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TOWARDS A LANDMINE-FREE WORLD

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Unmanned Ground Vehicles

Webinar by M.Sc. Eng. Ahmed Hussein

Outline

- ❖What is UGV?
- ❖Where am I?
- ❖Where am I going?
- ❖How do I get there?
- ❖Example

What is UGV?

Unmanned Ground Vehicles

- UGVs are ground-based mechanical devices that can sense and interact with the environment, with NO driver on board

- Platform

- Sensors

- Control

- Communication

Operation Mode

❖Autonomous

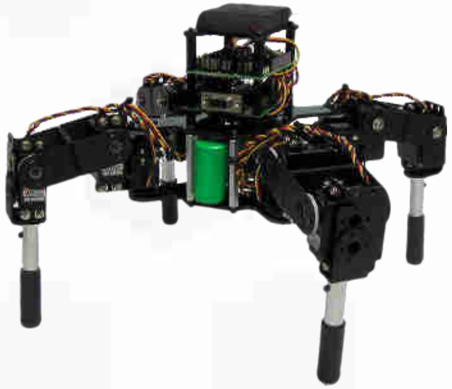
❖Tele-operated

Locomotion Types

- ❖Wheels

- ❖Tracks

- ❖Legs



- ❖Articulated Body

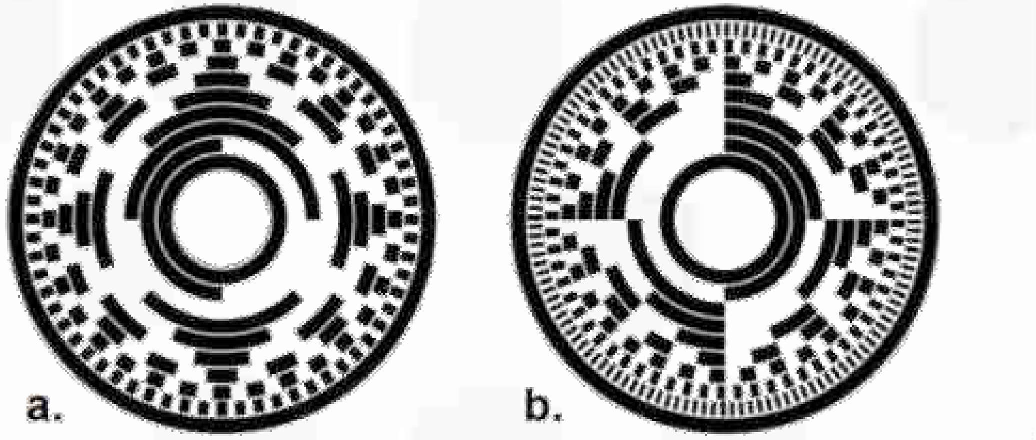
Mobility Configurations

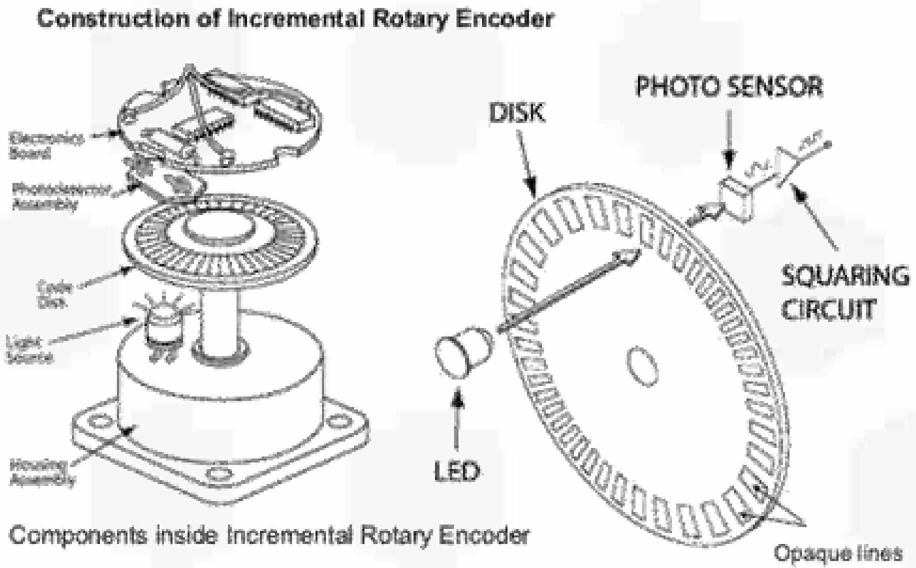
- ❖Ackerman Steering
- ❖Differential Drive
- ❖Omnidirectional Drive
- ❖… and more

Where am I?

Localization

❖Optical Encoders Odometry
- ❖Incremental
- ❖Absolute





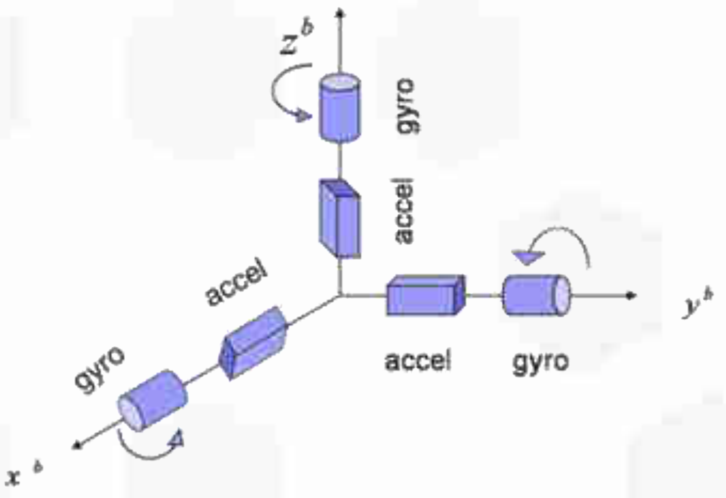
Localization

- Inertial Measurement Unit (IMU)
  - Accelerometers & Gyroscopes

$$\begin{bmatrix} v_x \\ v_y \end{bmatrix} = \begin{bmatrix} cos(\psi) & -sin(\psi) \\ sin(\psi) & cos(\psi) \end{bmatrix} \begin{bmatrix} u \\ v \end{bmatrix}$$

$$x = x_0 + \int_{t_0}^{t} v_x(t)d(t)$$

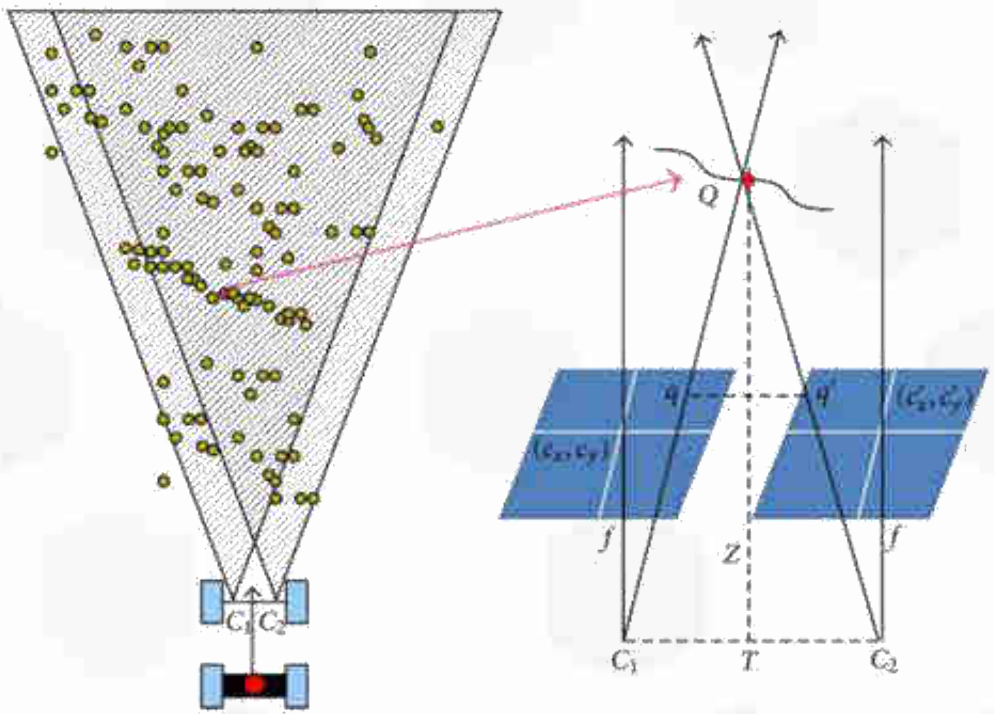
$$y = y_0 + \int_{t_0}^{t} v_y(t)d(t)$$



Inertial Measurement Unit
3 accelerometers, 3 gyroscopes

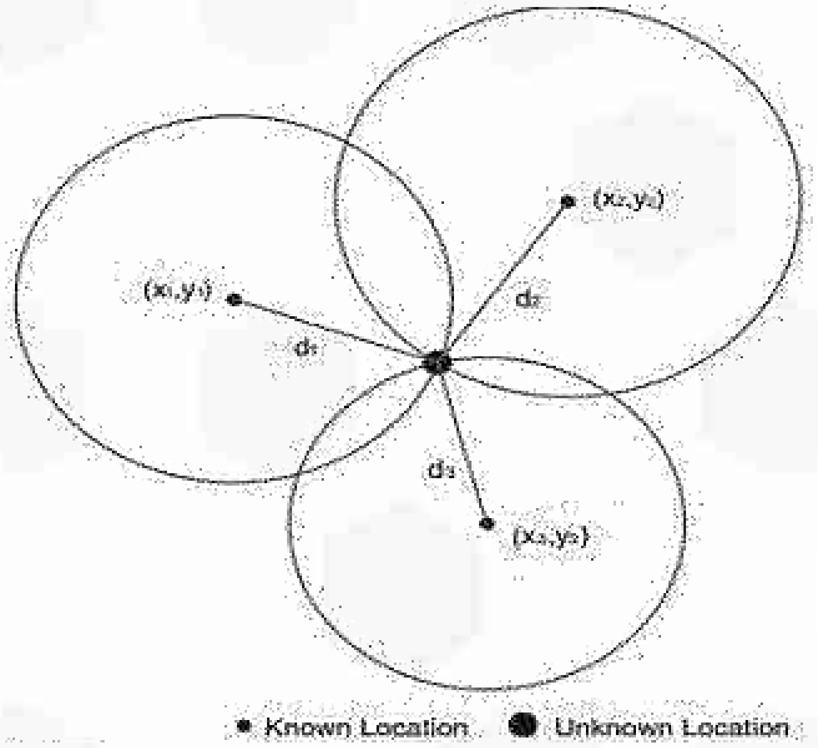
Localization

- ❖Vision-based Positioning
  - ❖Rectified images
  - ❖Features detection/extraction
  - ❖Features tracking/matching
  - ❖Pose estimation



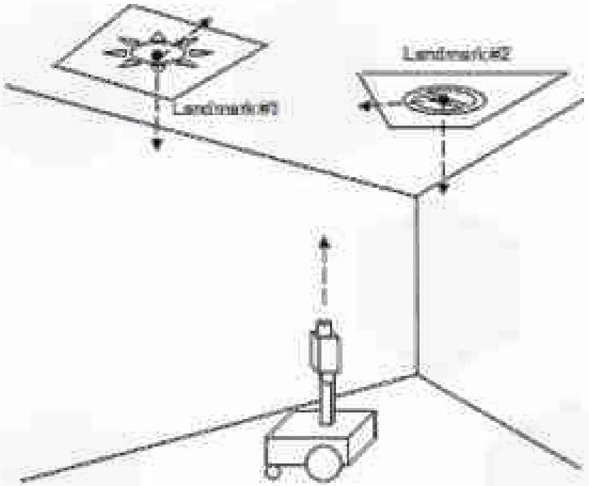
Localization

- Triangulation Methods
  - Three or more active transmitters
  - One receiver on the robot
  - Calculate distance from each transmitter to the receiver
  - Robot unknown location is in the intersection point of the nodes radii



Localization

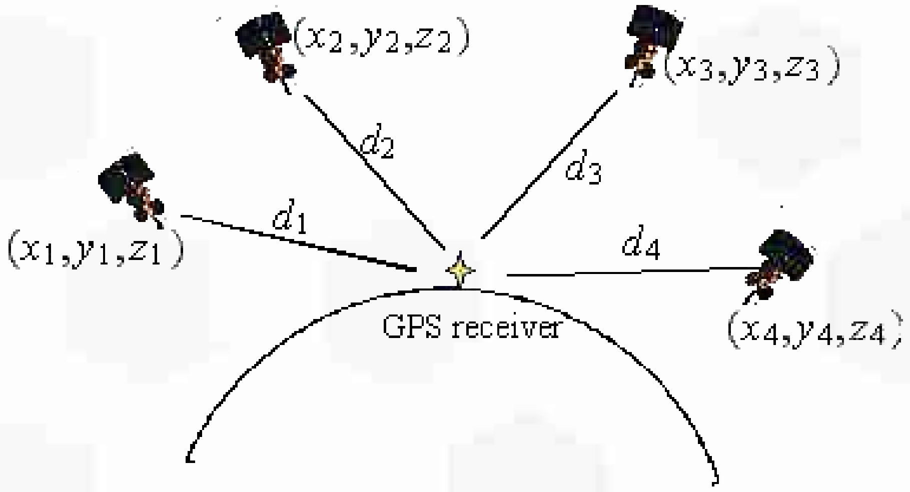
- ❖Landmark Recognition
  - ❖Based on triangulation using three or more landmarks “in view”
- ❖Landmark Position Correction
  - ❖Environment definition
  - ❖Error reduction
  - ❖Robot repositioning



(00) 0 0123456 000000001 8

Localization

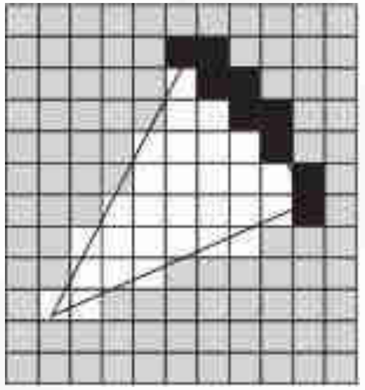
- Global Positioning System (GPS)
  - Based on triangulation from three or more satellites
  - Receiver compares signals from all available satellites to determine its own location
  - Accuracy of the GPS depends on confidence level for the readings

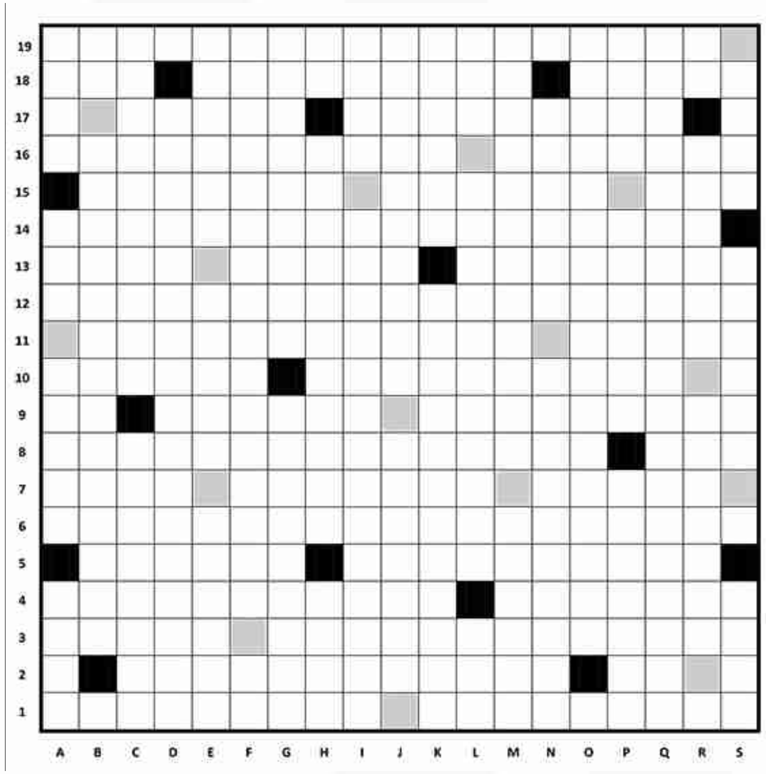


Where am I going?

Mapping

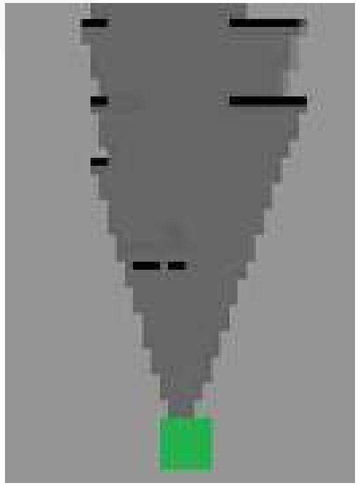
- ❖Occupancy Grid Map
  - ❖Maps the environment as an array of cells
  - ❖Each cell has a fixed size of a specific value
  - ❖Each cell holds a value that indicates the cell status
    - ❖Free
    - ❖Occupied
    - ❖Start / End
    - ❖Unknown / Unexplored

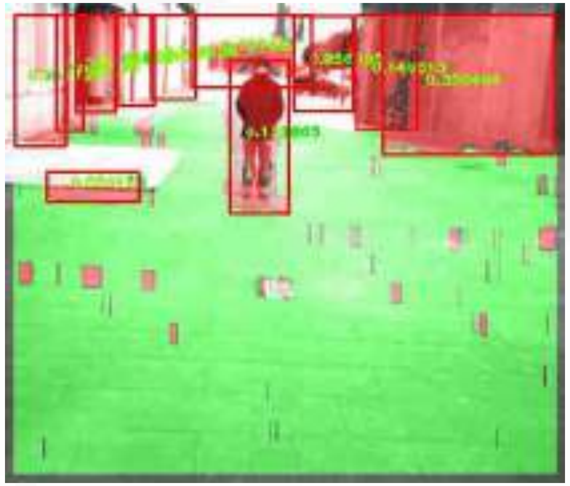


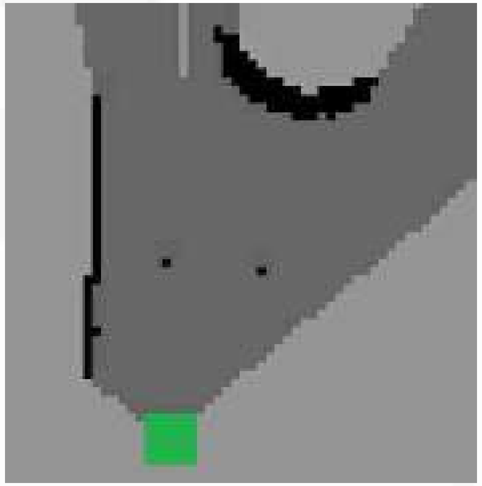


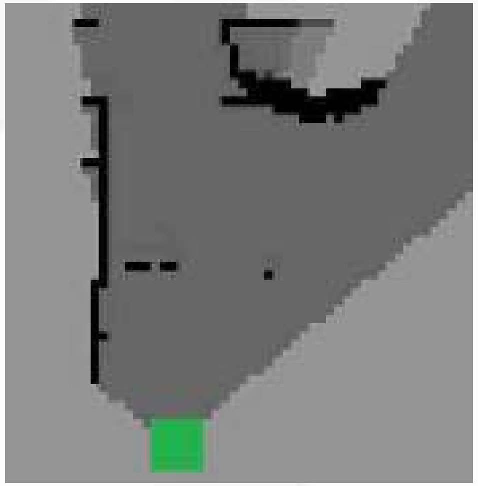
Environment Perception

- ❖Obstacle detection
  - ❖Free space detection
- ❖Map generation
  - ❖Sensor fusion
- ❖Obstacle recognition & classification
  - ❖Static
  - ❖Dynamic









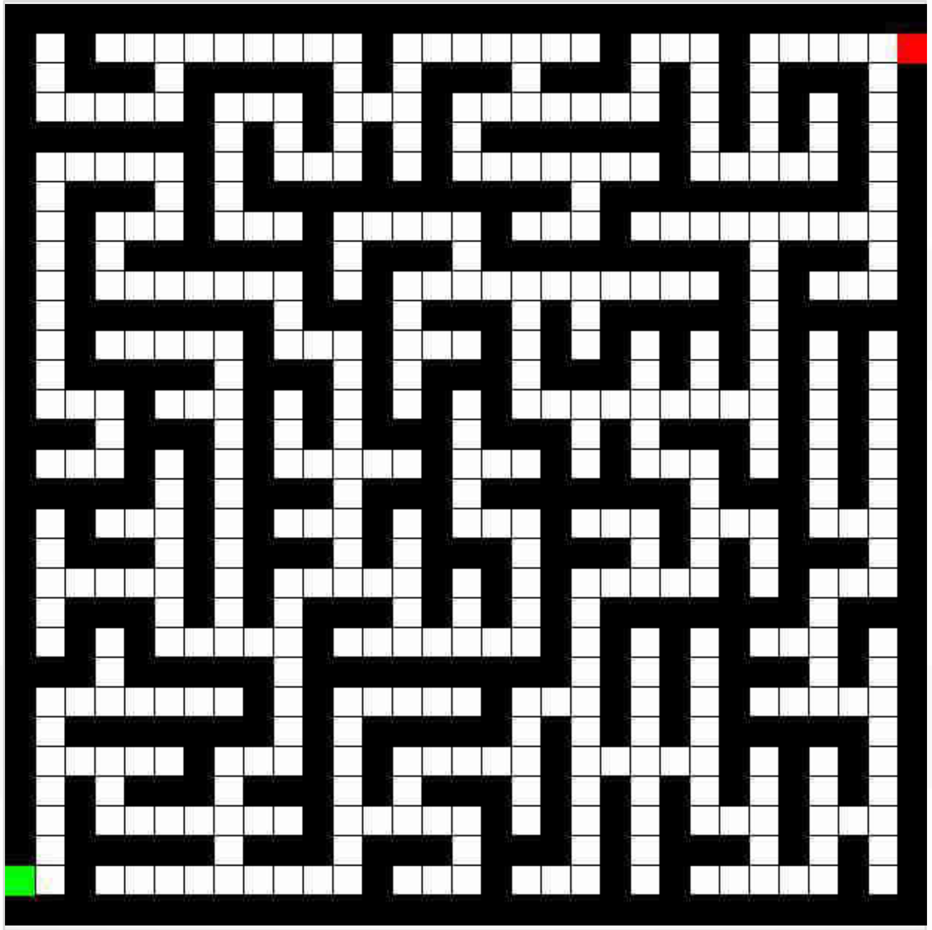
How do I get there?

Path-Planning

- Inputs
  - Grid-map
  - Start & Goal Positions

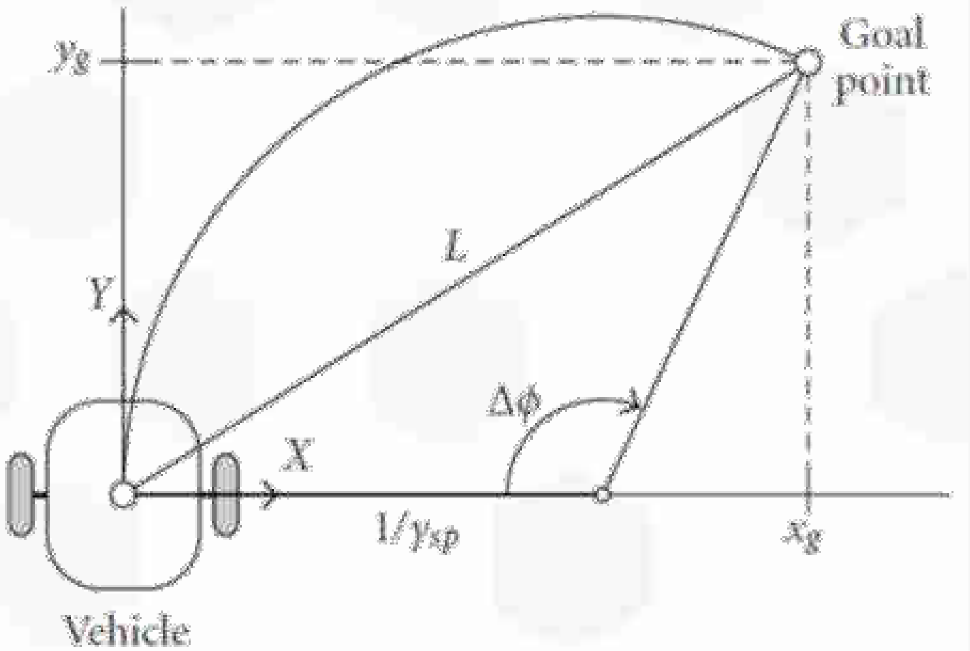
- Find the shortest collision free path
  - Check all directions

- Transform the path into several navigation waypoints
  - X & Y coordinates



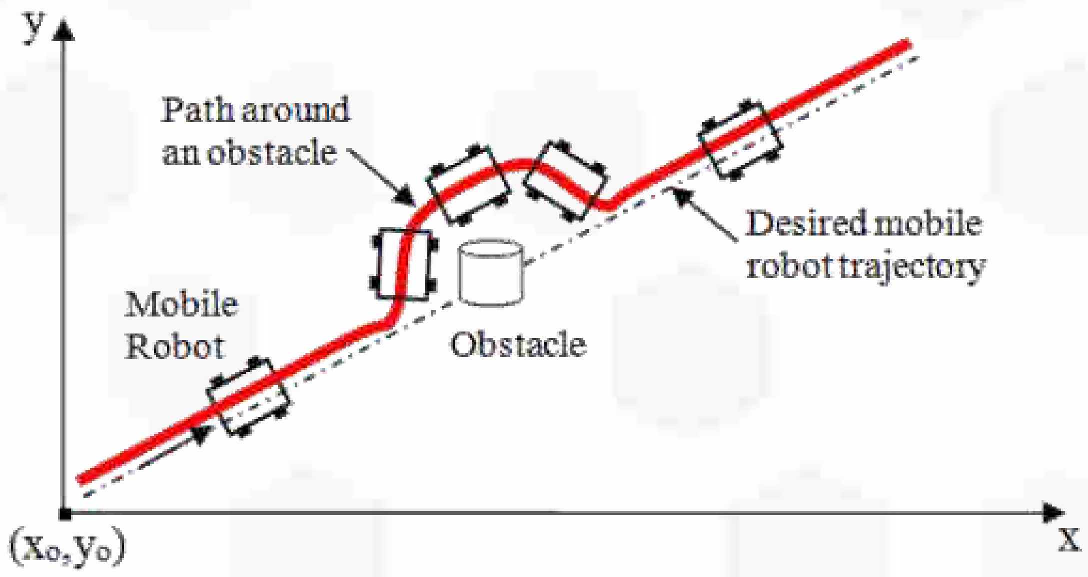
Navigation

- From
  - Current position and orientation
- To
  - Goal position and orientation
- Pure Pursuit Method
  - Navigation commands

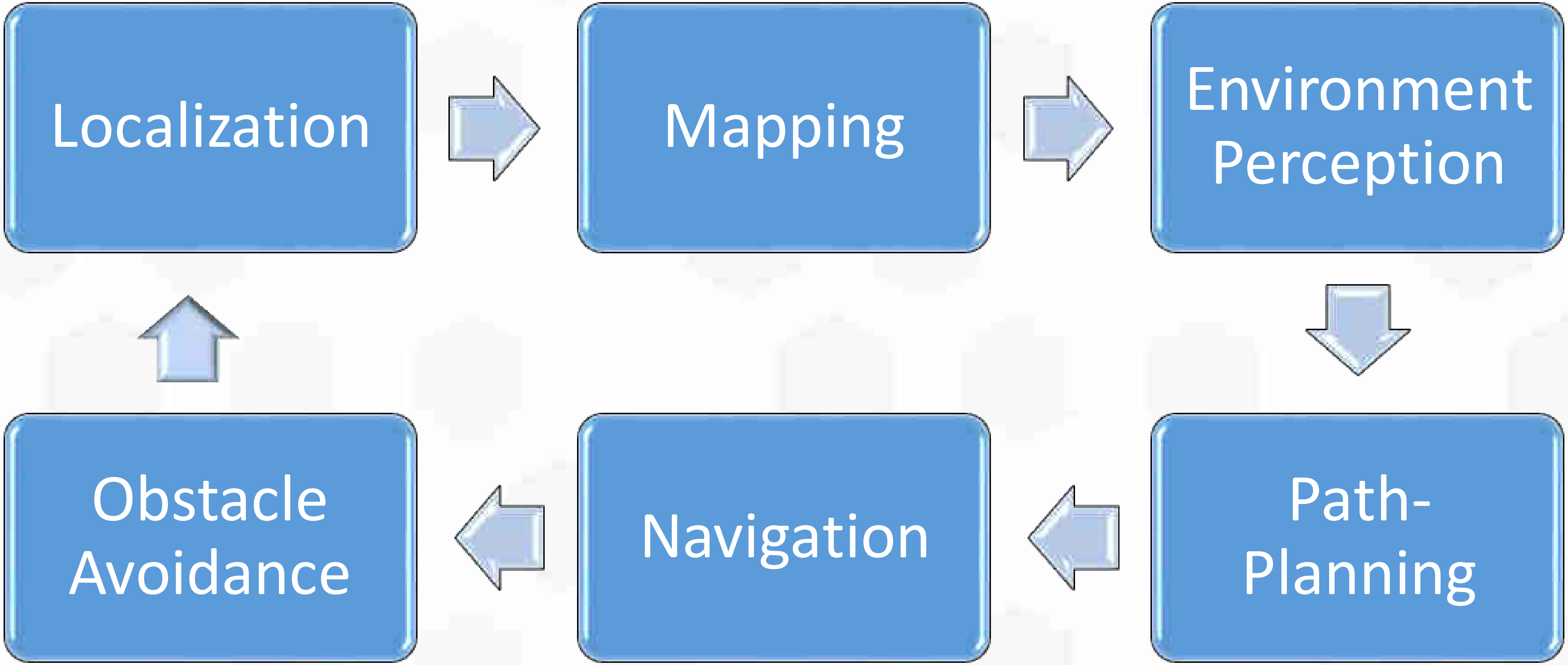


Obstacle Avoidance

- Presence of an obstacle in the designated route
  - Stop the vehicle till obstacle move, then continue original route
  - Maneuver around the obstacle, then get back to original route



System Flowchart



Example

iCab Project

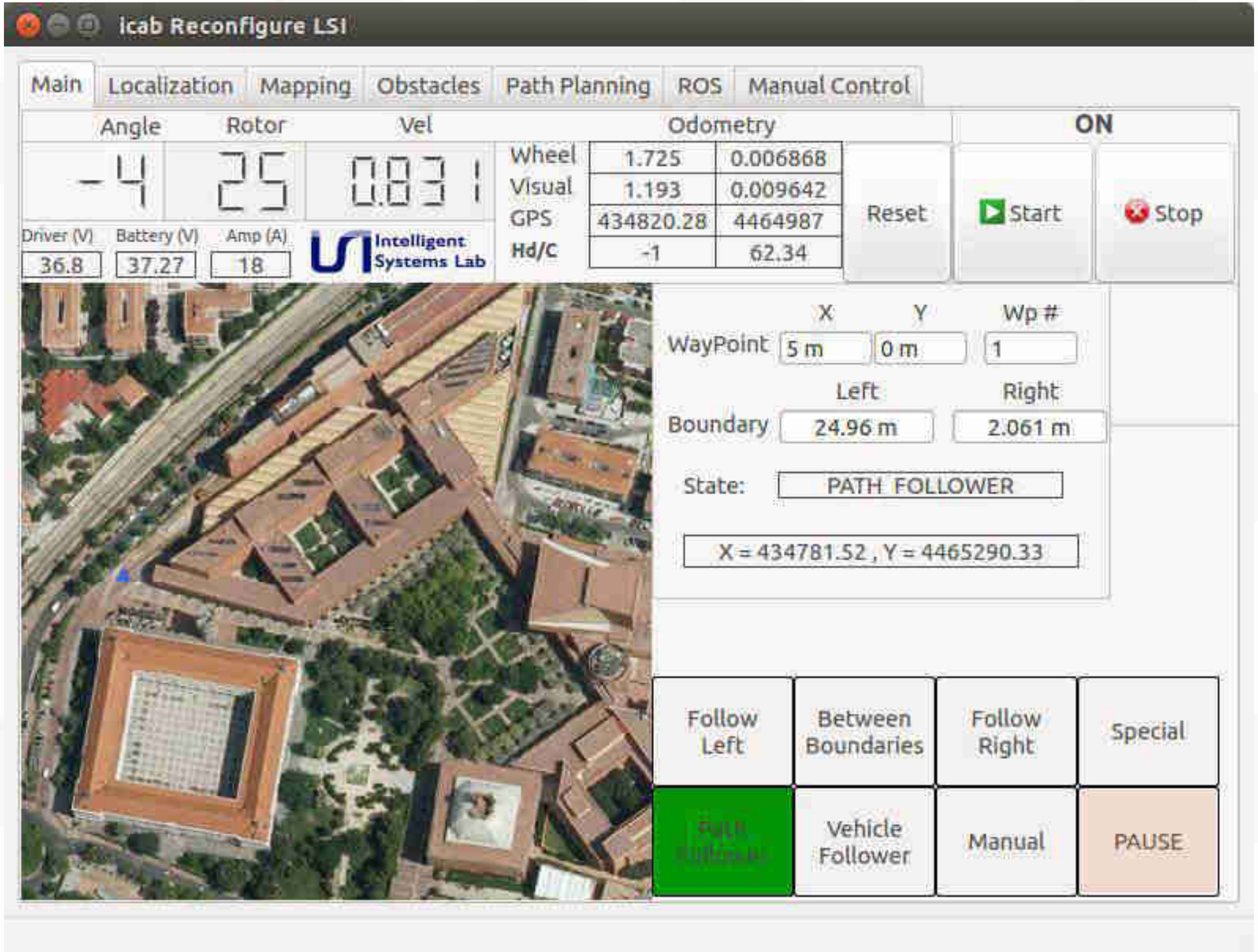
- iCab (<u>I</u>ntelligent <u>C</u>ampus <u>A</u>utomo<u>b</u>ile)
  - Multi-unmanned electric golf-carts
    - Cooperation and Coordination of Multi-agent System
  - Navigate within campus vicinity
    - Localization and Mapping
    - Path Planning and Navigation
    - Obstacles Detection and Classification
    - Obstacles Avoidance and Maneuver
    - Full Autonomous System
  - Transport visitors from one location to another
    - Transportation request is via a mobile app

iCab Project

- On-board Embedded Computer
  - Operating with ROS-architecture
- Touch-screen
- Odometry Wheel Encoders
- Compass & GPS Modules
- Laser Rangefinder Sensor
- Stereo-vision Camera
- Wireless Module

iCab Project

- ❖User Interface
  - ❖Vehicle Information
  - ❖Localization
  - ❖Mapping
  - ❖Obstacles
  - ❖Path Planning
  - ❖… and more



iCab Project

https://youtu.be/_FZHPgkN7AI

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Thank you ☺

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