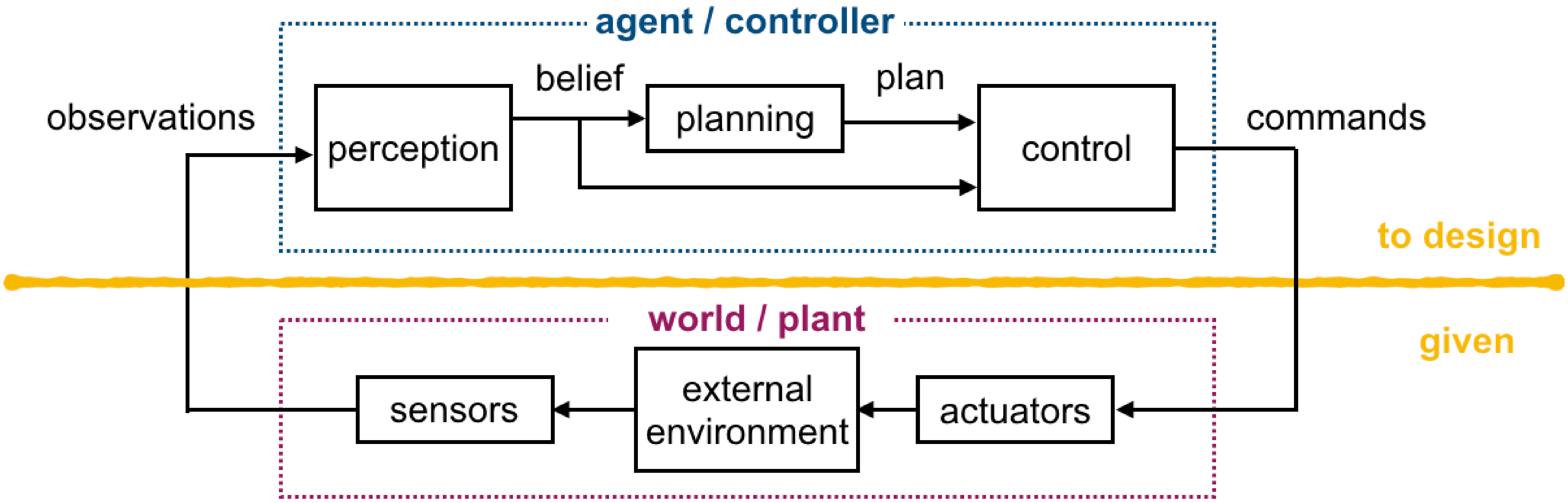
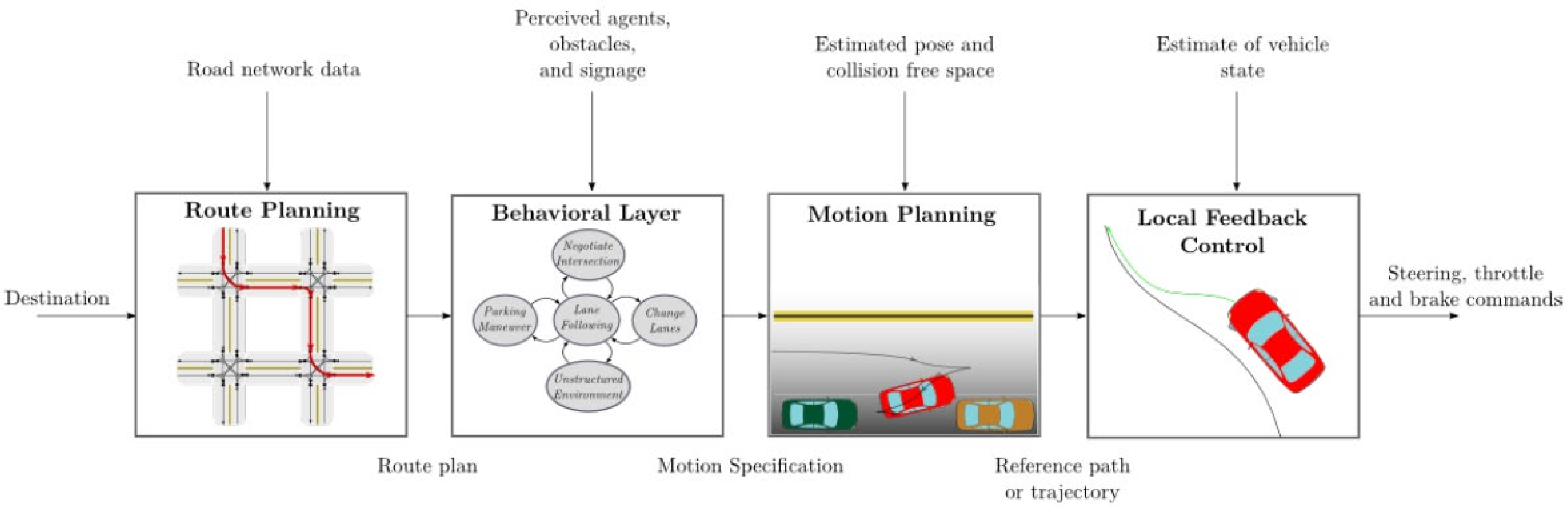
Introduction to motion planning

Credits: duckietown.org, S. LaValle’s book “Planning Algorithms”

Big picture


agent / controller
belief
plan
observations
perception
planning
control
commands
to design
given
world / plant
sensors
external environment
actuators

Hierarchical architecture



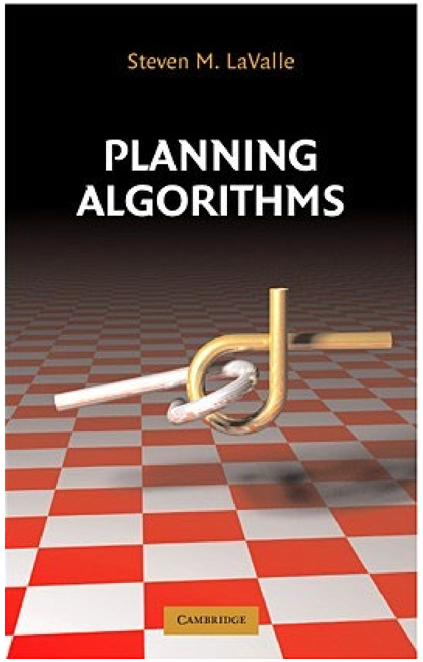
- Graph theory
- Search algorithms (A*, D*, …)

- Finite state machine

- Variational methods (e.g., PF)
- Graph-search methods (e.g., cell/grid)
- Incremental search methods (e.g., RRT)

Motion planning

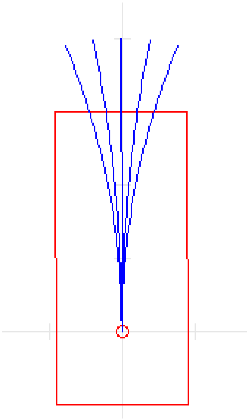
- **Motion Planning:** Find a feasible, collision-free path from given start pose to given destination pose.
- **Constraints** on path:
  - Starts at **current position**.
  - Ends at **goal position**.
  - Robot **does not collide** with obstacles
  - Respect kinematics constraints: **limited turning-radius**

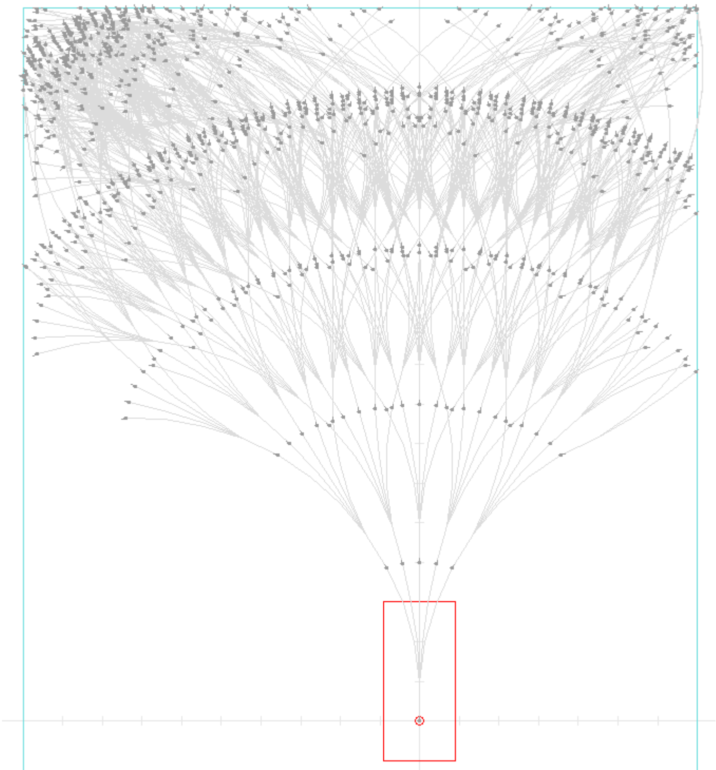


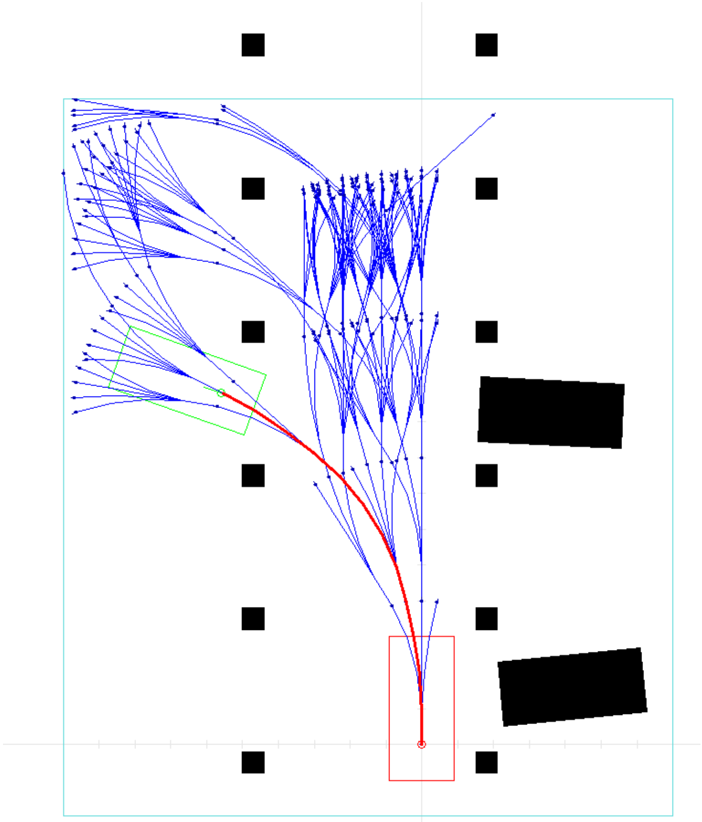
Reference: Planning Algorithms by Steve LaValle, free at http://planning.cs.uiuc.edu/

Motion primitives

- A discrete set of maneuvers that a vehicle can execute from each configuration
- Expanding maneuvers into future time steps from initial configuration
- Score each trajectories or use search algorithms to find the shortest path to the desired region







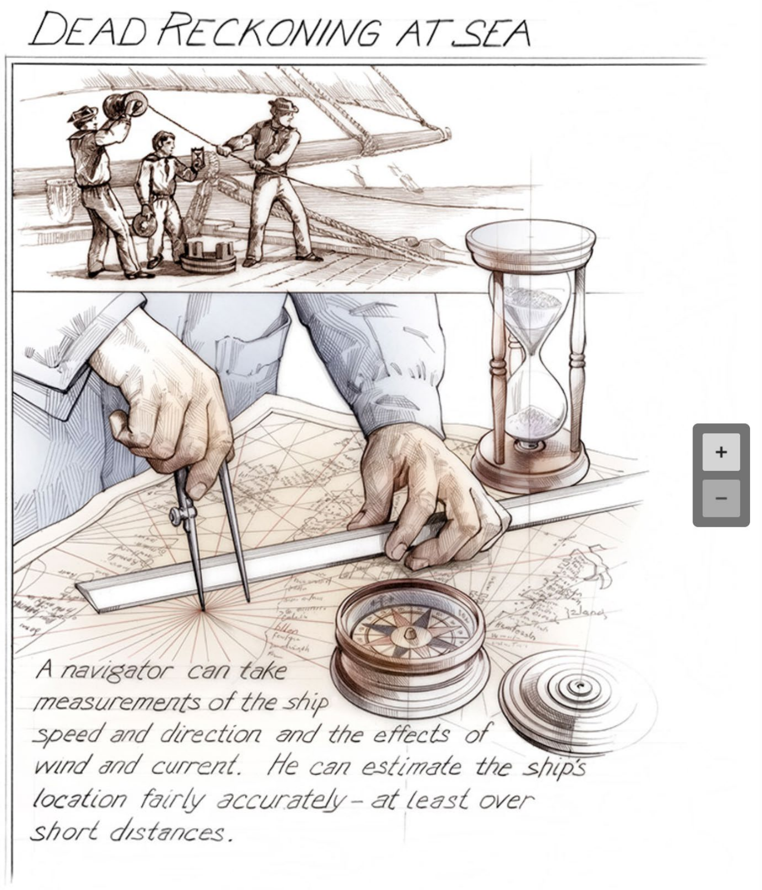
Pros/Cons

- Can handle differential constraints
- Model agnostic
- Can be efficient (real-time) and more deterministic
- ROS package: http://wiki.ros.org/sbpl

- Completeness and optimality achieved only up to discretization resolution

Localization

- Necessary: because no global position information is provided and because inertial sensors have noise and drift issues



Dead reckoning has error accumulation issues!!

Better localization

- Using external landmarks to reduce/avoid drift: need sensors like lidar, camera,…
  - If the landmarks are at known locations, it is a localization problem.
  - If the landmarks are at unknown locations, it is SLAM (simultaneous localization and mapping).
- Fuse odometry information with external landmark information
  - EKF
  - Particle filter
  - MAP (Maximum a posteriori) estimation
  - ROS package: gmapping (requires a 2D laser scanner and a decent odometry), ORB-SLAM (monocular, stereo, RGB-D), g2o, gtsam