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Introduction to Robot Mapping

Robot ⇒ A device, that moves through the environment.

Mapping ⇒ Modeling the environment

★ Related terms

State Estimation

Localization

Mapping

SLAM

→ (Main Focus of this Course)

→ {We Know Where the Sensor is & we just want to Estimate Map}

Navigation

Motion planning

★ What is SLAM

↳ Computing robot poses and the map of the environment at the same time.

\# Localization ⇒ Estimating the robot's Location.

\# Mapping ⇒ Building the Map

\# SLAM ⇒ Building the Map and localizing the robot Simultaneously.

⇒ SLAM is a Chicken-or-egg Problem:

↳ Map is needed for localization

↳ Pose estimate is needed for mapping.

Given

① The robots Control

$$u_{1:T} = \{u_1, u_2 \cdots u_T\}$$

② Observations

$$z_{1:T} = \{z_1, z_2 \cdots z_T\}$$

Wanted

① Map of the environment

m

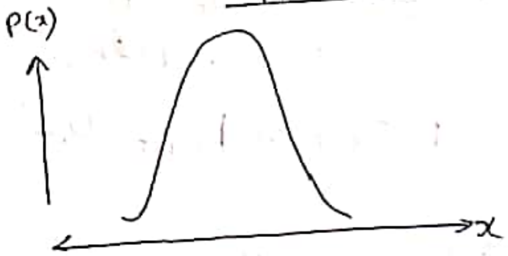
② Path of the robot

$$x_{0:T} = \{x_0, x_1, \cdots x_T\}$$

Deterministic Approach

{Robot is Exactly here}

Probabilistic Approach



{Robot is Somewhere here}

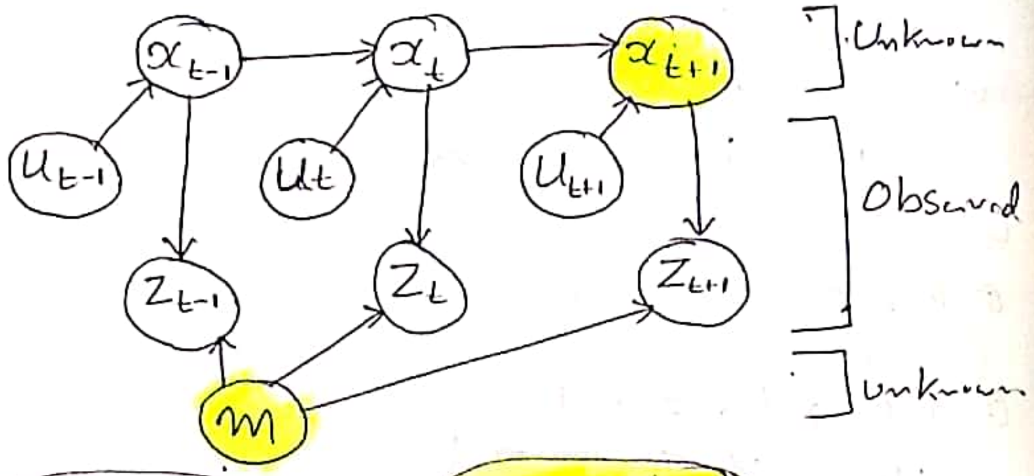
⇒ Estimating the robots path and the map (In Probabilistic world)

$$P(x_{0:T}, m \mid z_{1:T}, u_{1:T})$$

distribution, path, map, Given, observation, Controls

- → Kalman filter and family
- → Particle filter based technique
- → Graph based approaches.

★ Graphical Model



★ Full SLAM Vs Online SLAM

Full SLAM → Estimates the Entire path.

$$P(x_{0:T}, m \mid z_{1:T}, u_{1:T})$$

Online SLAM → Seeks to recover only the most recent pose

$$P(x_t, m \mid z_{1:t}, u_{1:t})$$

★ Online SLAM

⇒ Online SLAM means marginalizing out the Previous poses.

$$\boxed{P(x_t, m \mid z_{1:t}, u_{1:t}) = \int_{x_0} \cdots \int_{x_{t-1}} P(x_{0:t}, m \mid z_{1:t}, u_{1:t})\, dx_{t-1} \cdots dx_0}$$

⇒ Integrals are typically solved recursively, one at a time.

★ Taxonomy of

Volumetric SLAM

Topologic map

Know Correspond

Static Environ

Active SLAM

Robot Con to explore good m

Async-ti SLAM

Computat time

Single SLA

* Taxonomy of the SLAM Problem

Volumetric SLAM Vs Feature-based SLAM

Topologic map Vs Geometric map

Know Correspondence Vs Unknown Correspondence

Static Environment Vs dynamic Environment

Active SLAM Vs Passive SLAM

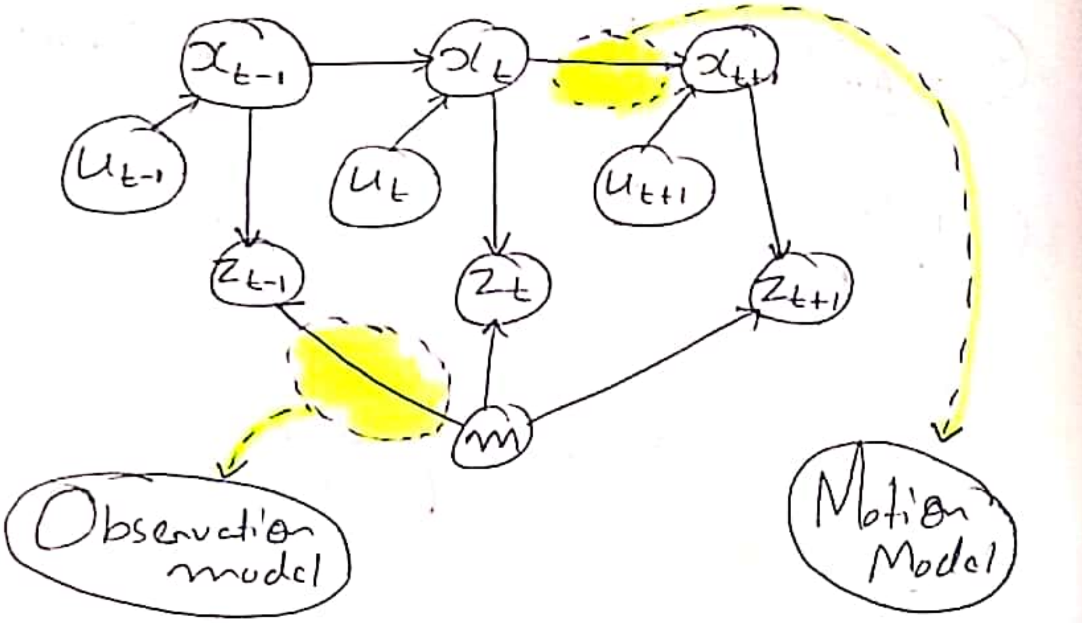
{Robot Control it self to explore and build good map} {Robot just observe the data comming and builds the map}

Any-time SLAM Vs Any Space SLAM

{Computation time} {RAM}

Single-robot SLAM Vs Multi-robot SLAM

* Motion and Observation model



$P(z_t \mid x_t, m)$

$P(x_t \mid x_{t-1}, u_t)$

- Gaussian model
- Non-Gaussian model.

* Standard Odometry Model

- Robot moves from $(\bar{x}, \bar{y}, \bar{\theta})$ to $(\bar{x}', \bar{y}', \bar{\theta}')$
- Odometry information $u = (\delta_{rot1}, \delta_{trans}, \delta_{rot2})$

$$\delta_{trans} = \sqrt{(\bar{x}'-\bar{x})^2 + (\bar{y}'-\bar{y})^2}$$

$$\delta_{rot1} = \operatorname{atan2}(\bar{y}'-\bar{y}, \bar{x}'-\bar{x}) - \bar{\theta}$$

$$\delta_{rot2} = \bar{\theta}' - \bar{\theta} - \delta_{rot1}$$