



# Robotics

Recap

University of Stuttgart  
Winter 2018/19

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# Main Components of Robotics

- Kinematics
- Dynamics
- Control
- Path Planning
- Mobile Robotics

# Kinematics

- Geometry: pose, frame, transformation
- Forward kinematics
  - Kinematics as composition of transformations
  - Kinematic maps  $\phi^{\text{pos}} : q \mapsto y$  and  $\phi^{\text{vec}}$
  - Definition of a Jacobian
- Inverse kinematics
  - Optimality criterion for IK
  - Algorithms for IK
- Motion profiles & Interpolation
- Multiple Tasks

# Dynamics

- 1D point mass & PID control
  - Dynamics of a 1D point mass
  - Closed-loop P(I)D systems & qualitative behaviors
- Euler-Lagrange equation
  - Basic structure
  - Application on modeling dynamical systems
- Robot dynamics & joint/operational space control
  - General form of the dynamics equation
  - Joint space control, operational space control
  - Following a reference trajectory

# Control

- Optimal Control
  - Concept & definition of the value function
  - Finite & infinite control problem
  - Linear-quadratic optimal control
- Controllability
- Stability

# Path Planning

- BUG algorithms
- Potential functions
- Probabilistic Road Maps
- Rapidly Exploring Random Trees
- Non-holonomic Systems

# Mobile Robotics

- Probability basics
- State estimation
  - Bayes Filter as the general analytic solution
  - Particle Filter
  - Kalman Filter
- Simultaneous Localization and Mapping
  - Definition of problem
  - Kalman SLAM
  - Particle SLAM

# Summary

- Robotics (including autonomous systems) becomes increasingly important
- Includes many components from computer science, engineering and statistics
- Challenging in real-world, interactive applications
- Advanced topics: Reinforcement learning, imitation learning