Final project system characterization

Arena (not needed for report)

For a 5 m x 5 m arena, each big tile

0.25 m x 0.25m ← for my zoom level

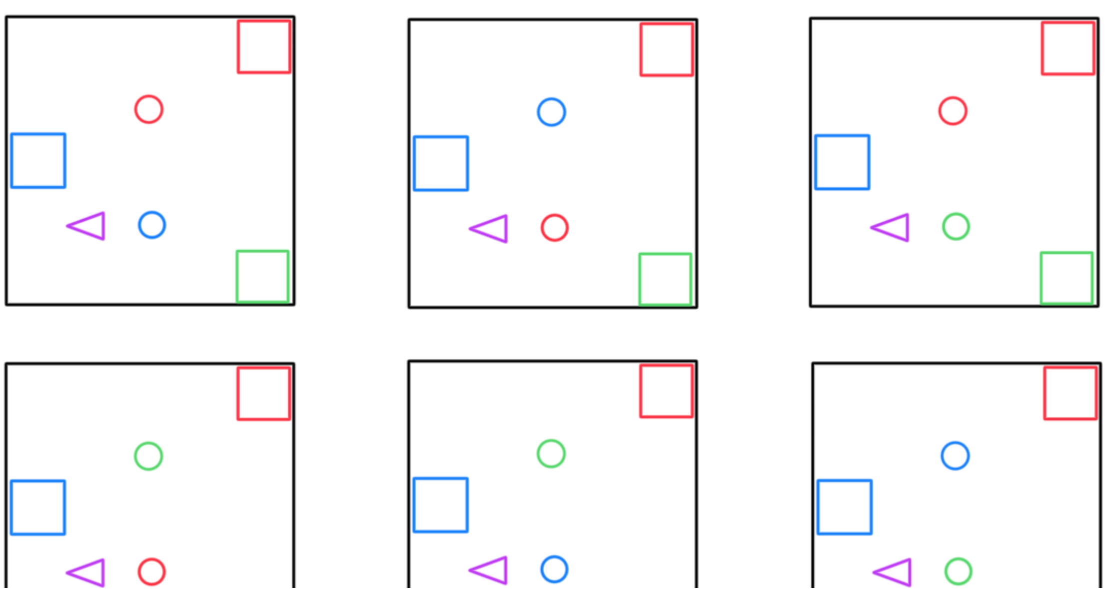
The walls may have a thickness of 0.1–0.2 m?

Ultrasonic sensors

From observations

$$|d_{actual} - d_{sensor}| = 0.1 - 0.2\,m$$ ← may relate to wall ticknees?

or perhaps due to position offset



Algorithm 1 (not used)

- Spin until colored object is detected
- Given color of target_object determine pre_plow_position
- Plan the path to get to pre_plow_position avoiding wall and objects. Treat objects as obstacles
- Plow object to storage_location
  - Use robot position and storage location to plan path
  - After reaching destination, move backwards a little bit to de engage from object
- Go to home posititon (0,0)
- Repeat loop 1 more time

Functions (not used)

- get_robot_location( )
- get_object_location(obj_distance, obj_angle)
- determine_pre_plow_position(object_location, color)
- create_map(robot_location, object_location, ...)
- determine_path(pre_plow_position, ...)

Object sensors

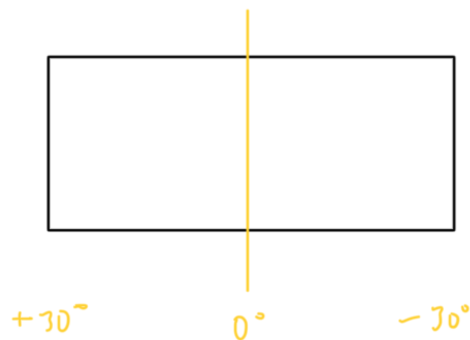
- Measure distance with respect to center of robot
- When robot is in contact with object

$d_{min} \approx 0.38\ m$ ← minimum distance

- Maximum detected distance and angle

  $d_{max} = 2\ m$ ← NaN in $d > 2m$

- Angle range $(-30, 30)$

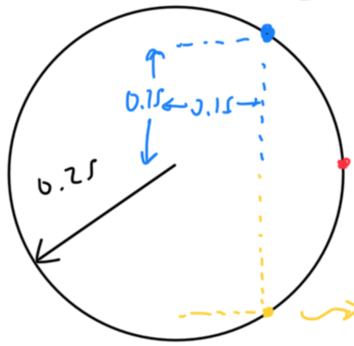


← camera image

Distance sensors

- Range $(0.02, 2m)$ ← NaN if $d > 2m$
- Not affected by objects
- Position in robot:

left sensor $(0.15, 0.15)$

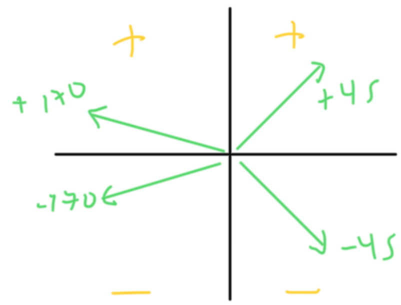


← front sensor $(0.25, 0)$

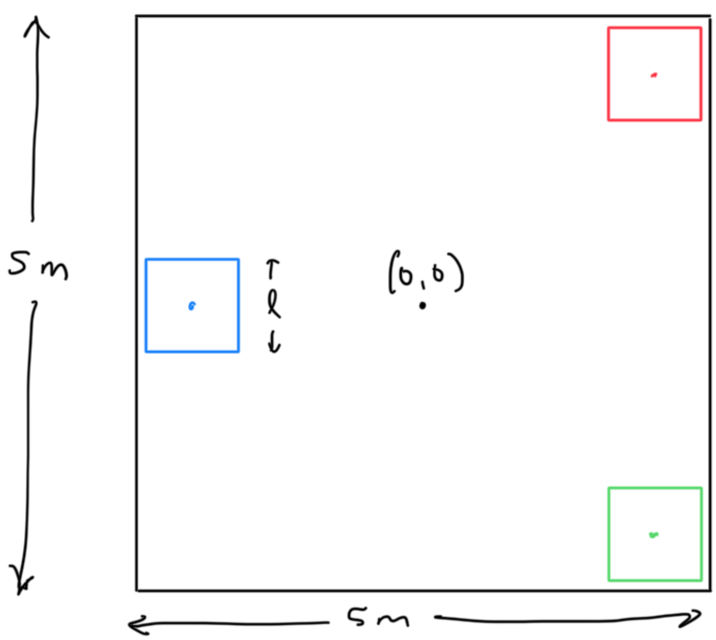
rigth sensor $(0.15, -0.15)$

Odometer

- Provides x, y position at all times
- Angle positive counter-clockwise



Collection Zones



All zones have dimension

$l \times l$

where
$l \approx 0.84$

Red Zone Center $\rightarrow$ r_z_c

r_z_c_x = 2.5 − 0.84/2 = 2.08

r_z_c_y = 2.5 − 0.84/2 = 2.08

So $\boxed{r\_z\_c = (2.08, 2.08)}$

Blue zone center $\rightarrow$ b_z_c

$$b\_z\_c\_x = -2.5 + \frac{0.84}{2} = -2.08$$
$$b\_z\_c\_y = 0$$

So $\boxed{b\_z\_c = (-2.08, 0)}$

Green zone center $\rightarrow$ g_z_c

$$g\_z\_c\_x = 2.5 - \frac{0.84}{2} = 2.08$$
$$g\_z\_c\_y = -2.5 + \frac{0.84}{2} = -2.08$$

So $\boxed{g\_z\_c = (2.08, -2.08)}$

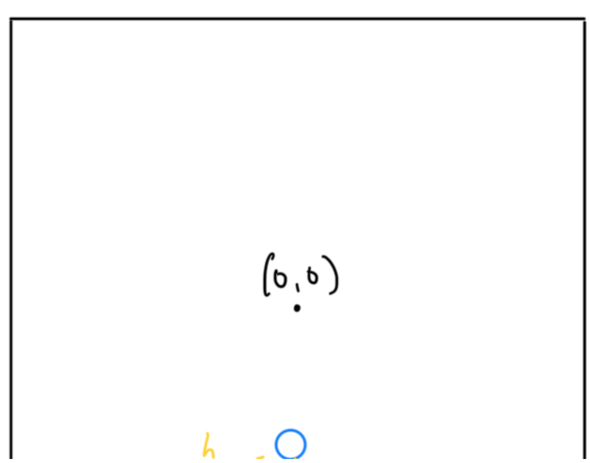
Determine Object Location (not used)

Given object angle and distance, determine location

We know α, h

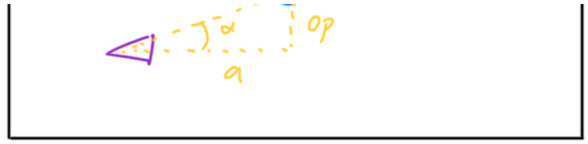
$$\cos(\alpha) = \frac{op}{h}$$

$$\boxed{op = h\cos(\alpha)}$$



$\text{sen}\,\alpha = \frac{\quad}{h}$

$$\boxed{a = h \cdot \text{sen}\,\alpha}$$



Assuming object is a point

position object $\longrightarrow$ p_obj
position robot $\longrightarrow$ p_rob

$$\boxed{\begin{aligned} p\_obj\_x &= p\_rob\_x + h \cdot \cos\alpha \\ p\_obj\_y &= p\_rob\_y + h \cdot \text{sen}\,\alpha \end{aligned}}$$

Example

$p\_rob = (-2, -2)$
$\alpha = 30 \ (\pi/6)$
$h = 1$

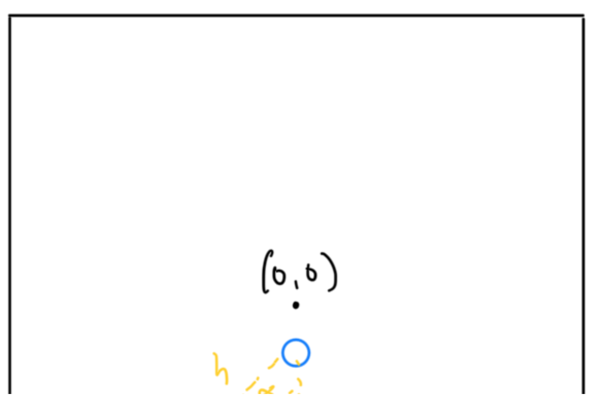
$p\_obj\_x = -2 + 1 \cdot \cos 30 \approx -1{,}13$
$p\_obj\_y = -2 + 1 \cdot \sin 30 = -1.5$

If robot is not oriented in the x axis direction
(not used)

$\cos(\theta+\alpha) = \frac{op}{h}$

$$\boxed{op = h \cdot \cos(\theta+\alpha)}$$

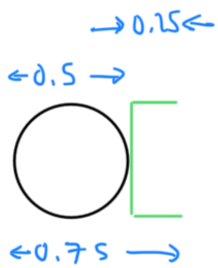
$\sin(\theta+\alpha) = \frac{a}{h}$



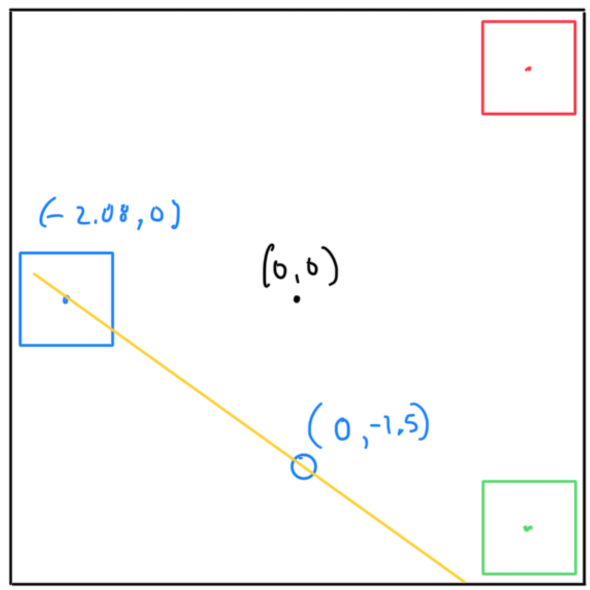
$$\boxed{a = h \cdot \sin(\theta + \alpha)}$$

$$\boxed{\begin{aligned} p\_obj\_x &= p\_rob\_x + h \cdot \cos(\theta + \alpha) \\ p\_obj\_y &= p\_rob\_y + h \cdot sen(\theta + \alpha) \end{aligned}}$$

Determine Pre-Plow Position



aproximate robots dimensions



Let's find the f(x) of a line that connects the blue object to the blue collection zone

Conditions:

$$F(x = -2.08) = 0$$
$$F(x = 0) = -1.5$$

$F(x) = mx + c$, let's find m, c

$$F(0) = \boxed{-1.5 = c}$$

$$F(-2.08) = 0 = m(-2.08) - 1.5 \Rightarrow m = \frac{-1.5}{2.08}$$

$$\boxed{m = -0.72}$$

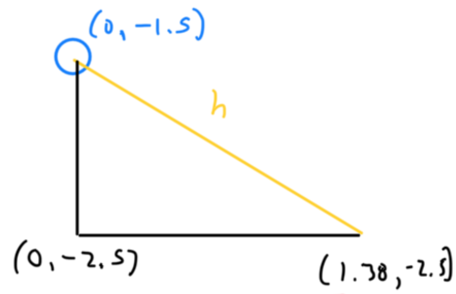
$$\boxed{F(x) = -0.72x - 1.5}$$

Can the robot fit between the object and the bottom wall when lining up with $f(x)$?

$$-2.5 = -0.72x_1 - 1.5$$

$$0.72x_1 = -1.5 + 2.5 = 1$$

$$x_1 = \frac{1}{0.72} = 1.38$$



$$h = \sqrt{1^2 + (1.38)^2} \approx 1.7$$

The robot should be able to fit in this position. In cases where there is not enough space for the robot we could use a different line that arrives at the collection zone but not in the centroid of the zone.

Let's choose $\frac{1.38}{2}$ as the pre-plow x position

$$f\left(x = \frac{1.38}{2}\right) = f(0.85) = -0.72 \cdot (0.85) - 1.5 = -2.11$$

So our pre-plow position is

$$p\text{-}p\text{-}p = (0.85, -2.11) \leftarrow \text{for Arena}(\_, \underbrace{\text{blue}})$$

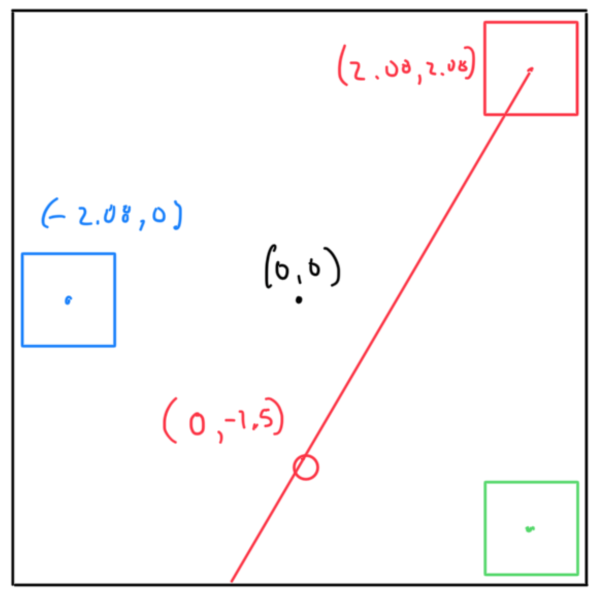
second color is blue

We need to determine six lines for the following conditions:

- Arena (_, blue)
- Arena (_, red)
- Arena (_, green)
- Arena (blue, _)
- Arena (red, _)
- Arena (green, _)

test first, hardest conditions!

Let's fine the line for Arena (_, red)



Conditions

$f(x = 2.08) = 2.08$

$f(x = 0) = -1.5$

$f(x) = mx + c$

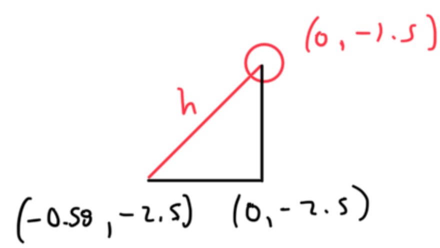
$f(0) = \boxed{-1.5 = c}$

$f(2.08) = 2.08 = m(2.08) - 1.5$

$$\boxed{m = \frac{2.08 + 1.5}{2.08} = 1.72}$$

so

$$\boxed{f(x) = 1.72x - 1.5}$$



$f(x_1) = -2.5 = 1.72x_1 - 1.5 \Rightarrow x_1 = \frac{-1}{1.72} = -0.58$

$h = \sqrt{0.58^2 + 1} = 1.16$

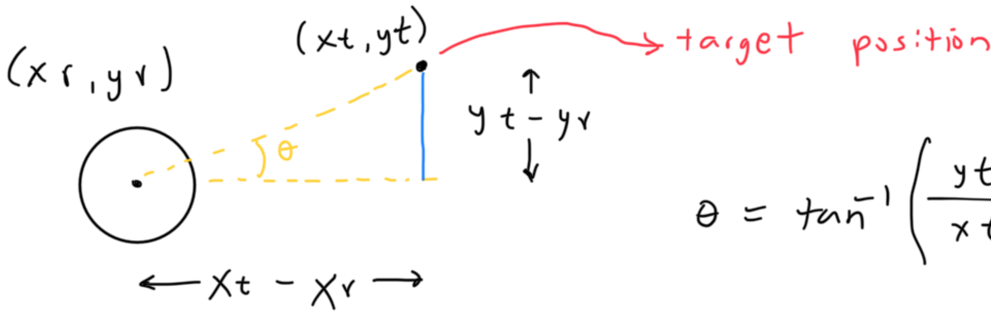
Tight fit for the robot. We need to test our path planning algorithm in this condition

Command Movement Algorithm

- Given a path of straigh segments (set of x-y coordinates)
- Loop over each segment
  - Spin robot to point to segment end
  - Move forward until segment end is reached
    - Check if x-y are within target range

↳ tolerance

Determine segment end angle (not used)



$$\theta = \tan^{-1}\left(\frac{yt - yr}{xt - xr}\right)$$