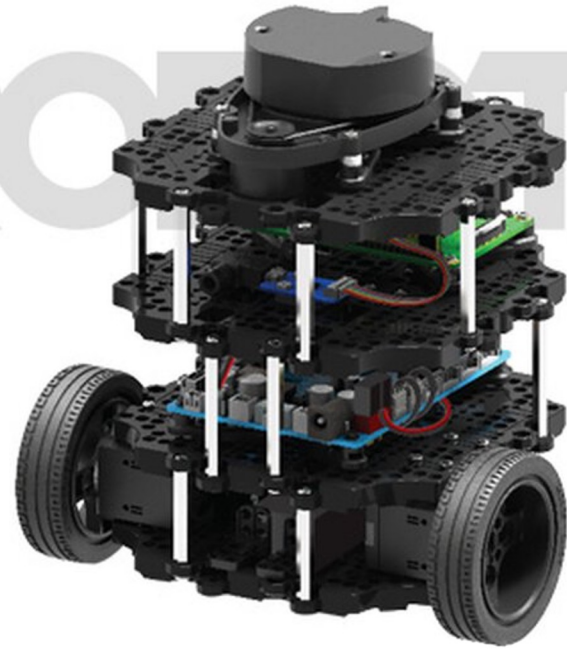


# AUTONOMOUS MOBILE ROBOTS

## TURTLEBOT3

### Burger



# COURSE INTRO

- Lecturers
  - Mirgita Frasheri & Andryi Sarabakha
- Course content
  - Robotics theory + Matlab exercises
  - Robotic software development + Turtlebot exercises
- Group exam based on final report (passed/not passed)
- 30 min. oral defence (presentation+questions)

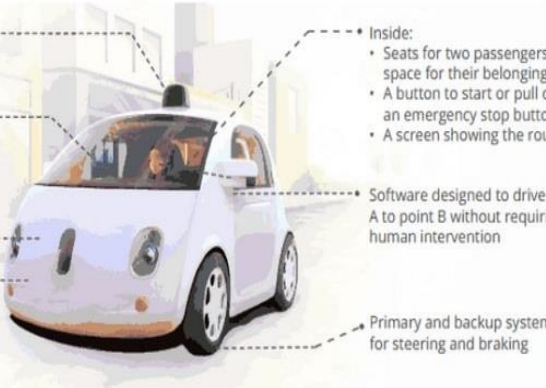


# WHAT IS ROBOTICS ?

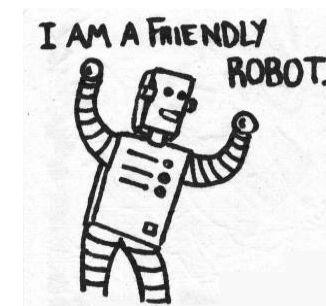
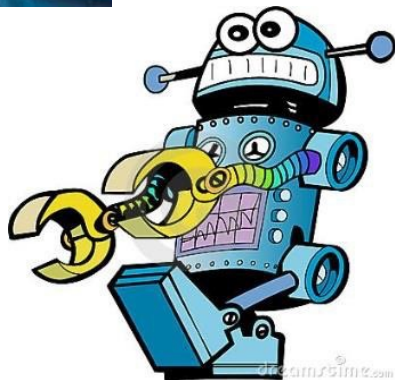


#### Key facts about the vehicle

- Sensors and hardware components that have been custom-built for self-driving
- New technologies to protect pedestrians, including a flexible windscreen and front made of a foam-like material
- An electric battery
- Speed capped at 25 mph
- Inside:
  - Seats for two passengers and a space for their belongings
  - A button to start or pull over, and an emergency stop button
  - A screen showing the route
- Software designed to drive from point A to point B without requiring any human intervention
- Primary and backup systems for steering and braking



# WHAT IS ROBOTICS ?



# ROBOTS

- One definition :

*"A goal-oriented machine that can sense, plan and act"*



# ROBOTS

- One definition :

*"A goal-oriented machine that can sense, plan and act"*



# ROBOTS

- One definition :

*"A goal-oriented machine that can sense, plan and act"*

- Robota – (slave) work, hard work
  - Dirty, Dangerous and Dull



# EXAMPLE 1







Imperial College London

<https://physicsworld.com/a/team-of-flying-robots-builds-structures-using-3d-printing/>





Imperial College London

Flying drones that mimic ants & bees

<https://physicsworld.com/a/team-of-flying-robots-builds-structures-using-3d-printing/>





Imperial College London

Flying drones that mimic ants & bees

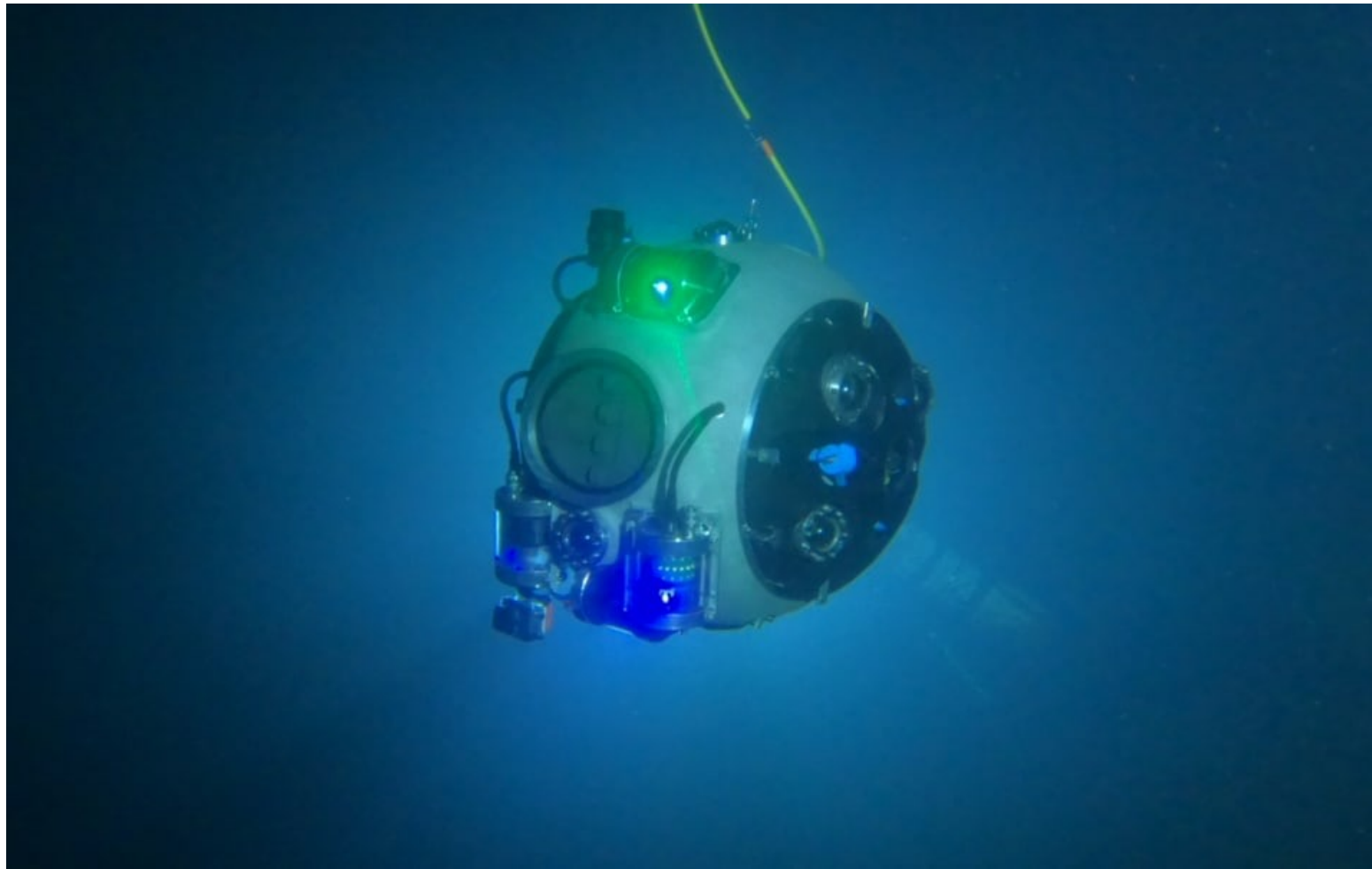
Dangerous, unreachable environments

<https://physicsworld.com/a/team-of-flying-robots-builds-structures-using-3d-printing/>



# EXAMPLE 2

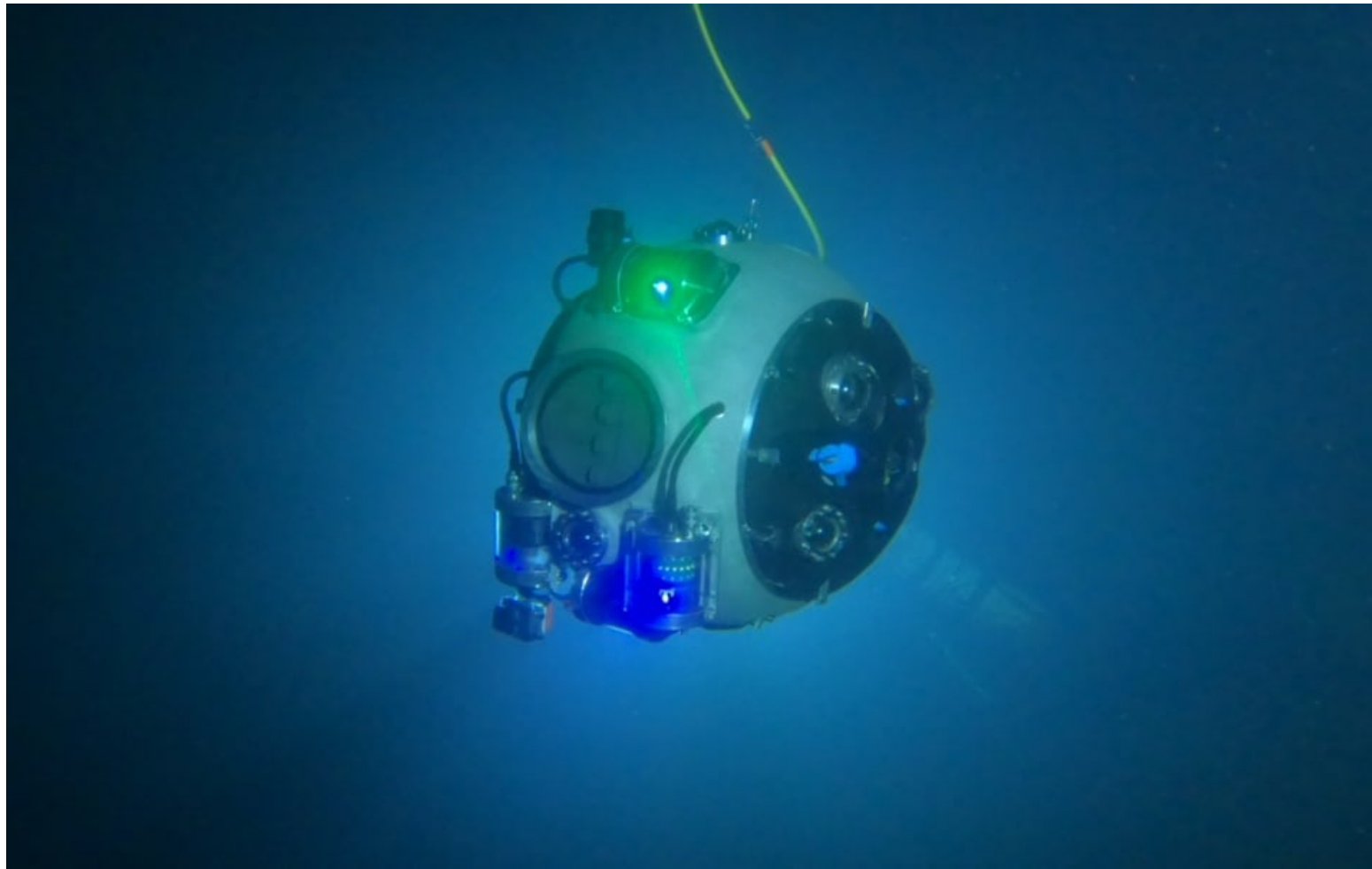




La Palma Research Centre

<https://physicsworld.com/a/swimming-robots-help-europe-rediscover-its-mining-mojo/>





La Palma Research Centre

3 robots for surveying the area

<https://physicsworld.com/a/swimming-robots-help-europe-rediscover-its-mining-mojo/>





# INDUSTRIAL ROBOTS

OMRON ADEPT QUATTRO



EPSON



KUKA



SCARA



MOTOMAN



# INDUSTRIAL ROBOTS

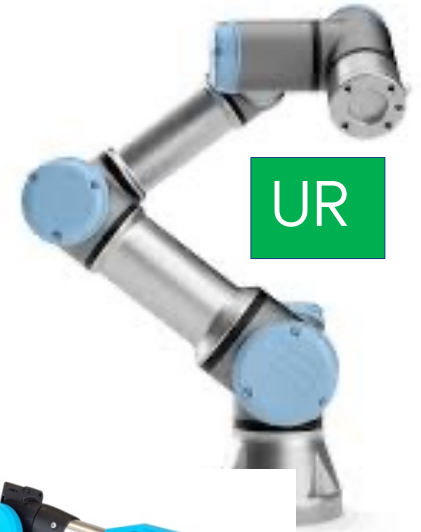
OMRON ADEPT QUATTRO



EPSON



UR



KUKA



SCARA



MOTOMAN



NED2

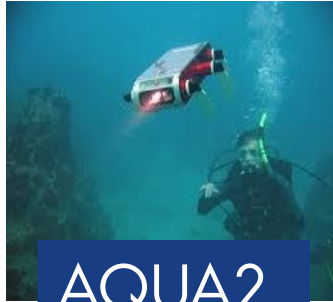




# AUTONOMOUS MOBILE ROBOTS



iRobot roomba



AQUA2



Phantom 2



ASIMO



Intelligent one



MIR100



Capra robotics



Robotti



# AUTONOMOUS MOBILE ROBOTS



iRobot roomba



AQUA2



Phantom 2



ASIMO

Desktop Robotti



Intelligent one



MIR100



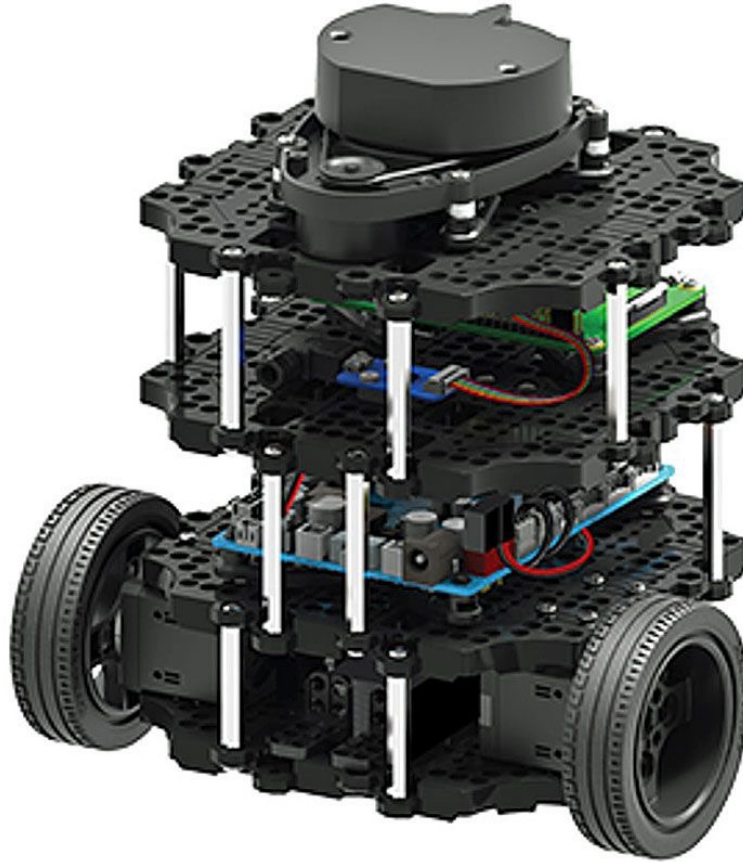
Capra robotics



Robotti



# TURTLEBOT3 – THE BURGER

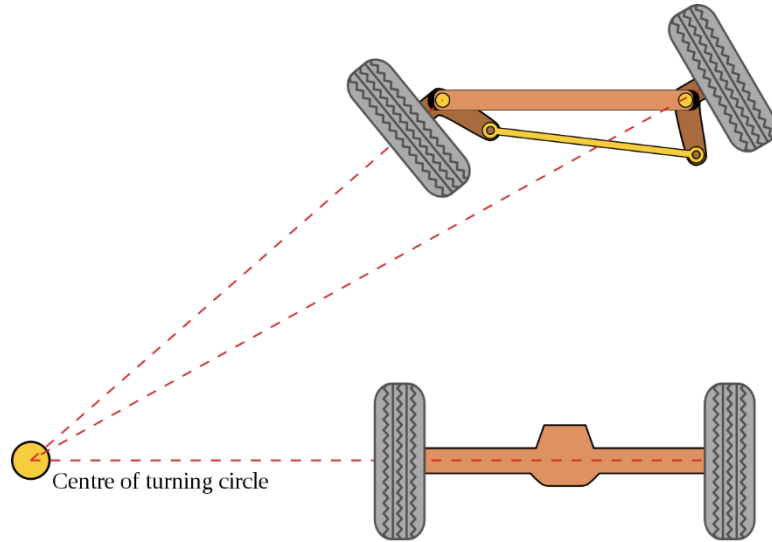


# AUTONOMOUS MOBILE ROBOTS - OVERVIEW

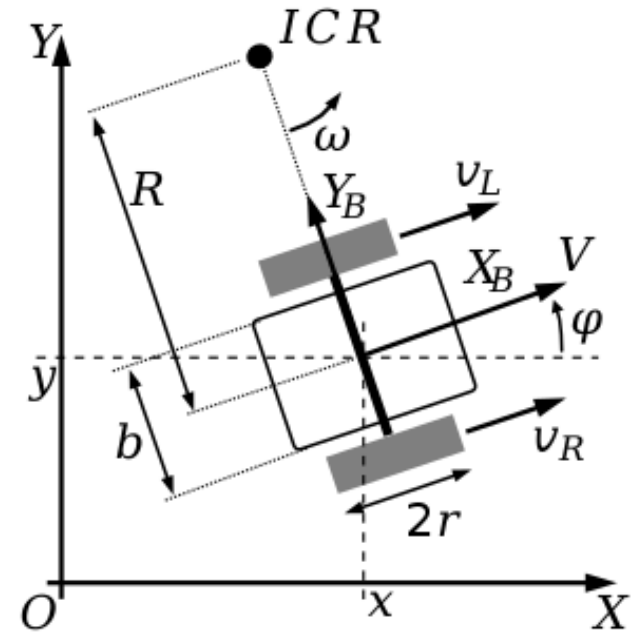
- Kinematics / dynamics
- Motion planning / navigation
  - Map-based planning / trajectory tracking
  - Motion control
- Localization
- Map building and updating
- Sensors and actuators
  - Vision-based, IMUs, tactile, ..



# KINEMATIC MODELS

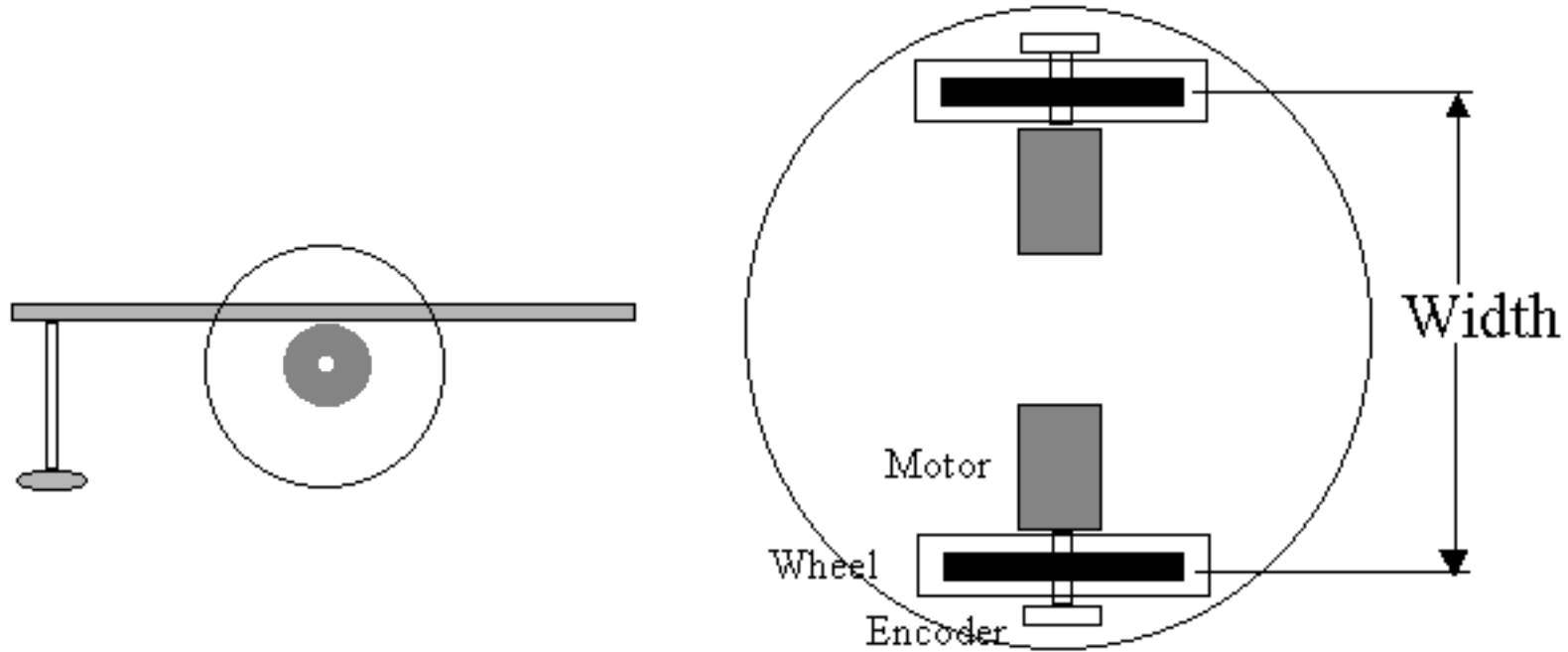


Ackermann steering



Differential drive steering

# TURTLEBOT KINEMATICS & DYNAMICS





# MATLAB DEMO



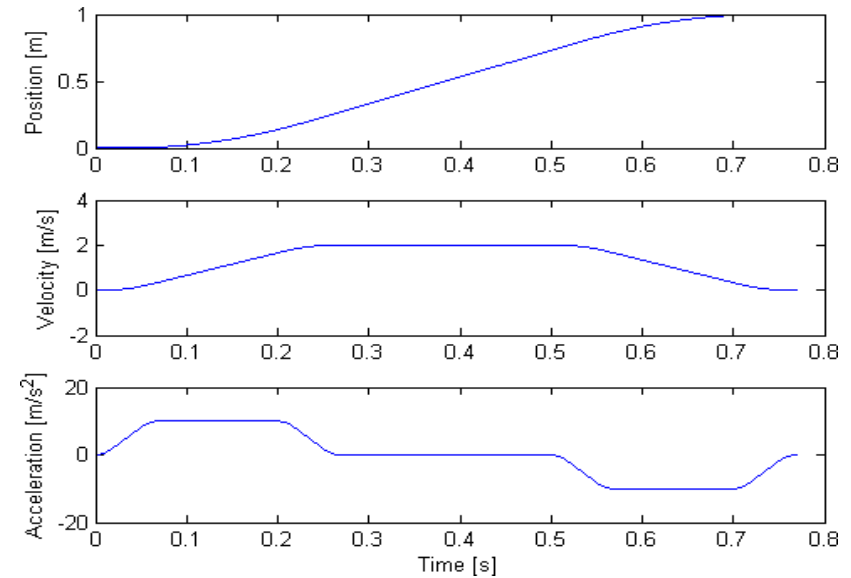
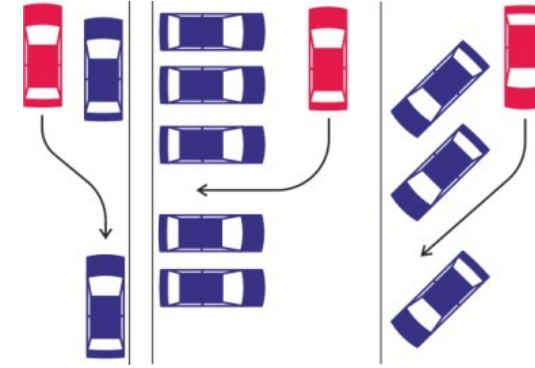
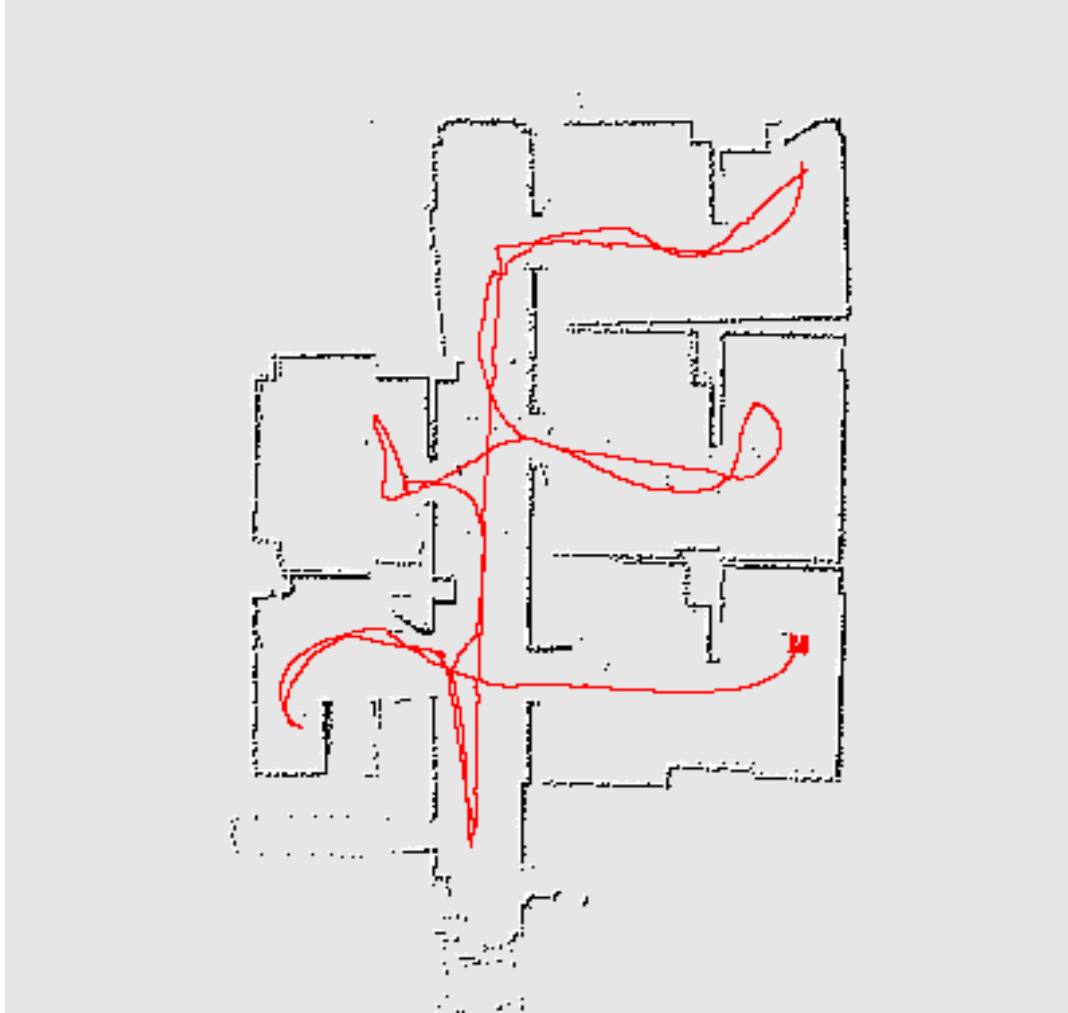
# PATHS, TRAJECTORIES & POSES

- Path - List of positions
  - $[[x_1, y_1], [x_2, y_2], \dots]$
- Trajectory – List of positions with time information
  - $[[t_1, x_1, y_1], [t_2, x_2, y_2], \dots]$
- Note – Pose for turtlebot is  $[x, y, \theta]$  (in world coordinates)

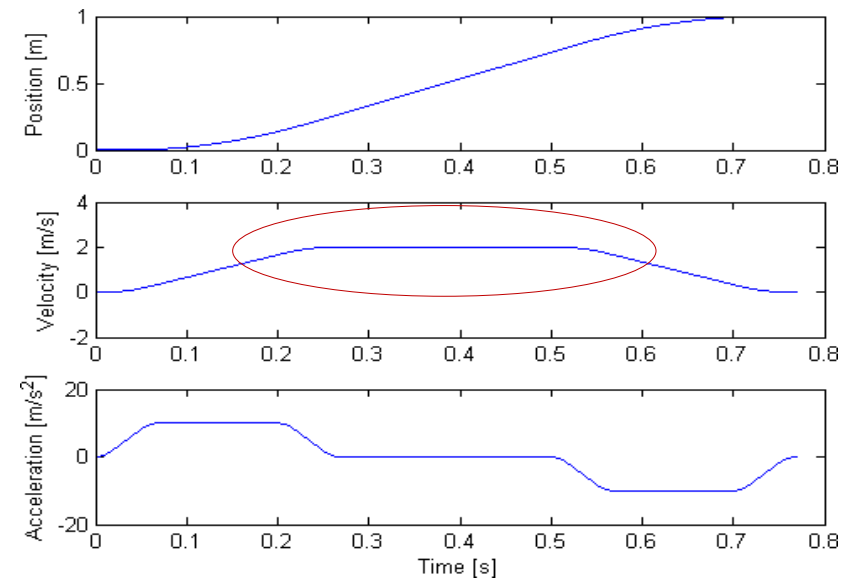
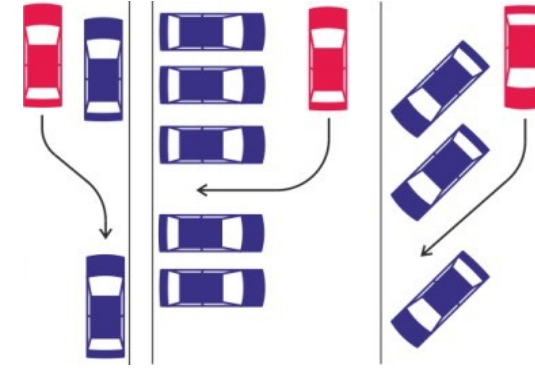
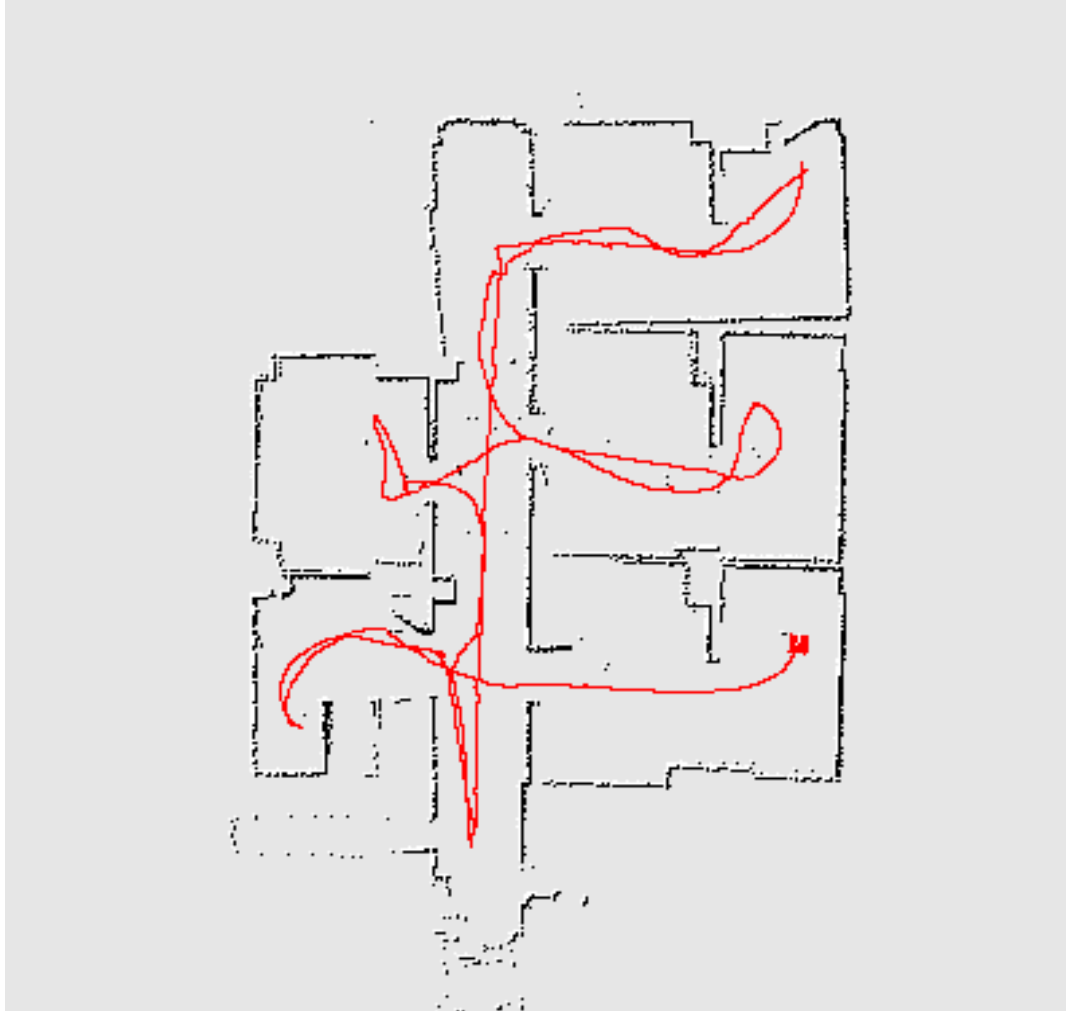




# TRAJECTORY GENERATION



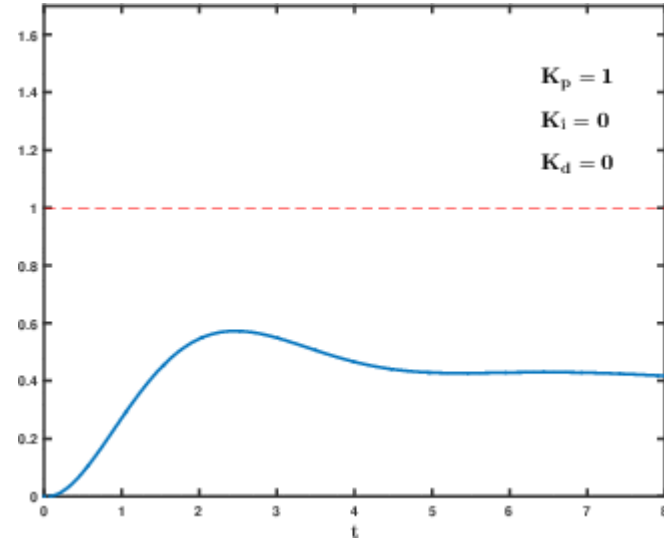
# TRAJECTORY GENERATION



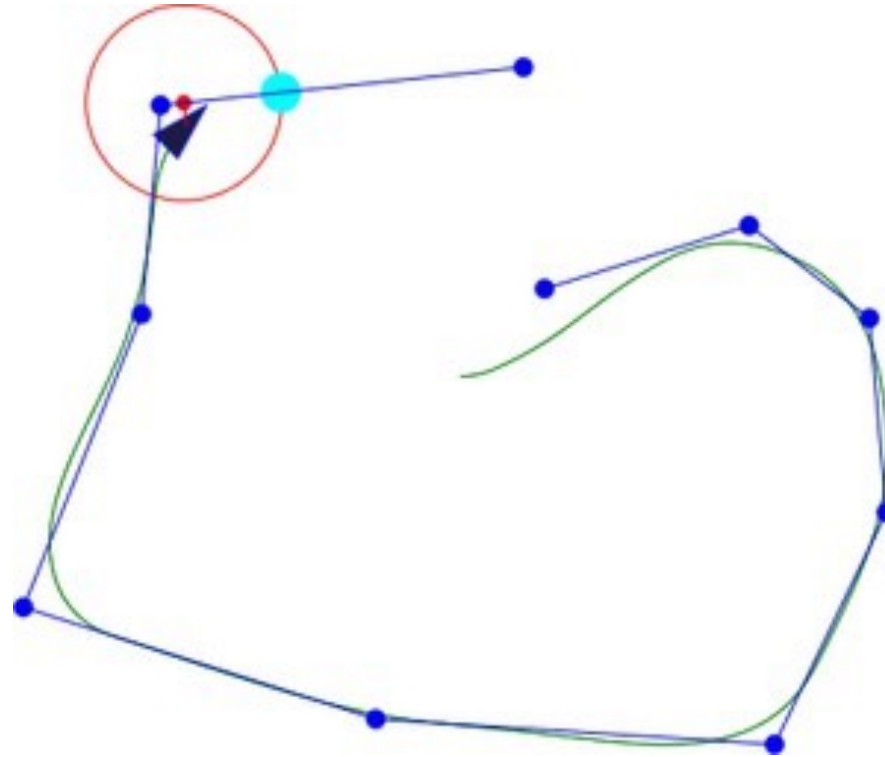
Chapter 3.3.1

# PATH TRACKING

$$u(t) = K_p e(t) + K_i \int_0^t e(t) dt + K_d \frac{de(t)}{dt}$$



# PURE PURSUIT

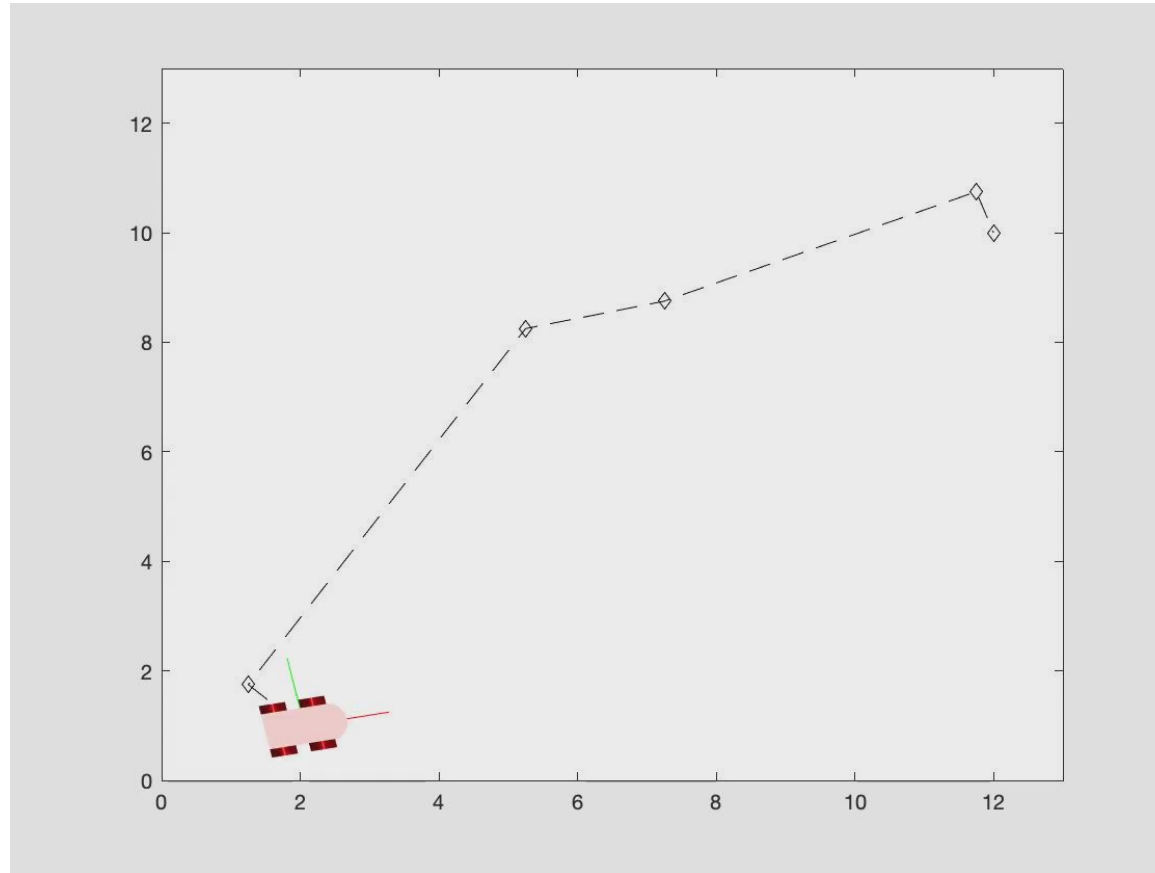


<http://se.mathworks.com/help/robotics/ug/pure-pursuit-controller.html>



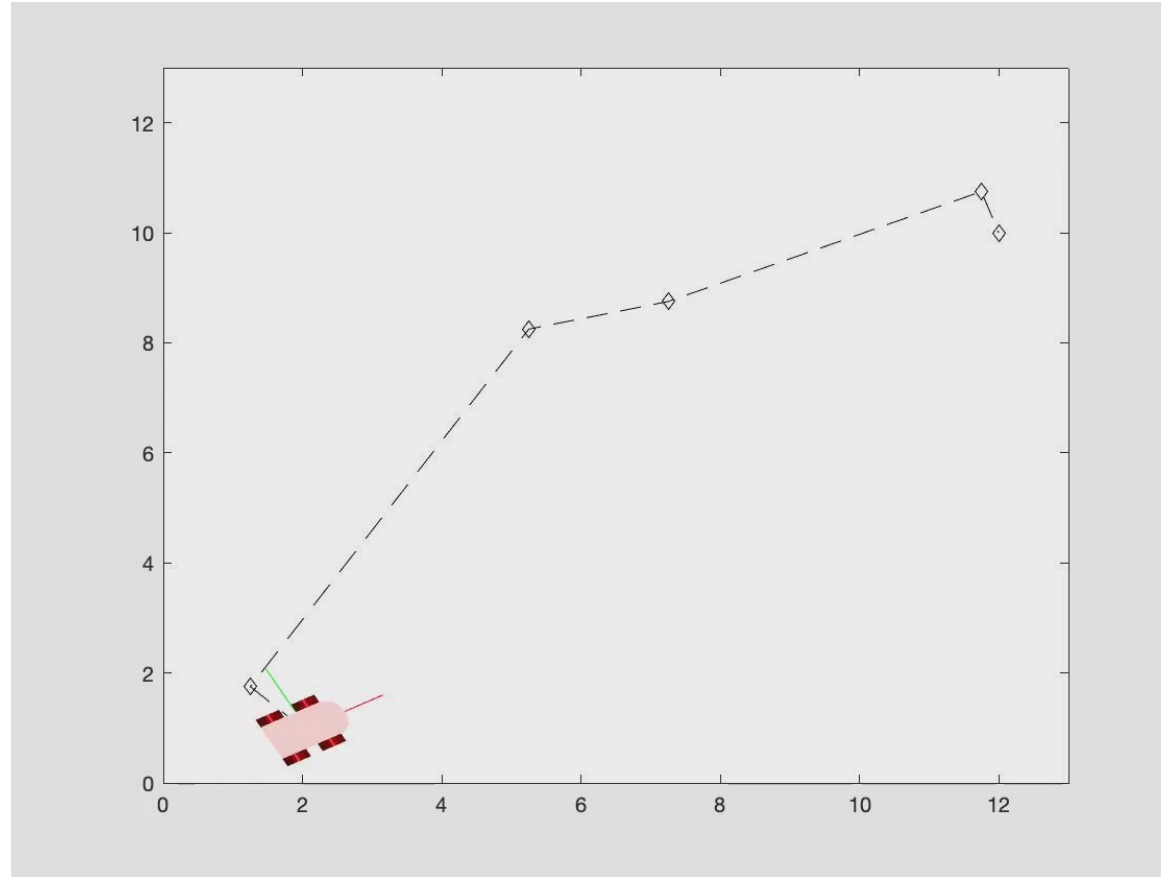
# PURE PURSUIT – MATLAB EXAMPLES

- Stable



# PURE PURSUIT – MATLAB EXAMPLES

- Unstable



# MATLAB DEMOS



# EXERCISES



Form groups of 3-4 persons (ideally multi- disciplinary)



Download and examine Peter Corke's Robotics Toolbox and Machine Vision Toolbox (<http://www.petercorke.com/Toolboxes.html>)



Have a look at Mathworks Robotics Systems Toolbox (<http://se.mathworks.com/help/robotics/index.html>)



Brightspace exercises (including **1 mandatory!**)



[mirgita.frasheri@ece.au.dk](mailto:mirgita.frasheri@ece.au.dk)

