What is SLAM?

Estimate the robot’s path and the map

\[ p(x_{0:T}, m \mid z_{1:T}, u_{1:T}) \]

distribution  path  map  given  observations  controls
The SLAM Problem

- SLAM is a **chicken-or-egg** problem:
  - a map is needed for localization and
  - a pose estimate is needed for mapping
Three Main Paradigms

Kalman filter

Particle filter

Graph-based
Graphical Model of Full SLAM

\[ p(x_{0:T}, m \mid z_{1:T}, u_{1:T}) \]
Graphical Model of Online SLAM

\[ p(x_{t+1}, m \mid z_{1:t+1}, u_{1:t+1}) \]
What You Should Have Learned

- SLAM problem
- Build landmark and grid maps
- EKF SLAM
- SEIF SLAM
- Particle filter-based SLAM
- Graph-based SLAM
- Front-Ends
- Hands-on experience (programming)
- Understand average SLAM papers
Comparison of Approaches

- KF
- EKF
- UKF
- EIF
- SEIF
- FastSLAM
- Grid-Based RBPF SLAM
- Graph-Based GN, LM & SGD
Where Do You See Open Issues?
Open Issues in SLAM

- Dynamic environments
- Systematically changing environments
- Seasonal changes
- Online solutions
- Life-long operation
- Resource-constraint systems
- Failure recovery/zero user intervention
- Exploiting prior knowledge
- Robots sharing maps
Sensor-Related Issues

- Efficient data association
- Sensor-related limitations
- Poorly structured scenes
- Missing light for vision
- Monocular SLAM in large environments
Good Luck for the Exam

(visit the tutors or make an appointment with me if you have questions during the preparation)