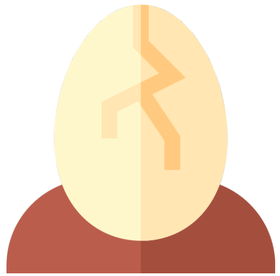
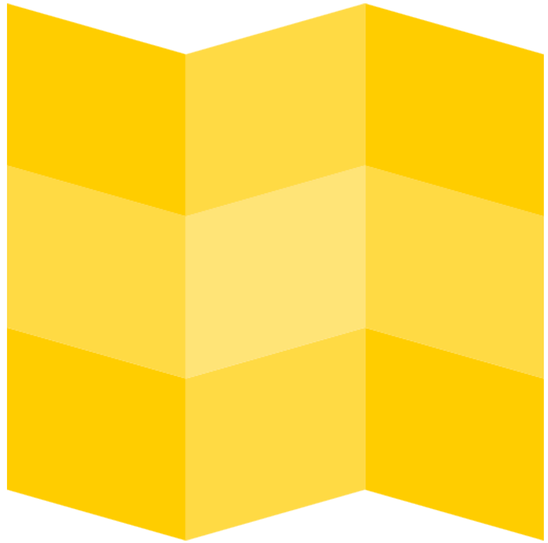
SLAM

Simultaneous localisation and mapping

Motivation



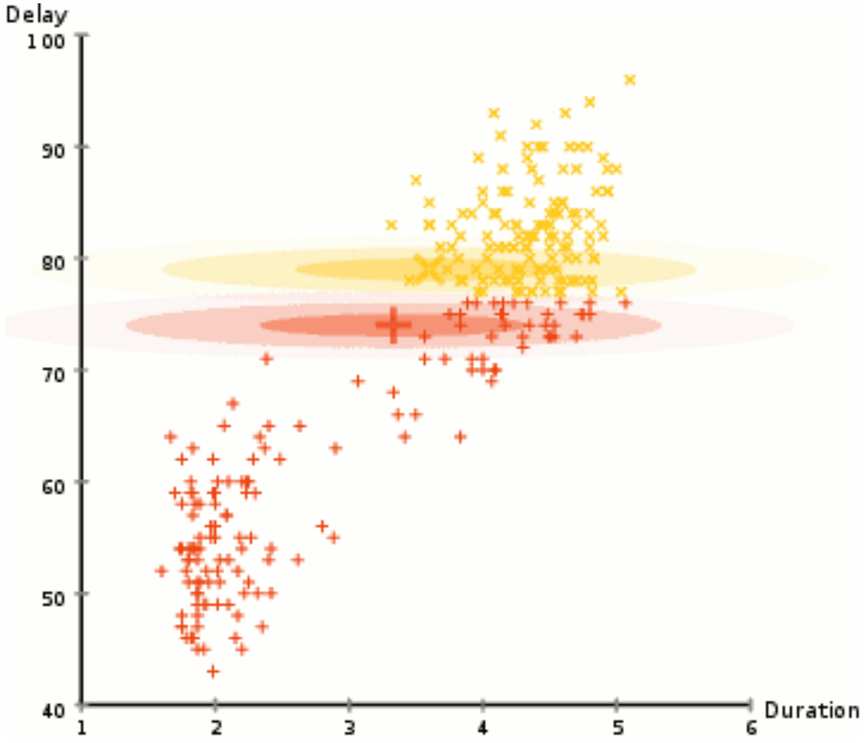


Location

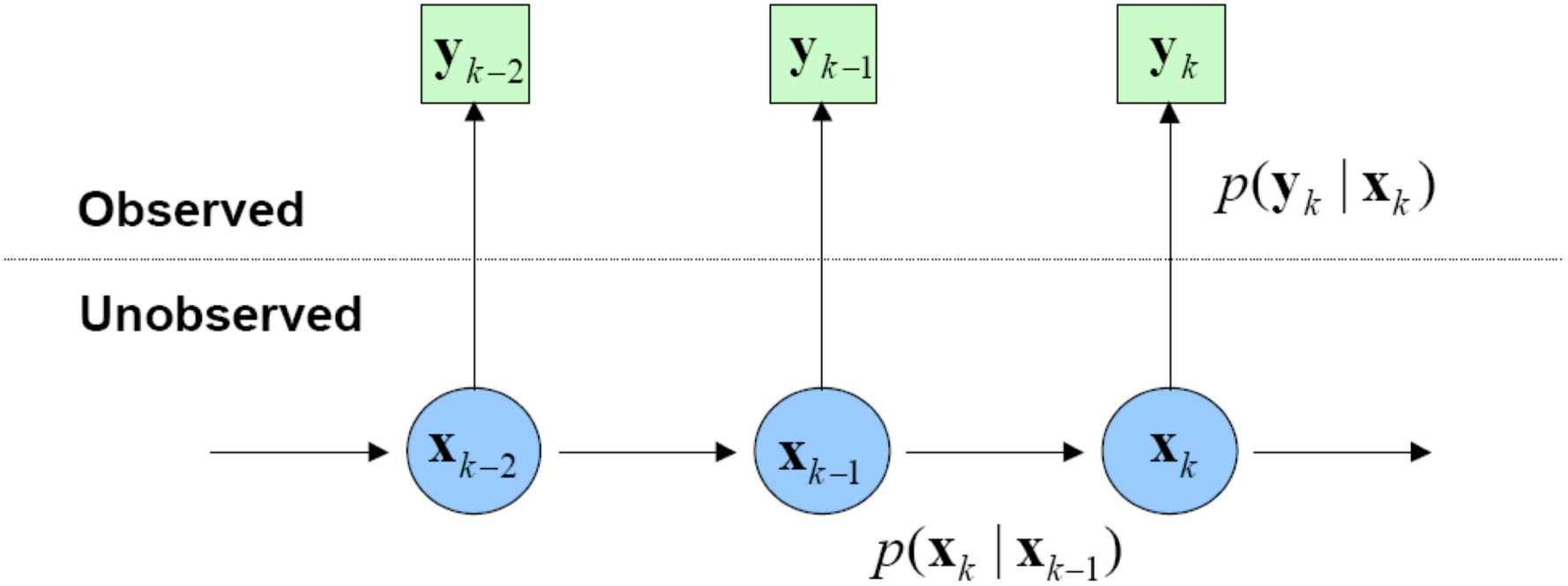
Map

Expectation–maximisation algorithm

- estimate unobservable latent variable
  - in our case: position and orientation of rover
- alternating update
  - expectation step
  - maximisation step



Filtering

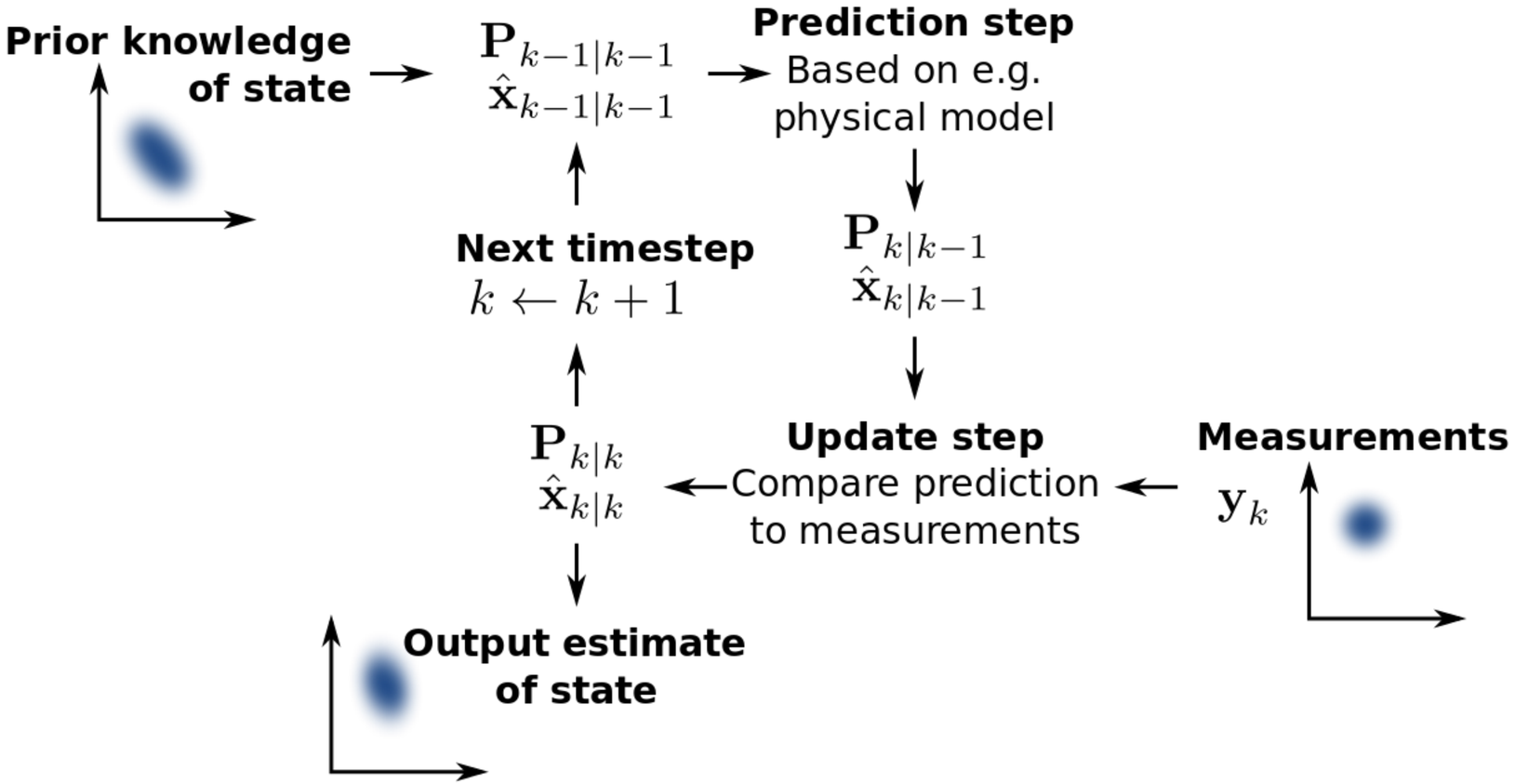


sequentially estimate the state as a set of observations becomes available

Kalman Filter

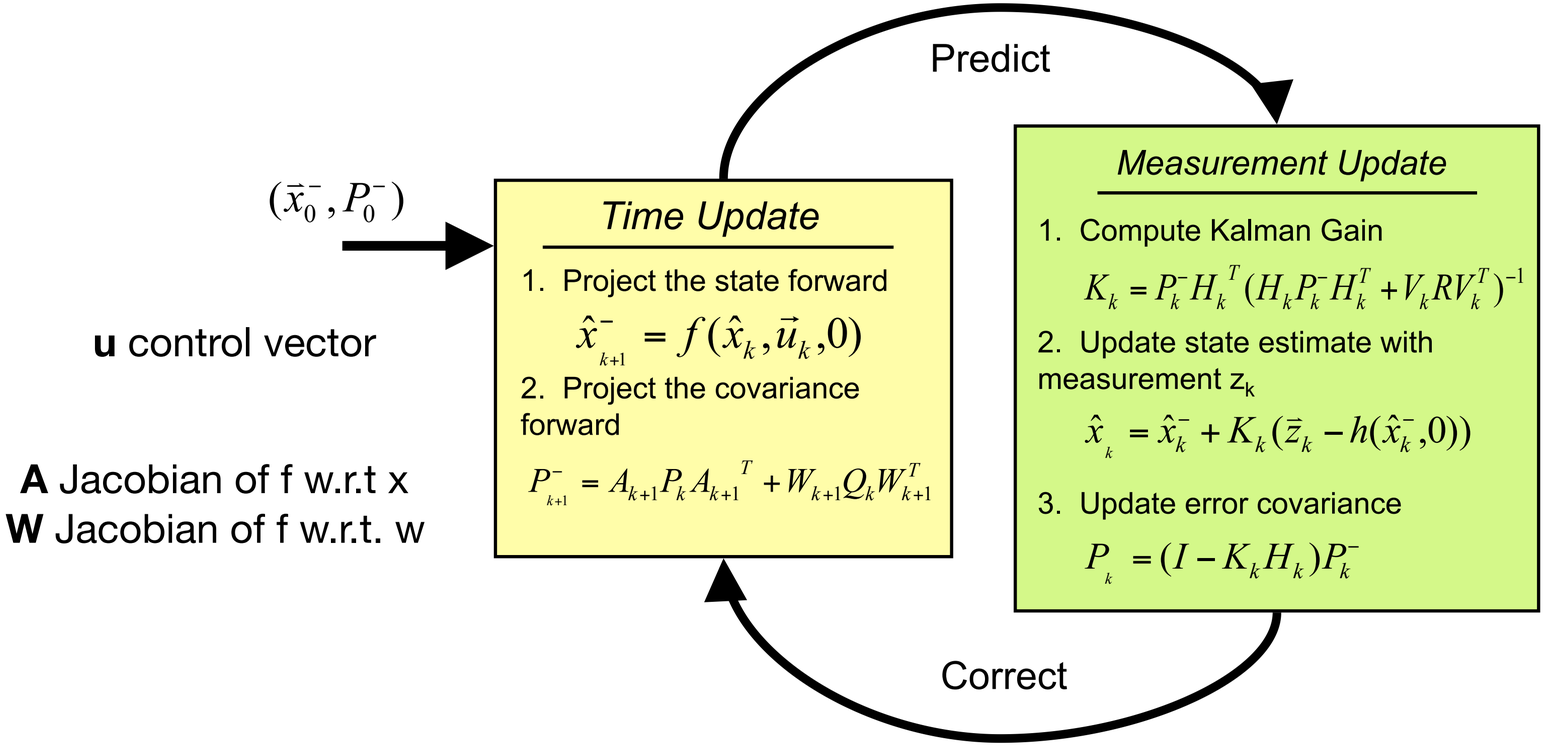
- maximum-a-posteriori estimation
- estimate of parameter
- estimate of uncertainty
  - Gaussian noise
- combine data over time
- extended Kalman Filter
  - estimate non-linearities

Kalman Filter



Extended Kalman Filter

The Discrete Extended Kalman Filter



u control vector

A Jacobian of f w.r.t x
W Jacobian of f w.r.t. w

H Jacobian of h w.r.t x
V Jacobian of h w.r.t. v

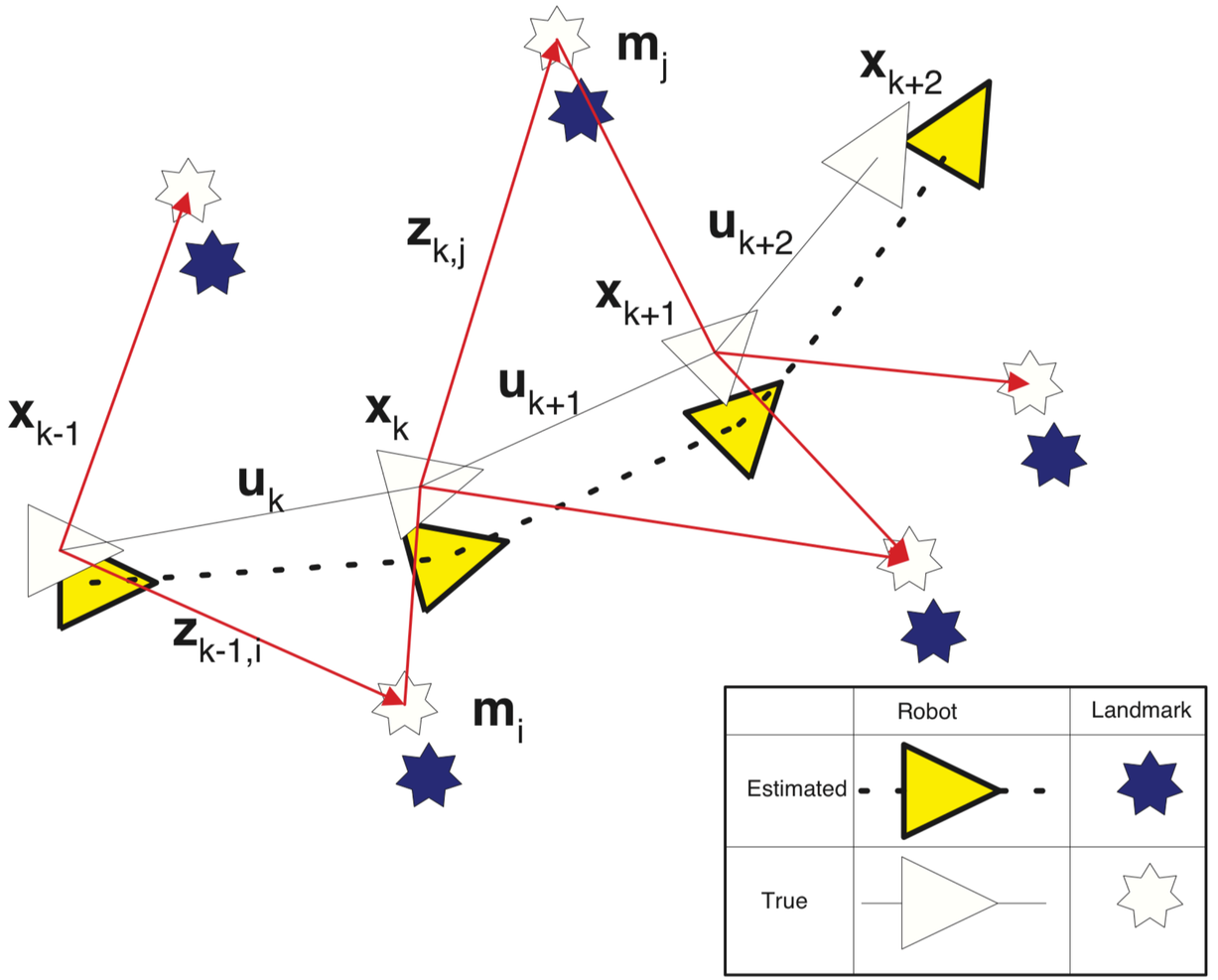
z measurements

Requirements EKF

- kinematic model
  - How does the control input influence the state?
- sensors
  - to measure environment
  - e.g. IMU, LIDAR, camera

EKF-SLAM

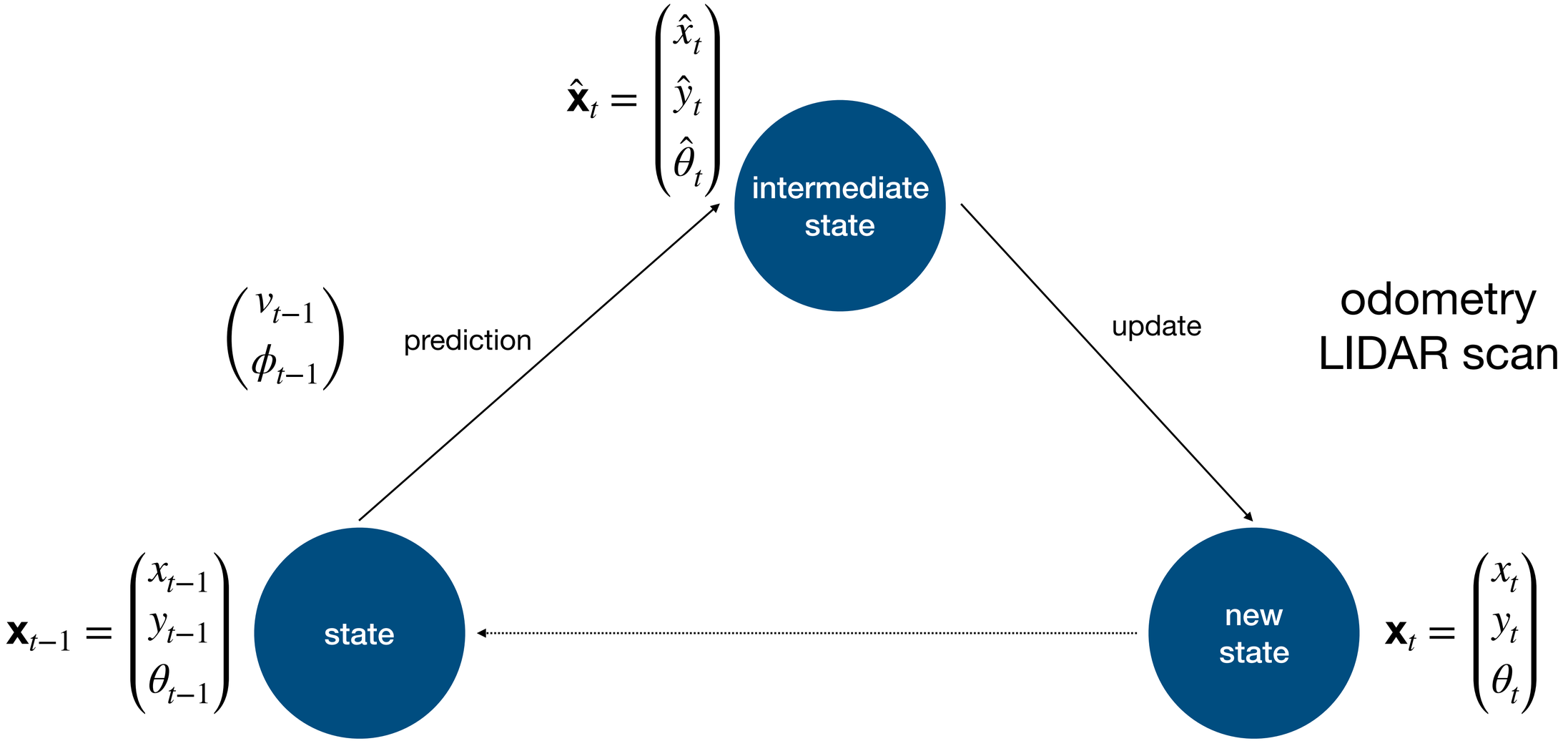
- incorporate landmarks into state
  - landmarks are key points in the environment



Difficulties

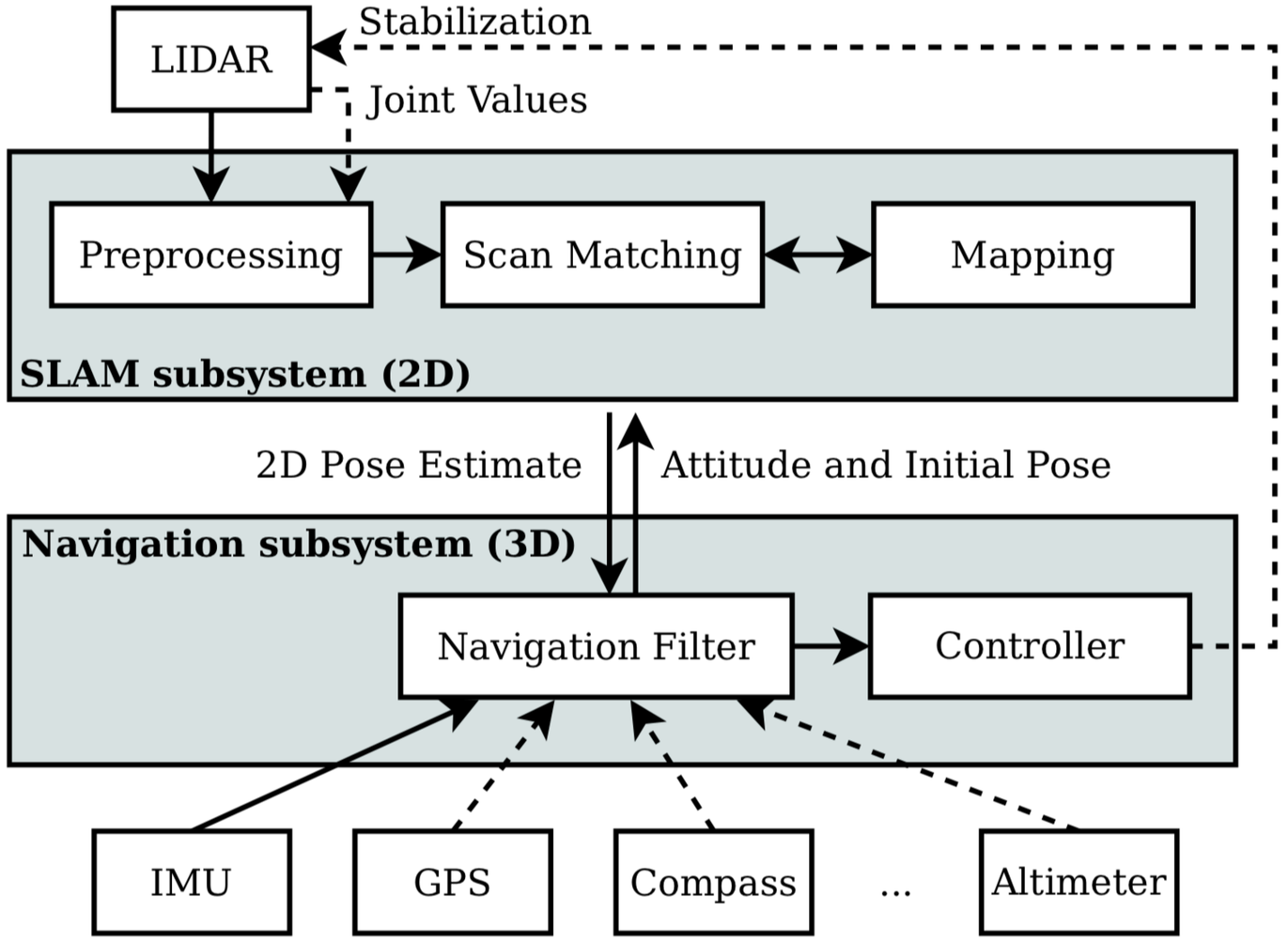
- dead reckoning
  - drift of position and orientation
  - increasing difference between true location and estimated location
- loop closure
  - recognise revisiting known areas

Red Rover


$\hat{\mathbf{x}}_t = \begin{pmatrix} \hat{x}_t \\ \hat{y}_t \\ \hat{\theta}_t \end{pmatrix}$
intermediate state
$\begin{pmatrix} v_{t-1} \\ \phi_{t-1} \end{pmatrix}$
prediction
update
odometry
LIDAR scan
$\mathbf{x}_{t-1} = \begin{pmatrix} x_{t-1} \\ y_{t-1} \\ \theta_{t-1} \end{pmatrix}$
state
new state
$\mathbf{x}_t = \begin{pmatrix} x_t \\ y_t \\ \theta_t \end{pmatrix}$

Hector SLAM

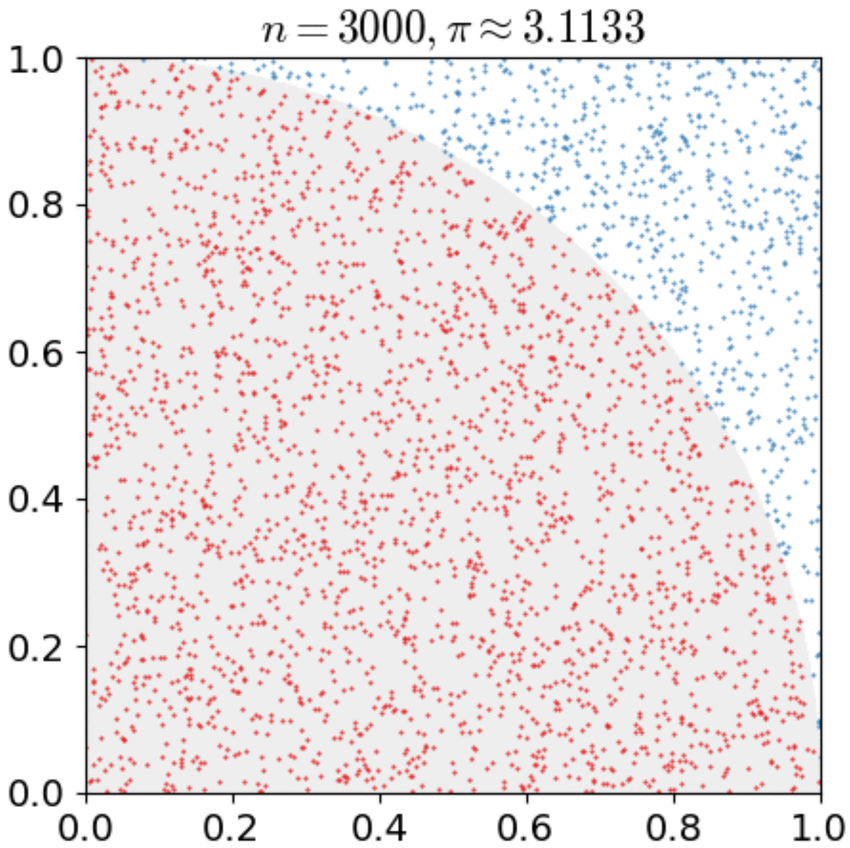
- low resources
- sensors
  - LIDAR
  - IMU
- right-handed coordinate system
- grid map
- EKF



Particle Filter

- Monte Carlo method
  - sample based algorithm

1. Define a domain of possible inputs
2. Generate inputs randomly from a probability distribution
3. Perform computation
4. Aggregate the results



Sources

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