Day 30

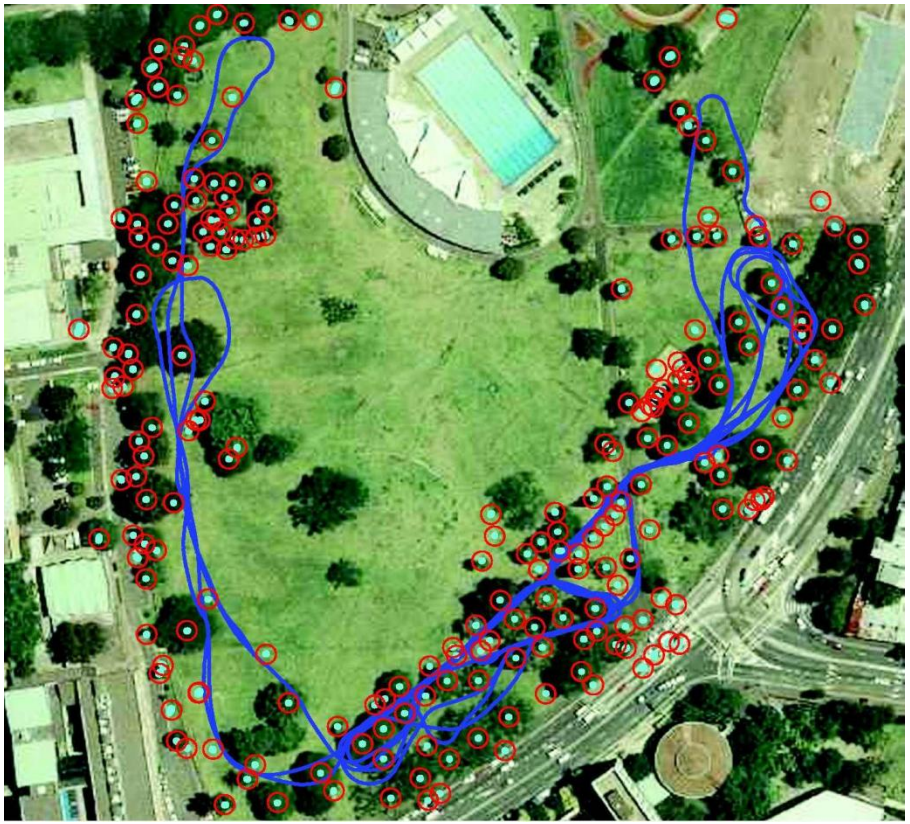
Simultaneous Localization and Mapping

SLAM

- simultaneous localization and mapping
  - one of the most fundamental problems in mobile robotics
- a robot is exploring an unknown static environment
  - robot is given sensor measurements and control inputs
    - does not have a map
    - does not know its pose

SLAM

- robot must acquire a map while simultaneously localizing itself relative to the map
  - harder than just localizing
    - has no map
  - harder than just mapping
    - does not know its pose



E. Nebot http://www-personal.acfr.usyd.edu.au/nebot/victoria_park.htm

Online SLAM

- in the online SLAM problem, we wish to estimate
  - the current pose of the robot x_t and
  - the map variables m
- we are given
  - the sensor measurements $z_{1:t} = \{z_1, z_2, \ldots, z_t\}$ and
  - the control inputs $u_{1:t} = \{u_1, u_2, \ldots, u_t\}$

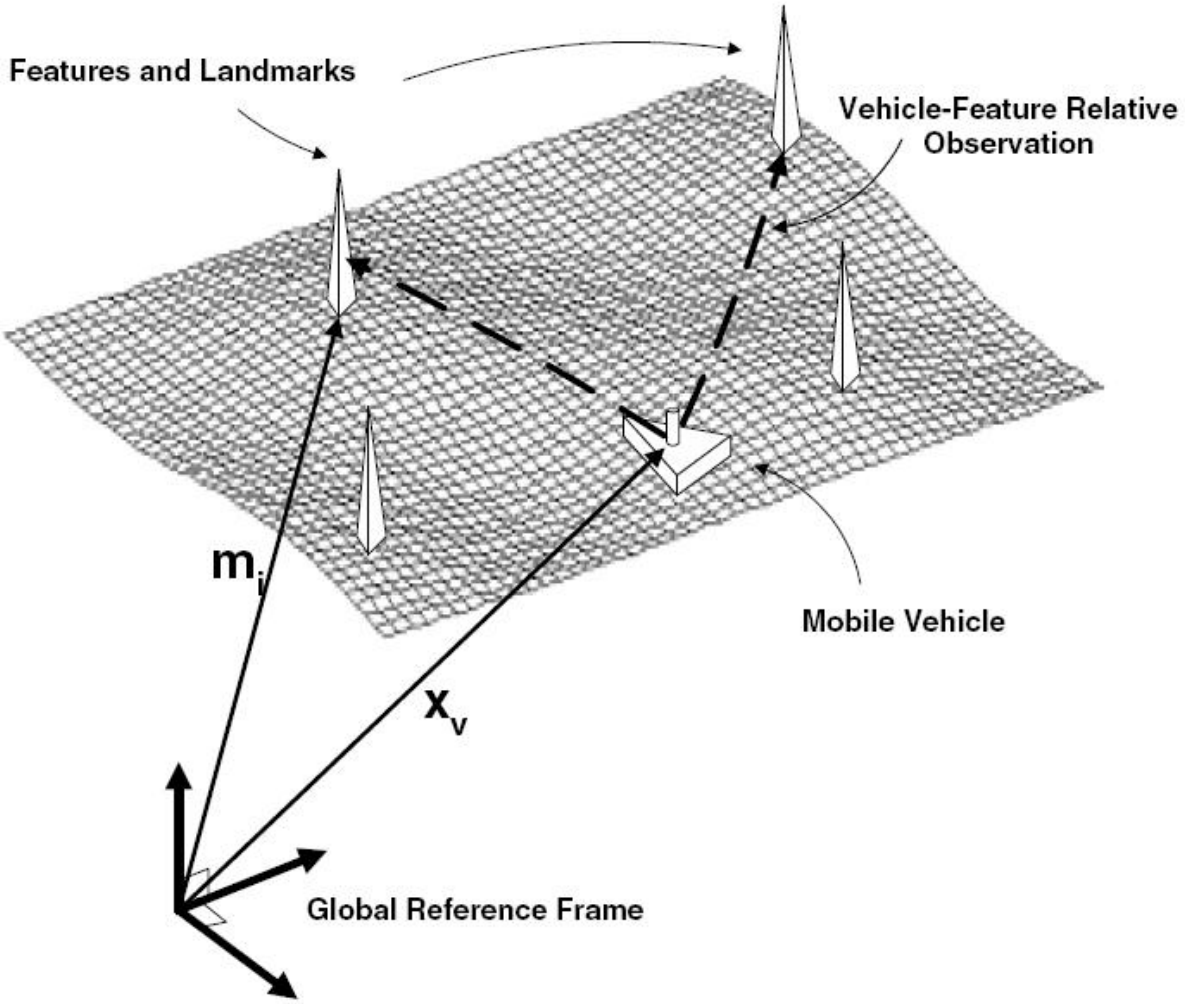
Online SLAM

- the online SLAM problem is often expressed in a probabilistic framework
  - compute the posterior probability

$$p(x_k, m \mid z_{1:k}, u_{1:k})$$

  - what is the probability density function of the robot's current pose and the map given the history of sensor measurements and control inputs?

Landmark-Based SLAM



A Simple Landmark-Based SLAM Problem

- given
  - a directionless robot (i.e., don't care about orientation) that moves in controlled but noisy steps
  - n fixed landmarks
  - the robot can measure all of the landmarks all of the time in a controlled order
  - the robot measures the relative offset from its position to each landmark

Kalman Filter: Plant or Process Model

- describes how the system state changes as a function of time, control input, and noise

$$x_{k+1} = \Phi x_k + \Gamma u_k + v_k$$

  - x_k state at time k
  - u_k control inputs at time k
  - v_k process noise at time k
  - Φ state transition model or matrix
  - Γ control-input model or matrix

Kalman Filter: Measurement Model

- describes how sensor measurements vary as a function of the system state

$$z_k = \Lambda x_k + w_k$$

  - z_k sensor measurement at time k
  - w_k sensor noise at time k
  - Λ observation model or matrix