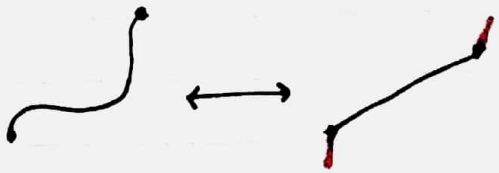
CR Sheet 3 Sol.



- Recall For Odometry

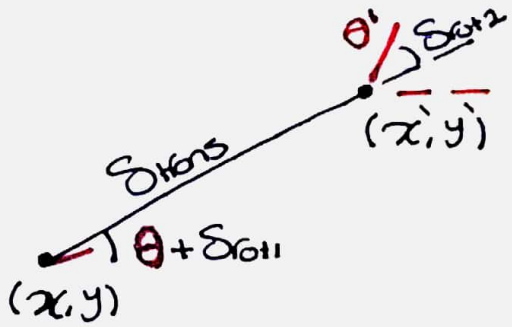
Motion Model

$x, u \rightarrow x'$

$$x' = x + \hat{\delta}_{trans} \cos(\theta + \delta_{rot1})$$

$$y' = y + \hat{\delta}_{trans} \sin(\theta + \delta_{rot1})$$

$$\theta' = \theta + \hat{\delta}_{rot1} + \hat{\delta}_{rot2}$$



→ Can be easily Proven from the visual.

- δ_{rot1} Change in θ to look towards
- δ_{rot2} Further change to look towards θ'

3.1)

→ Robot Starts at Pose $x_0 = (0\,m, 0\,m, 0\,deg)$

→ then Subsequent odometry measurment was obtained for 1st motion

$u_1 = (-20^\circ, 3\,m, -30^\circ)$ // δ_{rot1}, δ_{tr}, δ_{rot2}

- Assuming the odometry measurment is exact

→ Next Pose will exactly be

$$x_1 = 0 + 3\cos(0-20) = 2.819\,m$$
$$y_1 = 0 + 3\sin(0-20) = -1.026\,m$$
$$\theta_1 = 0 - 20 - 30 = -50^\circ$$

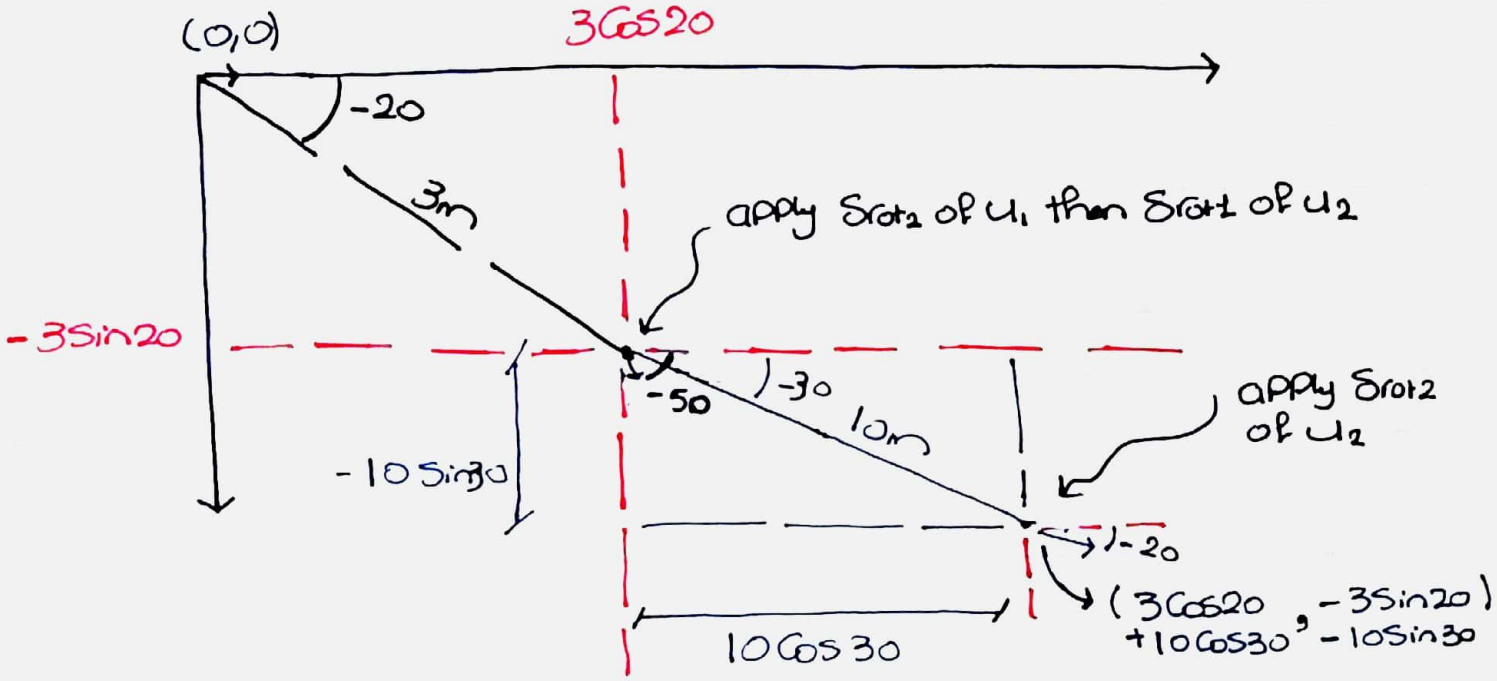
→ Then a 2nd motion was applied with odometry measurment $u_2 = (20^\circ, 10\,m, 10^\circ)$

. This will lead to the Pose

$$x_2 = 2.819 + 10\cos(-50+20) = 11.479\ m$$
$$y_2 = -1.026 + 10\sin(-50+20) = -6.026\ m$$
$$\theta_2 = -50+20+10 = -20^\circ$$

→ Resulting Pose is $(11.48, -6.03, -20^\circ)$

. Can be also done graphically



3.2) Redo motion one assuming the following simple error model

$$\hat{\delta}_{rot1} = \underset{-20^\circ}{\delta_{rot1}} \pm \varepsilon_{rot1}\ ,\ \varepsilon_{rot1} = 10^\circ$$

$$\hat{\delta}_{trans} = \underset{3m}{\delta_{trans}} \pm \varepsilon_{trans}\ ,\ \varepsilon_{trans} = 0.5\ m$$

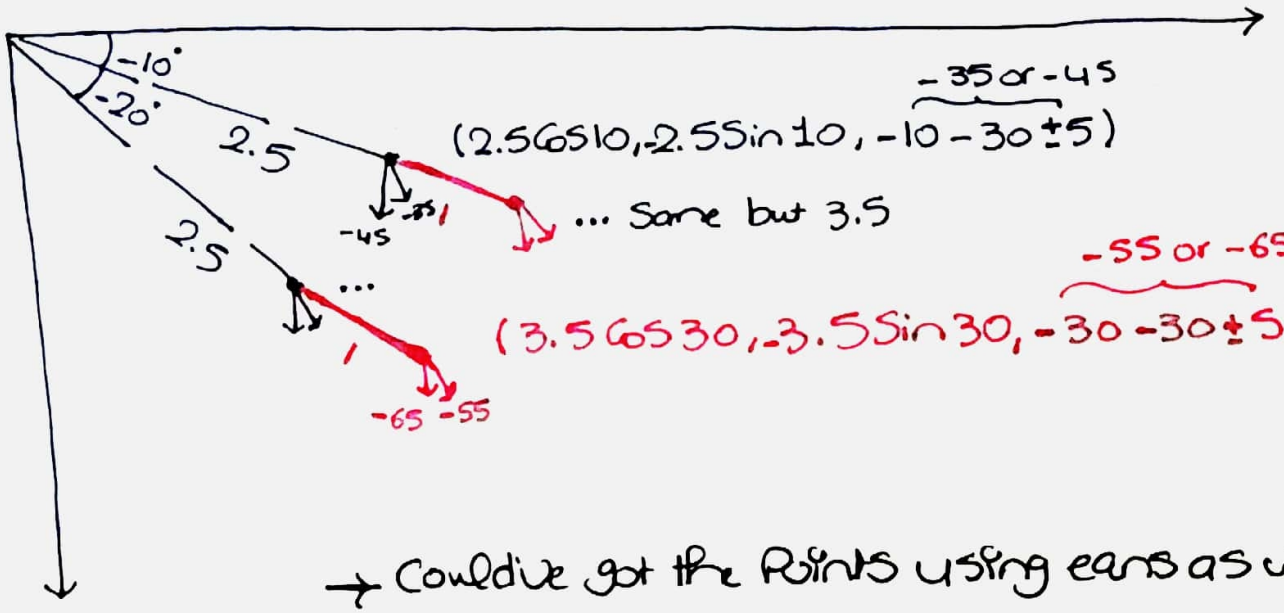
$$\hat{\delta}_{rot2} = \underset{-30^\circ}{\delta_{rot2}} \pm \varepsilon_{rot2}\ ,\ \varepsilon_{rot2} = 5^\circ$$

hence

$\hat{\delta}_{rot1} = -10^\circ$ or -30°
$\hat{\delta}_{trans} = 2.5\ m$ or $3.5\ m$
$\hat{\delta}_{rot2} = -25^\circ$ or -35°

} 8 Possible resulting Poses

- Draw movements & Pose estimates in one diagram

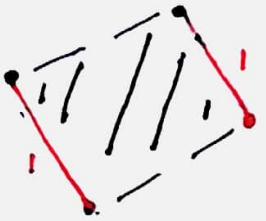


→ Could've got the Points using ears as well

- What if $\varepsilon_{trans} \sim$ uniform$(-0.5, 0.5)$ and

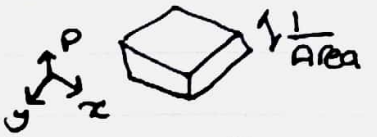
$\varepsilon_{rot1} \sim$ uniform$(-10°, 10°)$ and $\varepsilon_{rot2} \sim$ uniform$(-5°, 5°)$

⇒ Then Possible Poses are all those in



. where at any Point the angle θ is from $-55°$ to $-65°$

↳ If θ is 'marginalized out' (not considered in the Plot for the dist.) then this corresponds to a 2D dist



- 3.3 & 3.4 used to be Programming assignments to visualize the distribution after successive motions (will keep getting bigger) and then to draw samples from it.

→ was assumed ∩ rather than ⊓ as well