# COMP105P
# 5. Mapping with the robots

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To use dead reckoning to calculate the robot's position, you need to call get_motor_encoders in the main loop of your code, constantly reading the motor encoders as you drive, and calculating each small change in position and angle.

When the robot moves in a straight line (the encoders read the same thing), it's easy to calculate the change in position. When they read differently, you need to calculate the angle turned and how this affects the position.

Here's the basic maths.

**Calculating the Angle Change**

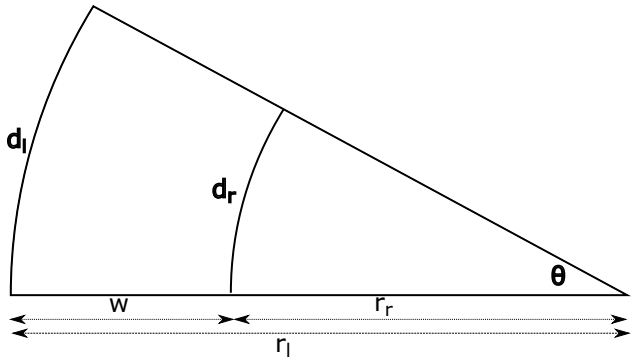


Figure 1: Calculating the change in angle and the radii

Suppose the left and right wheels move the distances $d_l$ and $d_r$ respectively. You also know the distance between the wheels, $w$. We want to find the two radii of turn, $r_l$ and $r_r$ and the change in angle $\theta$.

From the maths of arcs:

$$d_l = r_l\theta$$

$$d_r = r_r\theta$$

Where $\theta$ is in radians.

Also the two radii are related to each other:

$$r_l = r_r + w$$

Substituting for $r_l$ we get:

$$d_l = (r_r + w)\theta$$

Multiplying out:

$$d_l = r_r\theta + w\theta$$

Now $d_r = r_r\theta$, so we get:

$$d_l = d_r + w\theta$$

Rearranging this, we get:

$$\theta = \frac{d_l - d_r}{w}$$

Given $\theta$, it's trivial to calculate $r_l$ and $r_r$ from $d_l$ and $d_r$.

**Calculating the Position Change**

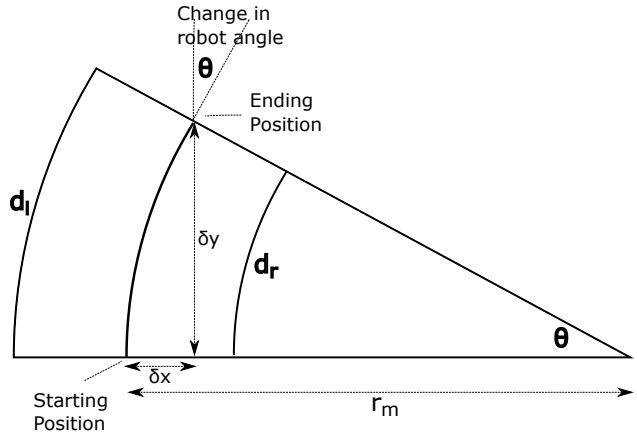


Figure 2: Calculating the change in position (starting at zero angle)

If the robot was facing straight ahead (angle is zero), then calculating the change in position is simple.

First, calculate the radius turned by the middle of the robot:

$$r_m = \frac{r_l + r_r}{2}$$

The change in $y$ position, $\delta y$, is:

$$\delta y = r_m sin(\theta)$$

and the change in $x$ position, $\delta x$, is:

$$\delta x = r_m - r_m cos(\theta)$$

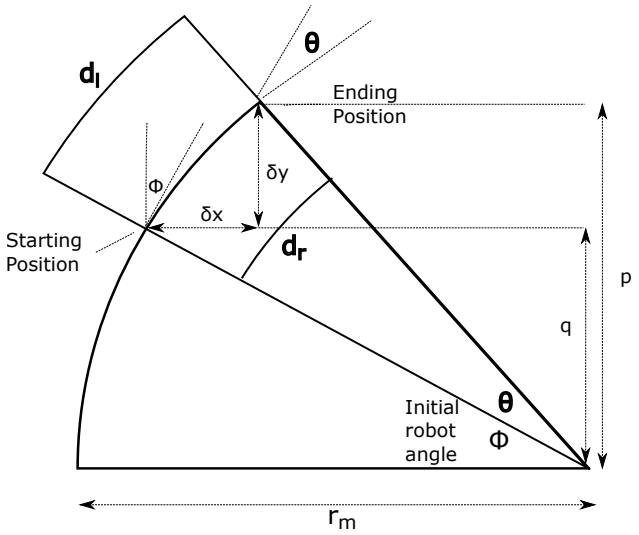


Figure 3: Calculating the change in position (starting at angle $\phi$)

Normally the robot won't be pointing dead ahead when you need to calculate the position change. Suppose after it's been driving a while, the robot has angle $\phi$ before it moves a short distance in a arc. What is the change in position?

You can calculate the change in angle, $\theta$, and the radius of turn, $r_m$, exactly as before.

Probably the simplest way to calculate $\delta y$ is to calculate $p$ and $q$ on the diagram. $\delta y$ is then the difference between them:

$$p = r_m sin(\phi + \theta)$$

$$q = r_m sin(\phi)$$

Then

$$\delta y = p - q$$

You can calculate $\delta x$ in the same way, as the difference of the two cosines.