2.12/2.120 Introduction to Robotics
Lab 7 Intro

March 23&24, 2023

Today's Tasks

- **Term project (first hour):**
  - Strategy planning and detailed design.
- **Lab 7 – Mobile robot path tracking using odometry:**
  - Odometry and differential motion
    - Estimate robot's change in pose using the encoders in the motors of the wheels.
    - Move the robot using delta pose.
  - Path planning and implementation.

Motor Drive Components

goBILDA 5203 Planetary Gear 12V DC Motor

https://www.gobilda.com/5203-series-yellow-jacket-planetary-gear-motor-19-2-1-ratio-24mm-length-8mm-rex-shaft-312-rpm-3-3-5v-encoder/

- 12VDC
- Reduction Ratio: 19.2:1
- Rated Torque: 24.3 kgf-cm
- Rated Speed: 312 RPM

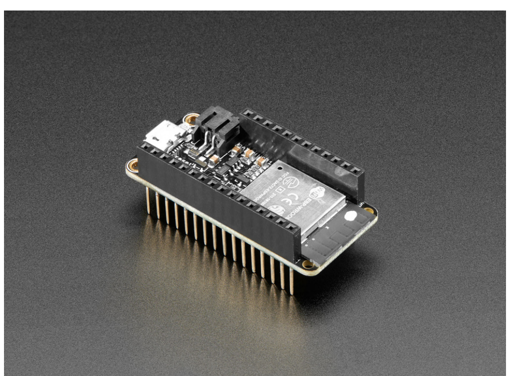
Cytron 10Amp 5V-30V DC Motor Driver (2 Channels)

https://www.cytron.io/p-10amp-5v-30v-dc-motor-driver-2-channels

- Operating voltage range: 5 – 30 V
- Output current: 10 A continuous (30 A peak) per motor

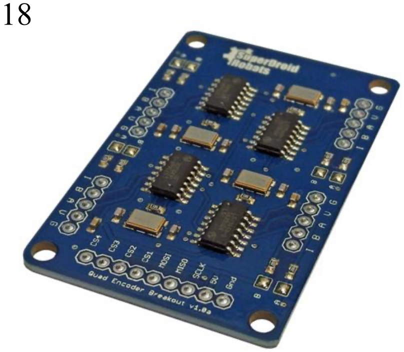
Adafruit HUZZAH32 – ESP32 Feather Board

https://www.adafruit.com/product/3619

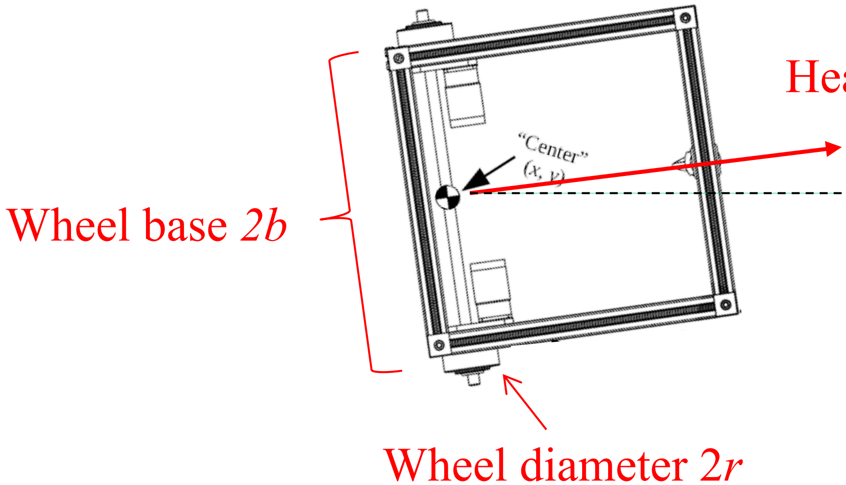


SuperDroid Quadruple LS7366R Quadrature Encoder Buffer

https://www.superdroidrobots.com/store/robot-parts/electrical-parts/encoders-accessories/buffer-pull-up-boards/product=2418



Differential Motion and Mapping



$$\dot{\theta} = \frac{r}{2b}(\dot{\phi}_R - \dot{\phi}_L)$$

$$\theta(t) = \theta(t - \Delta T) + \begin{bmatrix} \frac{r}{2b} & -\frac{r}{2b} \end{bmatrix} \begin{bmatrix} \Delta\phi_R(t) \\ \Delta\phi_L(t) \end{bmatrix}$$

$$= \theta(t - \Delta T) + \frac{r}{2b}(\Delta\phi_R(t) - \Delta\phi_L(t))$$

$$\begin{bmatrix} x(t) \\ y(t) \end{bmatrix} = \begin{bmatrix} x(t - \Delta T) \\ y(t - \Delta T) \end{bmatrix} + \frac{r}{2} \underbrace{\begin{bmatrix} cos\theta(t) & cos\theta(t) \\ sin\theta(t) & sin\theta(t) \end{bmatrix}}_{\boldsymbol{J}} \begin{bmatrix} \Delta\phi_R(t) \\ \Delta\phi_L(t) \end{bmatrix}$$

Vehicle Kinematics

Instantaneous center of rotation

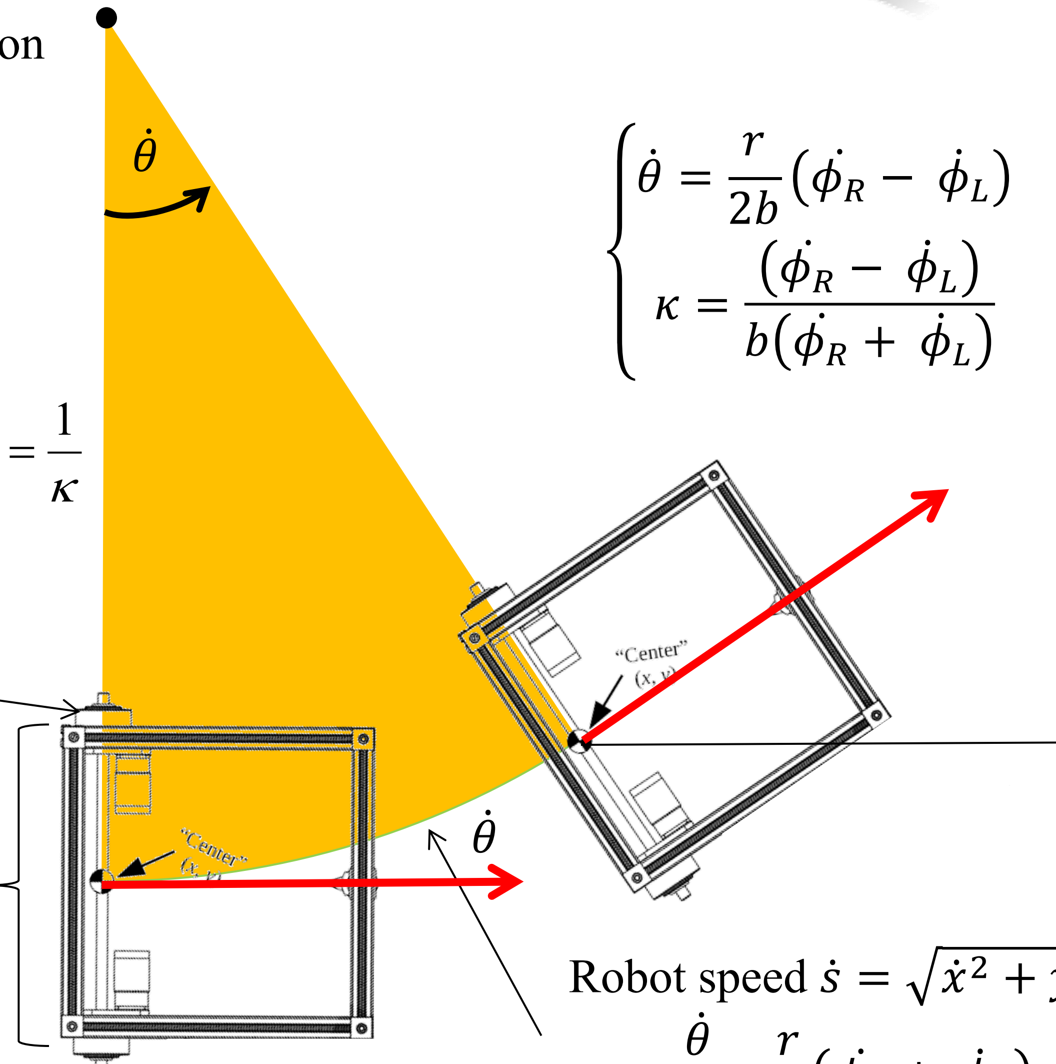
$$\begin{cases} \dot{\phi}_L = \dfrac{\dot{s}(1 - b\kappa)}{r} \\ \dot{\phi}_R = \dfrac{\dot{s}(1 + b\kappa)}{r} \end{cases}$$

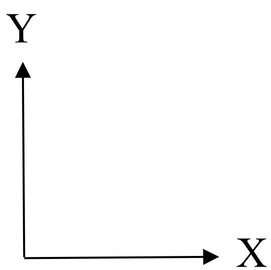
$$\begin{cases} \dot{\theta} = \dfrac{r}{2b}(\dot{\phi}_R - \dot{\phi}_L) \\ \kappa = \dfrac{(\dot{\phi}_R - \dot{\phi}_L)}{b(\dot{\phi}_R + \dot{\phi}_L)} \end{cases}$$

Turn radius $\rho = \dfrac{1}{\kappa}$

Wheel diameter $2r$

Wheel base $2b$





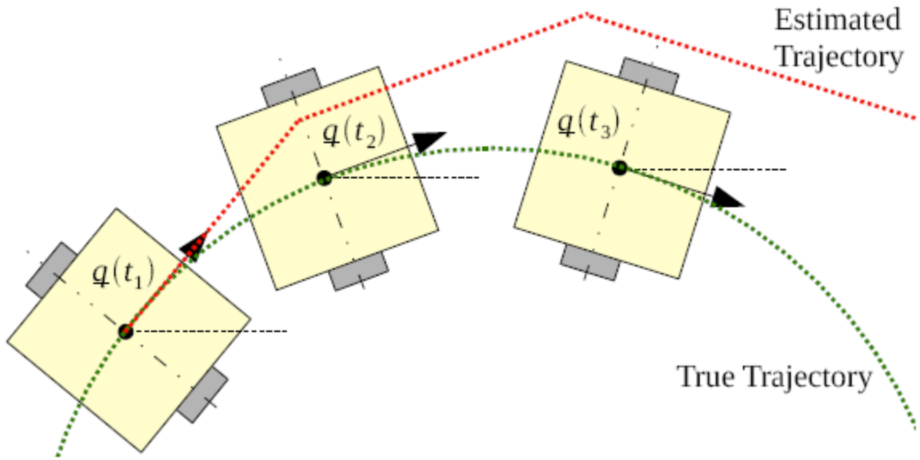
Robot speed $\dot{s} = \sqrt{\dot{x}^2 + \dot{y}^2}$

$$= \frac{\dot{\theta}}{\kappa} = \frac{r}{2}(\dot{\phi}_R + \dot{\phi}_L)$$

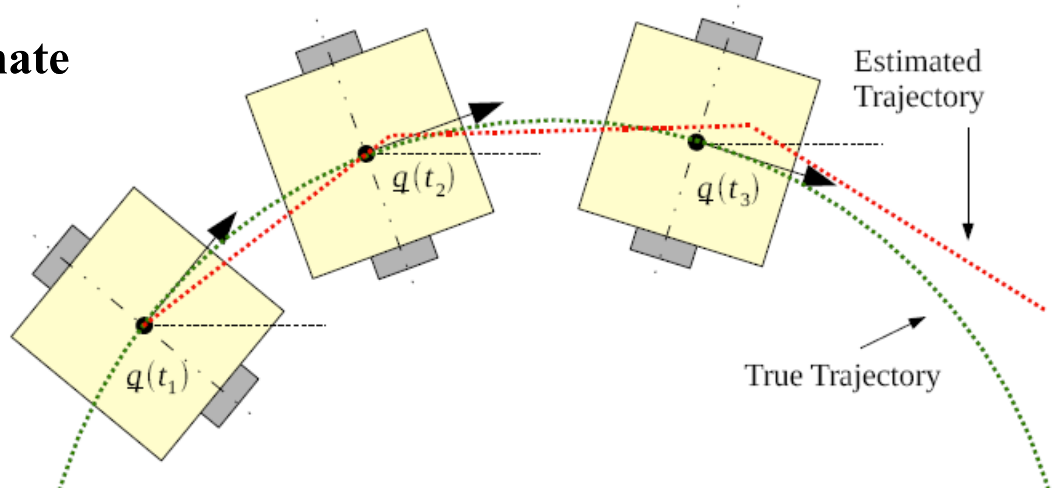
Dead Reckoning Estimate

Numerically integrate wheel velocities to estimate the vehicle's pose at any point in time.

Euler or Tangent Estimate

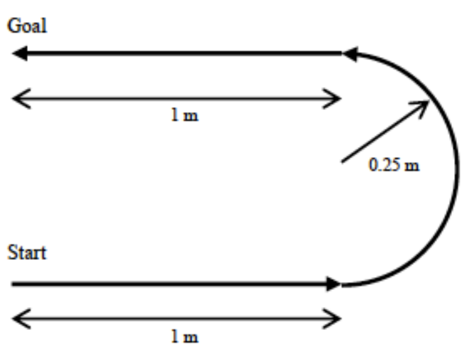


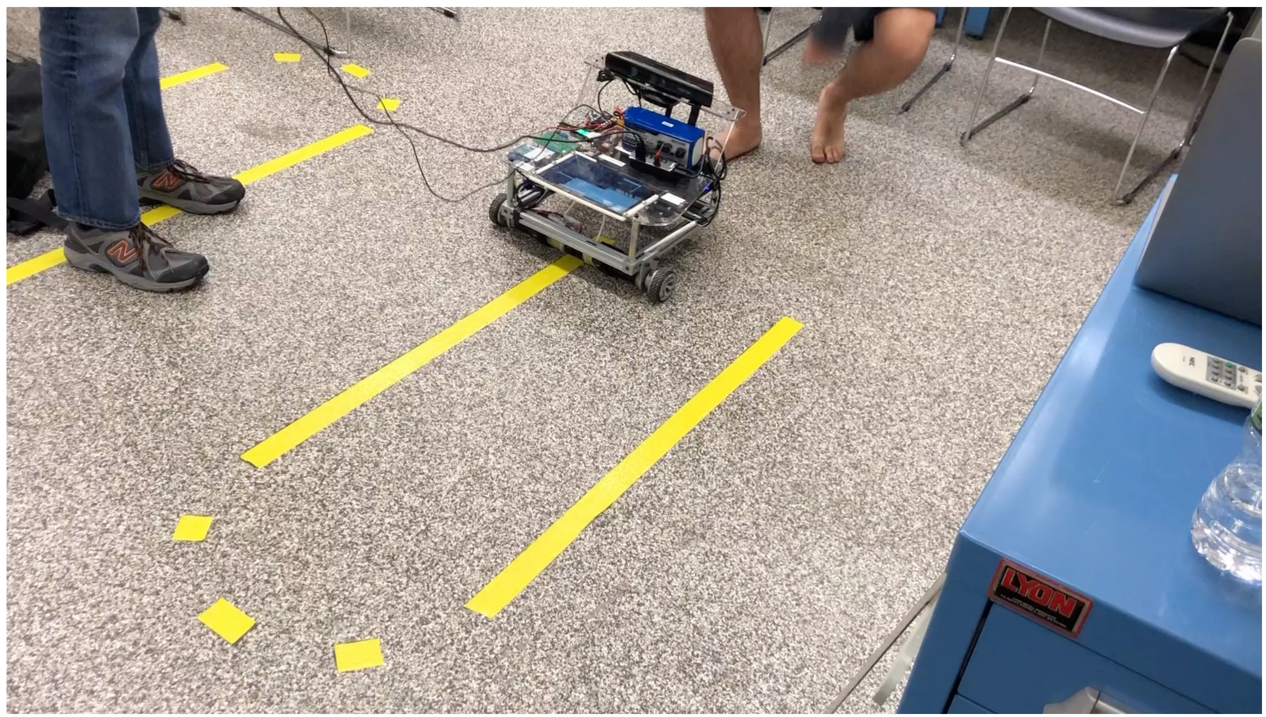
Trapezoid or Secant Estimate



Vehicle Navigation

- Implement feed-forward trajectory control of a wheeled vehicle using vehicle kinematics.
- Write code to command the vehicle to follow a U-shaped trajectory.





Code Files and Deliverable

- **Code files in GitHub: https://github.com/mit212/mobile_robot_2023.**
- **Ask a lab staff for check-off when you are done.**
- **Term project:**
  - Design review (April 6&7): 15-minute presentation with slides
    - Overall strategy
    - Design sketches, CAD
    - Additional sensors, actuators, components,…
    - Software implementation plan