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Planning

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⇒ Need to react to events.

⇒ Not all information is available in advance.

↳ Online planning

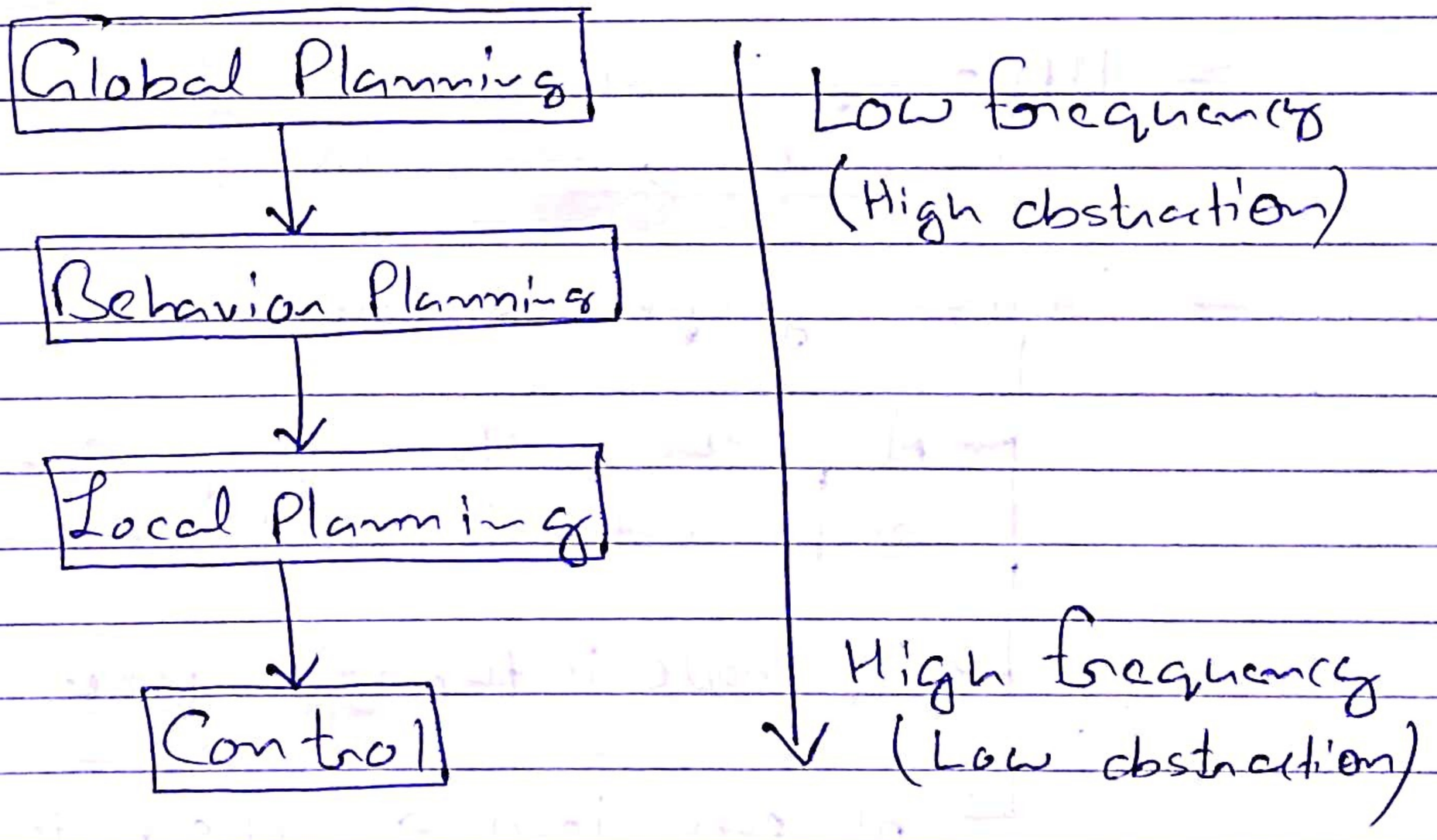
⇒ Not all information is needed for each decision.

↳ hierarchical planning

★ Hierarchical Planning

⇒ Divide driving task into subproblems.

⇒ Hierachy defines levels of abstraction & information access.



* Global Planning

{User defined destination
goal network}

↓

Global Planning

↓

{Sequence of Waypoints}

⇒ Often in robotics, we discretize world resulting in a grid.

⇒ Here, we use topological road map.

⇒ MD maps contains information about intersections, lanes etc.

⇒ Forom graph to tree

→ A path on the graph can be represented in a search tree

→ Top node is the start pose.

→ At each level an action is taken which result in a new pose.

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⇒ Search algorithms differ in

- Completeness
- Optimality
- Time Consumption
- Memory consumption.

⇒ Uninformed or informed Search.

- Uninformed:
  - Breadth-first Search
  - Depth-first Search
- Informed:
  - Greedy Search
  - A*

★ Behavior Planning

{Sequence of Waypoints & Perception of neighborhood}

↓

Behavior Planning

↓

{Maneuver specification (Stop, drive straight, Overtake)}

⇒ Cover all possible situations by a Finite state machine.

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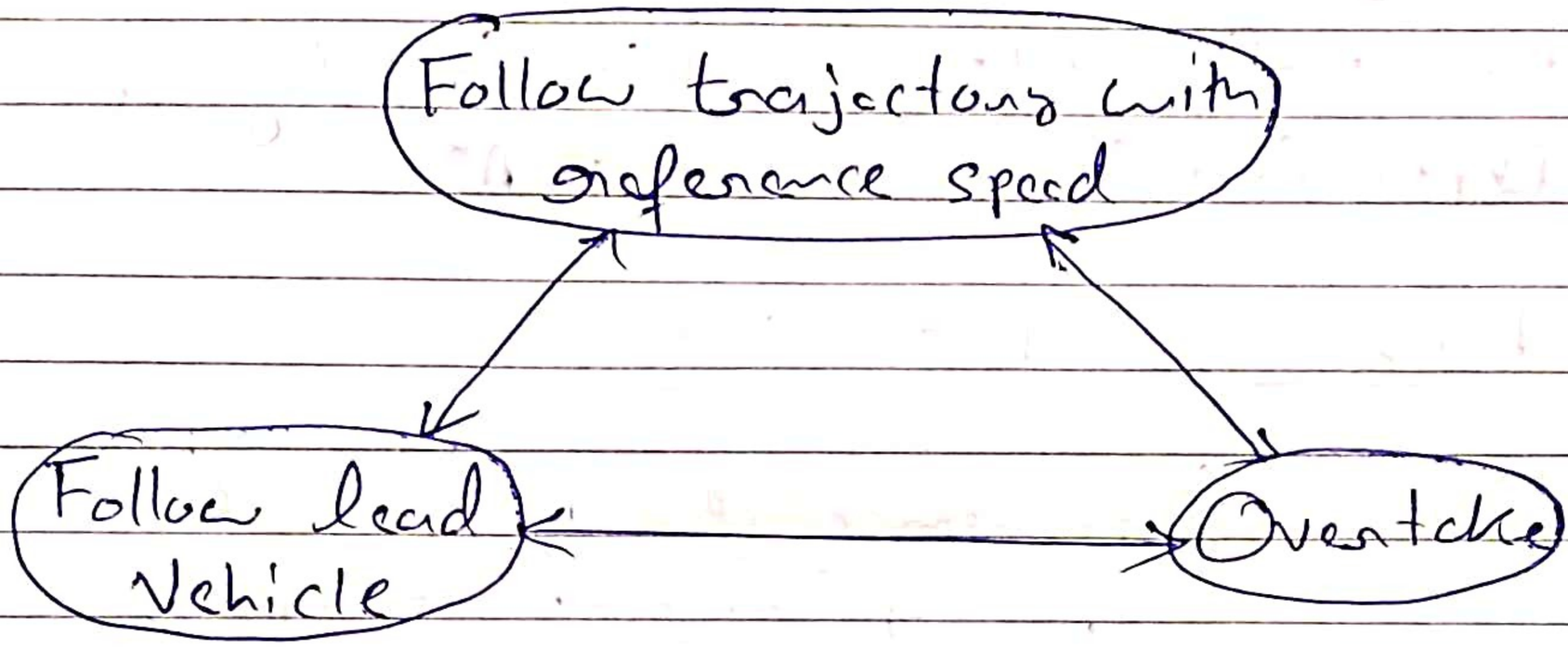
★ Finite State machine

⇒ Finite amount of possible states

⇒ Current state defines a maneuver

⇒ Transition between states based on input.

Example



★ Local Planning

{Desired maneuver & measurements of surroundings}

↓

Local Planning

↓

{Path with velocity profile to follow}

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⇒ Return reference trajectory to follow with a predefined horizon.

↳ Trajectory should be feasible & Obstacle free.

* Path Generation

* Combinatorial planner
  ↳ Explicitly model obstacles.

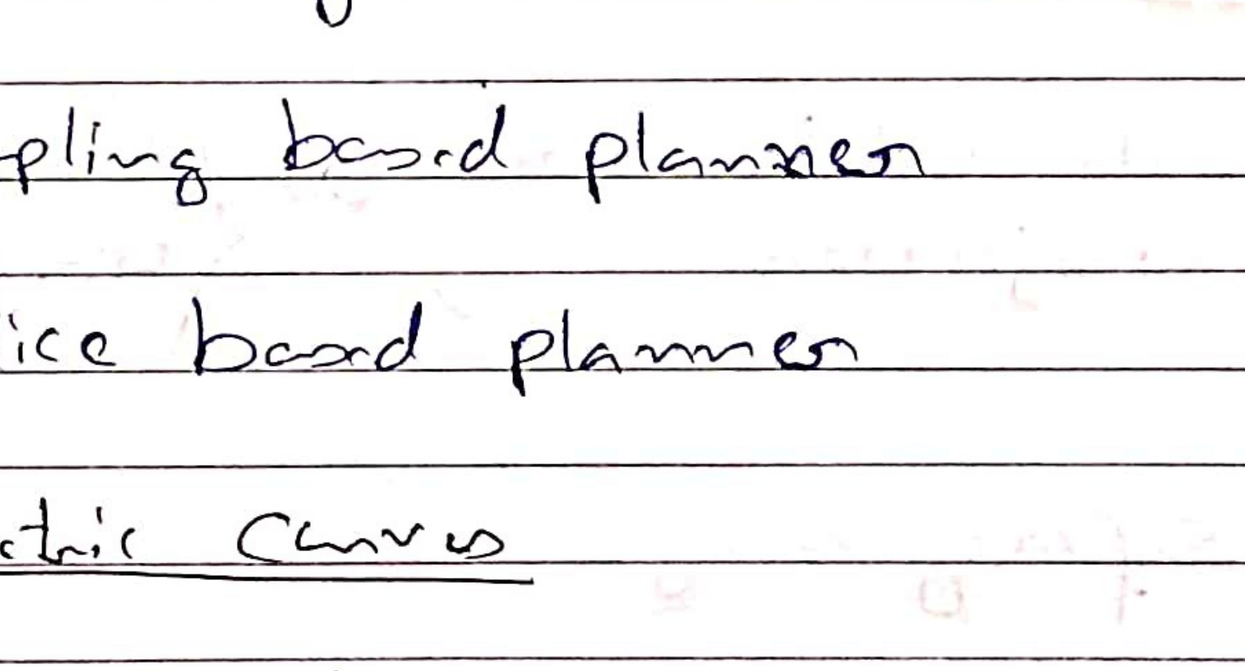
* Variational planner
  ↳ Optimize with respect to Obstacles & dynamics.

* Sampling based planners

* Lattice based planners

* Parametric curves

⇒ Account for boundary conditions & Kinematic constraints.



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Cubic Spline

$$g_1(u) = [x(u), y(u)] \quad u \in [0,1]$$

$$x(u) = \alpha_3 u^3 + \alpha_2 u^2 + \alpha_1 u + \alpha_0$$

$$y(u) = \beta_3 u^3 + \beta_2 u^2 + \beta_1 u + \beta_0$$

⇒ Objective function to optimize choice of local trajectory.

↳ Combine different objectives like distance to reference, control effort, curvature, collision etc.

* Collision Avoidance

{Generate collision-free trajectories} or {Generate arbitrary trajectories & check for collision}

⇒ Use safety margin

⇒ Collision free trajectory might not exist for longer planning horizons.

⇒ Checking Collision:

- → Time to Collision (TTC)
- → Search Computation for occupancy grid map.
- → Circle Collision Checking.

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* Velocity Profile Generation

⇒ Velocity profile is limited by:

- → V_{limit} ⇒ Speed limit
- → V_c ⇒ Imposed constraint of lateral acceleration
- → V_{beh} ⇒ Reference from Behavior planner

⇒ Easiest Implementation: Linear Ramp.
