Guidance, Navigation, and Control Concept

0.1 Frames of Reference

Robot Frame of Reference

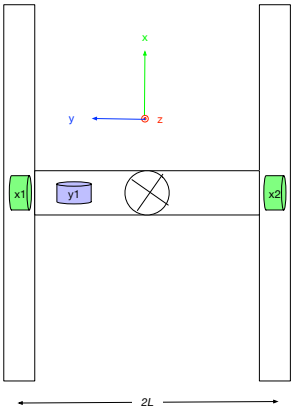

Figure 1: Robot Frame of Reference

- Coordinate Axes
  - $\hat{x}$: forward
  - $\hat{y}$: left
  - $\hat{z}$: up
- Encoders
  - **x1** and **x2**: forward and aft
  - **y1**: side to side
- Measured variables
  - R_0: radius of encoder wheel
  - N_0: number of "ticks" per encoder wheel rotation

- $N_{x_1}, N_{x_2}, N_{y_1}$: number of "ticks" recorded on each encoder

- Computed values
  - $\Delta N_{x_1}, \Delta N_{x_2}, \Delta N_{y_1}$: number of tickets measured on each encoder during time step
  - $\Delta s_x, \Delta s_y$: distance measured in forward and left direction in robot frame of reference during time step
  - $\Delta\theta$: Change in robot heading during time step

Field Frame of Reference

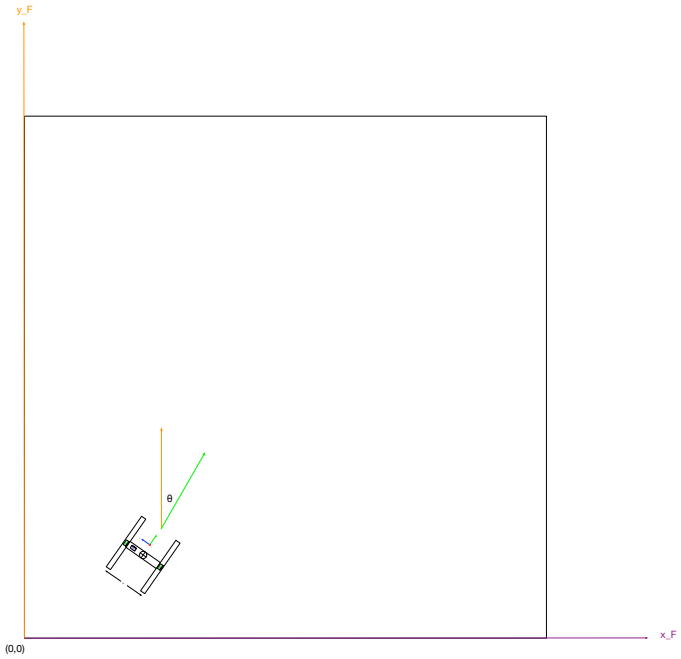

Figure 2: Field Frame of Reference

- Coordinate Axes
  - Origin defined for each game and alliance-specific
  - $\hat{X}_F$: to right from origin
  - $\hat{Y}_F$: away from origin
  - θ: robot heading; clockwise angle from $\hat{Y}_F$ to $\hat{x}$:

- Robot Starting Position: $(\hat{X}_{F_0}, \hat{Y}_{F_0}, \theta_0)$

0.2 Time Step

Definitions

- Each time step is an arbitrary amount of time within which robot identifies its location, determines trajectory to objective, and commands motors to follow trajectory
- Time step duration: Δt
- Time step starts at: $t - \Delta t$
- Time step ends at: t

Activities During Each Time Step

Navigation (Determine robot location)

- Measure each encoder's tick counter at end of time step: $[N_{x_1}(t), N_{x_2}(t), N_{y_1}(t)]$
- Compute change in each encoder's tick counter over time step:

$$\Delta N_{x_1} = N_{x_1}(t) - N_{x_1}(t - \Delta t)$$

$$\Delta N_{x_2} = N_{x_2}(t) - N_{x_2}(t - \Delta t)$$

$$\Delta N_{y_1} = N_{y_1}(t) - N_{y_1}(t - \Delta t)$$

- Compute change in position and heading in robot Frame of Reference

$$\Delta s_x = \frac{R_0}{N_0}\left(\frac{\Delta N_{x_1} + \Delta N_{x_2}}{2}\right)$$

$$\Delta s_y = \frac{R_0}{N_0}\Delta N_{y_1}$$

- Compute change in position in field Frame of Reference

$$\Delta X_F = \Delta s_x[\sin\theta(t - \Delta t)] - \Delta s_y[\cos\theta(t - \Delta t)]$$

$$\Delta Y_F = \Delta s_x[\cos\theta(t - \Delta t)] + \Delta s_y[\sin\theta(t - \Delta t)]$$

- Compute change in heading

$$\Delta\theta = \frac{R_0}{N_0}\left(\frac{\Delta N_{x_1} - \Delta N_{x_2}}{2L}\right)$$

- Update robot postion and heading

$$X_F(t) = X_F(t - \Delta t) + \Delta X_F$$

$$Y_F(t) = Y_F(t - \Delta t) + \Delta Y_F$$

$$\theta(t) = \theta(t - \Delta t) + \Delta\theta$$

Guidance (Determine trajectory to designated target)

Control (Command motors to execute guidance)

- Point and Shoot Technique
- Strafe Technique