ECE209AS (Fall 2025)

Computational Robotics

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Challenge problems: Other systems to explore

Two wheeled car (paperbot)

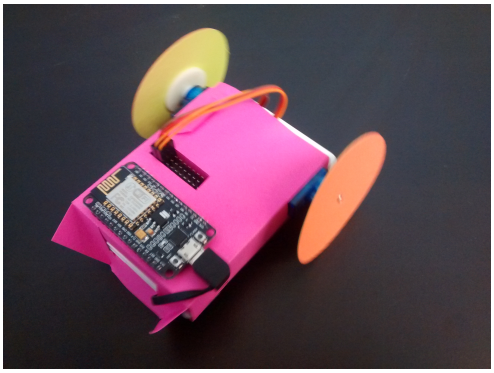

Figure 1: Two wheeled paperbot

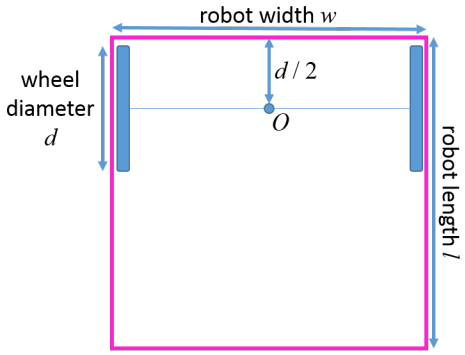

Figure 2: Simplified schematic with dimensions for two wheeled paperbot model

Consider a rigid body robot driving on the 2D plane through analog speed control of two wheels, as seen in Figures 1, 2.

Each wheel is actuated independently by a continuous rotation servo; the servo speeds are commanded directly by a microcontroller. This allows the robot to drive forwards or backwards at variable speed, or turn with any turning radius.

Two laser range sensors and an IMU will provide extrinsic position sensing. The output of these sensors will be a function of the positional state of the robot relative to its environment.

The laser range sensors are mounted on the robot such that they measure 1) the distance to a wall in a straight line in front of the robot, and 2) the distance to a wall in a straight line to the right of the robot. The IMU will return 1) a measurement of the in-plane rotational speed from a angular rate (gyro) sensor, and 2) the components of the measured magnetic field along each of the 2 in-plane coordinate axes, which can be used as a compass for absolute orientation relative to Earth's magnetic field. We will ignore the out-of-plane gyro and magnetometer axes, as well as the accelerometer on the IMU.

Both the actuators and sensors can be noisy, according to actual electromechanical devices.

2D underactuated system (wobbly rocket)

Consider a rocket constrained to an environment (operational space) that is a vertical 2D slice through the world (i.e. coordinate axes left-right, up-down; gravity always points down). The rocket body B produces a noisy thrust force F along its own axis, but has an off-center control mass C to be used for control.

That is, the rocket consists of a rigid body m_B and a point mass m_C separated by a time varying vector $\vec{d_0} + r(t)\vec{d_1}$ from the center of mass of B (in the B reference frame). It also produces a force $\vec{F} + \vec{w}(t)$ in the B reference frame, where $\vec{w}$ is the unknown disturbance.

The configuration state variable $r(t)$ is limited to the range $[-1, 1]$, and your single DOF input $u(t)$ controls the acceleration (second derivative) of $r(t)$: $\ddot{r}(t) = u(t)$.

Pursuit / evasion

Consider a gridworld environment with two (or more) agents—one (or more) pursuers and one (or more) evaders—that each take turns acting according their own system dynamics. Pursuers are trying to capture (occupy the same state as) evaders as quickly as possible, while evaders should avoid capture for as long as possible.

We typically consider each agent as a separate system; we can also consider the single system case with full state information about all agents in the environment, with output actions similarly to all agents.

The agents can have different dynamics, such as in the case of chess pieces trying to capture other chess pieces.

Mini Yahtzee

Consider a one-turn game of Yahtzee:

- https://en.wikipedia.org/wiki/Yahtzee.

That is, starting with a blank score sheet, roll 5 dice. You can choose to re-roll a subset of the dice to get a new result, or stay with what was rolled. You can then again choose to re-roll any subset of the 5 dice to get yet another new result, or stay with what you have. After the second re-roll, you must stay with the 5 numbers that are showing on the dice. You then get a score associated with your final set of 5 numbers, as seen at the above link.

Liar's dice

Consider the family of games known as Liar's dice:

- https://en.wikipedia.org/wiki/Liar%27s_dice

This can be viewed from either from an external observer's perspective, or from a player's perspective. The input to the system is each subsequent bid in a bidding round along with its bidder (ignoring calls or challenges for now).

If viewed from the player perspective, the action will be the subsequent bid.