



Range and Bearing Lab

Lab Outline

- ◉ Why range and bearings?
- ◉ Ranges: the theory
- ◉ But...
- ◉ Alternate Solution: Lookup Table
- ◉ Recording the data
- ◉ Using the table to find your range
- ◉ Calculating the bearing
- ◉ That's all you have to do!

Why ranges and bearings?

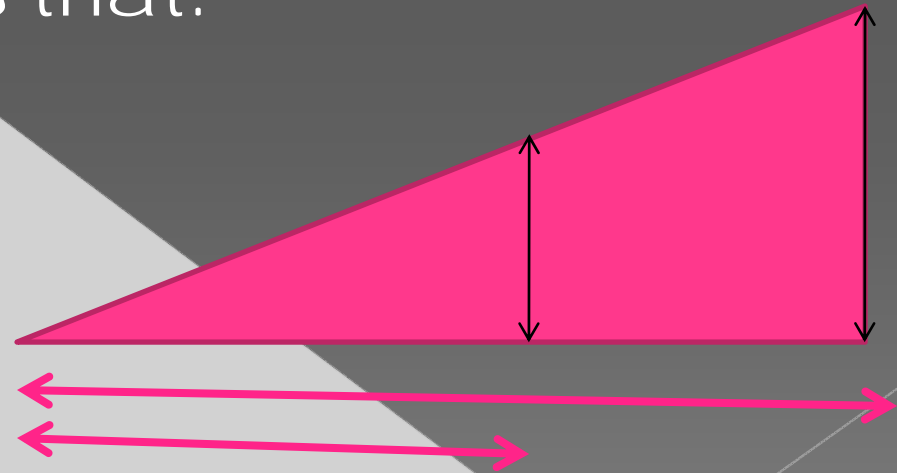
- It's difficult to reconstruct and compare images
- Instead, we can calculate bearing and range from two known points pretty easily.
- The challenge then lies in figuring out what the range and bearing to seen object is.

Ranges: the theory

- Calculating the range is a simple math problem
- Similar triangles tell us that:

$$\frac{h_{real}}{h_{seen}} * l_{focal}$$

- We know the height on screen, the real height, and we control the distance to the focal point, this should be easy



But...

Lens Construction

Focal Length 3.7 mm

Lens Iris F/2.0

Focus Adjustment Automatic

- The cameras we use this year have autofocus!
- Technically, some sort of software controls the auto-focus, but player does not let you access that control.
- No clever mathematics can solve this problem for us ☹

Alternate solution: lookup tables

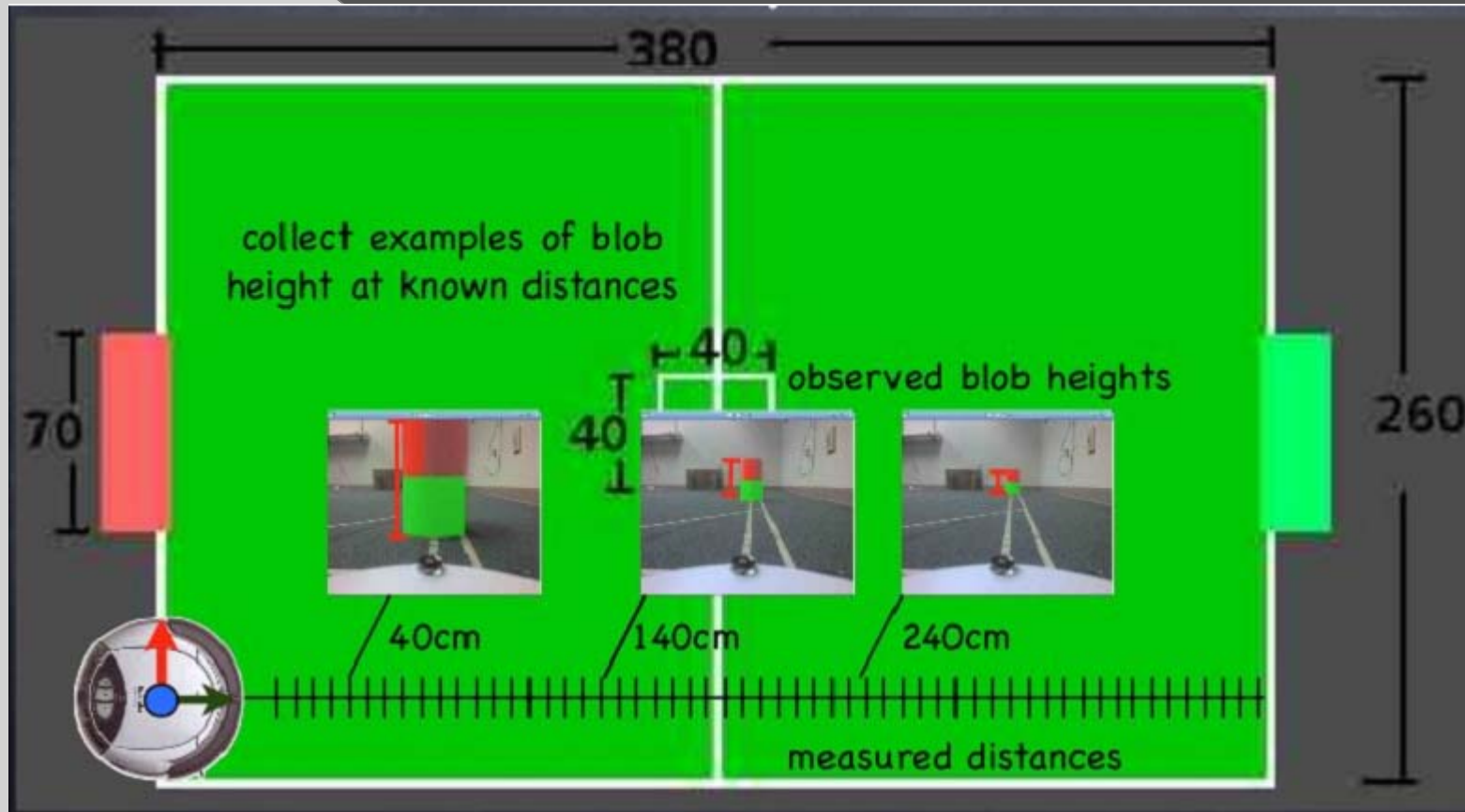
- Because we cannot solve this equation, we have to rely on sampling to find our ranges.
- The table will contain recorded on screen heights for each object at incremental distances
- Given a height measurements on a landmark, the robot can then look up its distance to it

distance	height	width	area
25	239	144	29807
30	211	122	21241
35	206	114	20141
40	188	95	11527
45	167	88	9963

Building the table

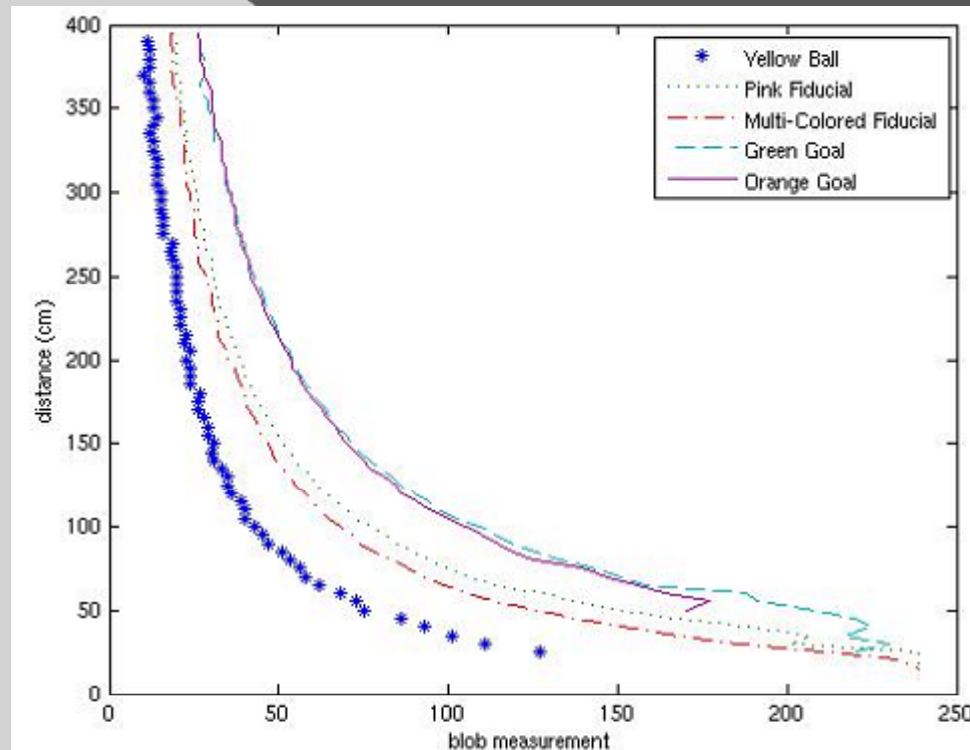
- ◉ Unfortunately, you guys all have to build this lookup table (sorry Alex, no tool provided).
- ◉ In order to do this, you will have to set each landmark at known distances and record the height of the blob(s) seen by the robot
- ◉ We suggest creating a client that outputs the blob heights for you as a method to build your table

Building the table (ct'd)



Using the table

- Your data will look something like this:



Using the table (ct'd)

- ◉ In order to use this data, you have to figure out what to do with measured height that do not fall on a measured data point.
- ◉ There are several options:
 - > Nearest neighbor regression
 - > RBF interpolation
 - > Spline Interpolation
 - > And many more...

Using the table (ct'd)

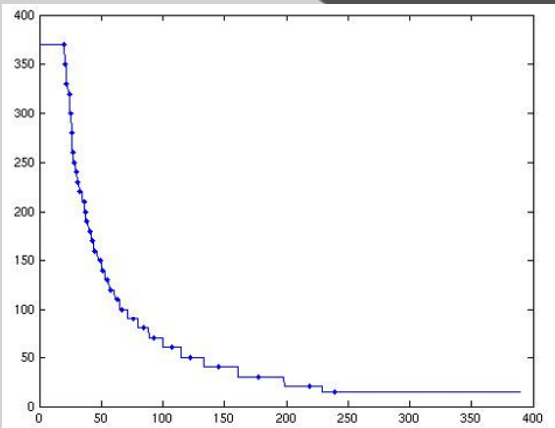


Figure 4: Range prediction using a nearest neighbor regressor.

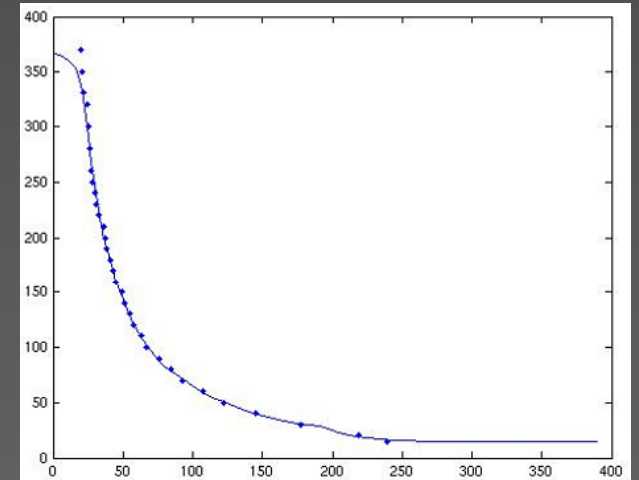


Figure 5: Range prediction using RBF interpolator.

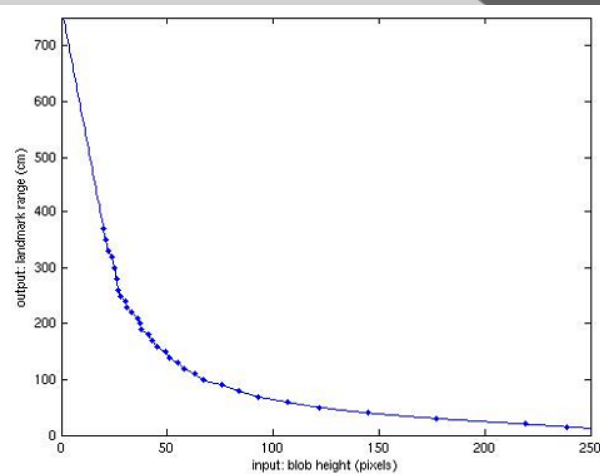


Figure 6: Range prediction using spline interpolator.

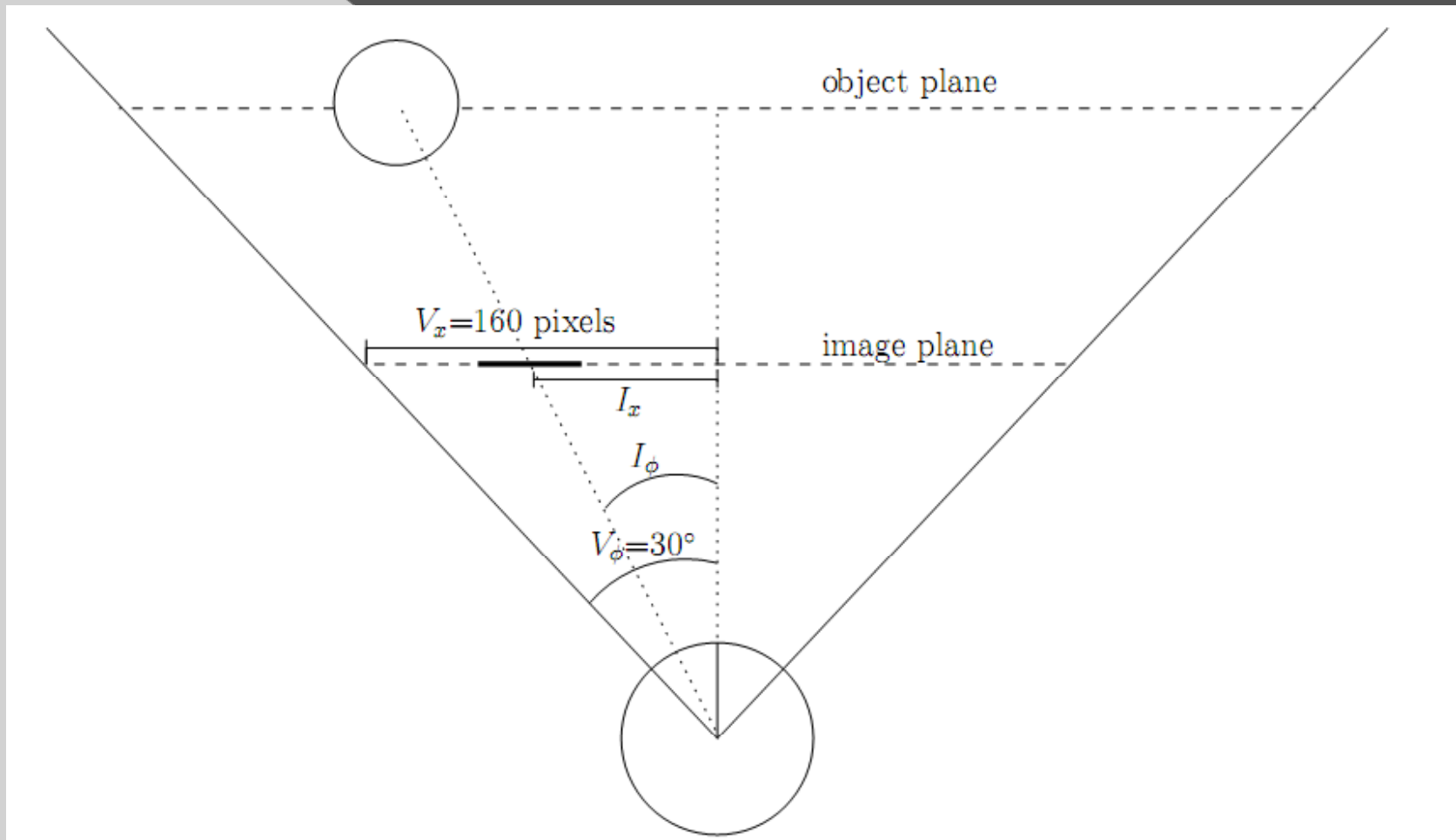
Calculating the bearing

- To calculate the bearing, it is suggested to use the relative proportions of the robot camera field of view.
- Knowing the camera has a 60 degrees FOV, with a screen resolution of 160 and a know distance from blob center to screen center, we can use the following formula:

$$I_x = V_x - \text{blob_center}$$

$$I_\phi = \frac{I_x}{V_x} * V_\phi$$

Calculating the bearing (ct'd)



That's it!

- This is all you have to do for your milestone (due next Friday, 11/6)
- We will set your robot on the field somewhere and a few objects will be set in its field of view.
- Your job is to give us accurate range and bearing for each of the visible objects, no more, no less.
- Question?