Robots Móviles

Navegación Topológica II

Imágenes y gráficos de elaboración propia.

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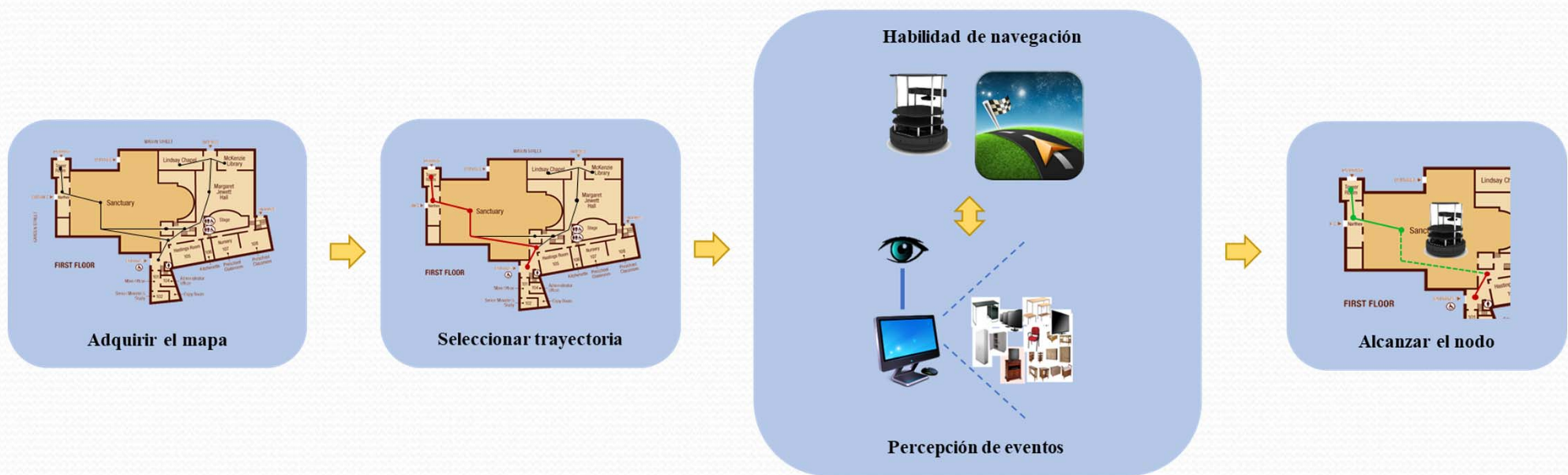
Modelo topológico basado en percepción

- Modelo topológico basado en percepción
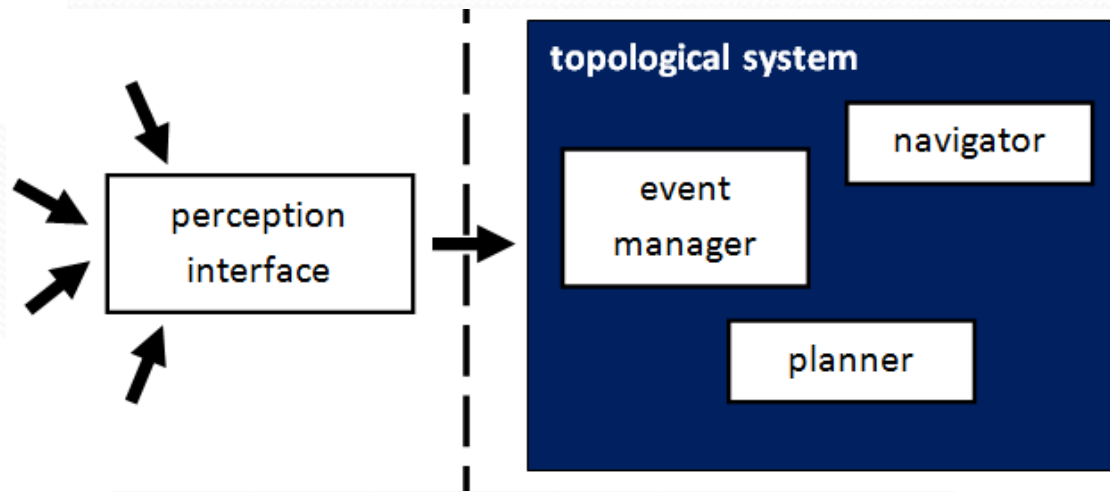- Integración de múltiples eventos
- Modelado de incertidumbre

Modelo topológico basado en percepción
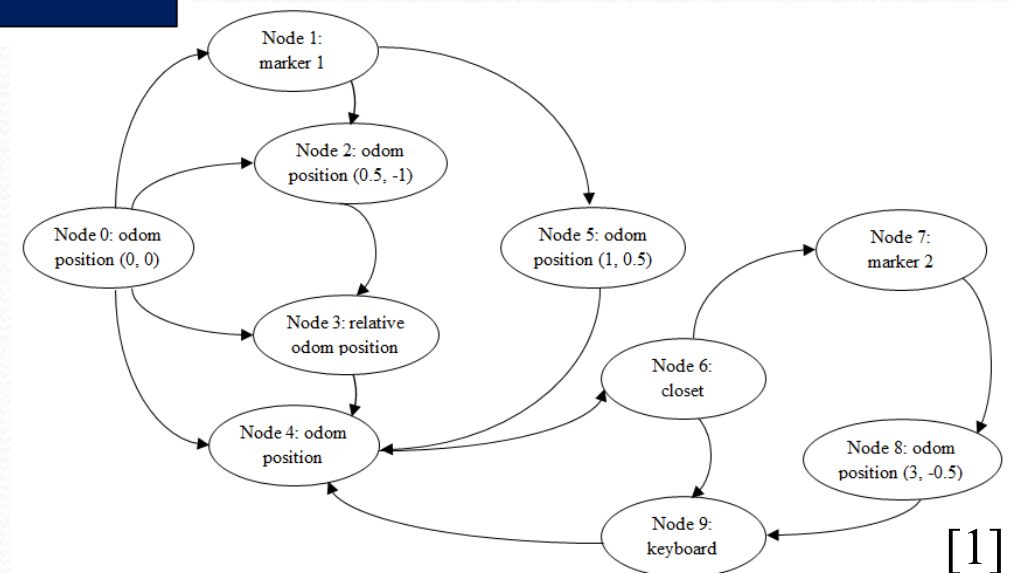
- Decision Process

Adquirir el mapa → Seleccionar trayectoria → Habilidad de navegación / Percepción de eventos → Alcanzar el nodo

[1]

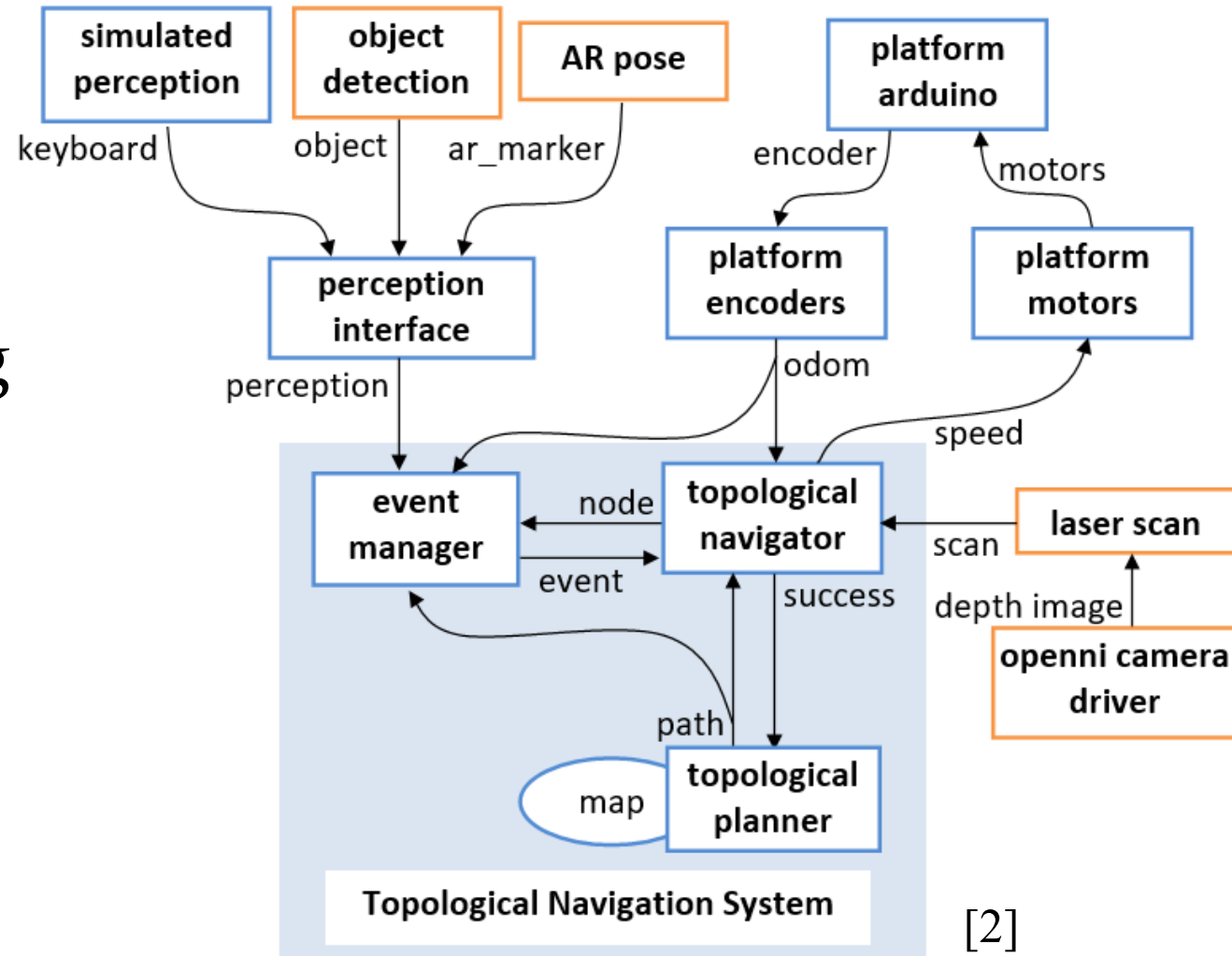# Modelo topológico basado en percepción

- Modular design

- A priori given map

- Oriented representation

[1]

Modelo topológico basado en percepción

- Path planning
- Navigation
- Perception

[2]

Modelo topológico basado en percepción

- Path to get to the target using a Dijkstra algorithm.
- Obtains the **shortest path** between nodes in a graph: minimize topological distance travelled
- Path: a subgraph of the map

```
0  {0 1}GP|odometry <0 0>
1  {0 2}GP|odometry <0 0>
2  {0 3}GP|odometry <0 0>
3  {0 4}GP|odometry <0 0>
4  {1 2}FF|marker 1 <>
5  {1 5}FF|marker 1 <>
6  {2 3}GP|odometry <0.5 -1>
7  {3 4}R |odometry <45 1>
8  {4 6}FF|odometry <>
9  {5 4}GP|odometry <1 0.5>
10 {6 7}R |object    <90>
11 {6 9}R |object    <90>
12 {7 8}FF|marker 2 <>
13 {8 9}GP|odometry <3 -0.5>
14 {9 4}FF|keyboard <>
```
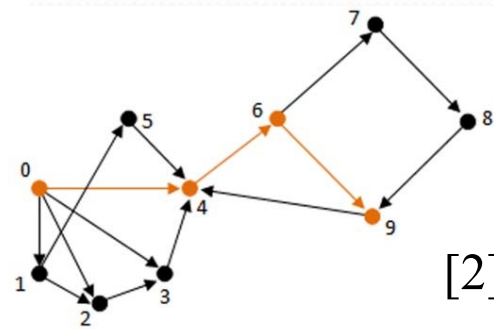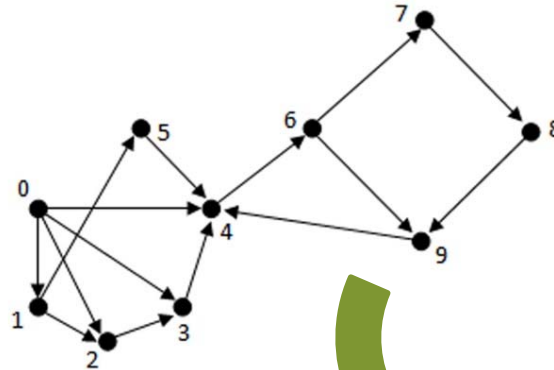
Map: element of the topological planner that builds the map at the beginning of each execution.

[2]

Modelo topológico basado en percepción

- Performs the required ability for each arc until the robot recieves the event of the target node.

    - go to point
    - turn
    - contour following → velocity commands
    - go to object

- Obstacle avoidance algorithm to guarantee safe navigation

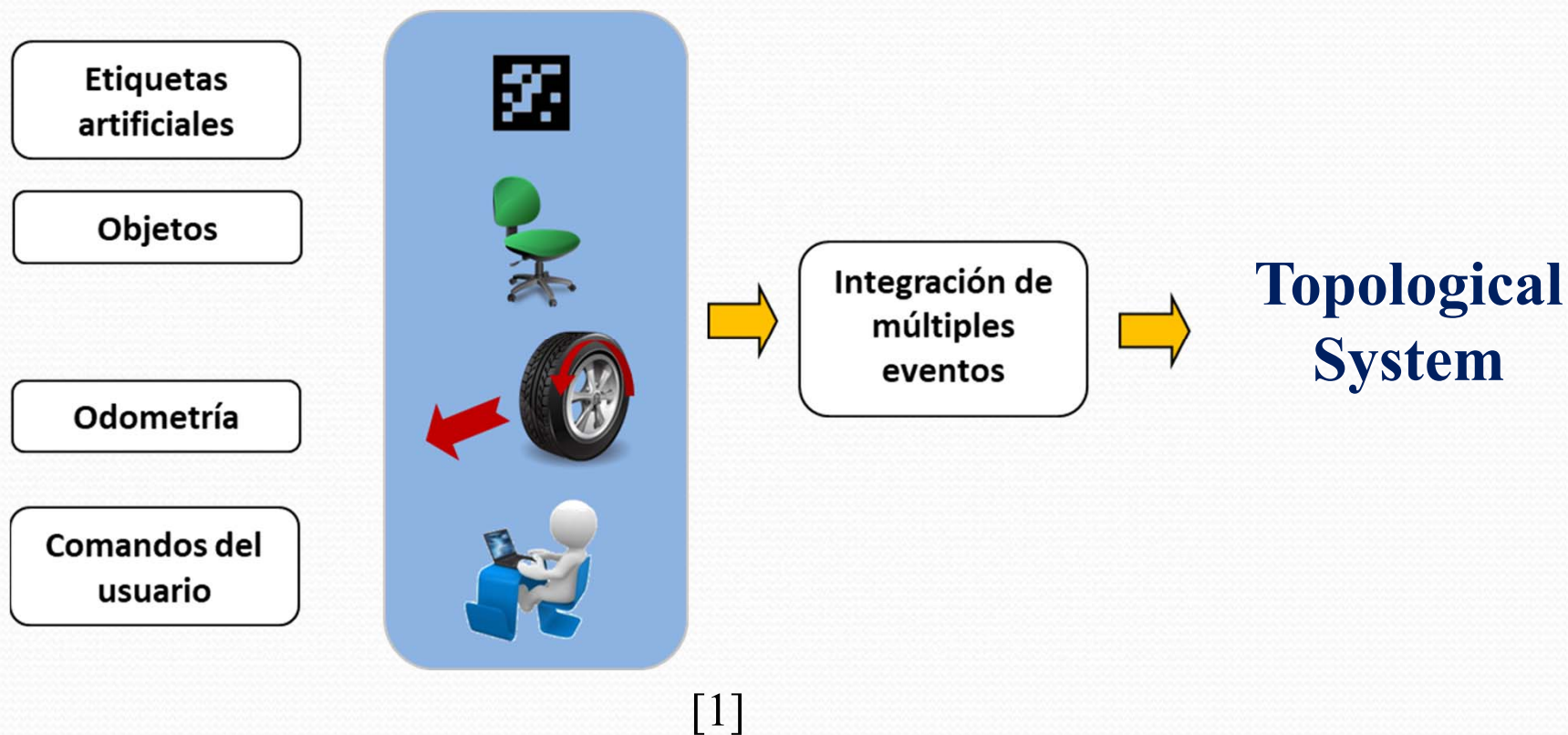# Indice de Contenidos

- Modelo topológico basado en percepción
- Integración de múltiples eventos
- Modelado de incertidumbre

Integración de múltiples eventos

Etiquetas artificiales

Objetos

Odometría

Comandos del usuario

Integración de múltiples eventos

Topological System

[1]

Integración de múltiples eventos

Extereoceptive
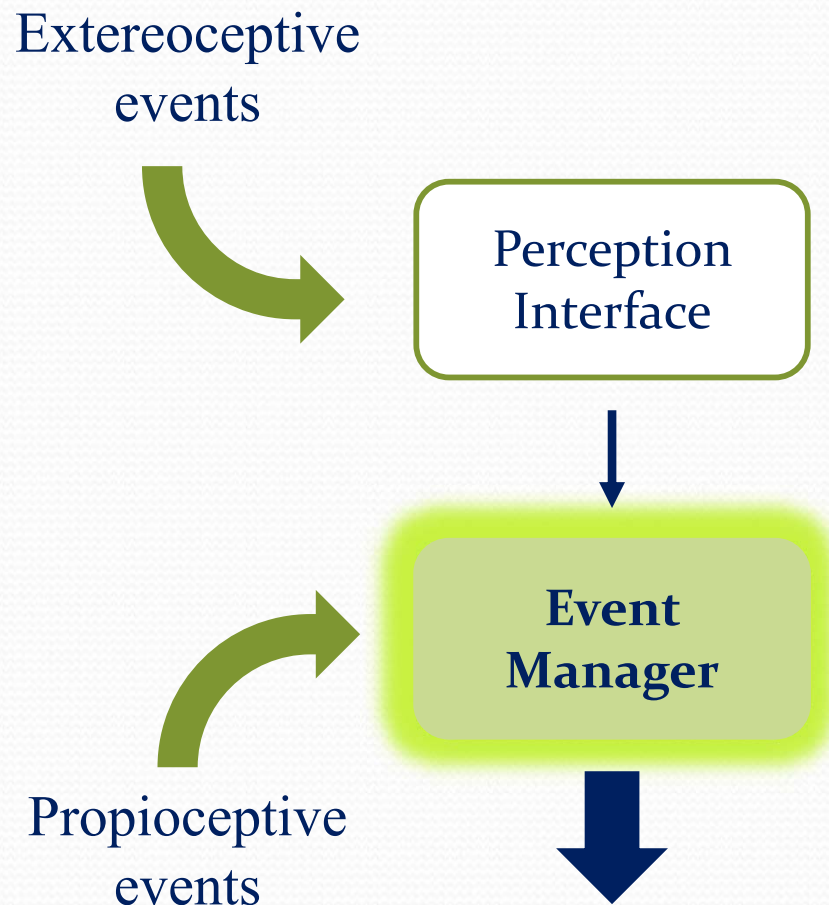events

**Perception
Interface**
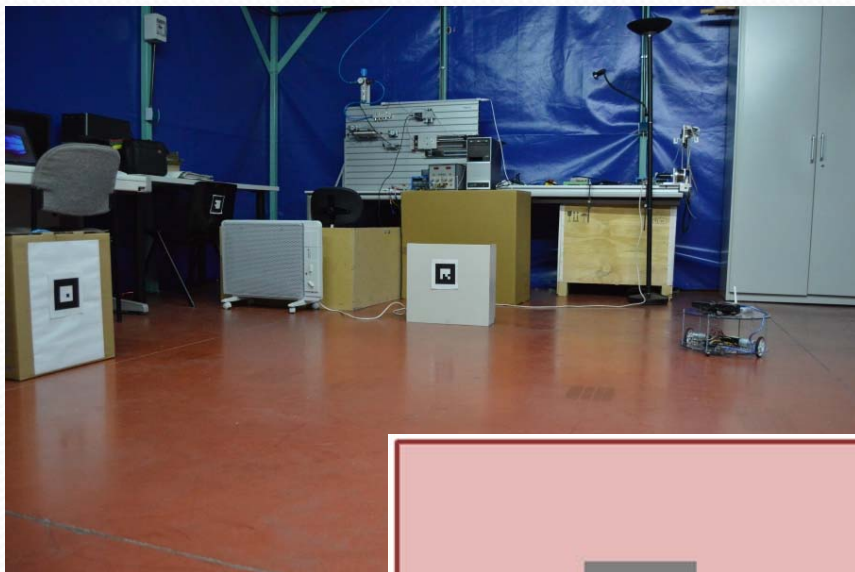
Event
Manager

Propioceptive
events

- Receives the sensorial information from **extereoceptive** events and translate it into a general structure

- Open structure: new types of perceptions can be easily added

Integración de múltiples eventos

Extereoceptive
events

Perception
Interface

Event
Manager

Propioceptive
events

- **Centralizes every process involving event communication**
  - extereoceptive: perception interface
  - propioceptive: odometry

- **Publishes the information regarding the events**

Integración de múltiples eventos


```
0{0 1}GP|odometry<2.3 0>
1{1 2}R|marker 0<-1.57>
2{2 3}R|marker 1<-3.15>
3{1 4}R|marker 2<1.57>
4{3 5}GP|odometry<2.5 1>
5{4 0}GP|odometry<0 0>
6{5 2}R|marker 0<2.5>
```
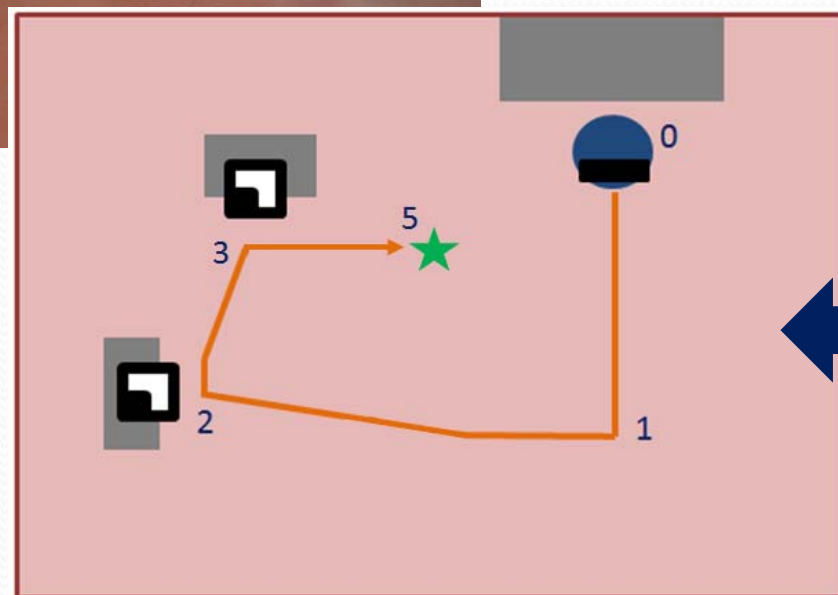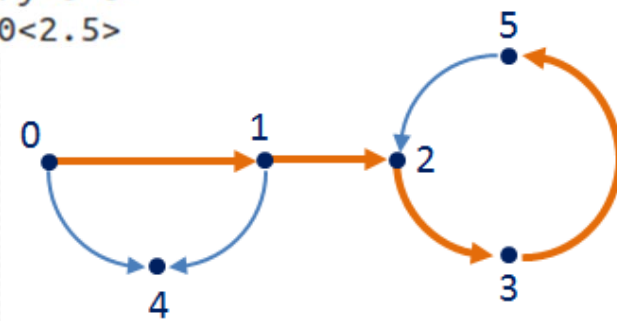
[1]

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Modelado de incertidumbre

Localization is knowing and updating continuously a robot position based on sensorial information
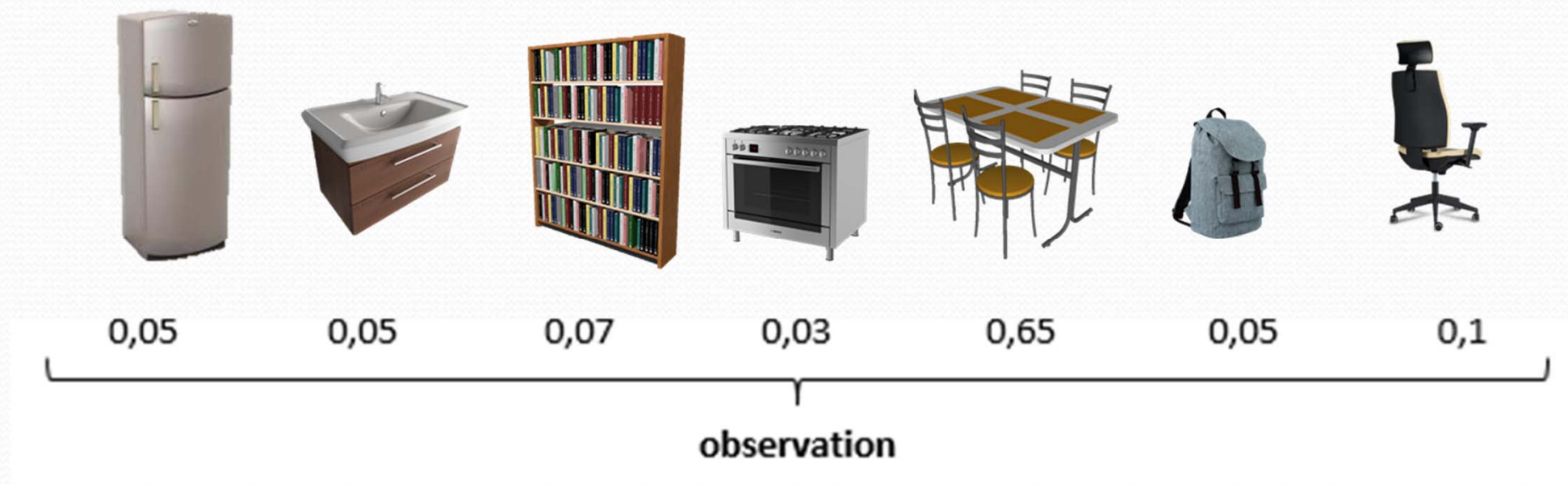
Sensors and Computer
vision systems are
imprecise

Model the uncertainty

Modelado de incertidumbre

Perceptions represented as probabilities

Model of sensorial uncertainty

observation

[3]

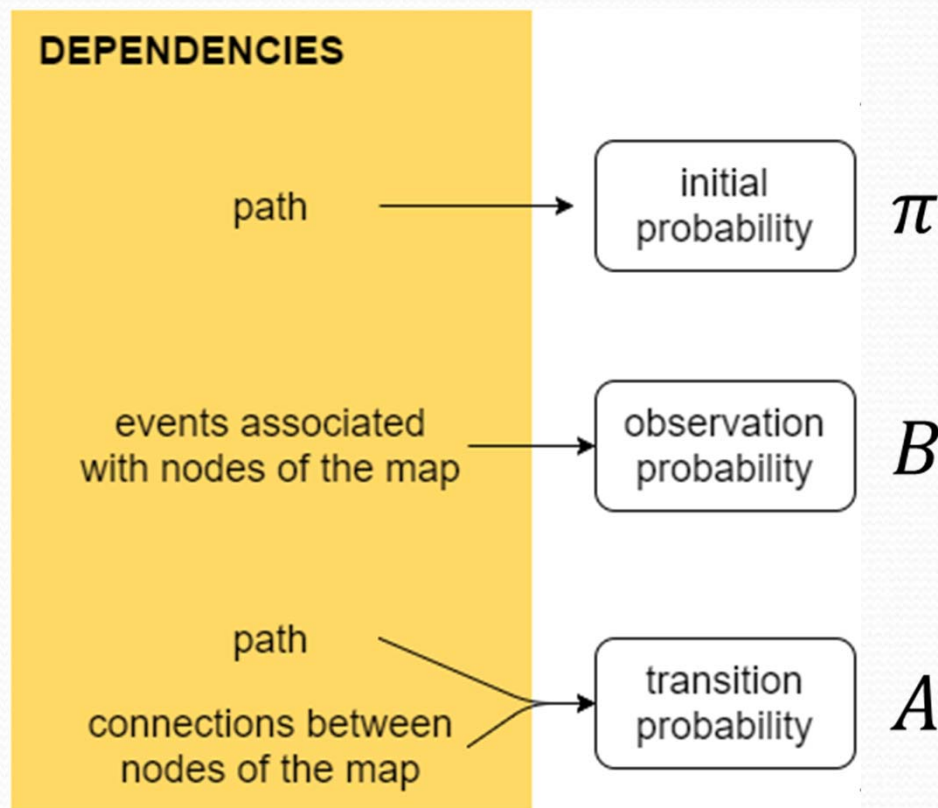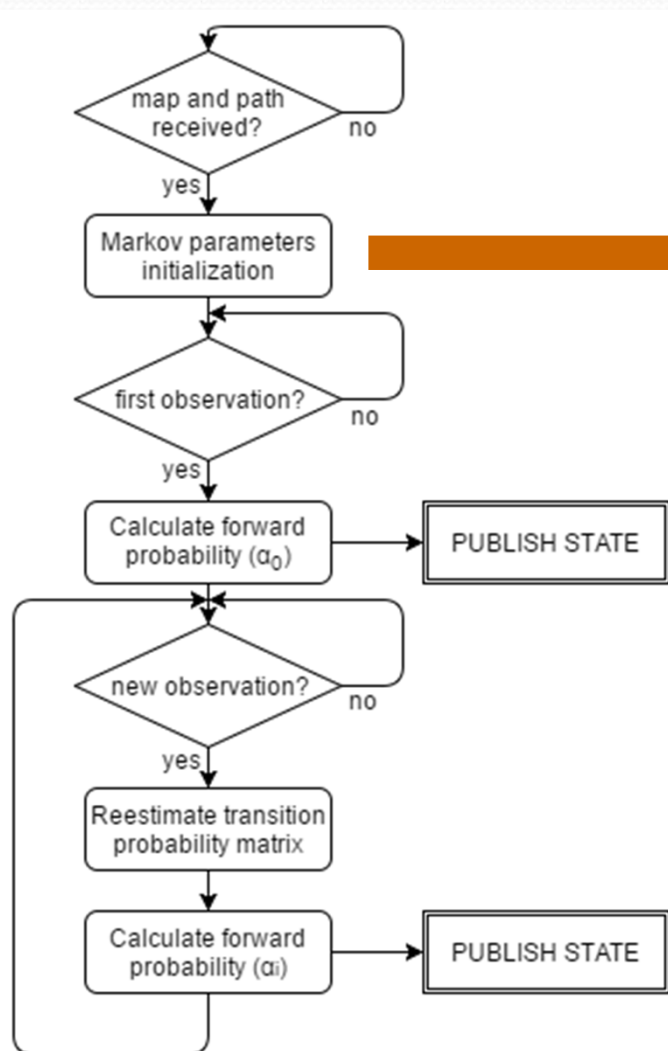# Modelado de incertidumbre

Discrete representation of the environment

State estimator

Hidden Markov Model (HMM):

- Stochastic model
- Hidden states to estimate through observations
- Next state only depends on current state and observation

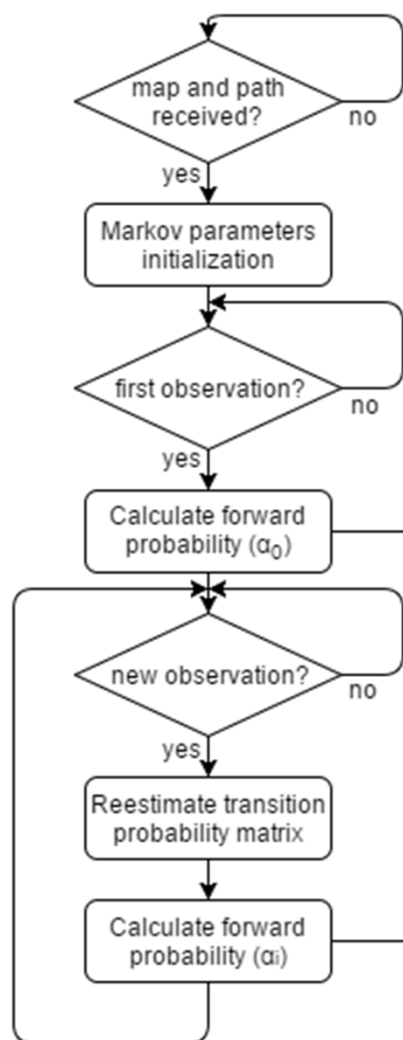# Modelado de incertidumbre

$$\lambda = (\pi, A, B)$$

[3]

Modelado de incertidumbre

Forward probability α is the probability of being at state i given the observation b

Initial probability distribution, α_0:

$$\alpha_0(i) = \pi_i \cdot P(b_0|S_i)$$

Sucesive probability distributions, α_t:

$$\alpha_t(i) = (\sum_{j=1}^{N} \alpha_{t-1}(j) \cdot a_{j,i}) \cdot P(b_t|S_i)$$

Modelado de incertidumbre
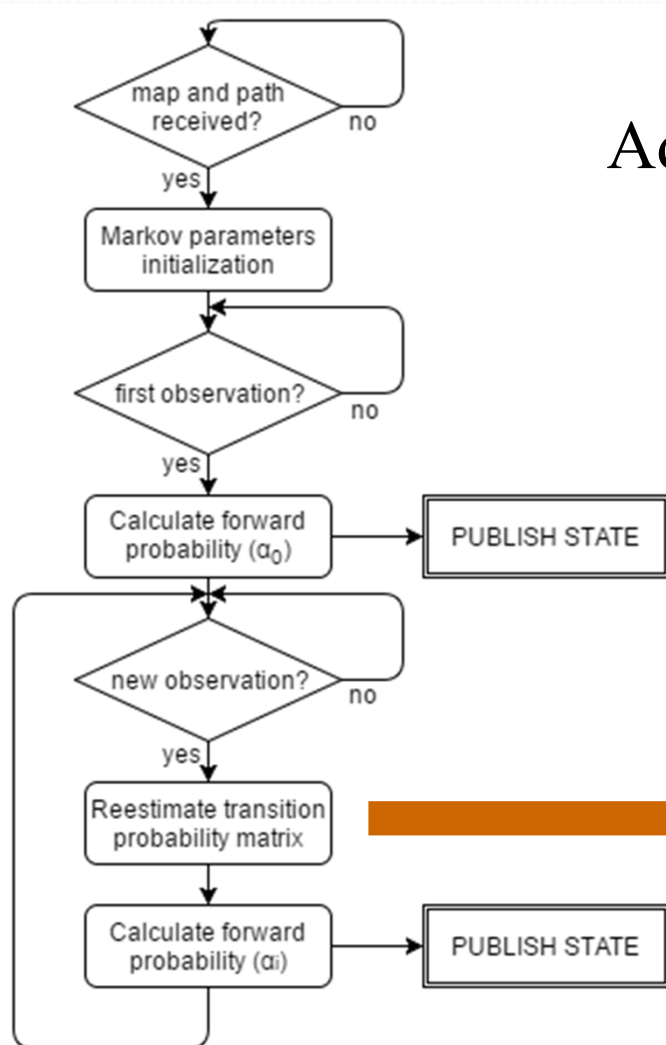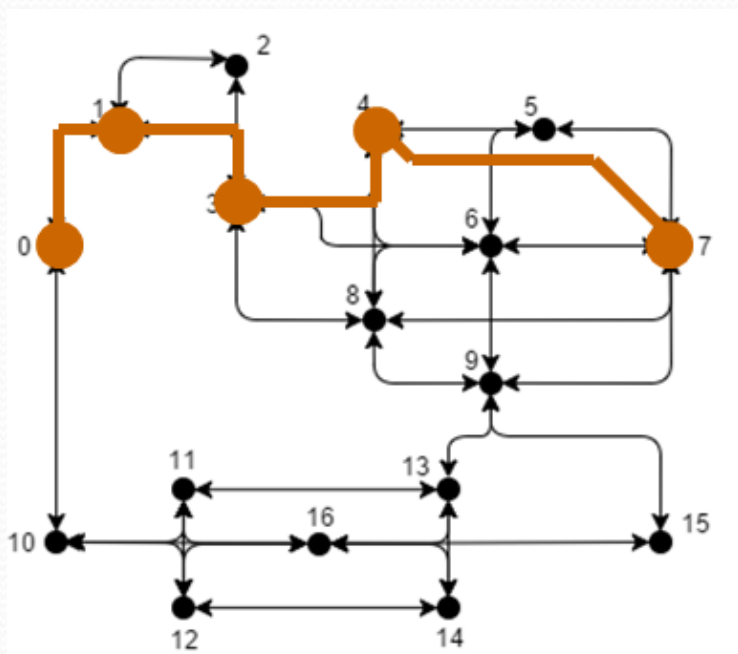

Adjust transition probability *A* after each observation

Improve transition probabilities

$$New\ a_{i,j} = \frac{\sum_{j=1}^{t} \alpha_t(i) \cdot a_{i,j} \cdot P(o_{t+1}|S_j)}{\sum_{j=1}^{t} \alpha_t(i)}$$

Modelado de incertidumbre

test	% right goal	% middle error	% recovery
Correct	100	0	-
Jump	100	25	100
Repetition	100	12.5	100
Inclusion	100	16.67	100
Global	100	13.54	100

[3]

$\alpha_0(0)$	$\alpha_1(1)$	$\alpha_2(3)$	$\alpha_3(4)$	$\alpha_4(7)$
0.9853	0.9689	0.9037	0.6016	0.8720

Modelado de incertidumbre
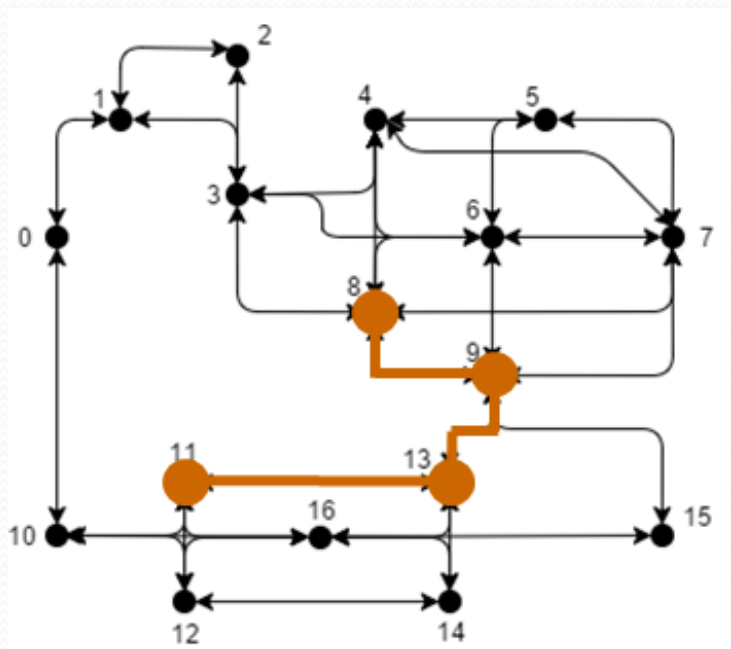
test	% right goal	% middle error	% recovery
Correct	100	0	-
Jump	88.89	33.33	66.67
Repetition	100	20	100
Inclusion	93.33	20	66.67
Global	95.55	18.33	77.78

test	$\alpha_0(11)$	$\alpha_1(13)$	$\alpha_2(9)$	$\alpha_3(8)$
estandar	0.9301	0.4536	0.3911	0.4071
re-estimate	0.9301	0.4874	0.5004	0.4765
Improvement	-	7.45%	27.95%	17.06%

Referencias

[1]   Gomez, C., Hernandez, A. C., Crespo, J., & Barber, R. (2016). A topological navigation system for indoor environments based on perception events. International Journal of Advanced Robotic Systems, 14(1).

[2]   Gomez, C., Hernández, A. C., Crespo, J., & Barber, R. (2016, May). Integration of multiple events in a topological autonomous navigation system. In 2016 International Conference on Autonomous Robot Systems and Competitions (ICARSC) (pp. 41-46). IEEE.

[3]   Gomez, C., Hernández, A. C., Crespo, J., & Barber, R. (2017, April). Uncertainty-based localization in a topological robot navigation system. In 2017 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC) (pp. 67-72). IEEE.