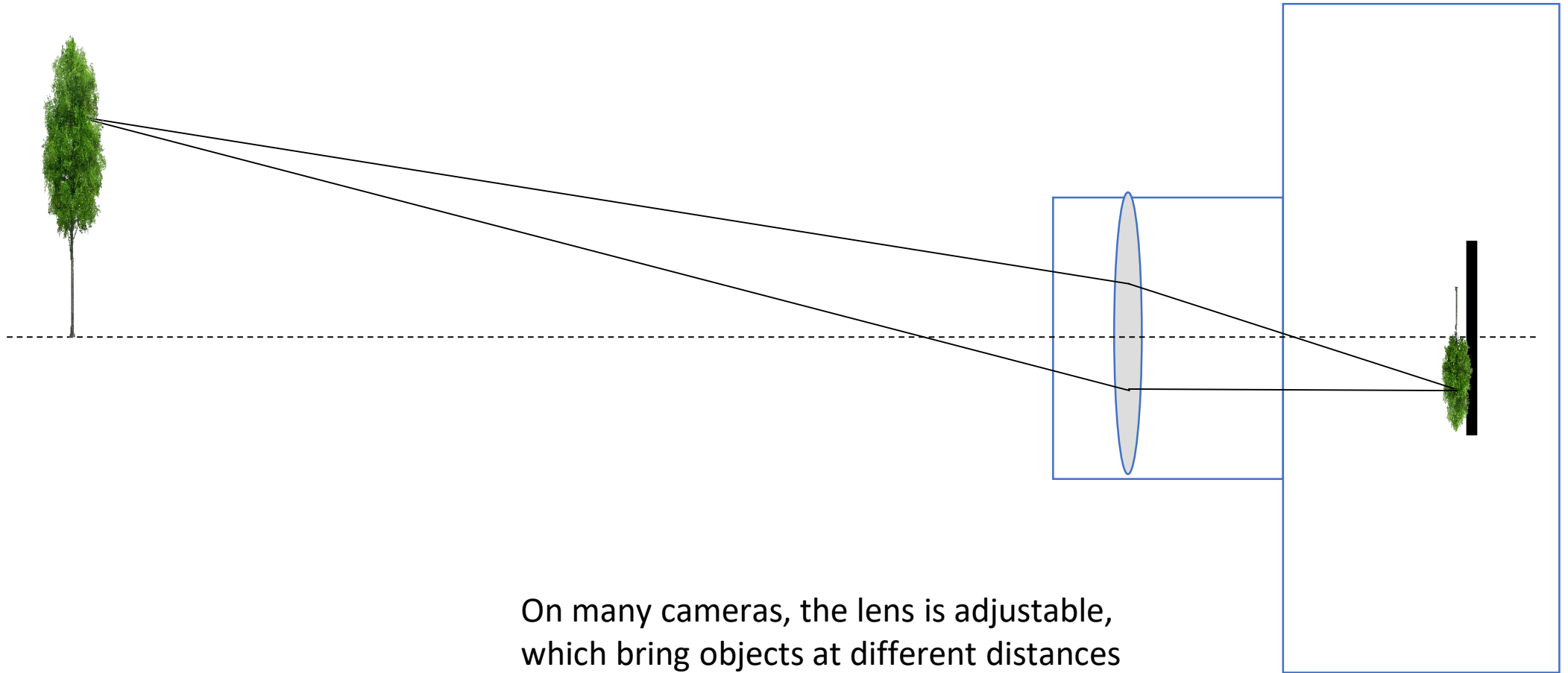


A lens projects an image onto a *focal plane*.
Digital cameras have a sensor placed at the
focal plane to record images.

Focal length

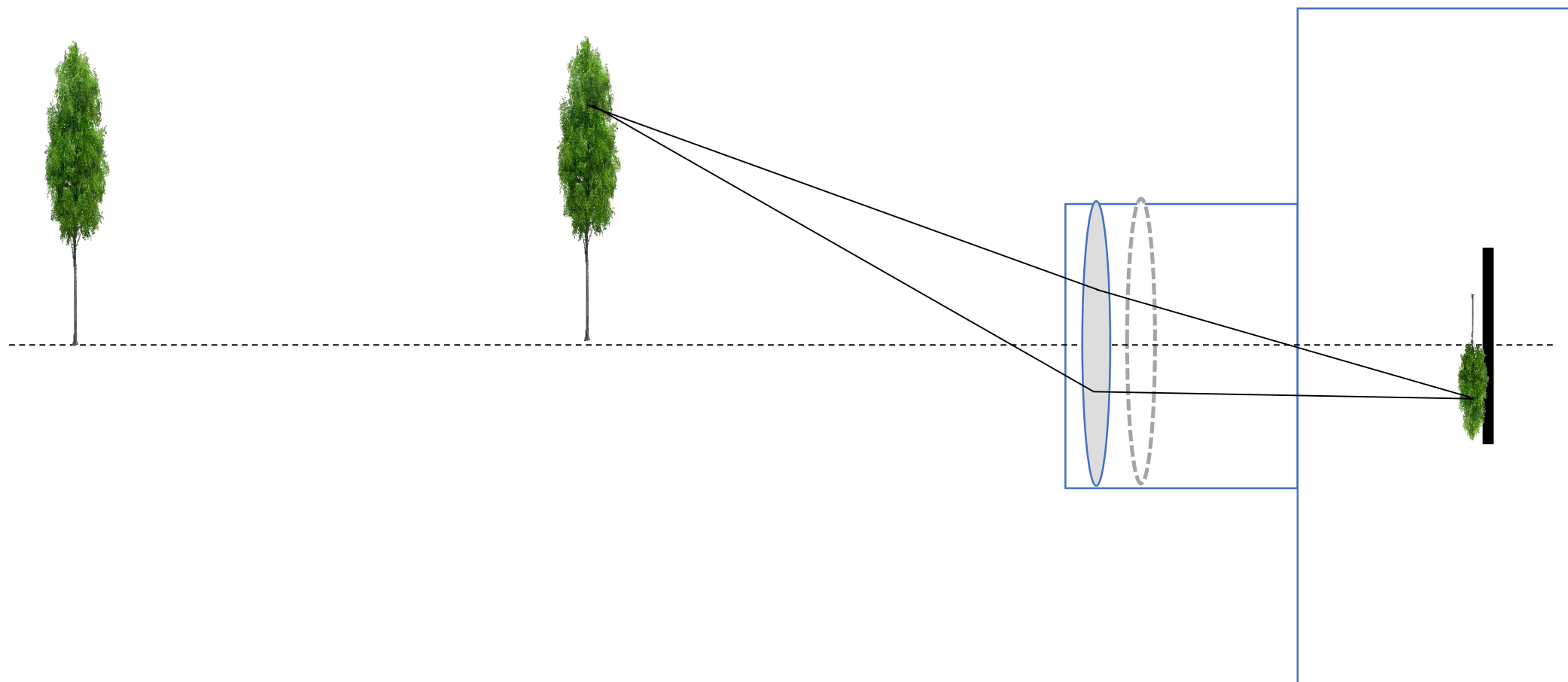


Camera fundamentals

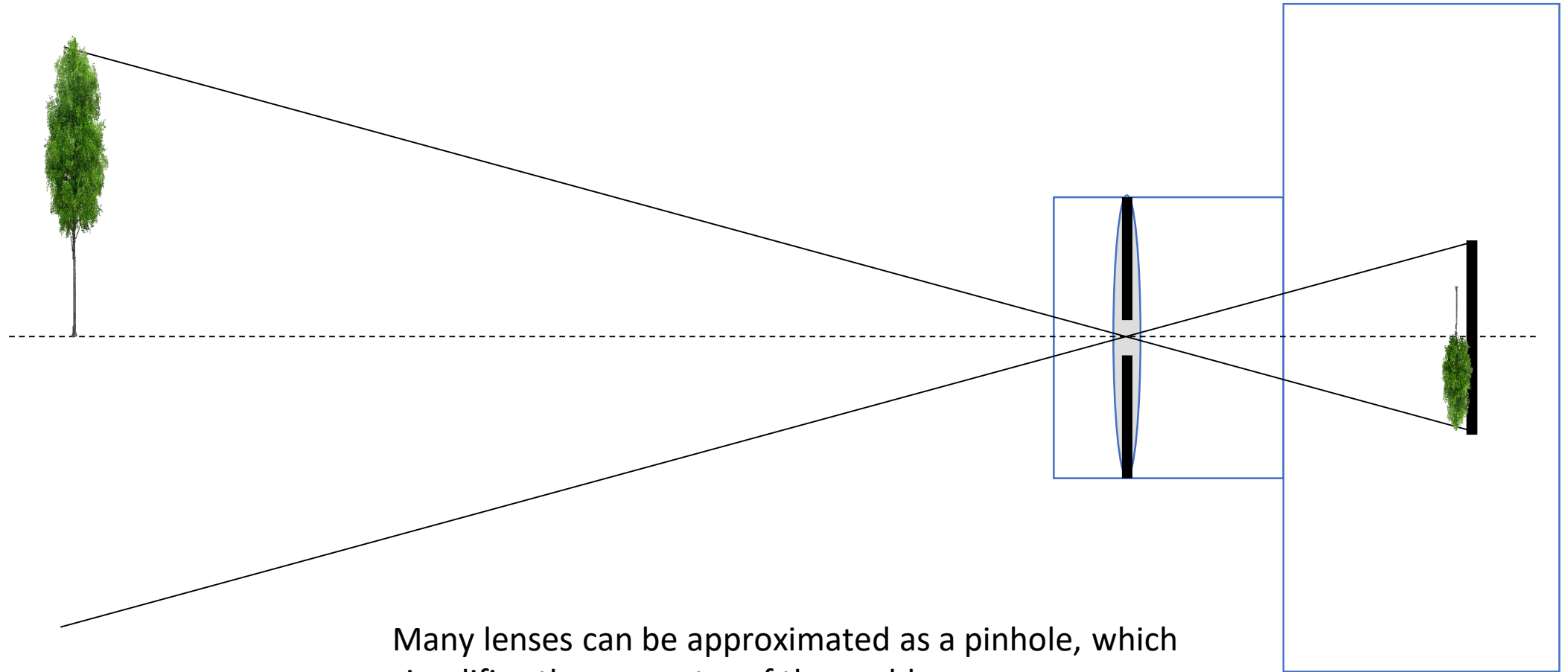


On many cameras, the lens is adjustable, which bring objects at different distances into focus on a fixed plane.

Focusing

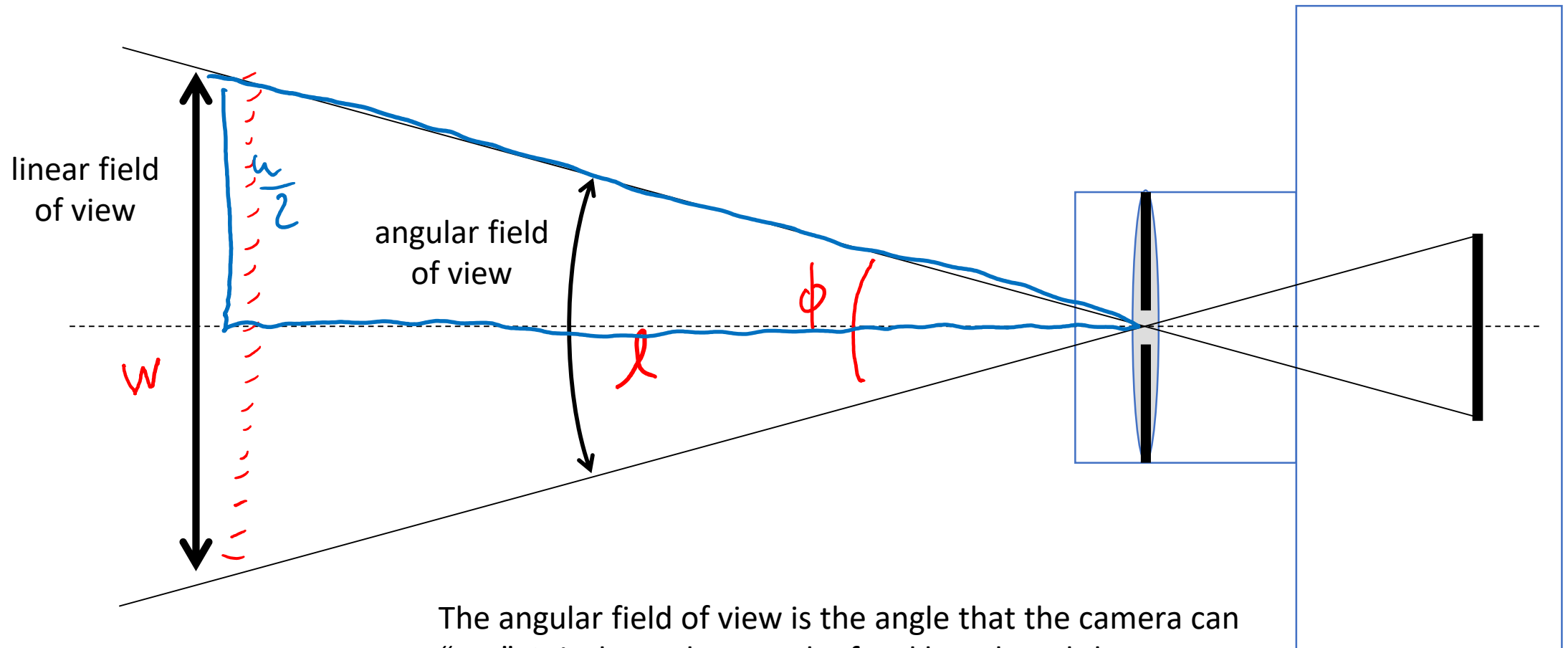


Pinhole approximation



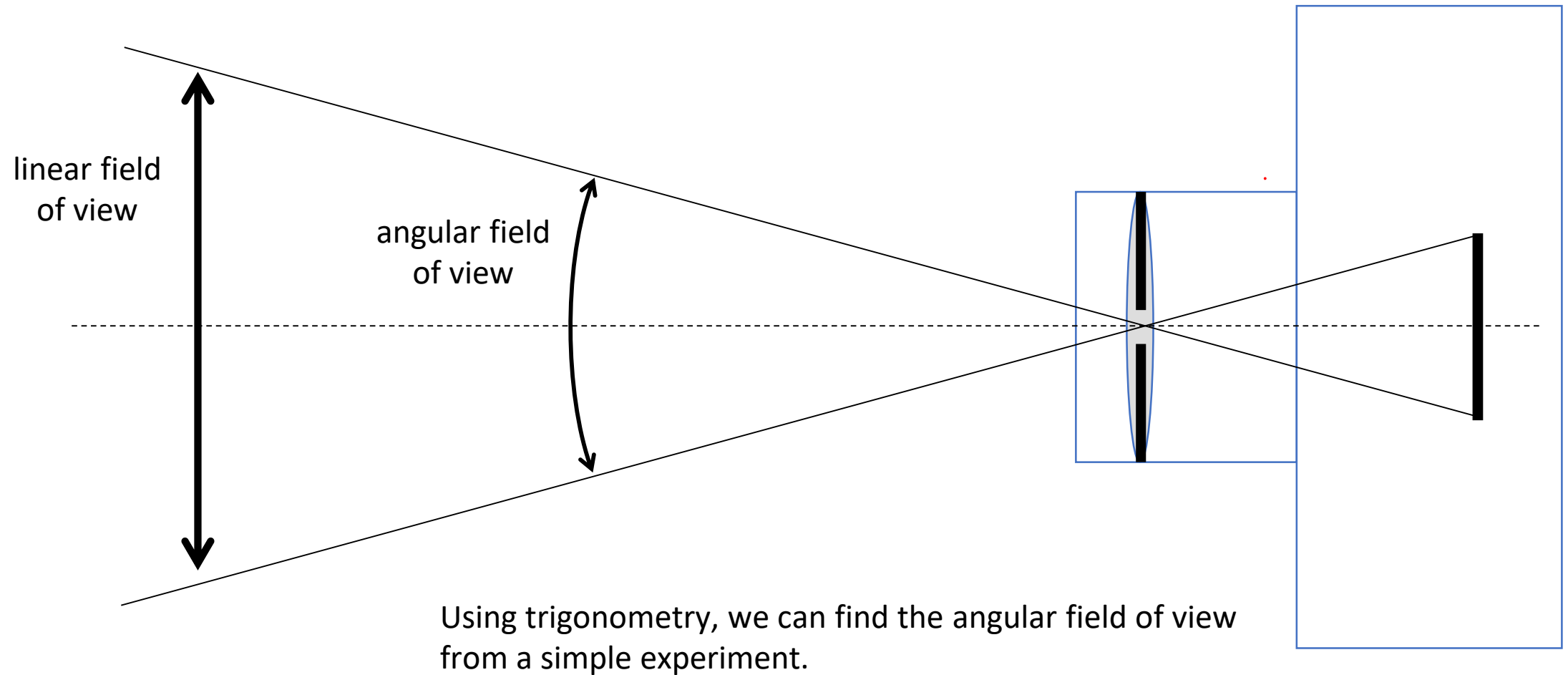
Field of View

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

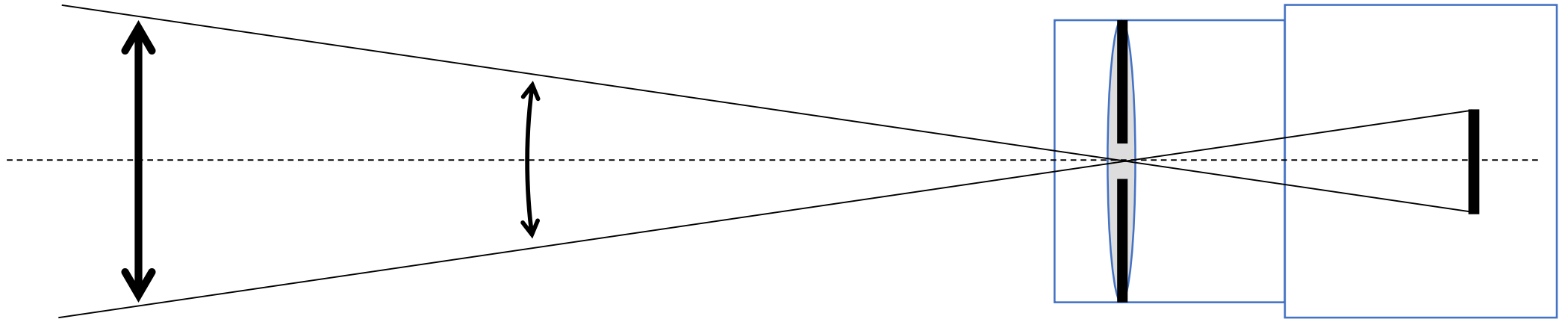


The angular field of view is the angle that the camera can "see". It is dependent on the focal length and the sensor size. The linear field of view is also dependent on the distance from the camera lens.

Field of View

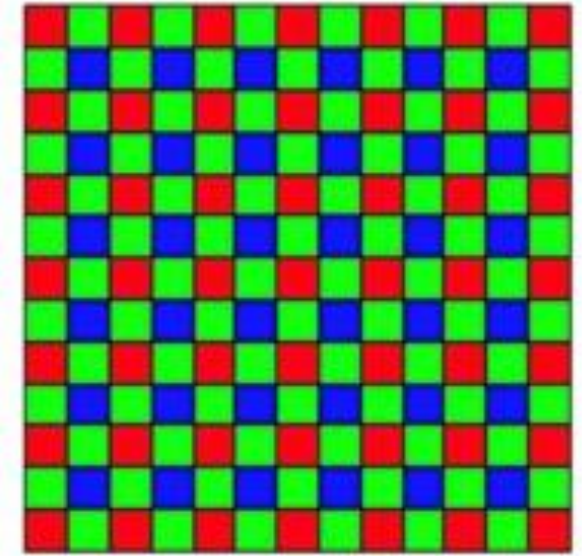
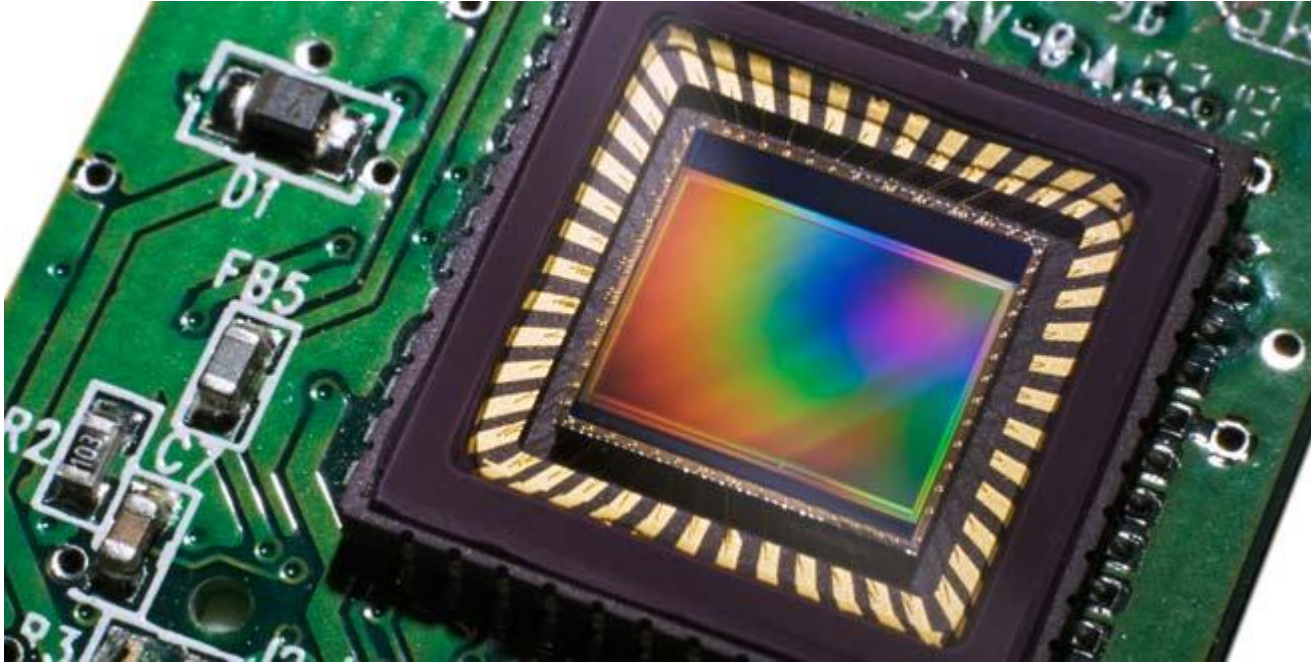


Field of View



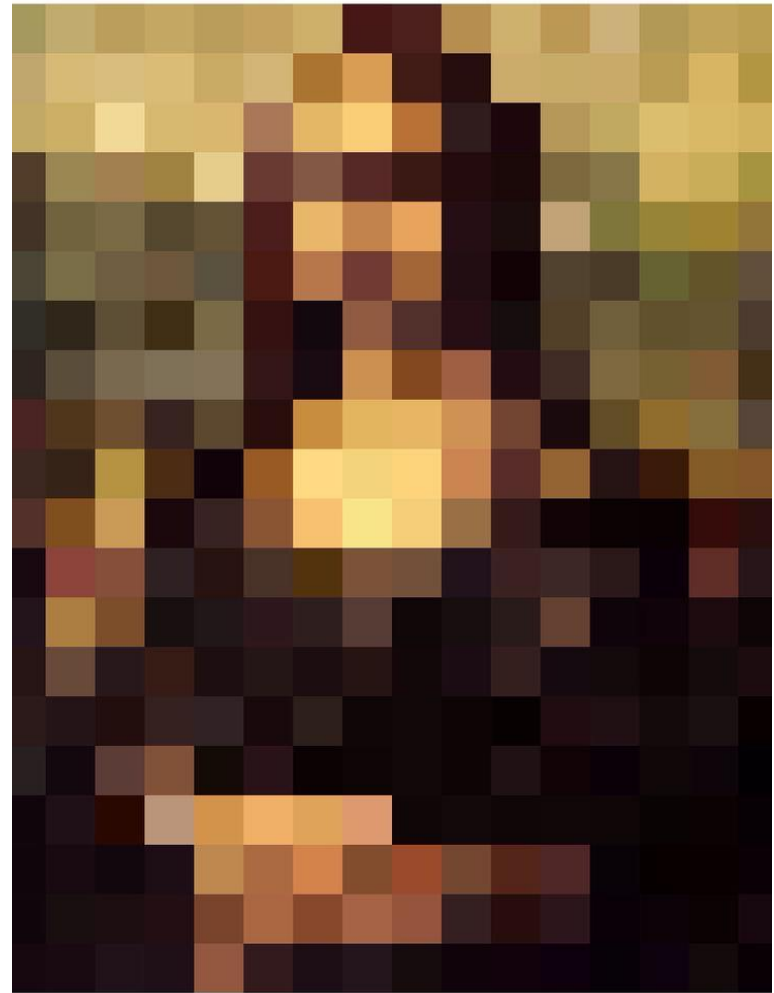
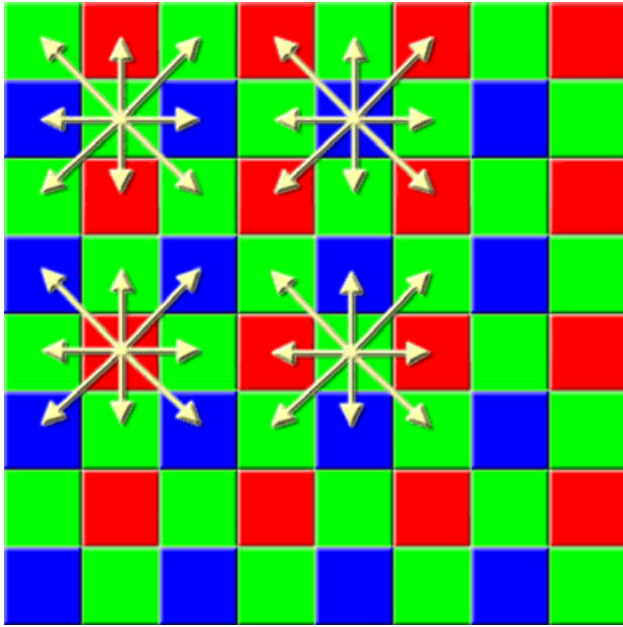
The horizontal and vertical fields of view are typically different.

The sensor



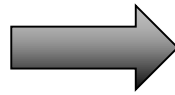
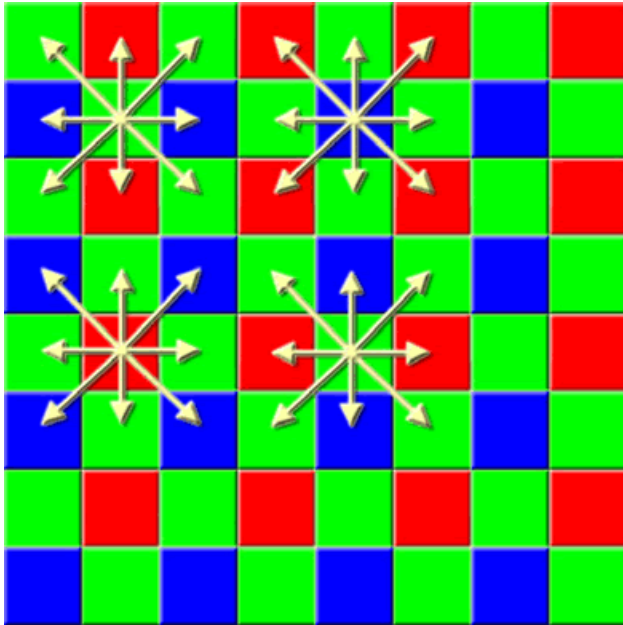
The sensor is made of a number of pixels, which are light sensitive electronic elements. Typically, filters are used to separate out the RGB colors. More green pixels are used to make a more “true” color to the human eye.

Representing color



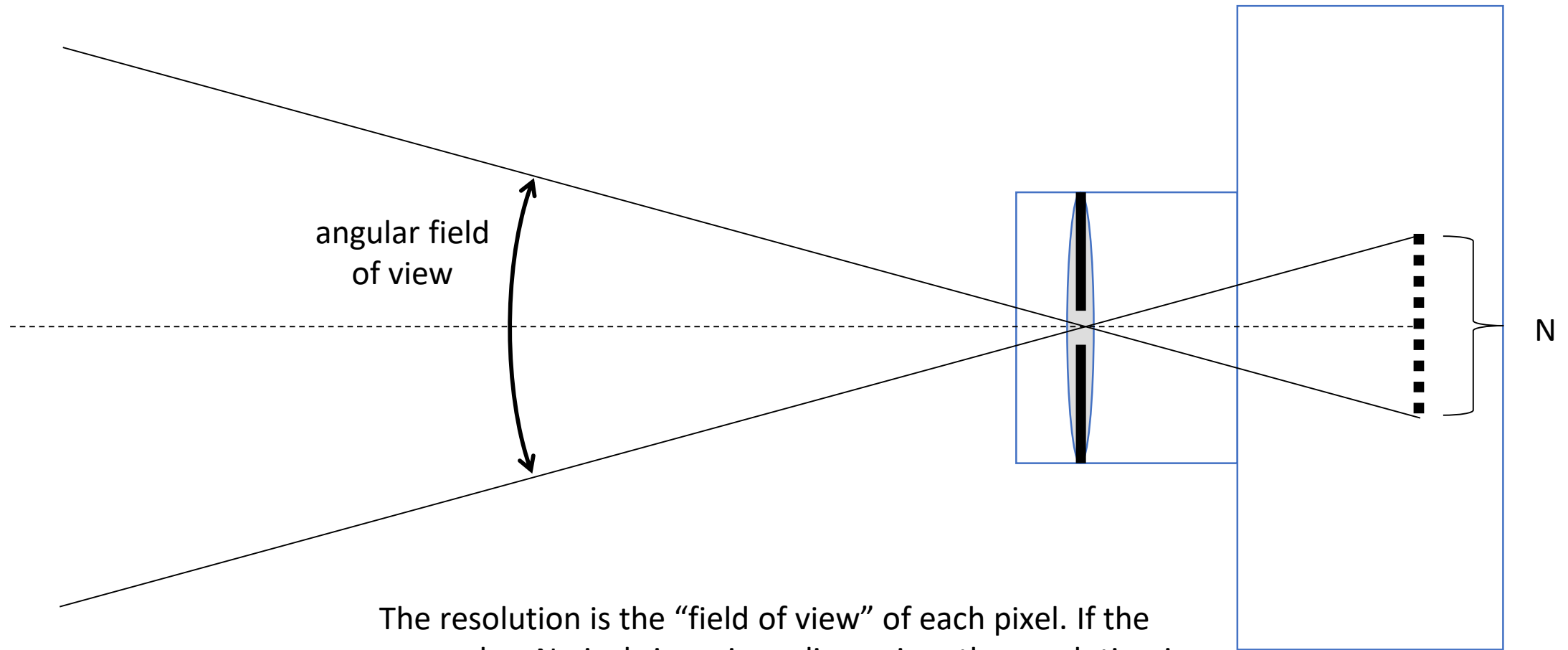
Interpolation is used to estimate the RGB signature at each pixel. The end result is an RGB signature for a rectangular region of pixels.

RGB formats



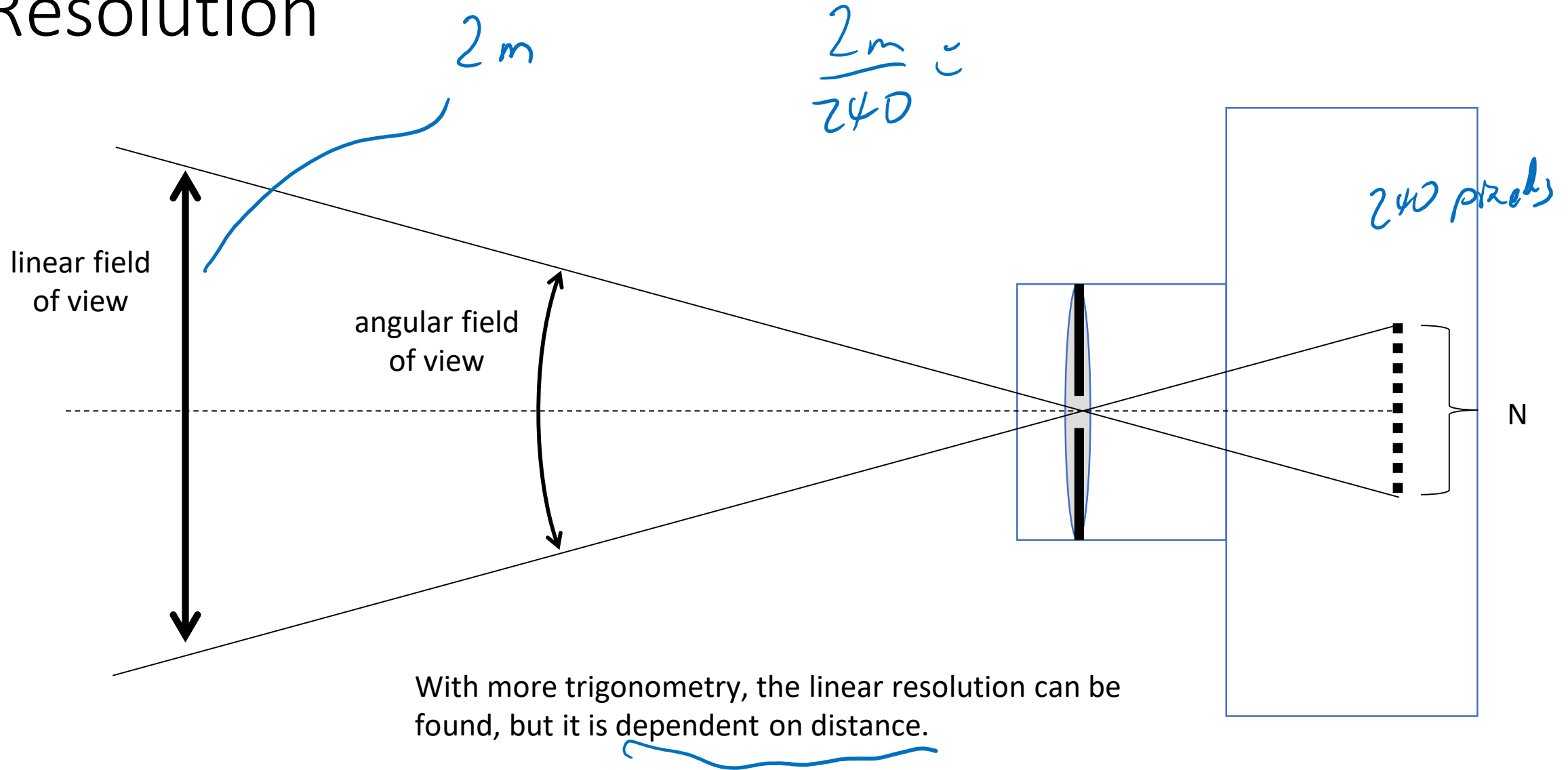
The color resolution is determined by the number of bits that are used to represent each color. Fewer bits means fewer colors can be represented, so there are bigger “jumps” between colors. The “RGB-565” format is a popular, low-memory format.

Resolution

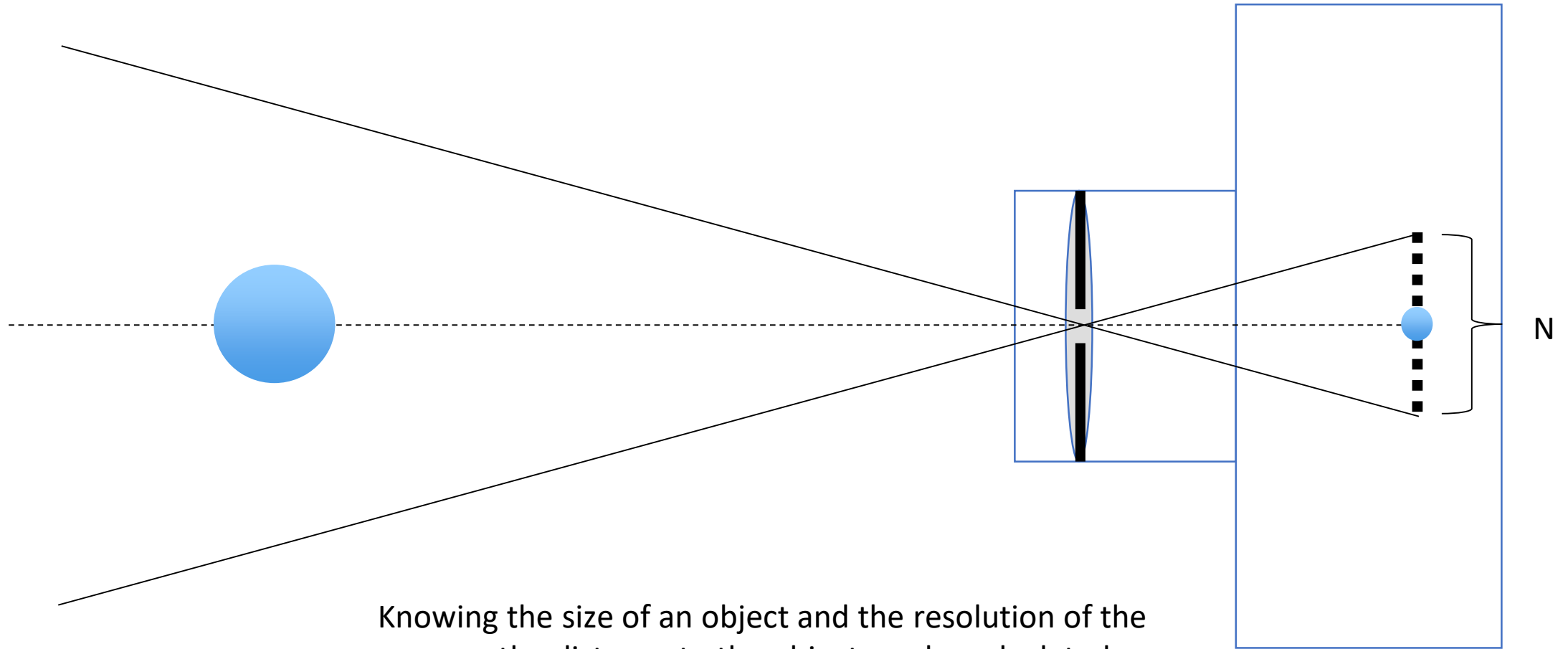


The resolution is the “field of view” of each pixel. If the sensor has N pixels in a given dimension, the resolution is the angular field of view divided by N , which is in degrees per pixel.

Resolution

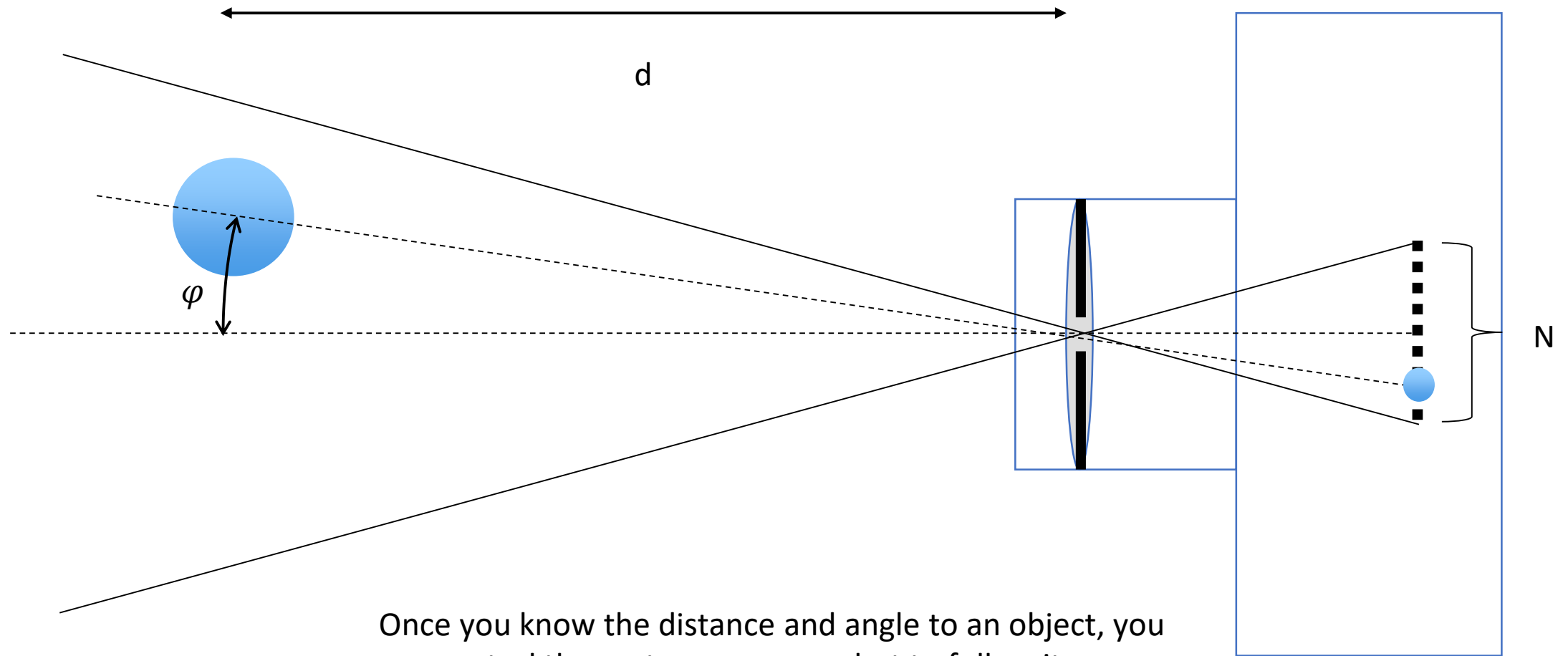


Resolution

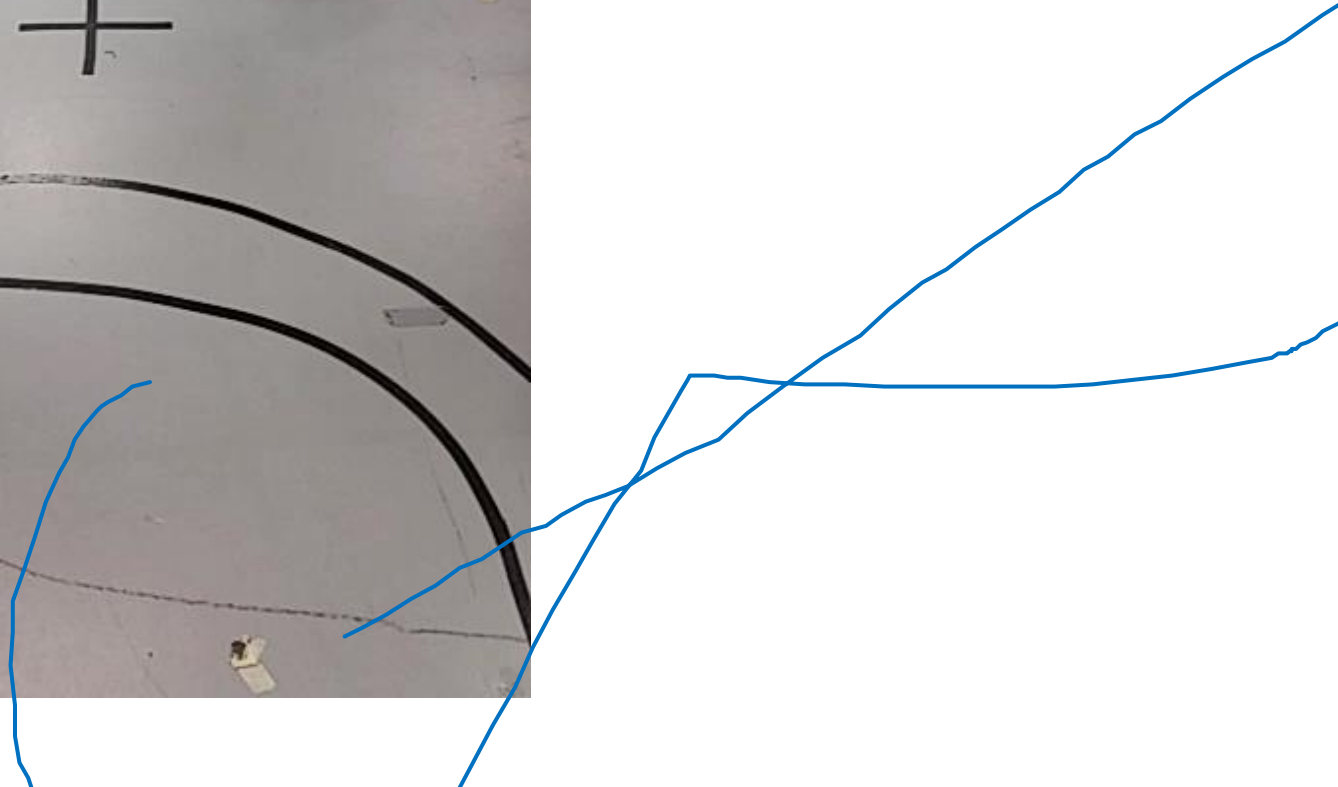
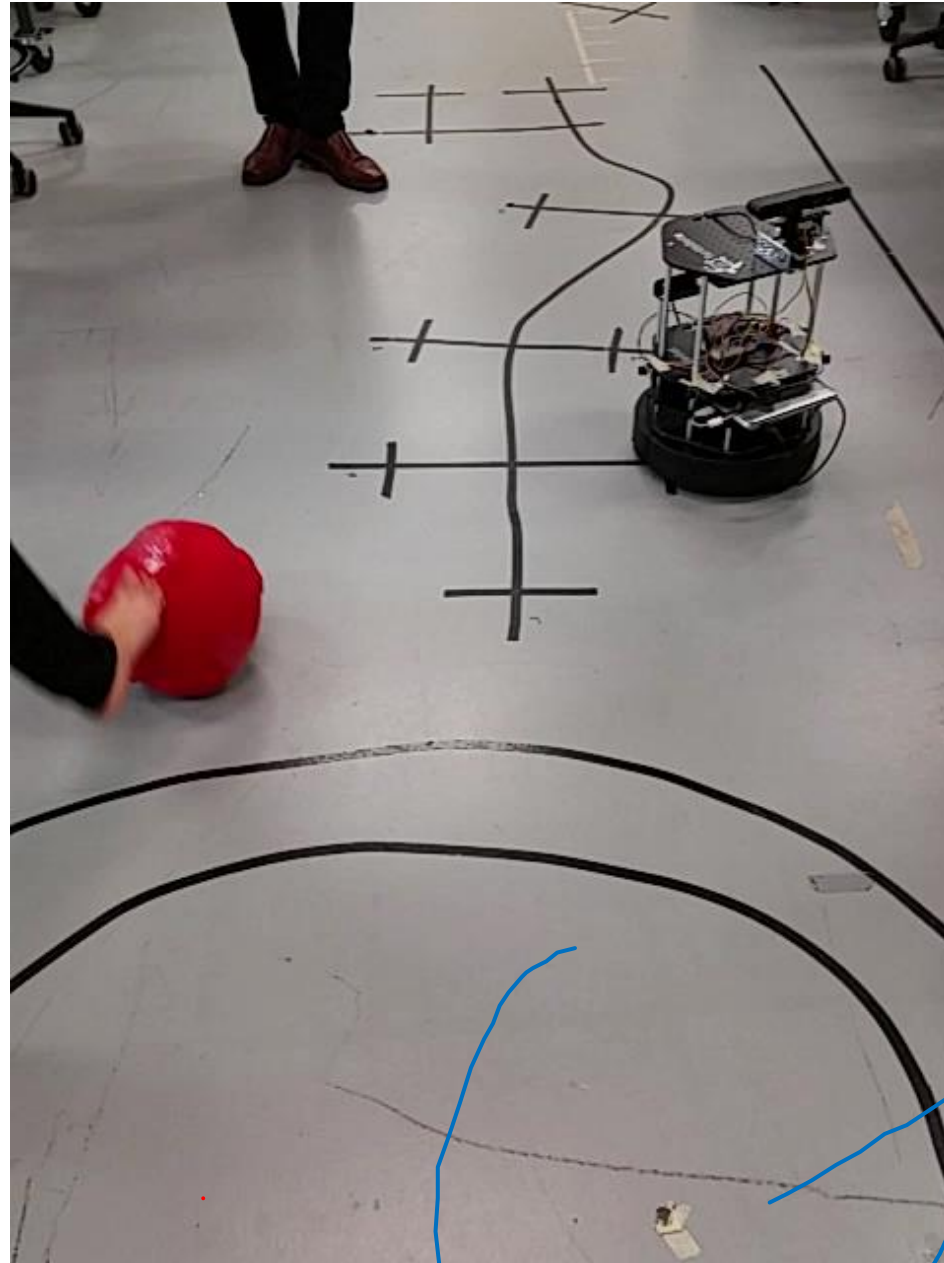


Knowing the size of an object and the resolution of the camera, the distance to the object can be calculated.

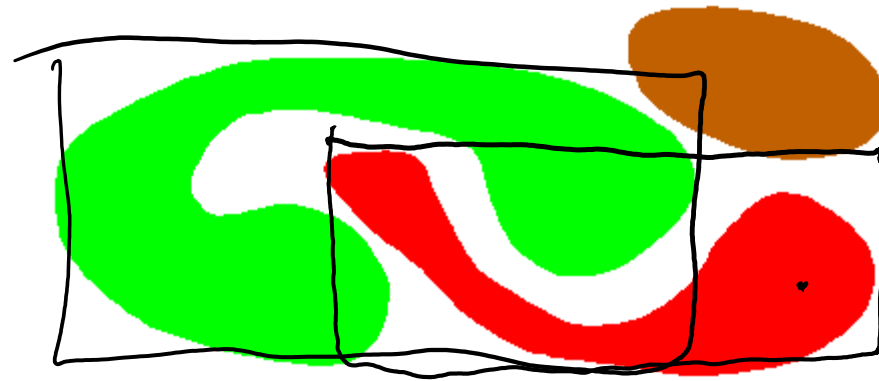
Object following



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!

The screenshot displays a video analysis interface. The main window shows a video feed with two tracked objects. The top object has coordinates X 44 Y 64, W 12 H 6. The bottom object has coordinates X 94 Y 146, W 32 H 34. A 'Freeze' button is visible at the bottom right of the video area. The bottom status bar shows 'V1.0.18', '6', 'Connected', and a green status indicator.

On the right, a control panel contains a table of objects and their settings. Red annotations highlight specific elements:

- A**: A red circle around the 'Clear' button for the first object (Y).
- B**: A red circle around the 'Set' button for the seventh object (s7).
- C**: A red circle around the 'Codes' tab.

Object	Set	Clear	Navigation
Y	<input checked="" type="checkbox"/> Set	Clear	↔
O	<input checked="" type="checkbox"/> Set	Clear	↔
s3	<input type="checkbox"/> Set	Clear	↔
s4	<input type="checkbox"/> Set	Clear	↔
s5	<input type="checkbox"/> Set	Clear	↔
s6	<input type="checkbox"/> Set	Clear	↔
s7	<input type="checkbox"/> Set	Clear	↔
Clear All		Brightness	↔

At the bottom of the control panel, there are two tabs: 'Objects' and 'Codes'.

Color codes can be used for greater specificity

The screenshot displays a video analysis software interface. On the left, a video frame shows a scene with a color calibration chart in the foreground. The chart has a white crosshair and is labeled with coordinates: X 56 Y 146, W 70 H 36, and Sig 12 Ang=6. A 'Freeze' button is located below the video frame. On the right, a panel lists color codes. The first entry, 'YELLOW_ORANGE', is circled in red, with its corresponding code 'Y,O' also circled. Below this are seven entries with '---' and 'Enter Code...' text. At the bottom of the right panel are 'Objects' and 'Codes' tabs. The bottom status bar shows 'V1.0.18', '6', 'Connected', and an 'Info' button.

Color Code	Code
YELLOW_ORANGE	Y,O
---	Enter Code...
---	Enter Code...
---	Enter Code...
---	Enter Code...
---	Enter Code...
---	Enter Code...
---	Enter Code...

Objects Codes

V1.0.18 6 Connected Info

There are other ways to represent color

