Localization and Map Building

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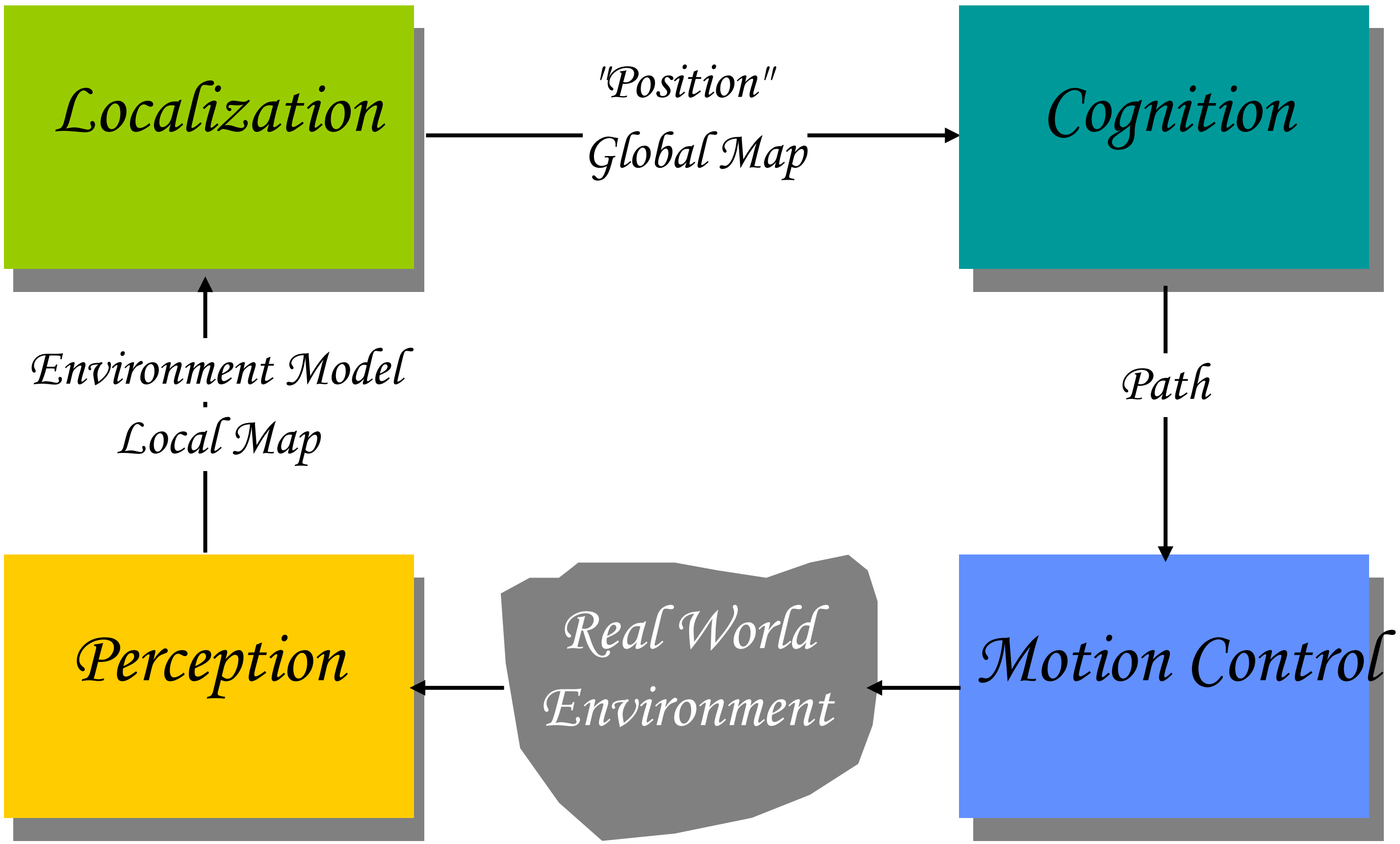
Robotics

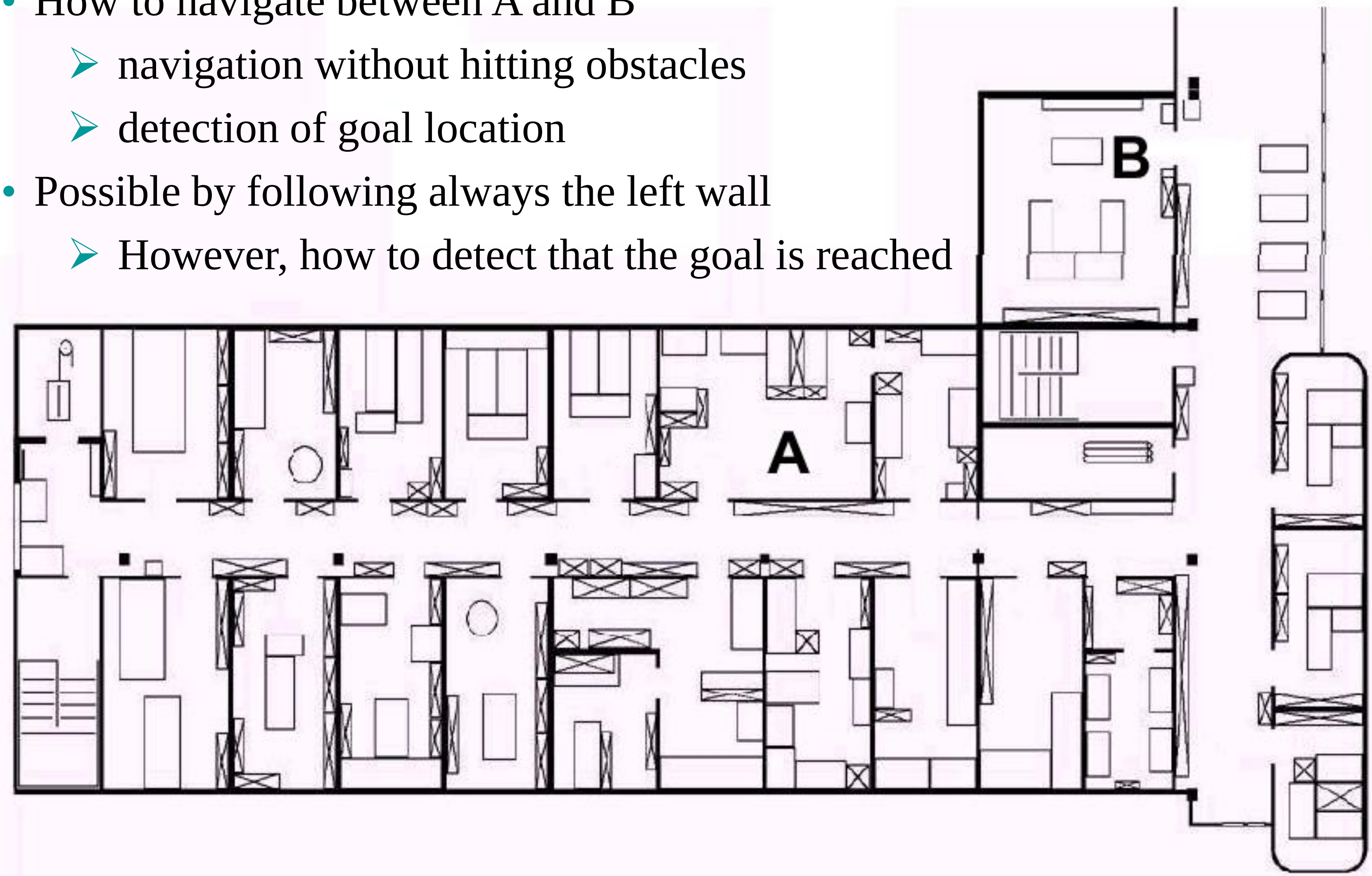
Control Cycle of Autonomous Robots



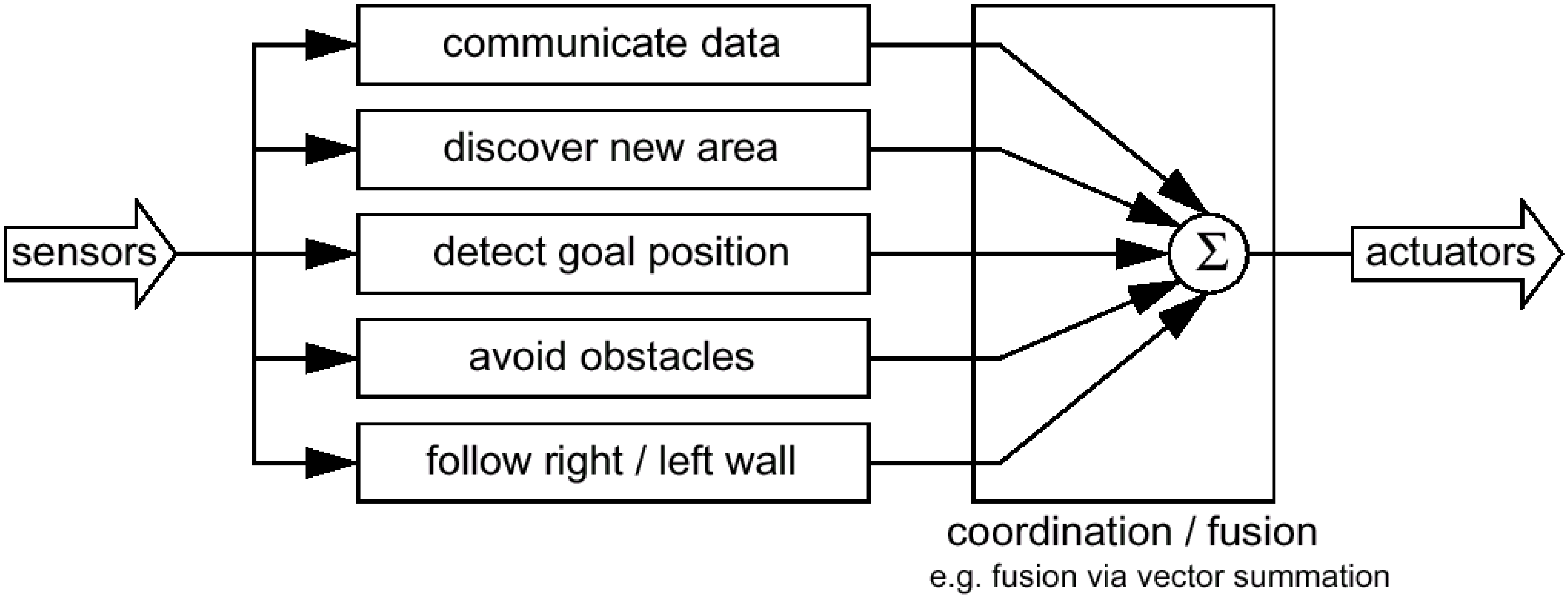
Robotics

To localize or not?

- How to navigate between A and B
  - navigation without hitting obstacles
  - detection of goal location
- Possible by following always the left wall
  - However, how to detect that the goal is reached



Behavior Based Navigation



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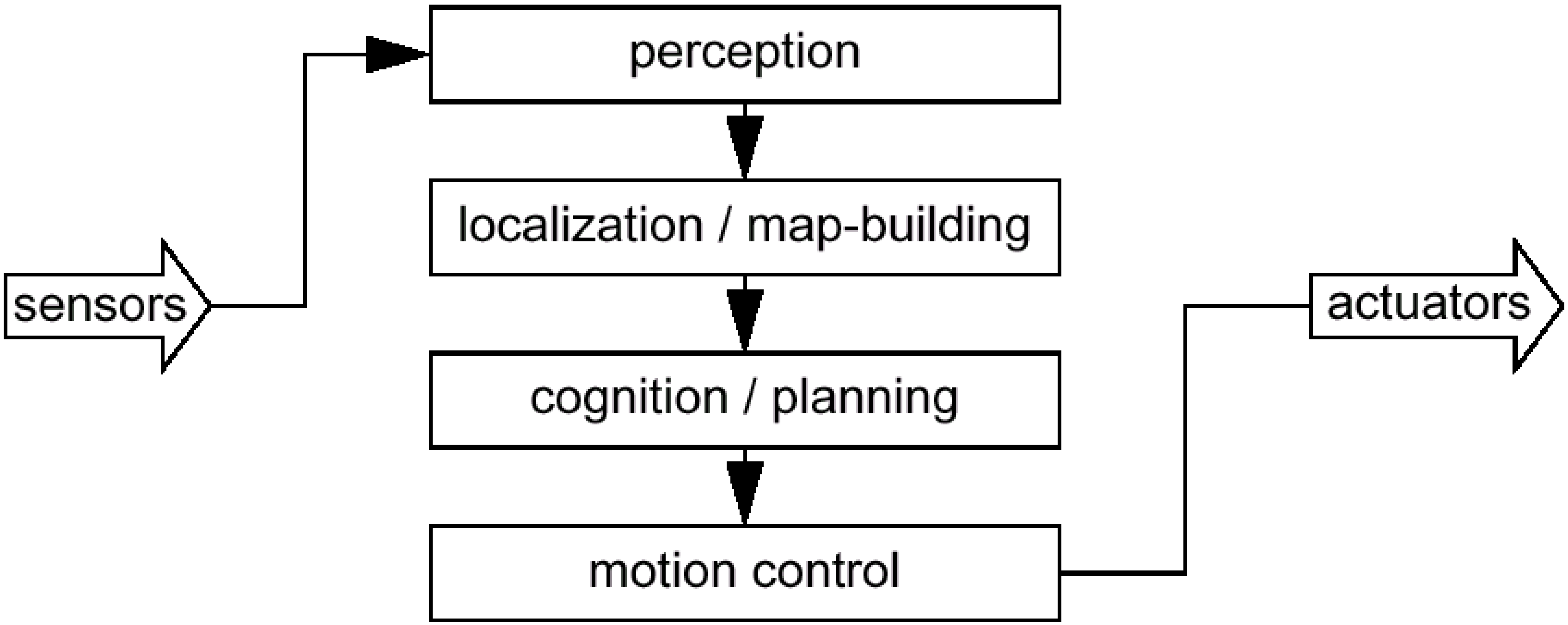
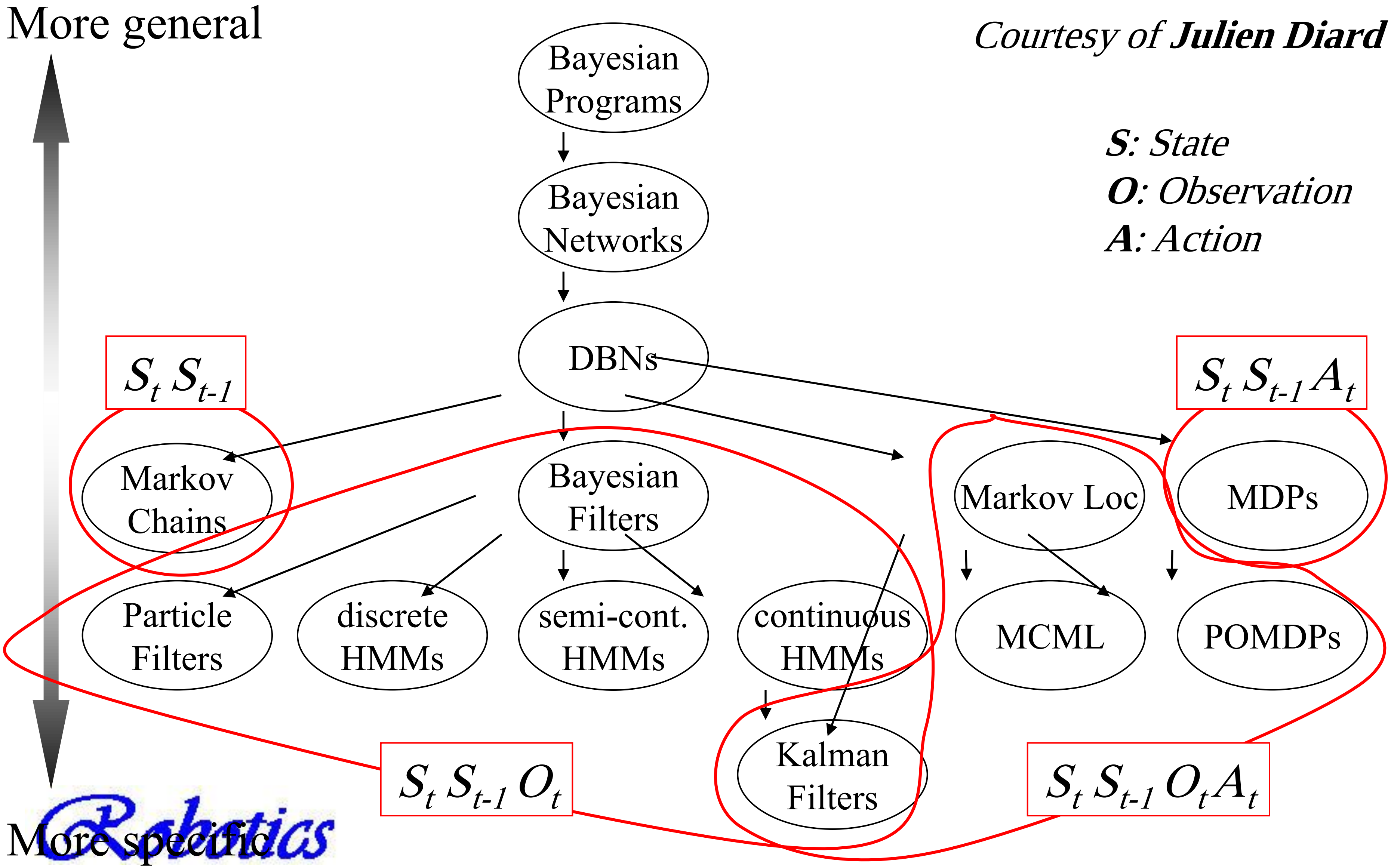
Model Based Navigation



Robotics

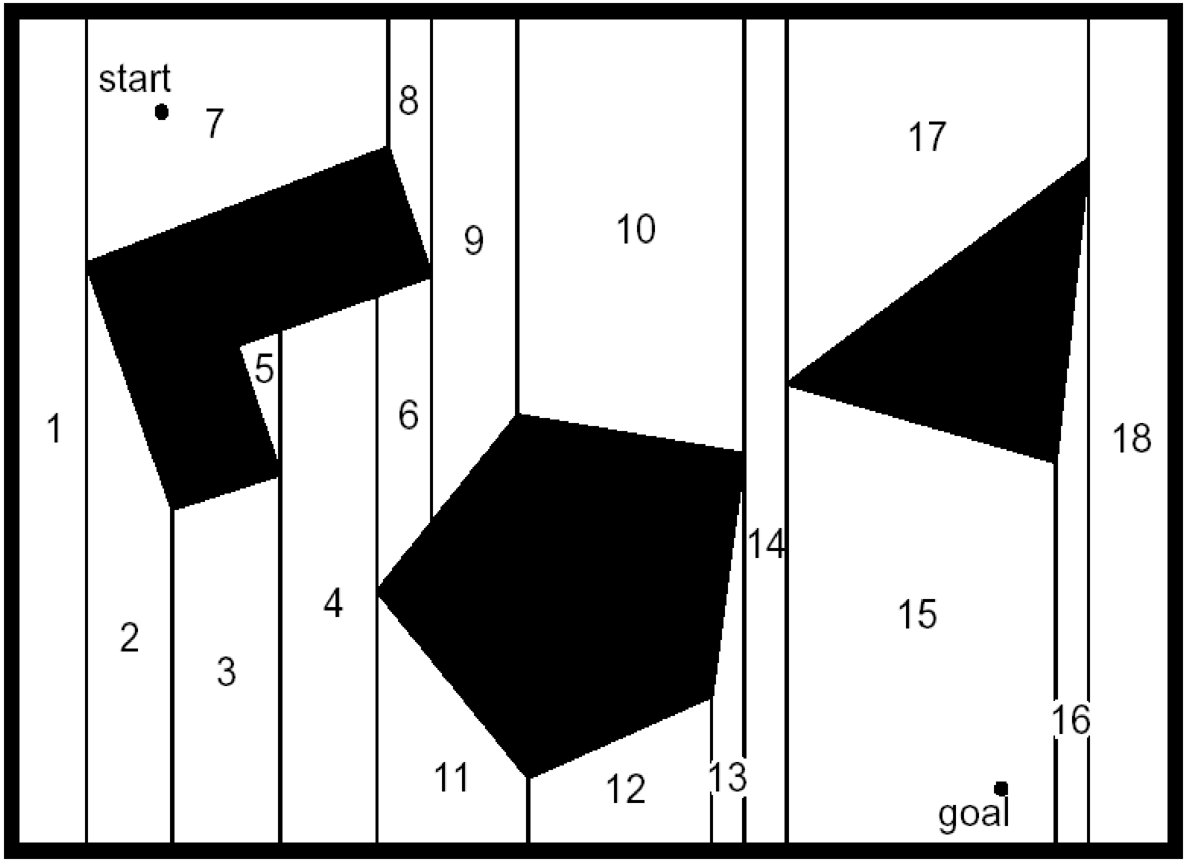
A taxonomy of probabilistic models

*Courtesy of **Julien Diard***



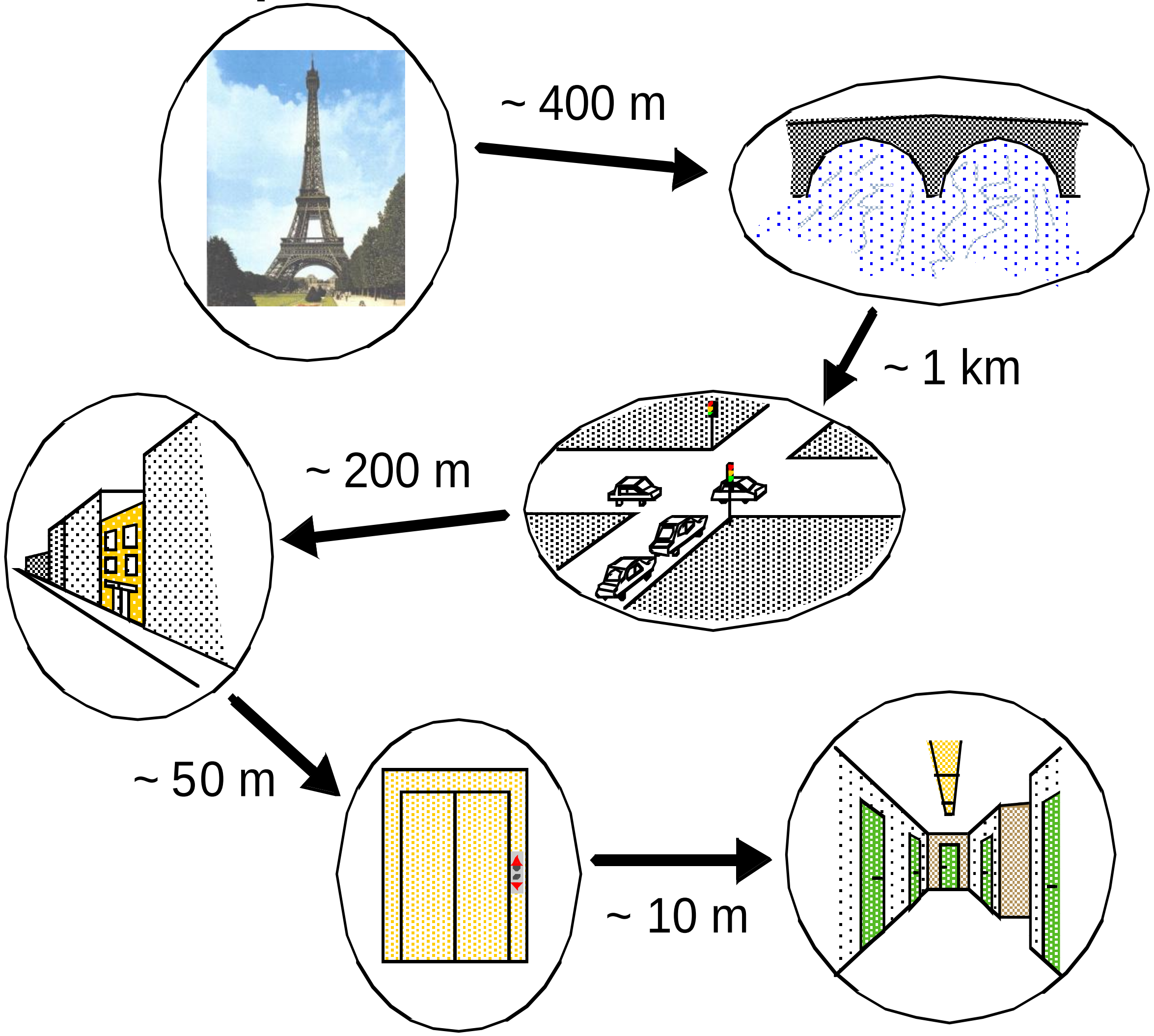
Map Representation: Decomposition

- Exact cell decomposition



Map Representation: Decomposition

- Topological Decomposition



Robotics

Probabilistic, Map-Based Localization

- Consider a mobile robot moving in a known environment.
- As it start to move, say from a precisely known location, it might keep track of its location using odometry.
- However, after a certain movement the robot will get very uncertain about its position.

➔ update using an observation of its environment.

- observation lead also to an estimate of the robots position which can than be fused with the odometric estimation to get the best possible update of the robots actual position.

Robotics

Markov ⇔ Kalman Filter Localization

- Markov localization
  - localization starting from any unknown position
  - recovers from ambiguous situation.
  - However, to update the probability of all positions within the whole state space at any time requires a discrete representation of the space (grid). The required memory and calculation power can thus become very important if a fine grid is used.

- Kalman filter localization
  - tracks the robot and is inherently very precise and efficient.
  - However, if the uncertainty of the robot becomes to large (e.g. collision with an object) the Kalman filter will fail and the position is definitively lost.

Markov Localization (1)

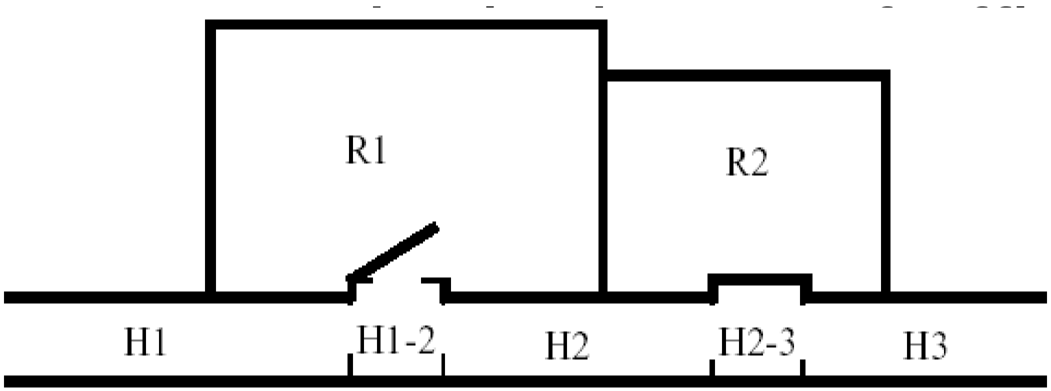
- Markov localization uses an explicit, discrete representation for the probability of all position in the state space.

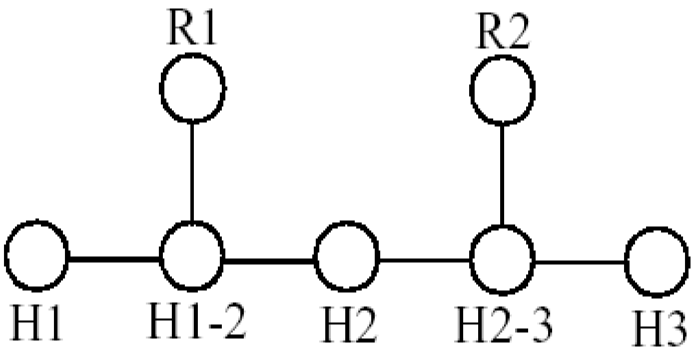
- This is usually done by representing the environment by a grid or a topological graph with a finite number of possible states (positions).

- During each update, the probability for each state (element) of the entire space is updated.

Robotics

Markov Localization: Topological Map

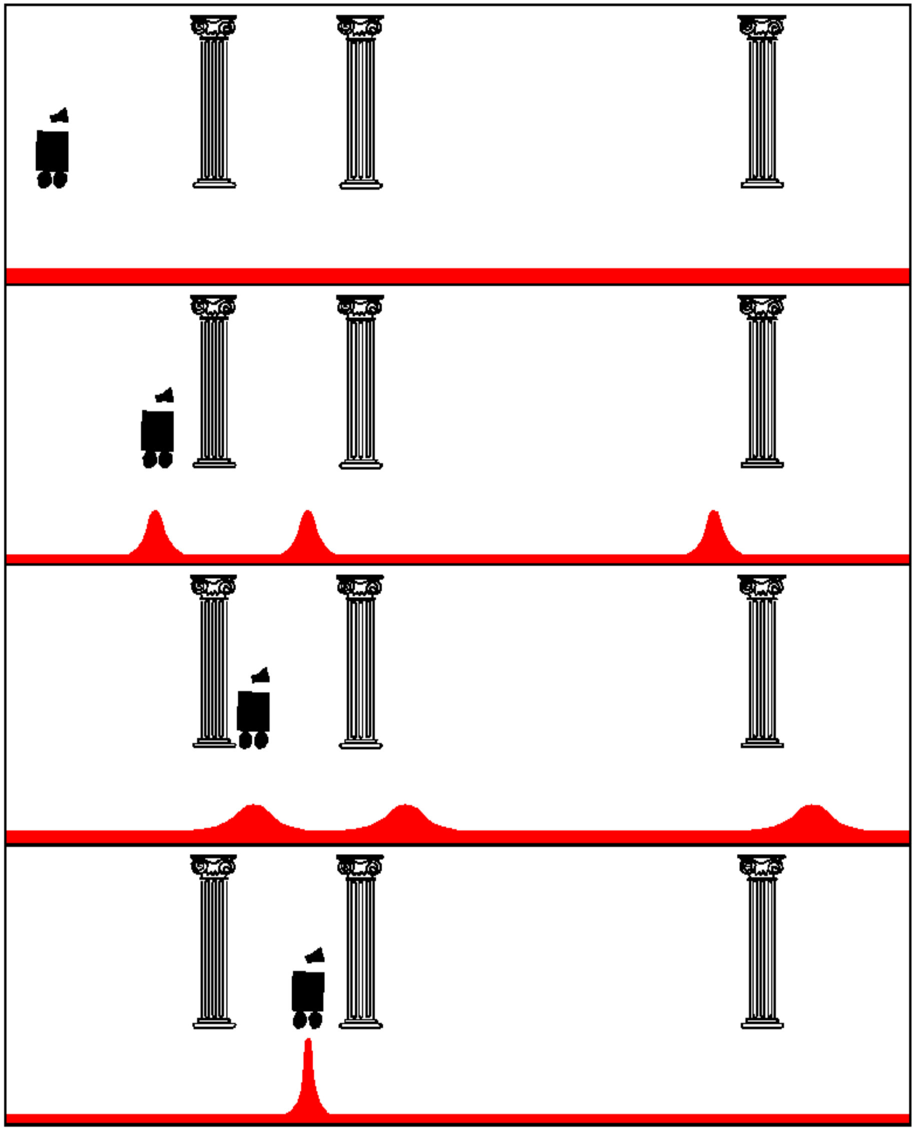




	Wall	Closed door	Open door	Open hallway	Foyer
Nothing detected	0.70	0.40	0.05	0.001	0.30
Closed door detected	0.30	0.60	0	0	0.05
Open door detected	0	0	0.90	0.10	0.15
Open hallway detected	0	0	0.001	0.90	0.50

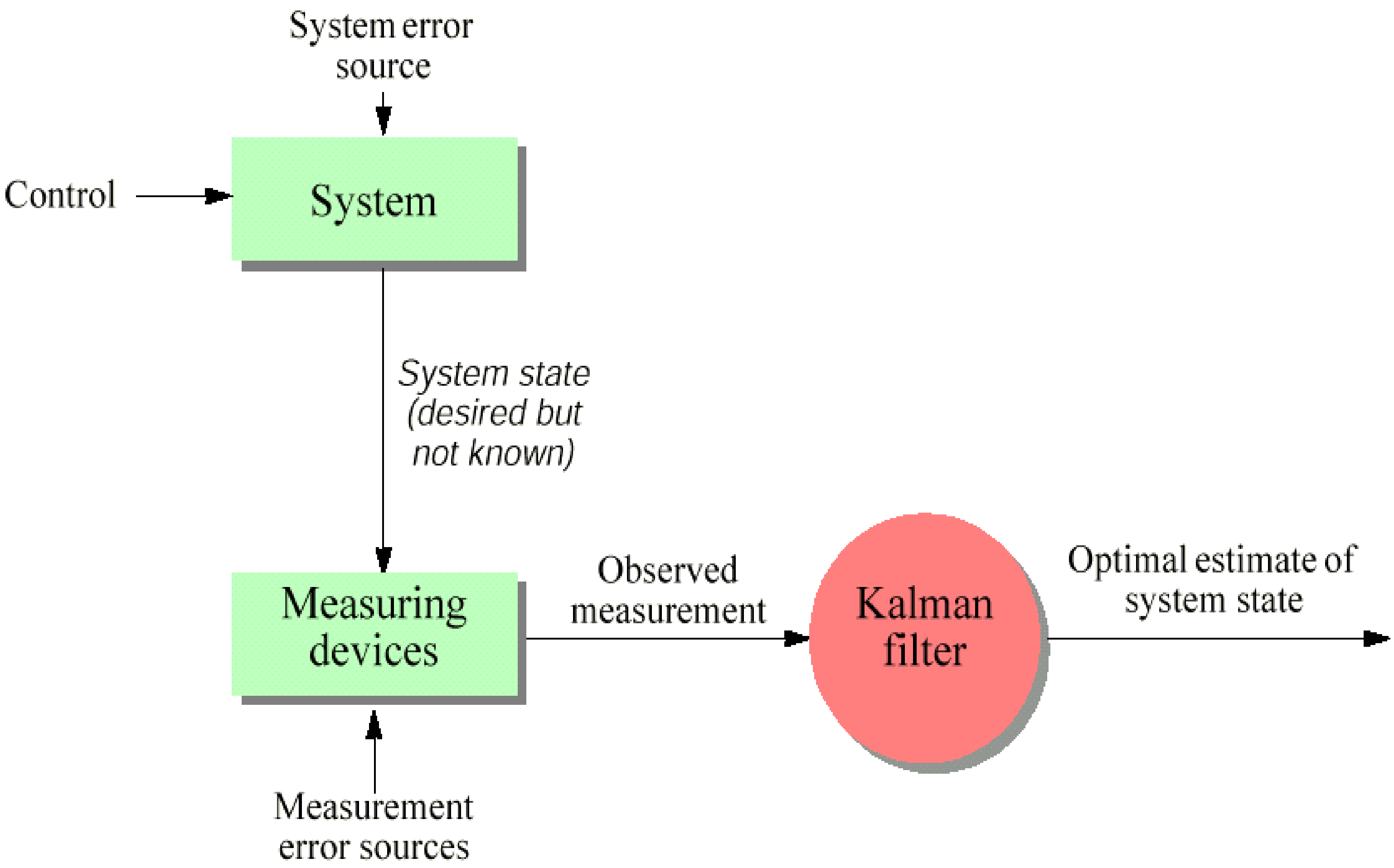
Markov Localization: Grid Map

- The 1D case
  1. Start
     - ➢ No knowledge at start, thus we have an uniform probability distribution.
  2. Robot perceives first pillar
     - ➢ Seeing only one pillar, the probability being at pillar 1, 2 or 3 is equal.
  3. Robot moves
     - ➢ Action model enables to estimate the new probability distribution based on the previous one and the motion.
  4. Robot perceives second pillar
     - ➢ Base on all prior knowledge the probability being at pillar 2 becomes dominant



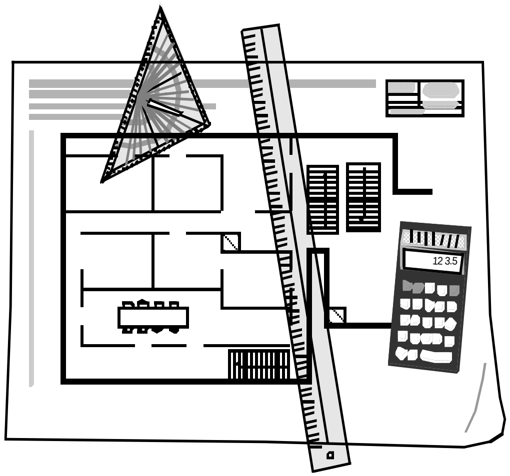
Robotics

Kalman Filter Localization



How to Establish a Map

1. By Hand



2. Automatically: Map Building

The robot learns its environment

Motivation:

- by hand: hard and costly

- dynamically changing environment

- different look due to different perception

3. Basic Requirements of a Map:

- a way to incorporate newly sensed information into the existing world model
- information and procedures for estimating the robot's position
- information to do path planning and other navigation task (e.g. obstacle avoidance)

- *Measure of Quality of a map*
  - topological correctness
  - metrical correctness

  → *predictability*

- *But: Most environments are a mixture of predictable and unpredictable features*
  → hybrid approach

  model-based vs. behaviour-based

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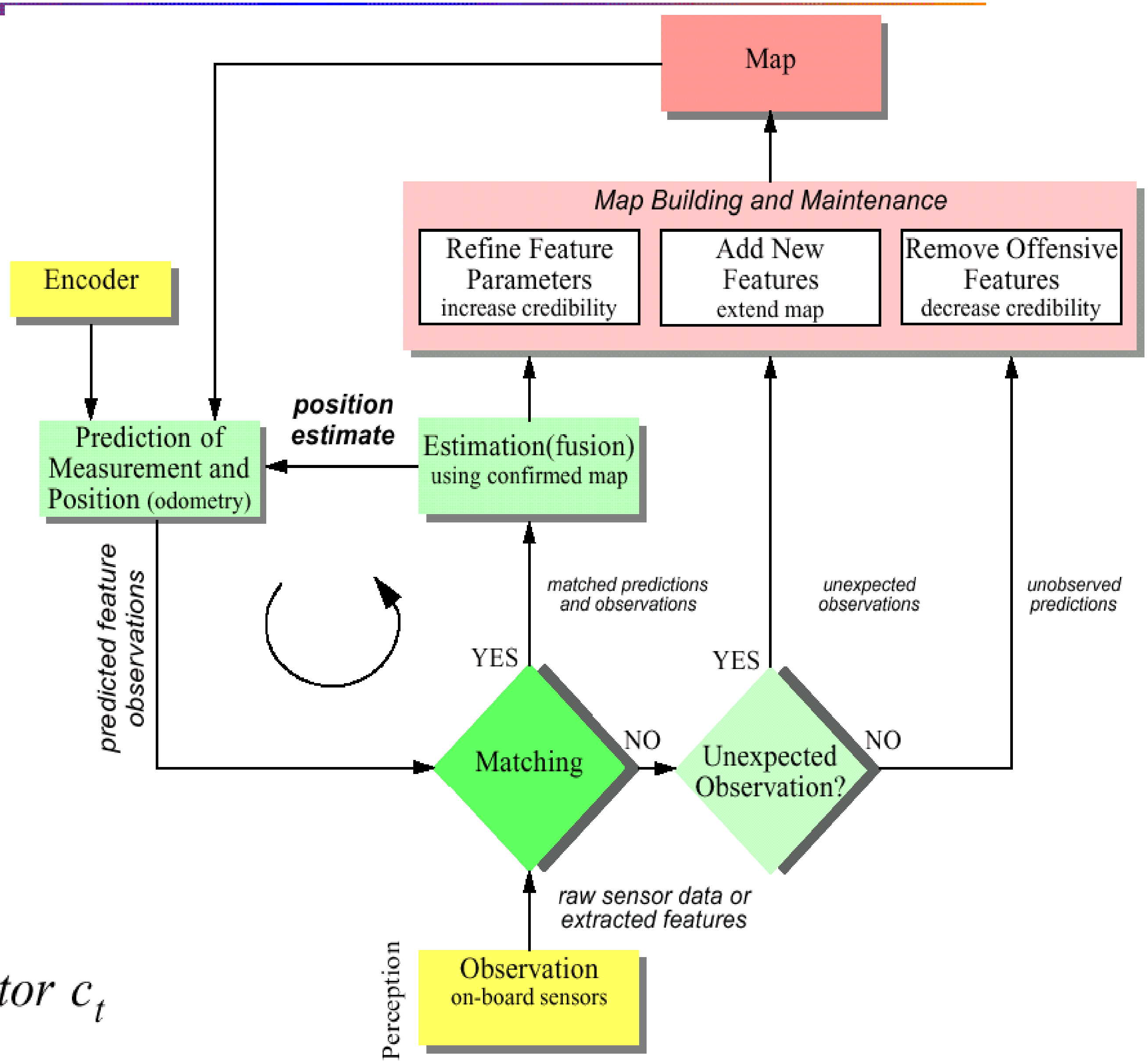
General Map Building Schematics



credibility factor c_t

Autonomous Map Building

Starting from an arbitrary initial point,

a mobile robot should be able to autonomously explore the environment with its on board sensors,

gain knowledge about it,

interpret the scene,

build an appropriate map

and localize itself relative to this map.

SLAM

The Simultaneous Localization and Mapping Problem

Robotics

References

- Roland Siegwart, Illah R. Nourbakhsh, "Introduction to Autonomous Mobile Robots (Intelligent Robotics and Autonomous Agents series) " MIT Press, 2004

Robotics

Thank you!

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