

**Universidade Federal do Paraná**  
**Especialização em Inteligência Artificial Aplicada**

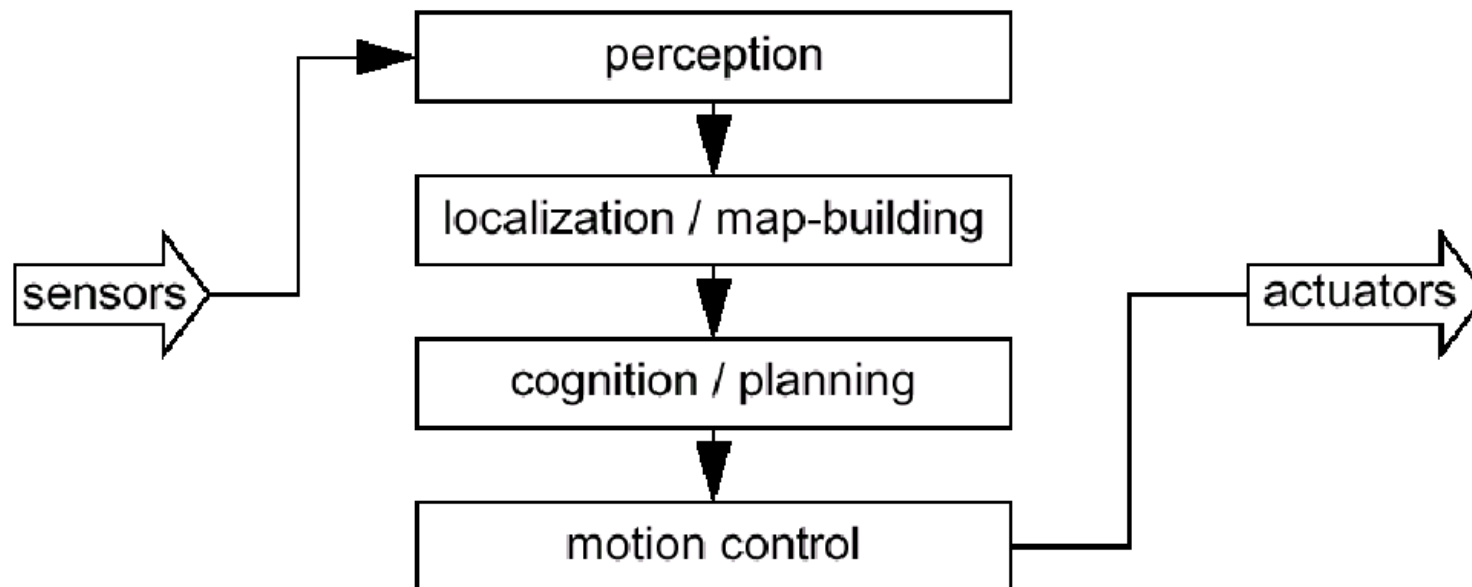
# **Mobile Robotics**

**Mapas e localização**

Prof. Eduardo Todt  
2019

# Navegação

- Navegação baseada em modelos





# Representação

## Contínua

- Precisão limitada pelos sensores
- Tipicamente uma única hipótese
- Perdido quando diverge
- Representação compacta (closed world)

## Discreta

- Precisão pela resolução de discretização
- Tipicamente múltiplas hipóteses
- Nunca perde (se diverge ocupa outra célula)
- Custo computacional conforme grid

# Representação

## Modelagem do ambiente

### Raw sensor data (laser range, imagens)

- Grande volume de dados, valores individuais pouco distinguíveis, uso de toda informação adquirida

### Low level features (linhas e outras formas geometricas)

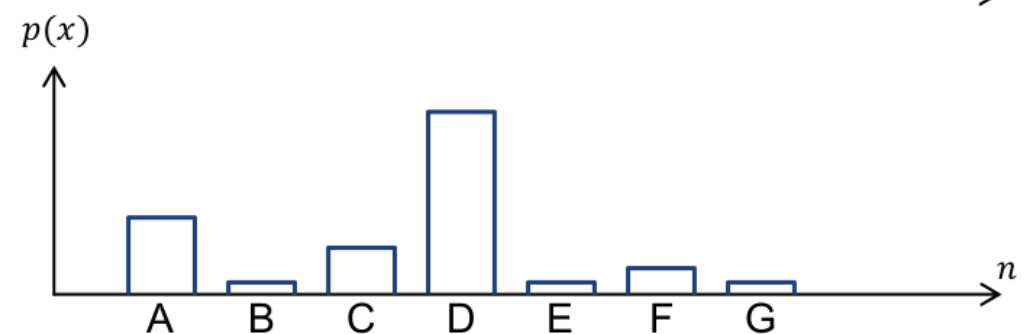
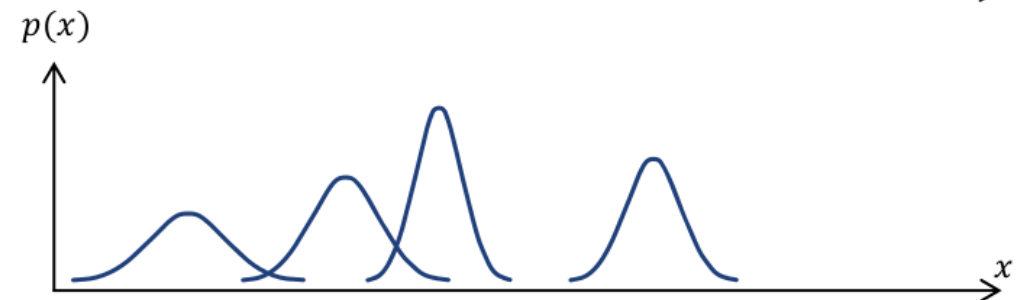
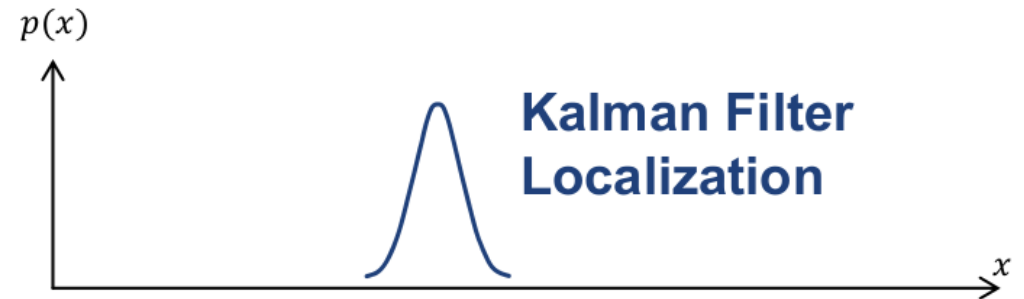
- Médio volume de dados, média distinguibilidade
- Informação útil é eliminada, permanecem ambiguidades

### High level features (porta, carro, janela)

- Pequeno volume de dados, alta distinguibilidade
- Informação útil eliminada, baixa ambiguidade

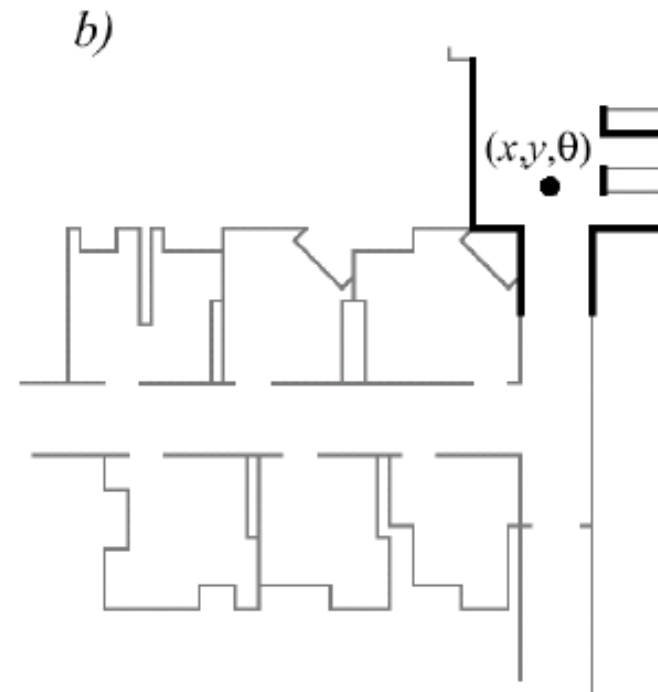
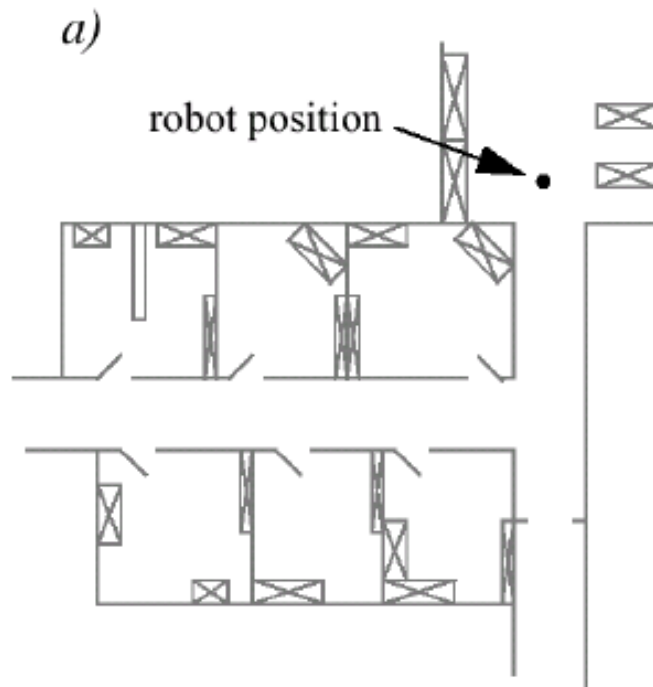
# Representação de crença de posição

- Continuous map with single hypothesis probability distribution  $p(x)$
- Continuous map with multiple hypotheses probability distribution  $p(x)$
- Discretized metric map (grid  $k$ ) with probability distribution  $p(k)$
- Discretized topological map (nodes  $n$ ) with probability distribution  $p(n)$

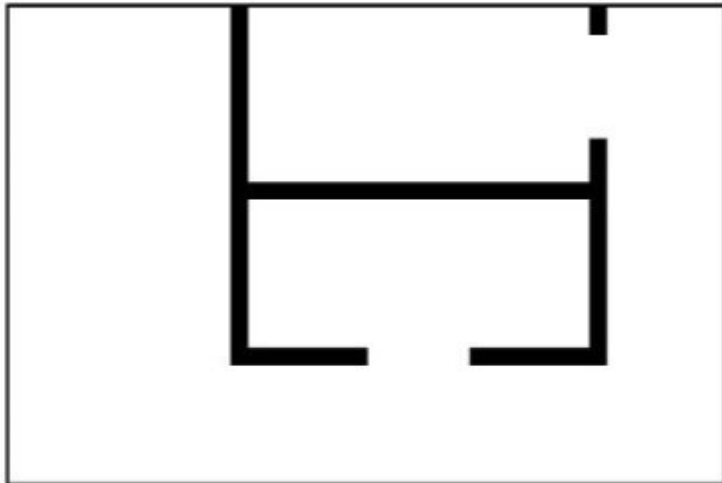


# Hipótesis única

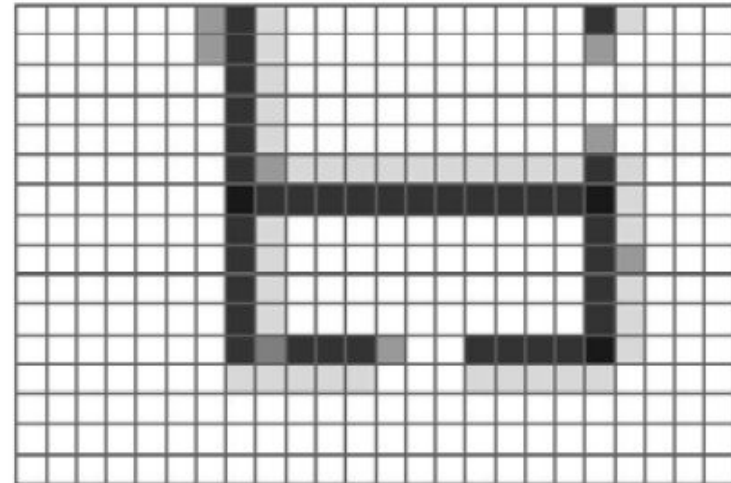
## Mapa contínuo



# Grade de ocupação



Real environment



Occupancy grid

# Mapa métrico vs Topológico

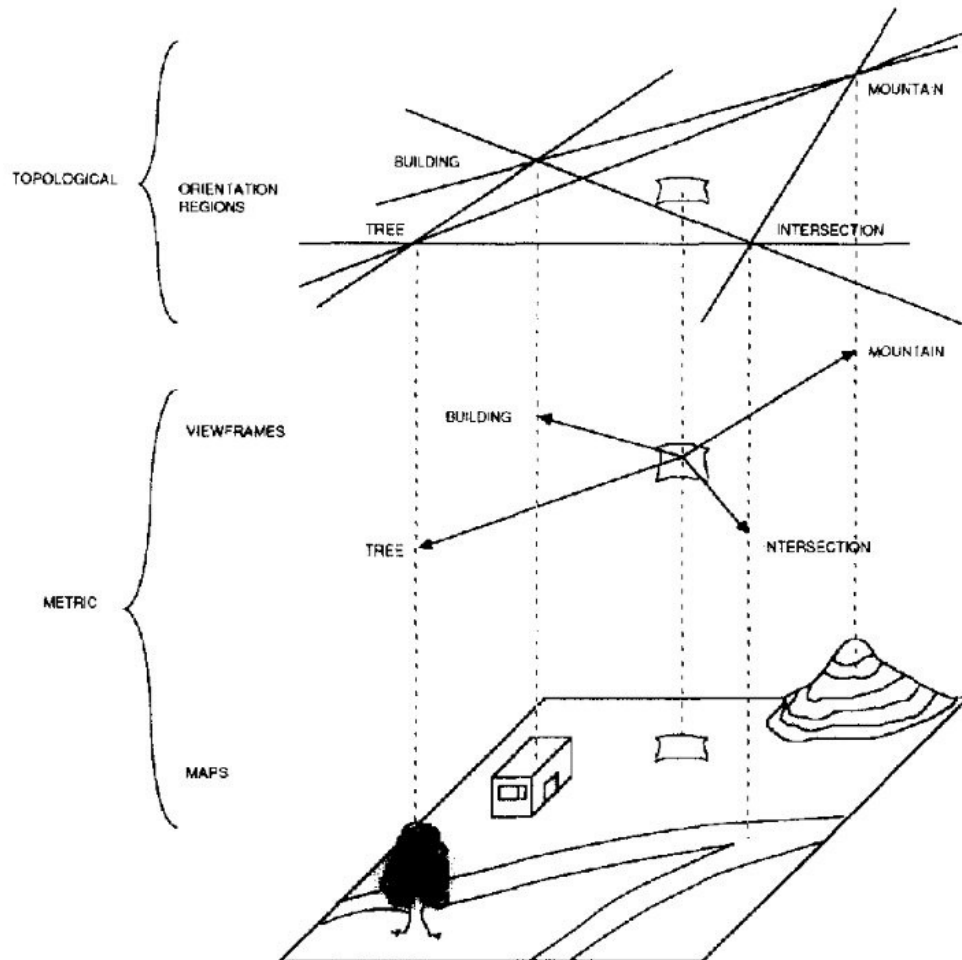


Fig. 1. Multiple levels of spatial representation.

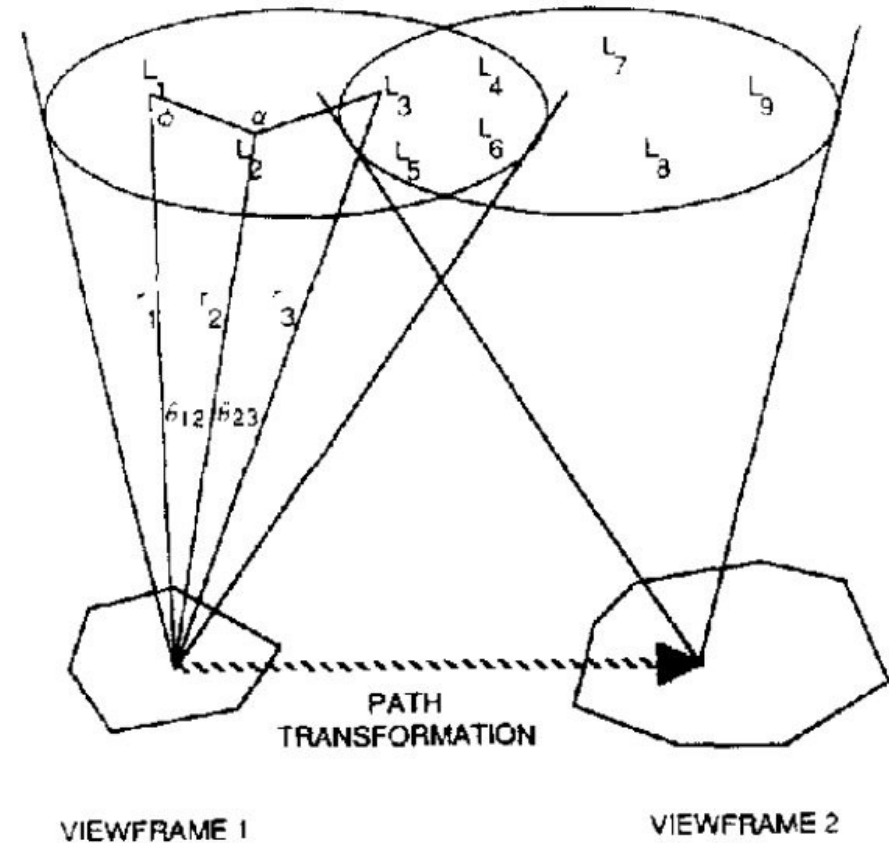
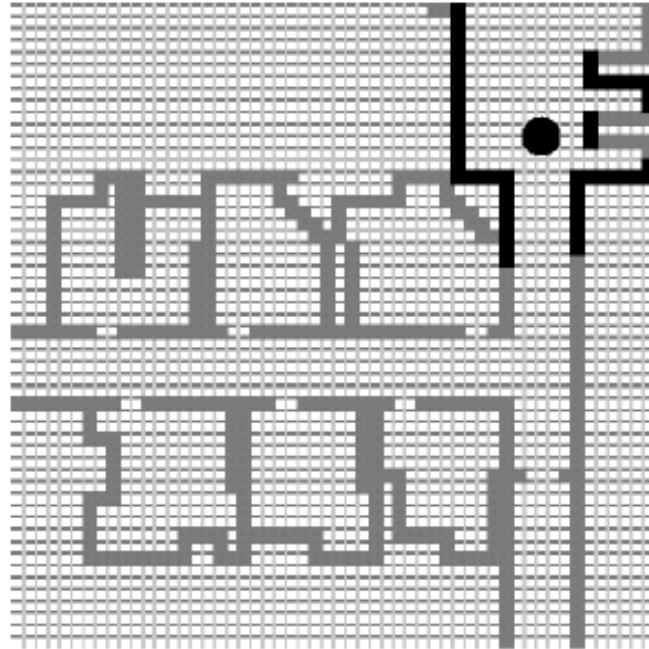


Fig. 7. Viewframe heading.



# Hipótese única

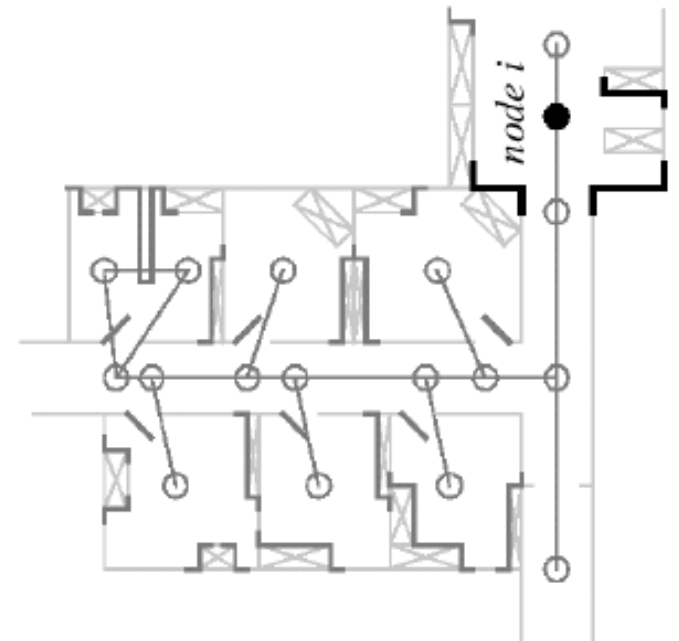
c)



Grid

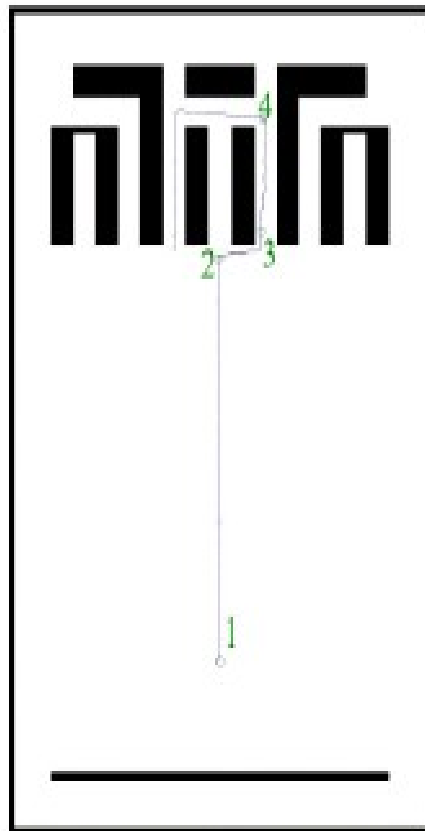
Topológico

d)

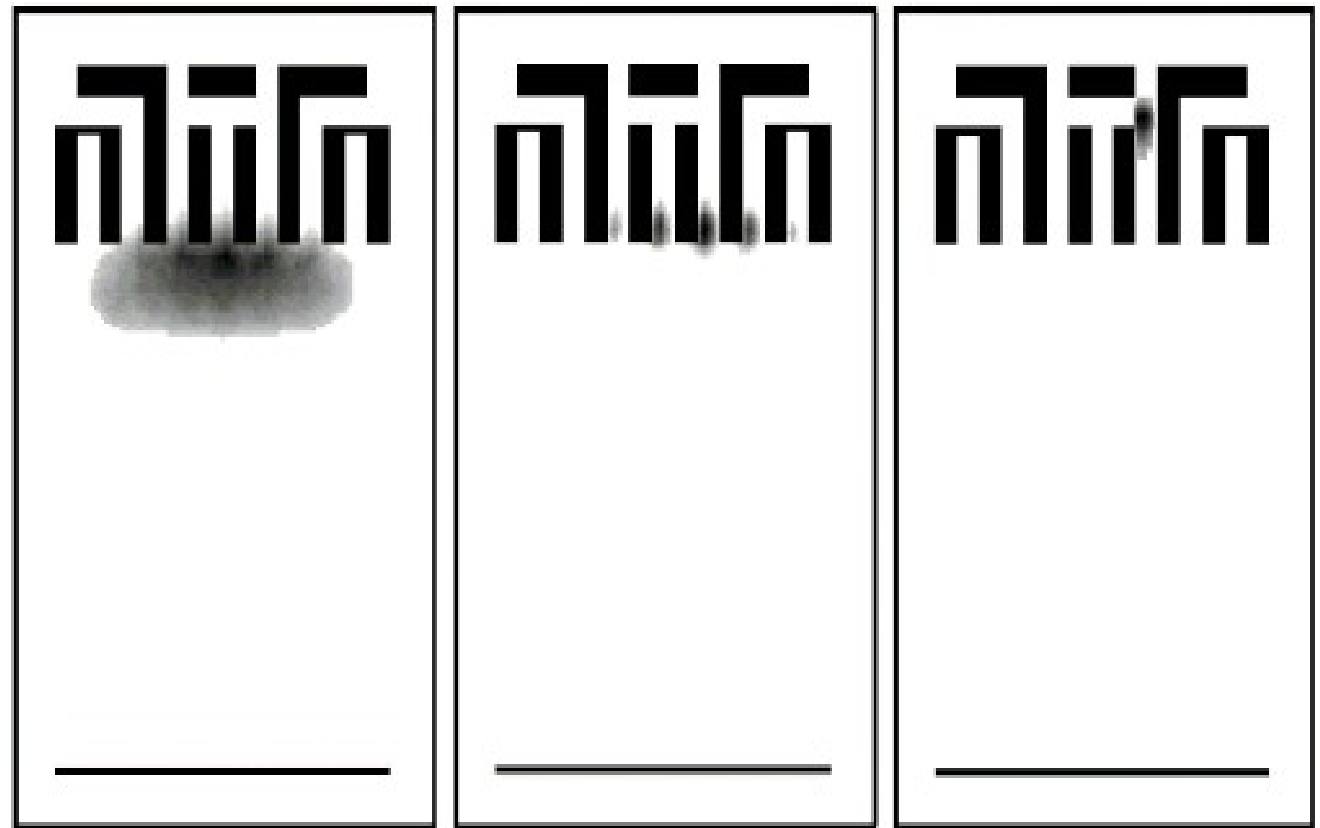


# Múltiplas hipóteses em grid

*Courtesy of W. Burgard*



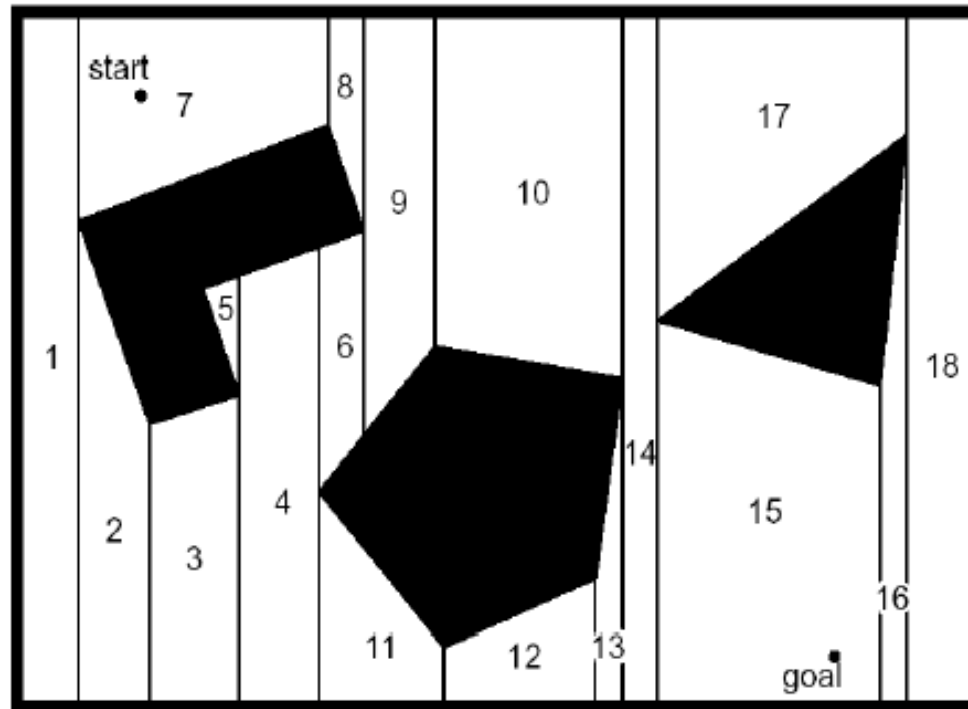
*Path of the robot*



*Belief states at positions 2, 3 and 4*

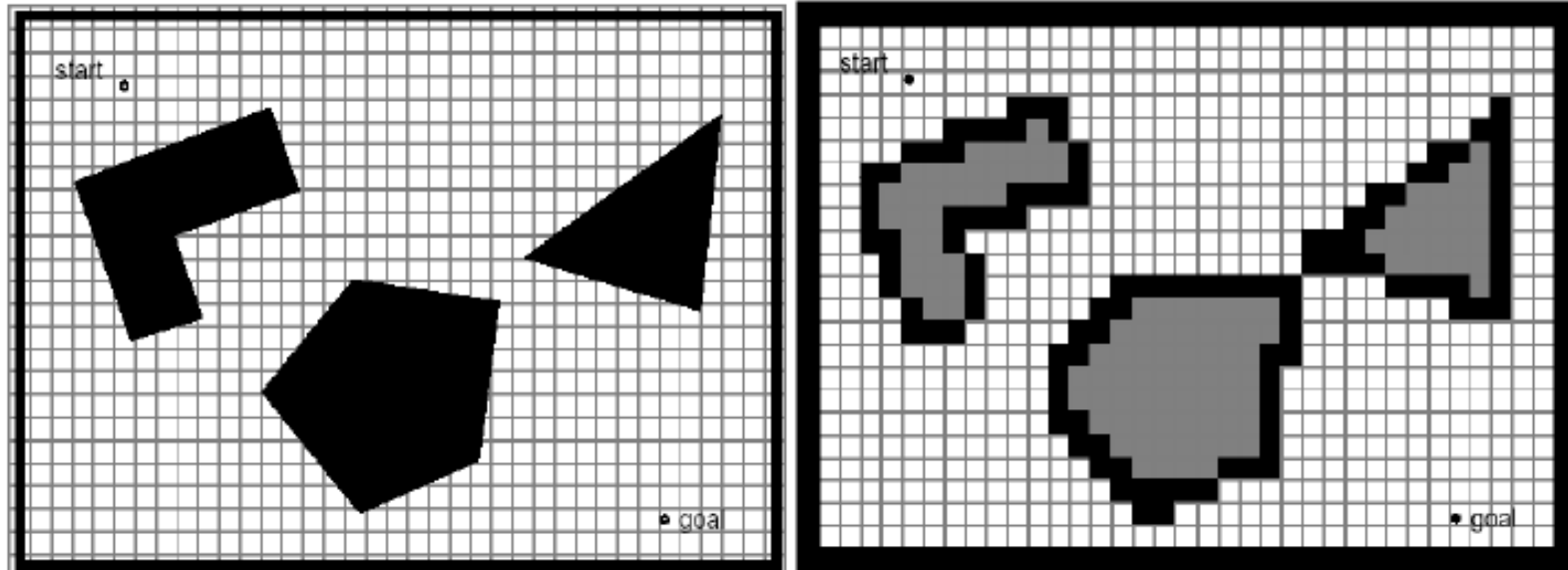
# Representação discreta (Decomposição)

## Decomposição células exatas



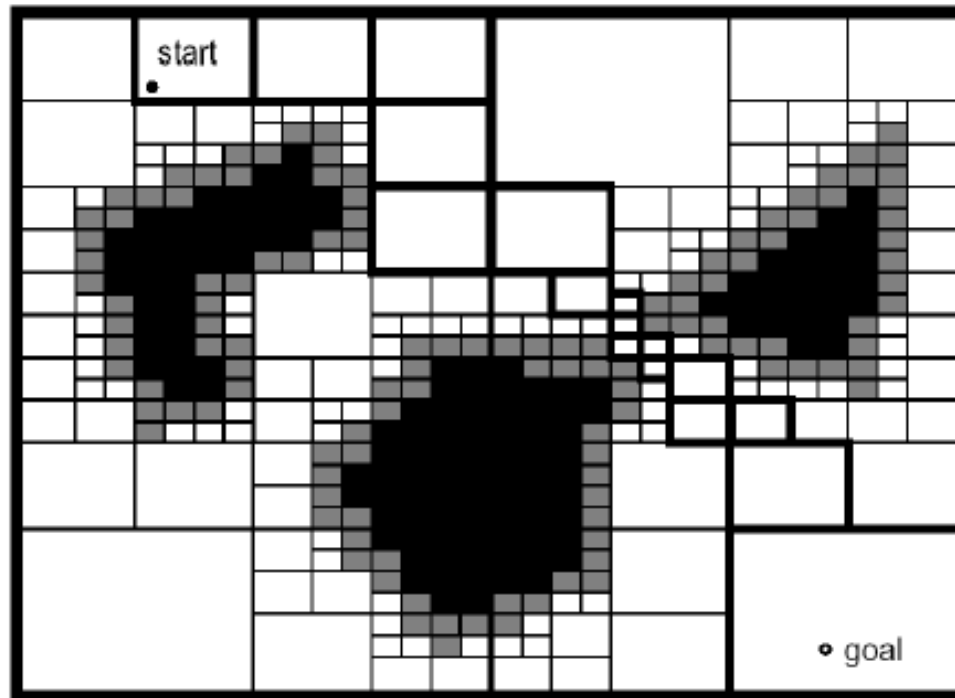
# Representação discreta (Decomposição)

Decomposição em células fixas



# Representação discreta (Decomposição)

Decomposição em células adaptativas



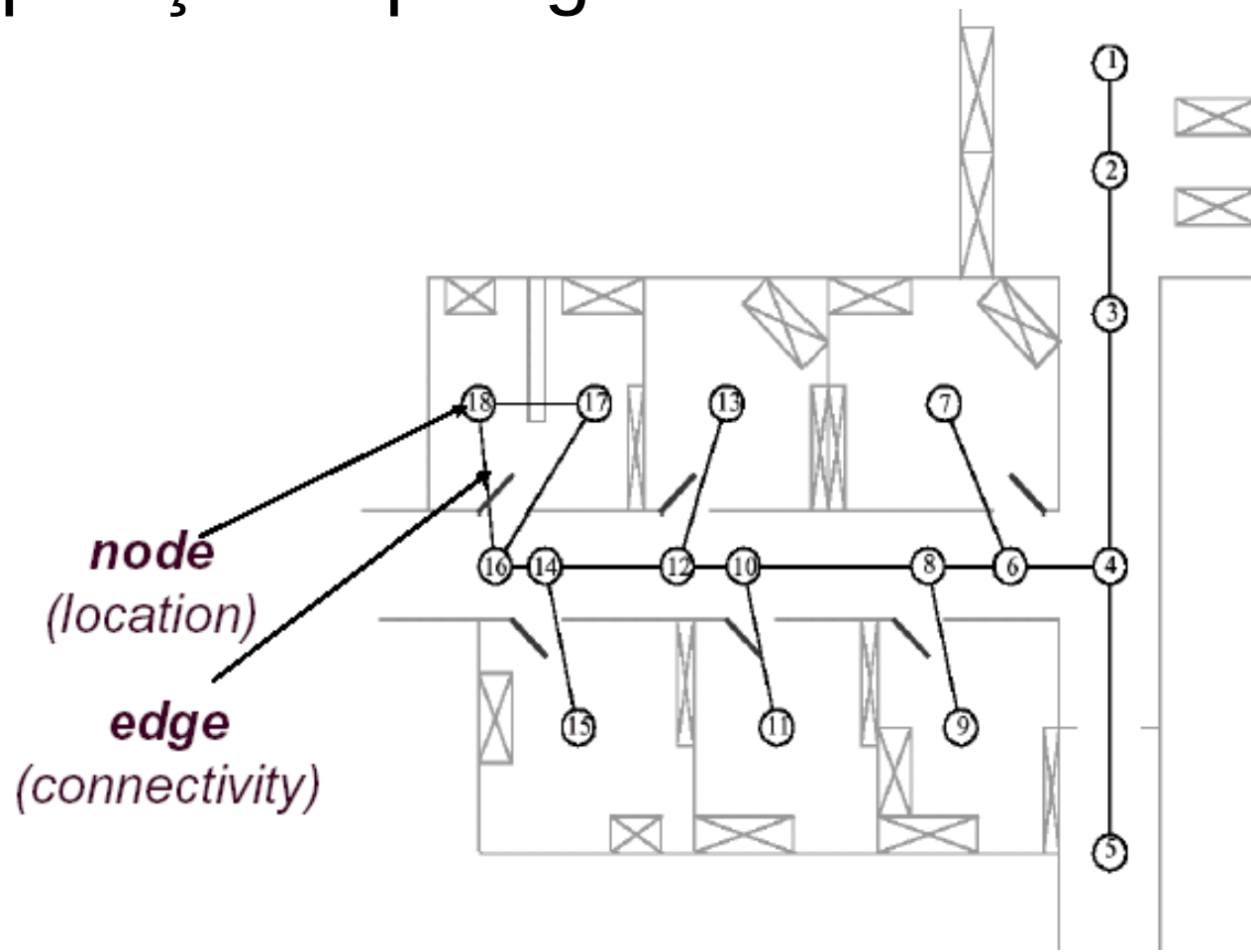
# Representação discreta (Decomposição)

Decomposição em células muito pequenas



# Representação discreta (Decomposição)

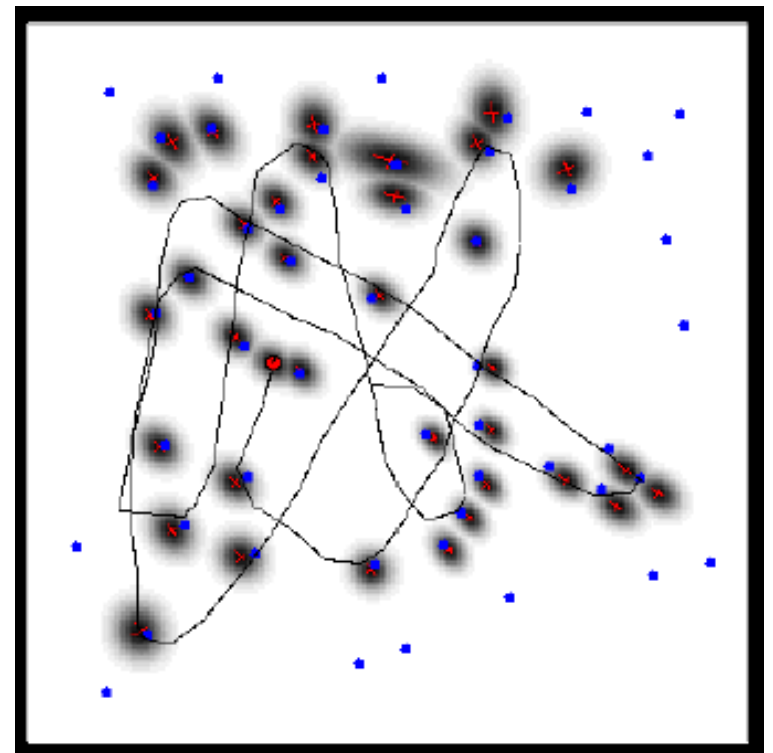
## Decomposição topológica



## 1. Landmark-based map representation

Track the positions of a fixed number of predetermined sparse landmarks.

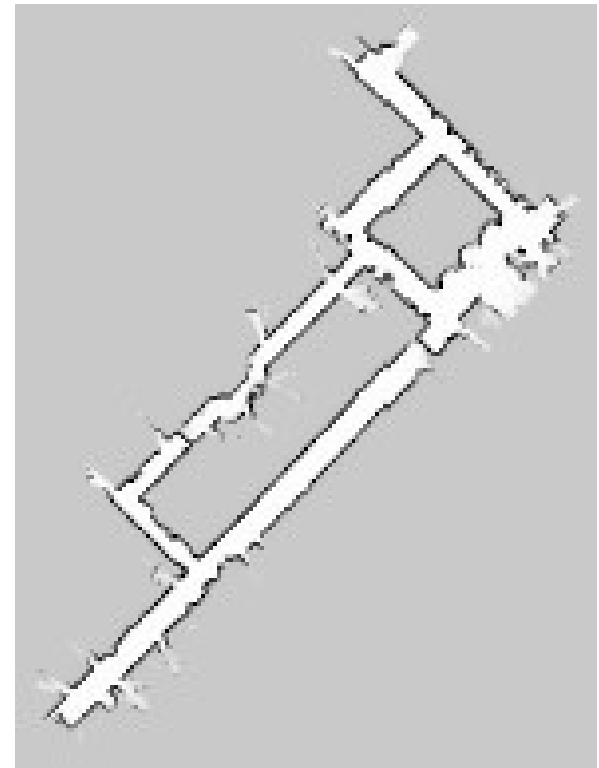
Observation: estimated distance from each landmark.



## 2. Grid-based map representation

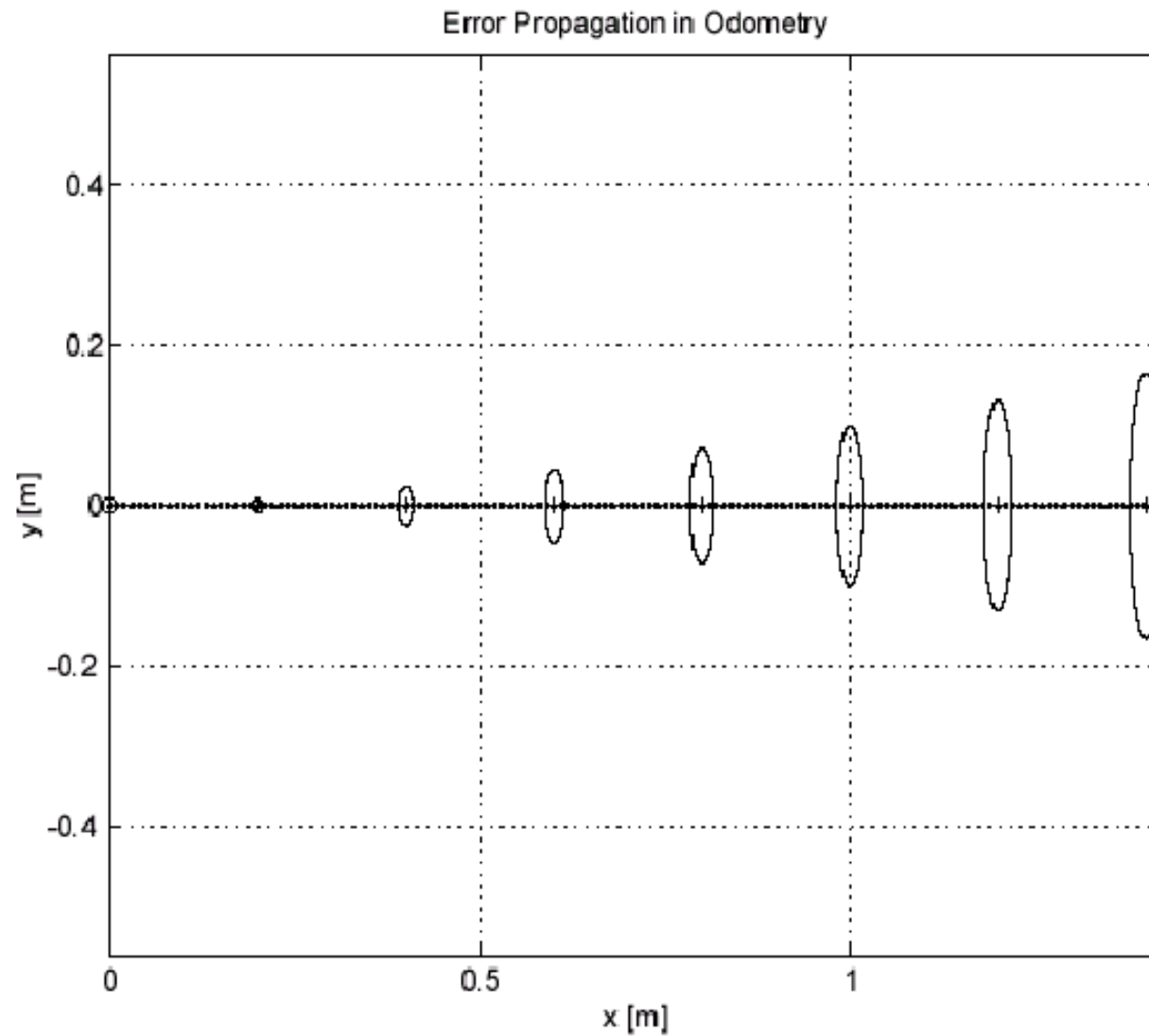
Map is represented by a fine spatial grid, each grid square is either occupied or empty.


Observation: estimated distance from an obstacle using a laser range finder.





# Localização





# Localização e landmarks

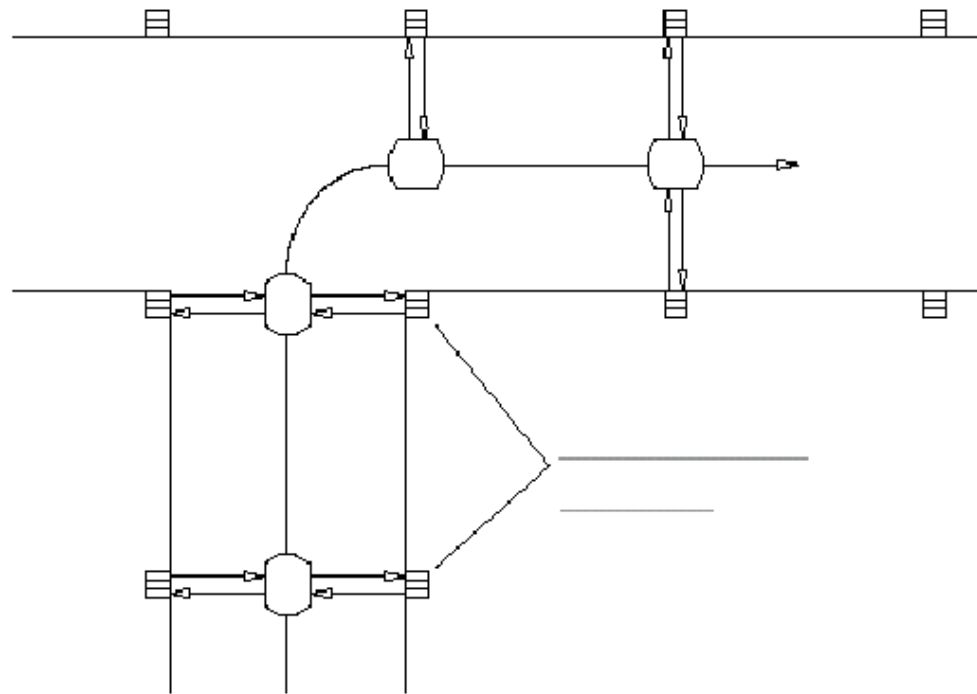
## Landmarks

### Características de landmarks

- Naturais x artificiais
- Passivos x ativos
- Indistinguíveis x distinguíveis
- Discretos x densos

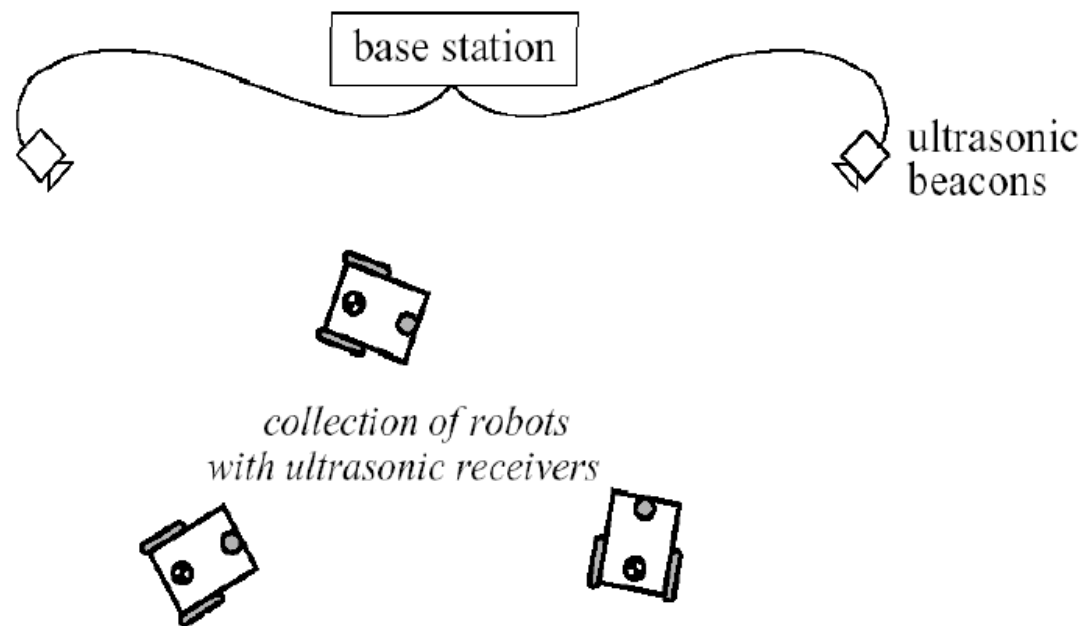
# Landmarks artificiais

Placas com códigos

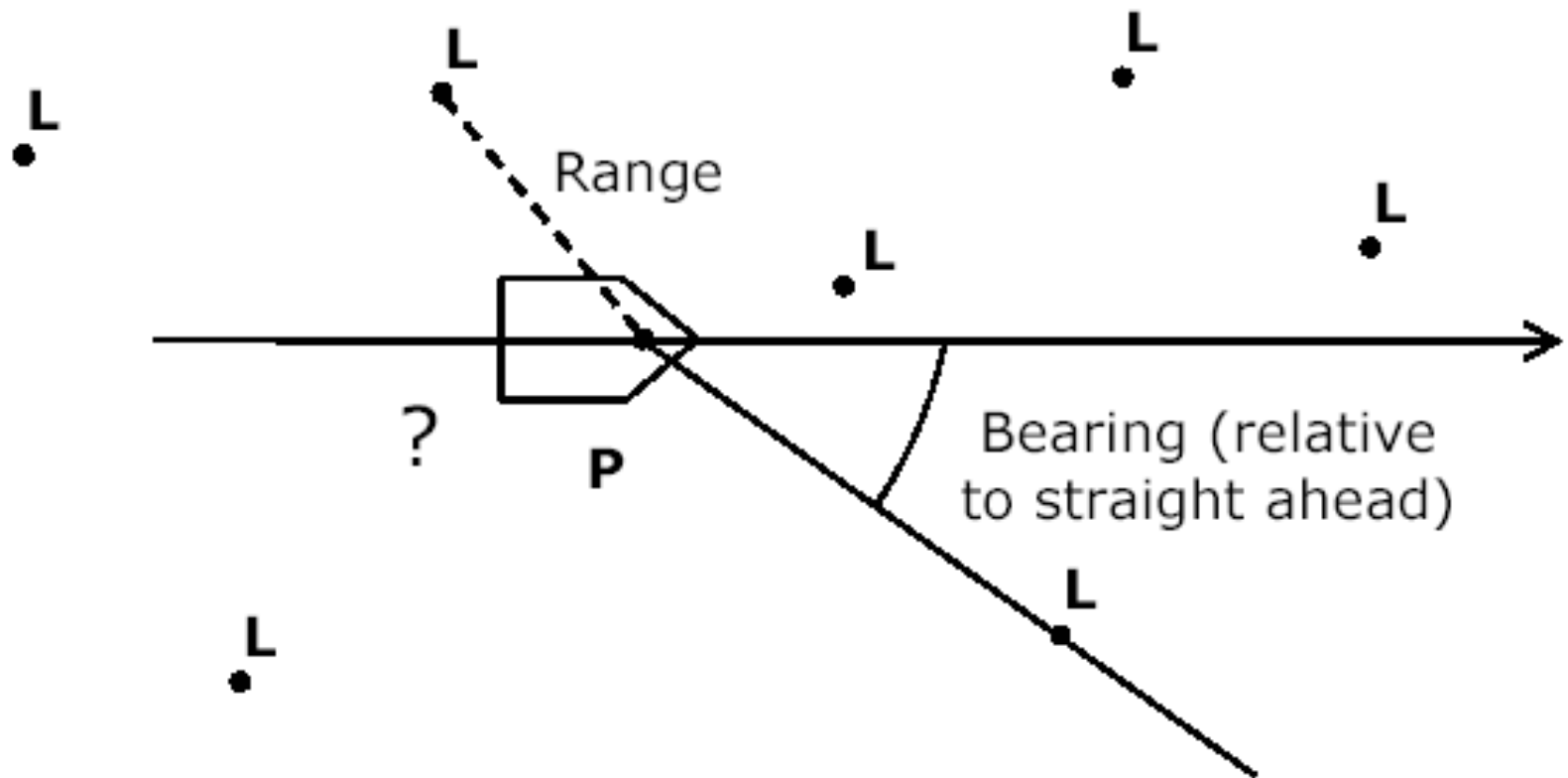


# Landmarks artificiais

## Marcadores com ultrassom

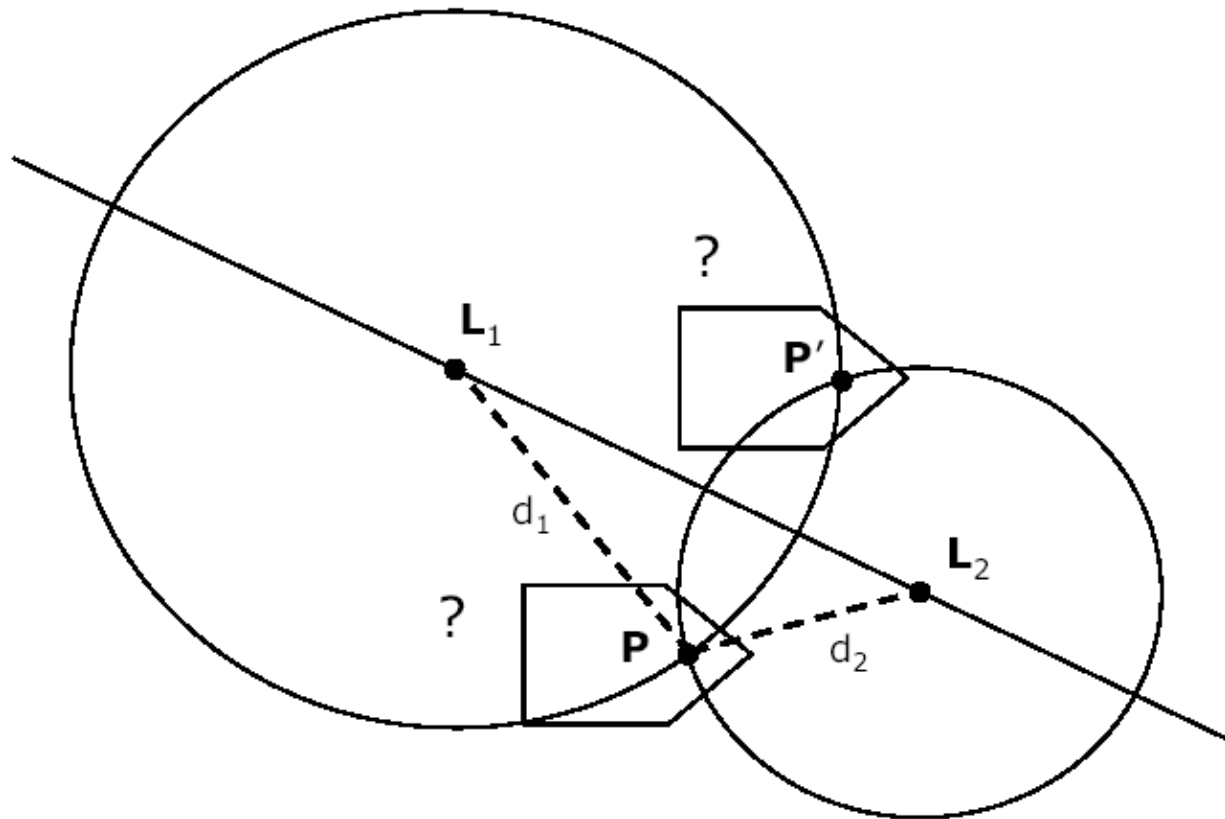


# Triangulação



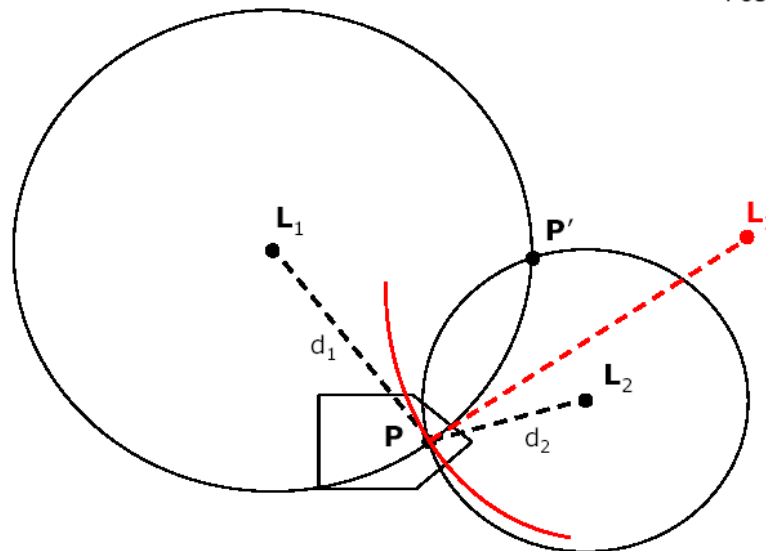
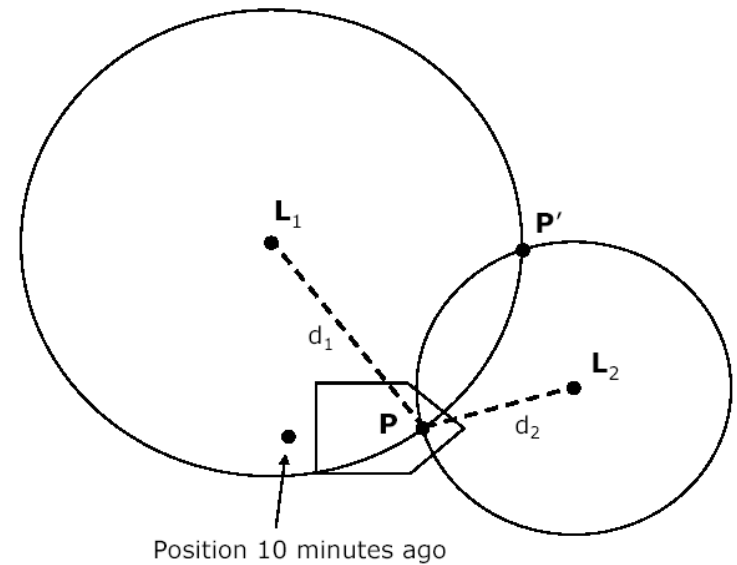
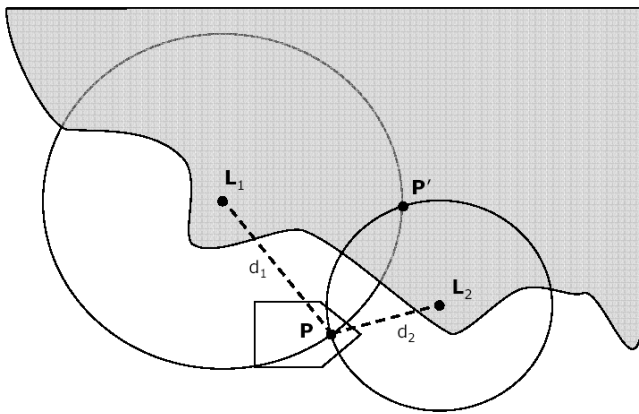
# Triangulação por distâncias

Ambiguidade



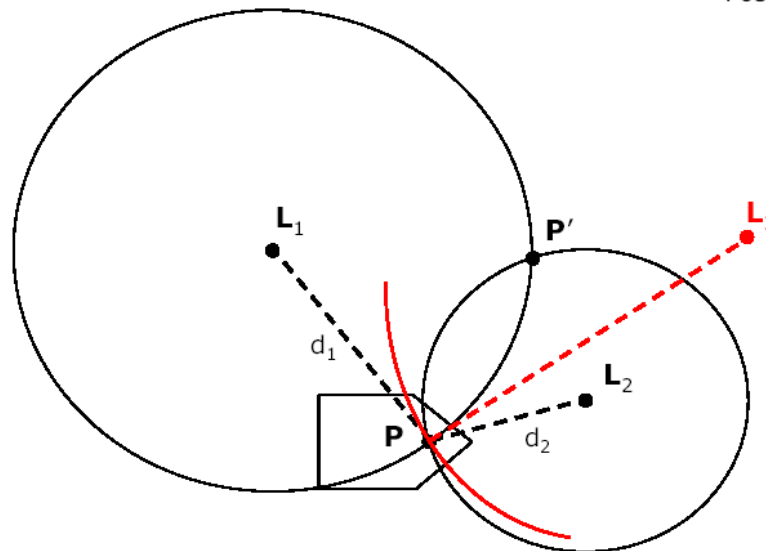
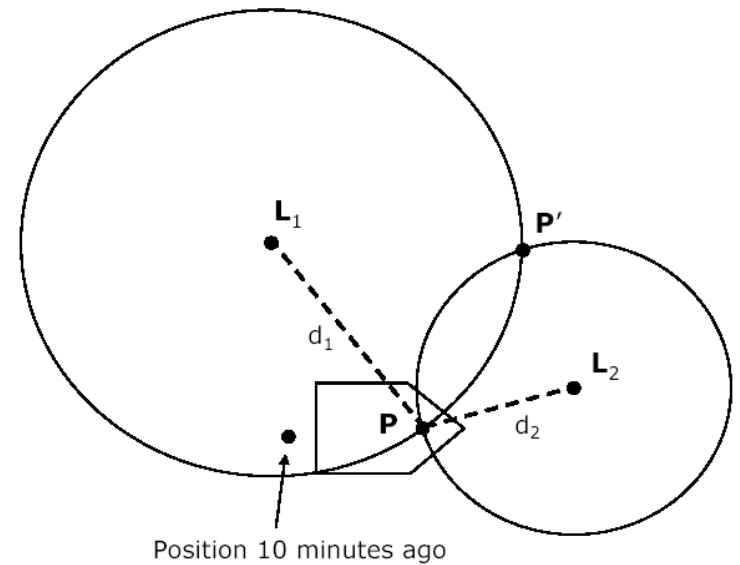
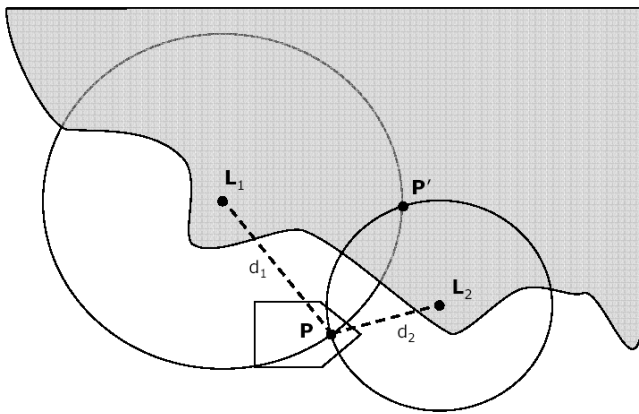
# Triangulação por distâncias

## Resolvendo ambiguidade



# Triangulação por distâncias

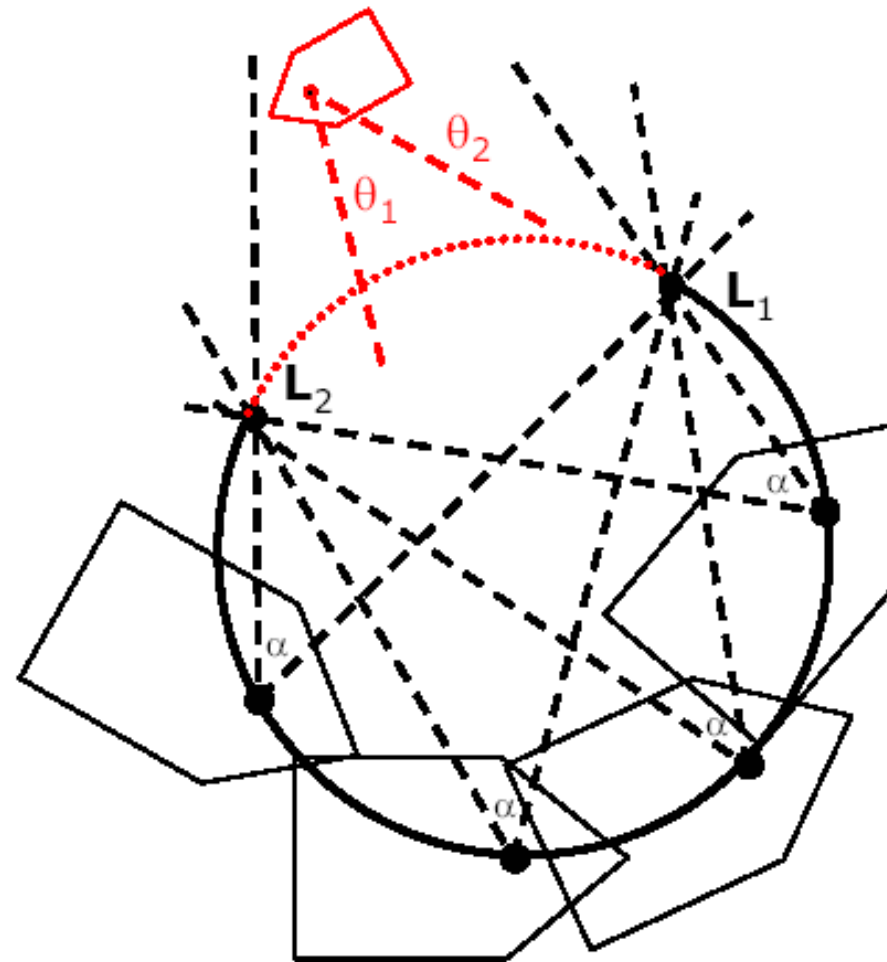
## Resolvendo ambiguidade





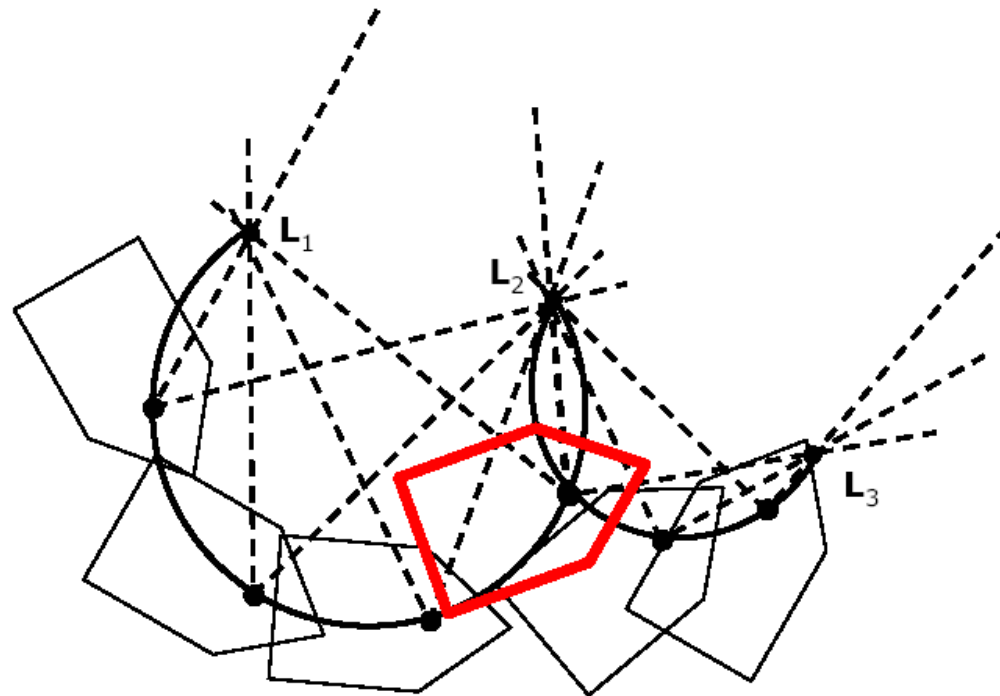
# Triangulação por ângulos

Dois landmarks oferecem infinitas soluções

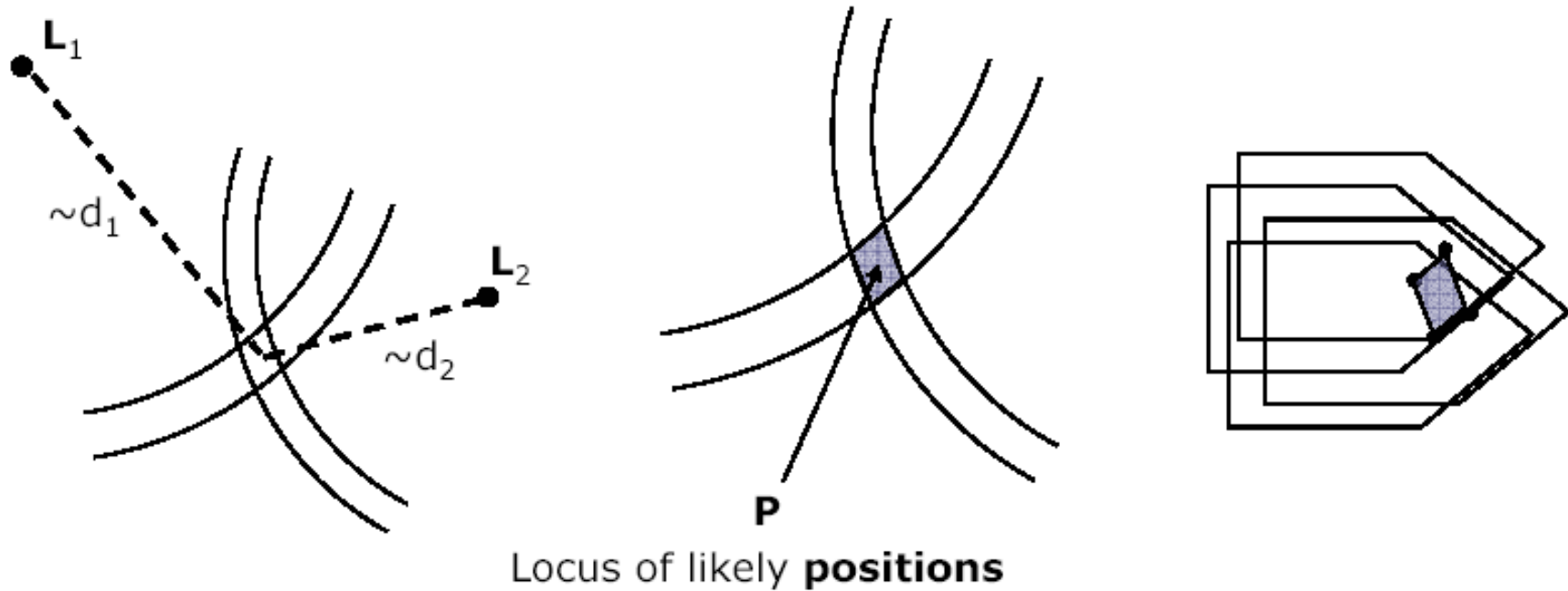


# Triangulação por ângulos

Terceiro landmark permite obter posição e orientação



# Uncertainty in measurements

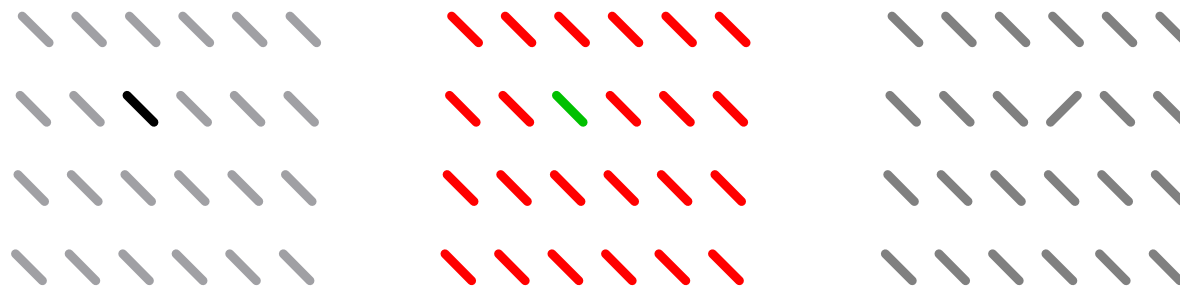


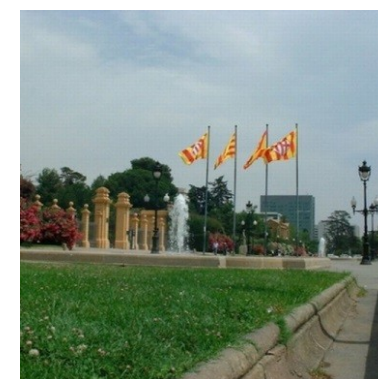
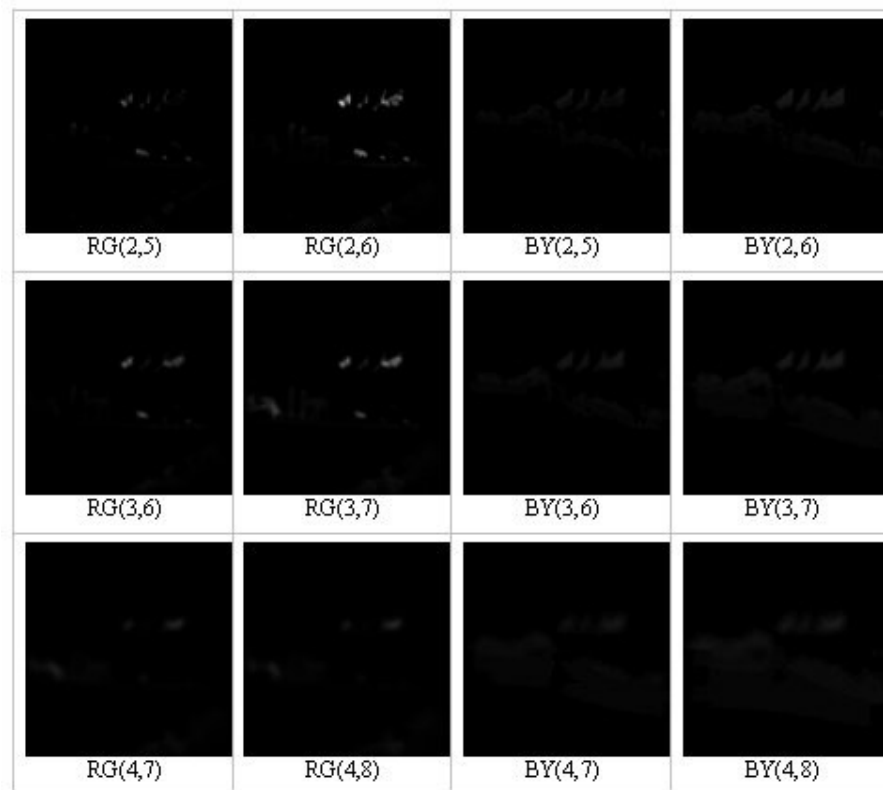
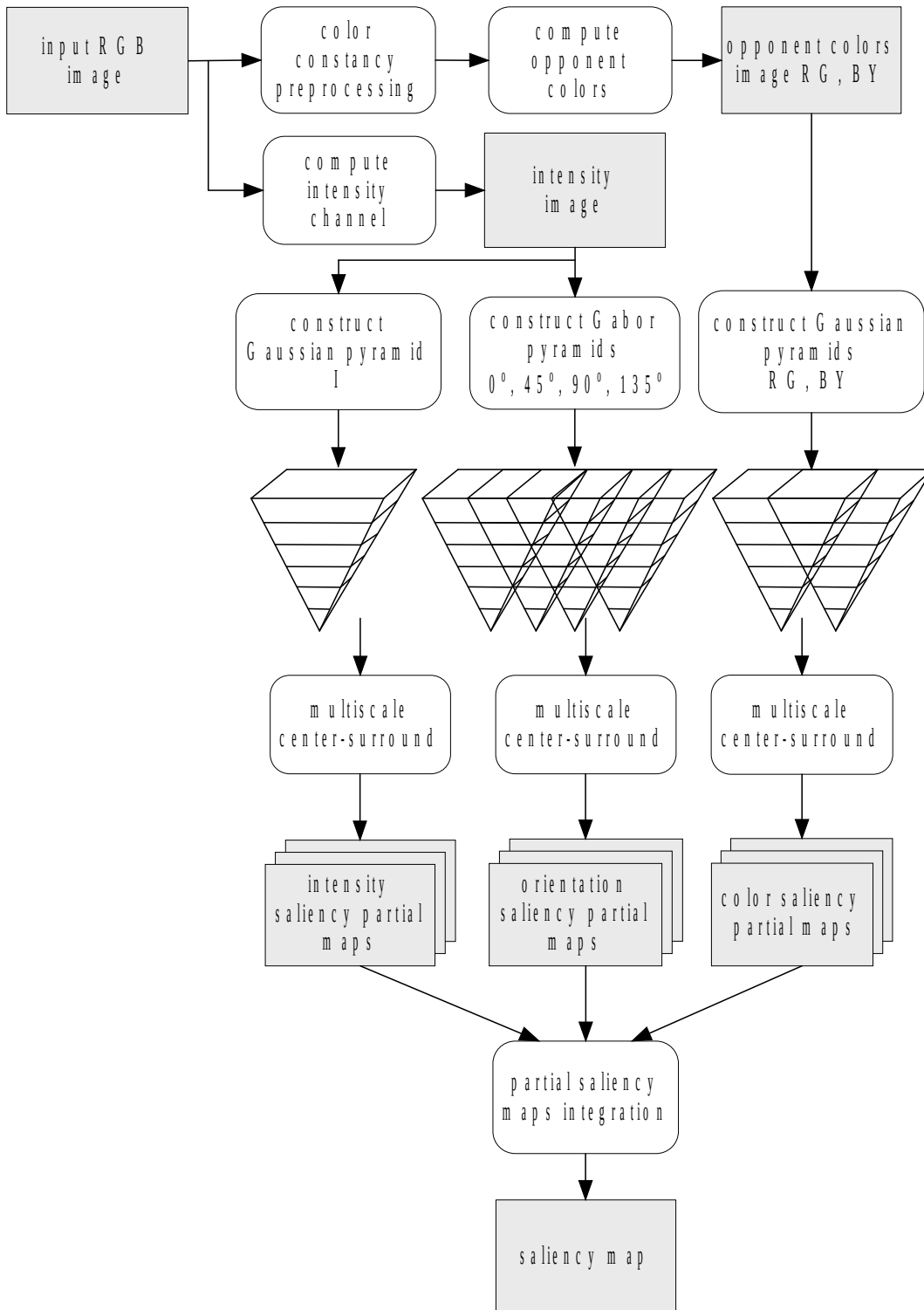
# Detectando landmarks

Modelo de saliência visual de Treisman e Gelade, 1980

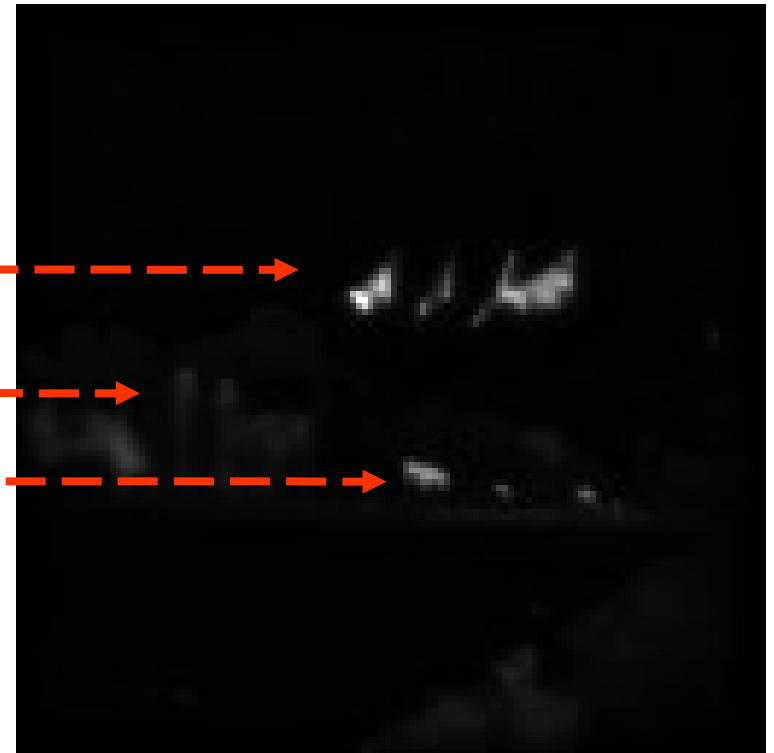
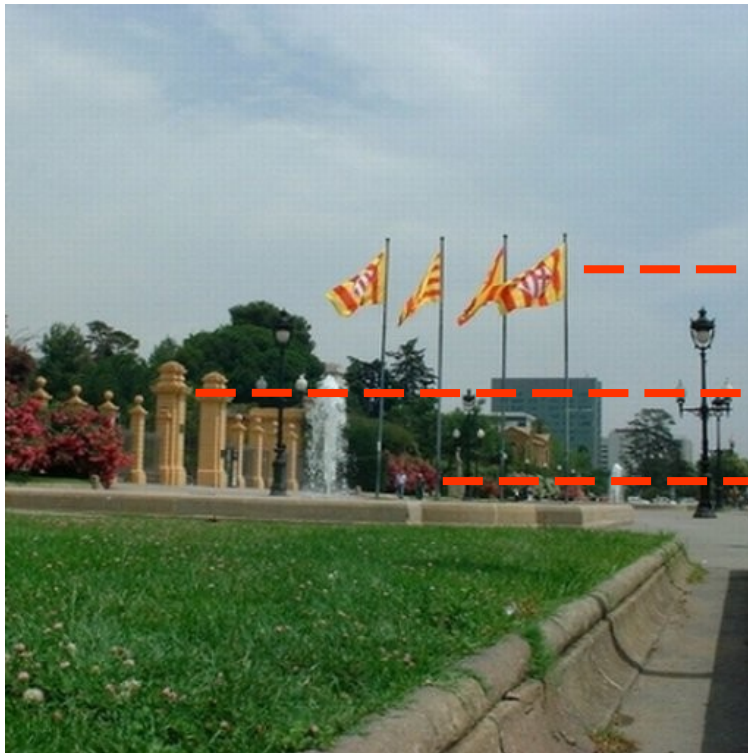
Reduzir quantidade de informação

Amplitude x contraste

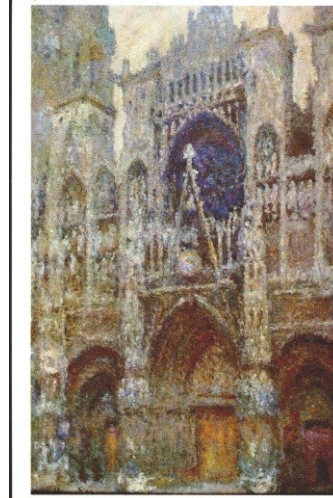
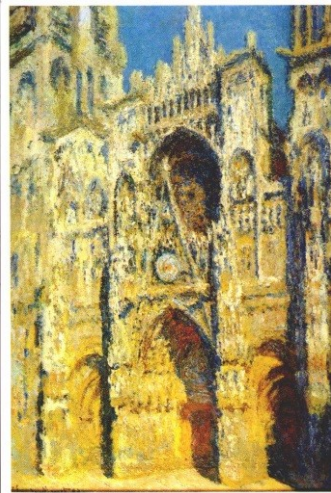
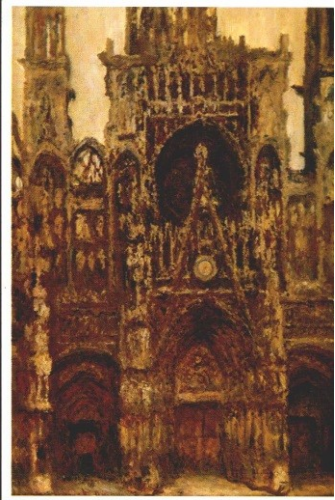




# Exemplo de detecção de saliência



# Color constancy



Monet - cathédrale de Rouen ... 1894



# Caracterizando landmarks

## Características

- Saliência relativa
- Histograma de cromaticidade
- Textura

## Landmark matching

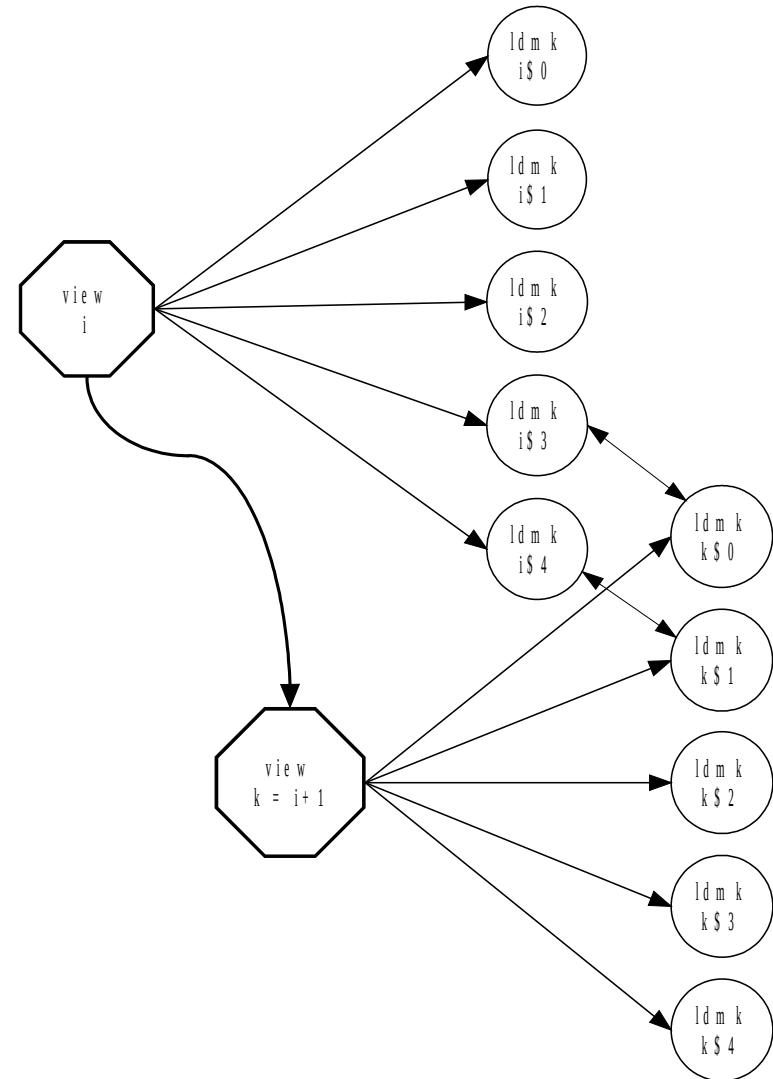
- Distância simples
- Distância quad-form



# Reforçando com coocorrência

Vistas formadas pelos  $N$   
*landmarks* mais salientes

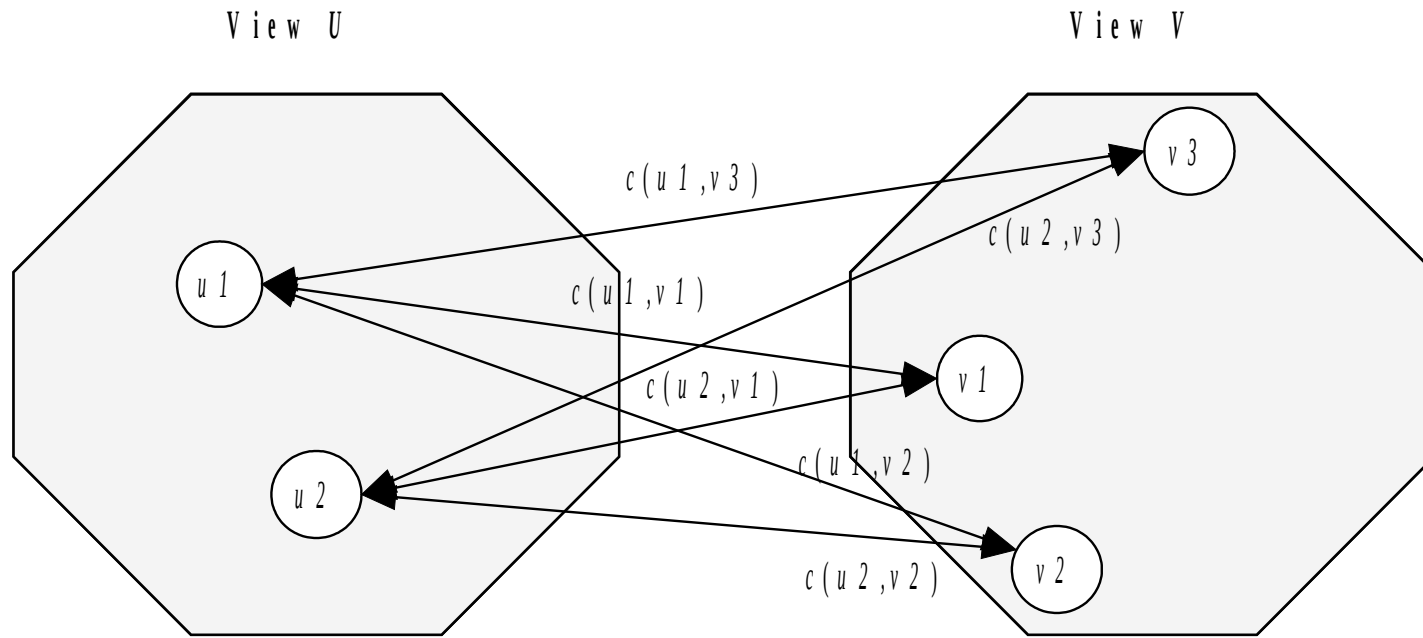
Informação espacial



# Comparando vistas

Weighted bipartite graph

Relaxation algorithm (Berretti et al., 2001)



# Comparando vistas

