Probabilistic SLAM: $P(\mathbf{x}_k, \mathbf{m} | \mathbf{Z}_{0:k}, \mathbf{U}_{0:k}, \mathbf{x}_0)$

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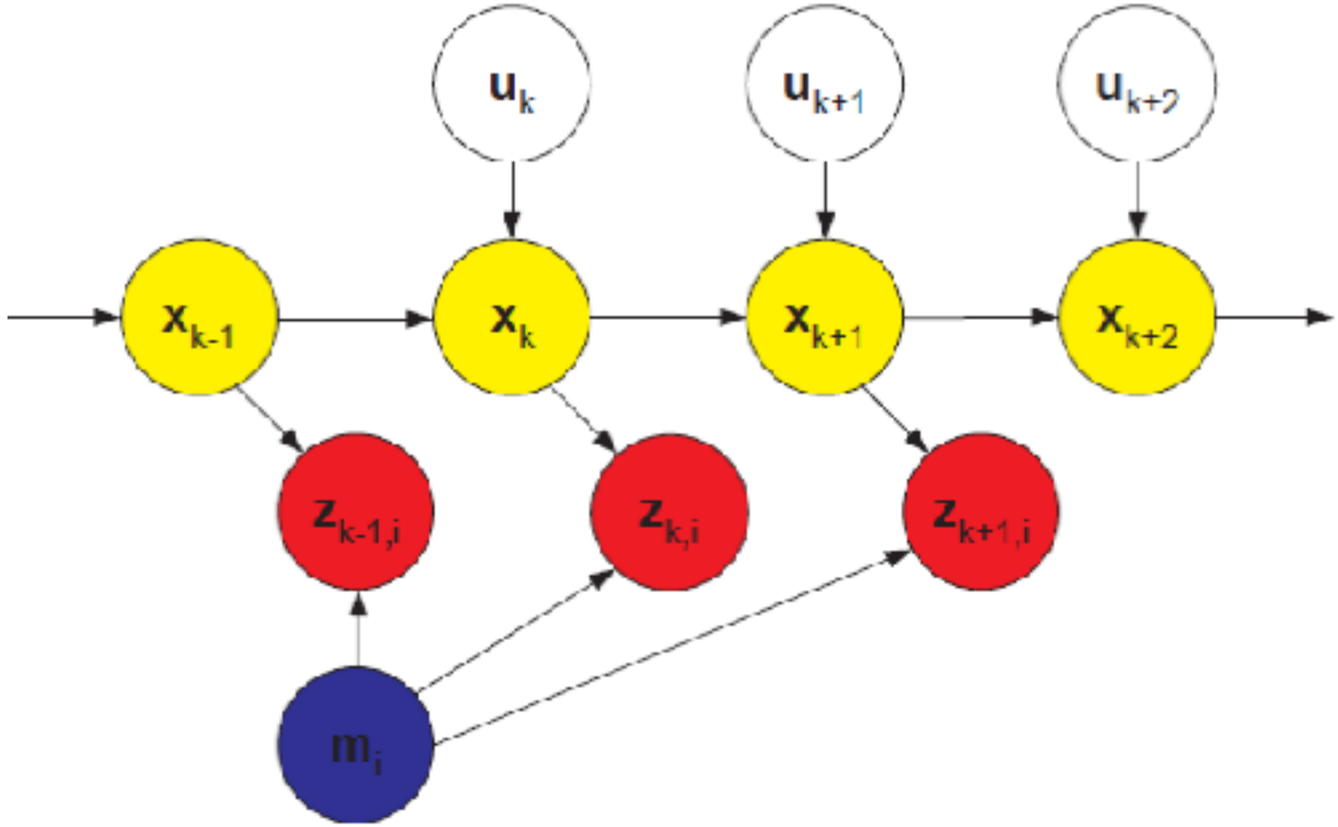
State history: $\mathbf{X}_{0:k} = \{\mathbf{x}_0, \mathbf{x}_1, \ldots, \mathbf{x}_k\}$

Control history: $\mathbf{U}_{0:k} = \{\mathbf{u}_1, \mathbf{u}_2, \ldots, \mathbf{u}_k\}$

Set of all landmarks: $\mathbf{m} = \{\mathbf{m}_1, \mathbf{m}_2, \ldots, \mathbf{m}_n\}$

Observation history: $\mathbf{Z}_{0:k} = \{\mathbf{z}_1, \mathbf{z}_2, \ldots, \mathbf{z}_k\}$

Bayesian SLAM



Start with knowledge of:

$$P(\mathbf{x}_{k-1}, \mathbf{m} | \mathbf{Z}_{0:k-1}, \mathbf{U}_{0:k-1}, \mathbf{x}_0)$$

And new control and observation at time k: $\mathbf{u}_k$ $\mathbf{z}_k$

Start with knowledge of:

$$P(\mathbf{x}_{k-1}, \mathbf{m} | \mathbf{Z}_{0:k-1}, \mathbf{U}_{0:k-1}, \mathbf{x}_0)$$

And new control and observation at time *k*: $\mathbf{u}_k$ $\mathbf{z}_k$

Use Bayes Theorem to update estimation of $\mathbf{x}_k, \mathbf{m}$:

$$P(\mathbf{x}_k, \mathbf{m} | \mathbf{Z}_{0:k}, \mathbf{U}_{0:k}, \mathbf{x}_0)$$

Start with knowledge of:

$$P(\mathbf{x}_{k-1}, \mathbf{m} | \mathbf{Z}_{0:k-1}, \mathbf{U}_{0:k-1}, \mathbf{x}_0)$$

And new control and observation at time *k*: $\mathbf{u}_k$ $\mathbf{z}_k$

Use Bayes Theorem to update estimation of $\mathbf{x}_k, \mathbf{m}$:

$$P(\mathbf{x}_k, \mathbf{m} | \mathbf{Z}_{0:k}, \mathbf{U}_{0:k}, \mathbf{x}_0)$$

Assuming we know:

Sensor Model: $P(\mathbf{z}_k | \mathbf{x}_k, \mathbf{m})$

Motion Model: $P(\mathbf{x}_k | \mathbf{x}_{k-1}, \mathbf{u}_k)$

Time Update:

$$P(\mathbf{x}_k, \mathbf{m} | \mathbf{Z}_{0:k-1}, \mathbf{U}_{0:k}, \mathbf{x}_0)$$
$$= \int P(\mathbf{x}_k | \mathbf{x}_{k-1}, \mathbf{u}_k)$$
$$\times P(\mathbf{x}_{k-1}, \mathbf{m} | \mathbf{Z}_{0:k-1}, \mathbf{U}_{0:k-1}, \mathbf{x}_0) d\mathbf{x}_{k-1}$$

Measurement Update:

$$P(\mathbf{x}_k, \mathbf{m} | \mathbf{Z}_{0:k}, \mathbf{U}_{0:k}, \mathbf{x}_0)$$

$$= \frac{P(\mathbf{z}_k | \mathbf{x}_k, \mathbf{m}) P(\mathbf{x}_k, \mathbf{m} | \mathbf{Z}_{0:k-1}, \mathbf{U}_{0:k}, \mathbf{x}_0)}{P(\mathbf{z}_k | \mathbf{Z}_{0:k-1}, \mathbf{U}_{0:k})}$$