A short introduction to mobile robots

LEGO Mindstorms @ Chair Brauer

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Introduction
Locomotion is the process of causing an autonomous robot or vehicle to move. In order to produce motion, forces must be applied to the vehicle. The study of motion in which these forces are modeled is known as dynamics, whereas kinematics is the study of the mathematics of motion without considering the forces that affect the motion.’ (taken from [DJ00])
Fundamental Kinematic Problems

- Forward kinematic problem: Given the control inputs, how does the robot move?
- Inverse kinematic problem: Given a desired motion, which control inputs should be chosen?
Application Domains

- Terrestrial robots (e.g. service robots, robocup)
- Aquatic robots (e.g. research robots)
- Airborne robots (e.g. military drones)
- Space robots (e.g. repair robots)
Terrestrial Movement Systems

- Wheels (e.g. mars robot Sojourner)
- Tracks (e.g. tanks)
- Legs (e.g. humanoids, insects)
Mobile Robots in Detail
Wheeled Mobile Robots
Three degrees of freedom \((x, y, \Theta)\), often: not all three can be changed as desired simultaneously.

Complex wheel configurations, castor wheels.

Instantaneous center of curvature (ICC), instantaneous center of rotation (ICR), center of rotation (COR):

For a wheeled mobile robot to move, a point must exist around which each wheel on the vehicle follows a circular course.
Wheeled Mobile Robots (WMR) II

- Odometry: estimation of the distance traveled by the measurement of how much the wheels on the robot platform have turned (see shaft encoders in the sensors lecture)

- Steered wheel: orientation and rotational axis of the wheel can be controlled (in contrast to e.g. a castor wheel)
WMRs - Differential Drives

- Two wheels (one on each side of the robot) on a common axis, controlled by separate motors
- Center of rotation lies on this common axis
- By varying the wheel velocity, the center moves along the axis
  - special case 1: $v_l = v_r$
  - special case 2: $v_l = -1 \times v_r$
WMRs - Synchronous Drives

- All wheels are steered and driven
- All of the wheels turn and drive in unison
- All of the wheels point in the same direction and turn at the same rate
- Synchronous drive robots are an example of a idealized point robot
WMRs - Ackerman Steering

- Also known as car steering or kingpin steering
- The front wheels each rotate on separate arms to rotate different amounts to point at the ICC
- The ICC lies on a line through the rear axis.
- The inside wheel travels a shorter distance than the outer wheel
- The inside wheel turns a larger angle than the outside wheel
Other Locomotion Mechanism
Tracked Vehicles

- Similar to the differential driver (seen from the kinematic point of view)
- Turning is possible due to slipperage between the robot and the ground
- Problems arise from the slipperage
- Need for external positioning system or use of caster or omnidirectional wheel (which measures the motion with respect to the ground plane)
Limbed Vehicles

Motivation: wheeled vehicles need ground contact all the time, in SAR situations or in rough terrain a different mechanism is needed.

Static stability: balance is preserved even if all legs are frozen in position at any time.

Dynamic stability: the center of gravity is allowed to move outside of the convex hull of the support polygon and the robot moves in a controlled manner.

Typically 1, 2, 4, 6 or 8 legs.
This talk heavily bases on [DJ00].
References


End