ROB311 Quiz 1

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Contents

1 Prologue

Summary:
- Variables:
  - State: $\mathbf{x}(t)$
  - Action(s): $\mathbf{u}(t)$
  - Measurement: $\mathbf{y}_k^{(i)}$
  - Context: $\mathbf{z}_k^{(i)}$
  - Old Context: $\mathbf{z}_{k-1}^{(i)}$
  - Plan: $\mathbf{p}_k^{(i)}$
  - (i): Ith agent
- Conversion to DT is necessary because robots are digitalized system and then converted back to CT for execution.

1.1 Setup of Planning Problems

Definition: In a planning problem, it is assumed that:
- the environment is representable using a discrete set of states, $\mathcal{S}$
- for each state, $s \in \mathcal{S}$, each agent, i, has a discrete set of actions, $\mathcal{A}_i(s)$, with $\mathcal{A}(s) := \times_i \mathcal{A}_i(s)$ (joint action set)
- **Move:** Any tuple, (s, a), where $s \in \mathcal{S}$ and $a \in \mathcal{A}(s)$
- **Transition:** Any 3-tuple, (s, a, s'), where $s, s' \in \mathcal{S}$ and $a \in \mathcal{A}(s)$
  - the transition resulting from a move may be deterministic/stochastic
- **Reward:** $\text{rwd}_i(s, a, s')$ is agent i's reward for the transition, (s, a, s')
- **Path:** Any sequence of transitions of the form.

$$p = \left\langle (s^{(0)}, a^{(1)}, s^{(1)}), (s^{(1)}, a^{(2)}, s^{(2)}), \ldots \right\rangle$$

- **Objective:** Each agent wants to realize a path that maximizes its own reward

Warning: $\mathcal{A}(s)$ is the joint action set of all agents at state s.

1.2 Components of a Robotic System

Summary:

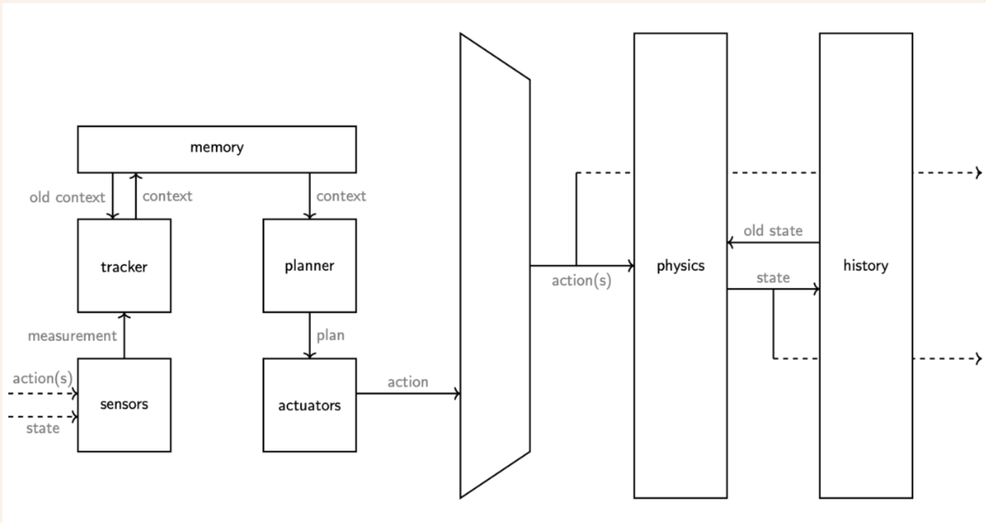

Figure 1: Components of a Robotic System (Words)

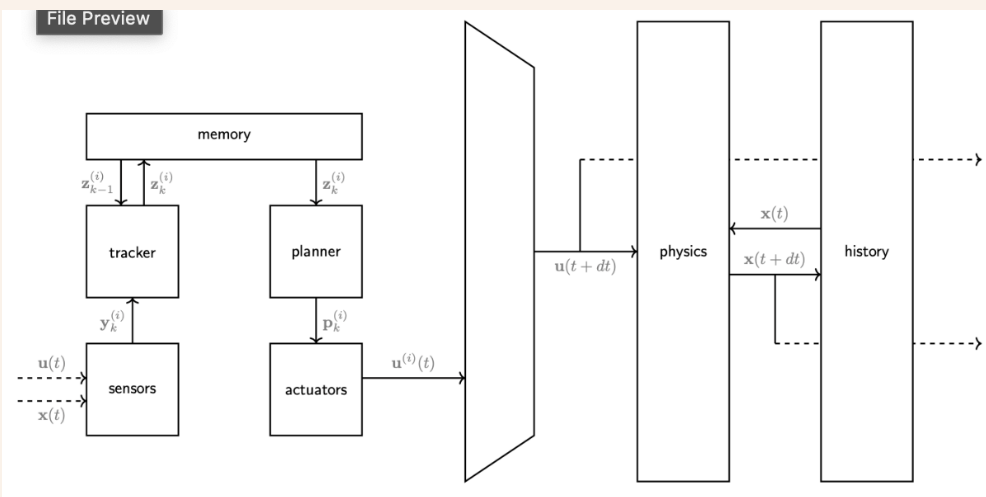

Figure 2: Components of a Robotic System (Math)

1.2.1 Overview (Robots, the Environment)

Definition:

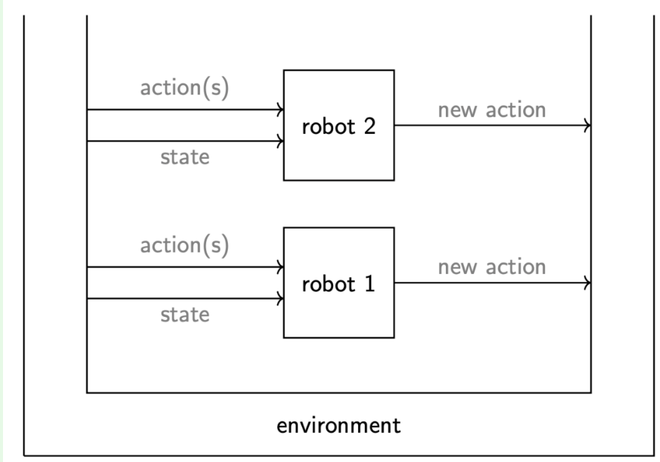

Figure 3: Overview (Robots, the Environment)

Notes:
- Environment → previous actions + current state → robot → new action → environment

1.2.2 Robot (Sensors, Actuators, the Brain)

Definition:

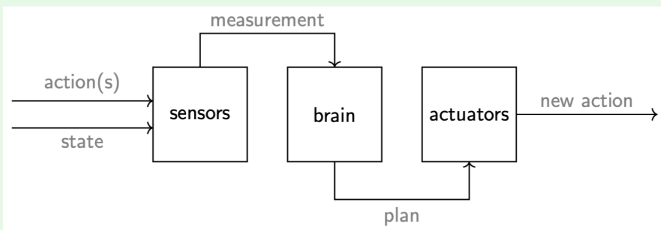

Figure 4: Robot (Sensors, Actuators, the Brain)

Notes:
- Measurements can be noisy and inaccurate if not a perfect sensor.
- Measurements go into the brain which can create a plan.

1.2.3 Brain (Tracker, Planner, Memory)

Definition:

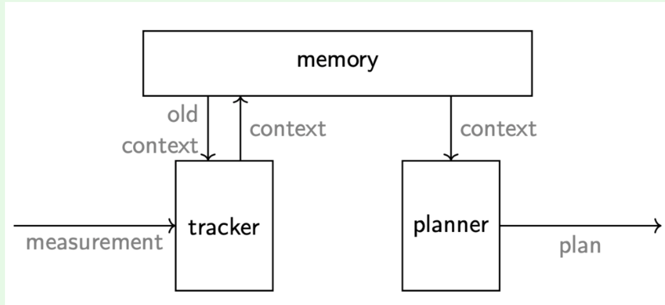

Figure 5: Brain (Tracker, Planner, Memory)

Notes:
- The tracker takes in the measurements and old context and updates the context.
- The planner takes in the context and creates a plan.
- The memory stores the context.

1.2.4 Environment (Physics, State)

Definition:

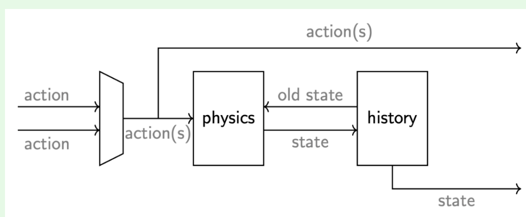

Figure 6: Environment (Physics, State)

1.3 Equations of a Robotic System

1.3.1 Sensing

Definition: Take a measurement:

$$\mathbf{y}^{(i)}(t) = \mathrm{sns}^{(i)}\big(\mathbf{x}(t), \mathbf{u}(t), t\big)$$

Convert the measurement into a discrete-time signal using a sampling period of $T^{(i)}$:

$$\mathbf{y}_k^{(i)} = \mathrm{dt}\big(\mathbf{y}^{(i)}(t), t, T^{(i)}\big)$$

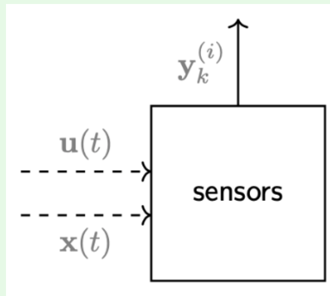

Figure 7: Sensing

1.3.2 Tracking

Definition: Track (update) the context:

$$\mathbf{z}_k^{(i)} = \mathrm{trk}^{(i)}\big(\mathbf{z}_{k-1}^{(i)}, \mathbf{y}_k^{(i)}, k\big)$$

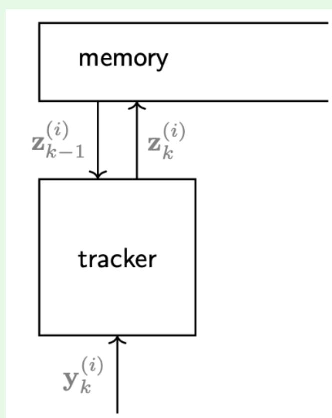

Figure 8: Tracking

1.3.3 Planning

Definition: Make a plan:

$$\mathbf{p}_k^{(i)} = \mathrm{pln}^{(i)}\left(\mathbf{z}_k^{(i)}, k\right)$$

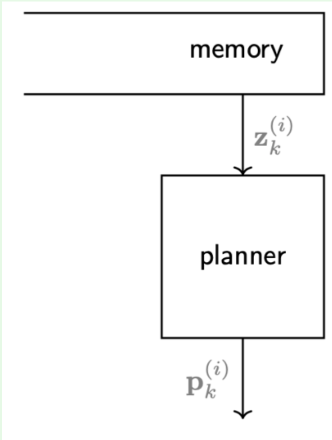

Figure 9: Planning

1.3.4 Acting

Definition: Convert the plan into a continuous-time signal using a sampling period of $T^{(i)}$:

$$\mathbf{p}(t) = \mathrm{ct}\left(\mathbf{p}_k^{(i)}, t, T^{(i)}\right)$$

Execute the plan:

$$\mathbf{u}^{(i)}(t) = \mathrm{act}^{(i)}\left(\mathbf{p}^{(i)}(t), t\right)$$

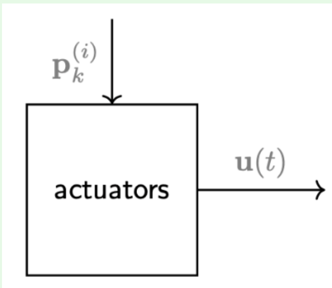

Figure 10: Acting

1.3.5 Simulating

Definition: Simulate the environment's response:

$$\dot{\mathbf{x}}(t) = \mathrm{phy}\big(\mathbf{x}(t), \mathbf{u}(t), t\big)$$

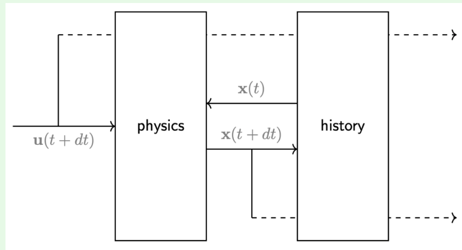

Figure 11: Simulating