BLG456E
Robotics
Intro to Localisation
(Without Probability)

Lecture Contents:

- Intro to perceptual reconstruction.
- Localisation problem & sub-problems.
- Representations.
- Localisation from features.
- Triangulation.

Lecturer:	Damien Jade Duff
Email:	djduff@itu.edu.tr
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Schedule:	http://djduff.net/my-schedule
Coordination:	http://ninova.itu.edu.tr/Ders/4709

Some slides based on slides by Dr. Sanem Sarıel-Talay

Towards cognitive robotics

Reactive robots have huge potential:

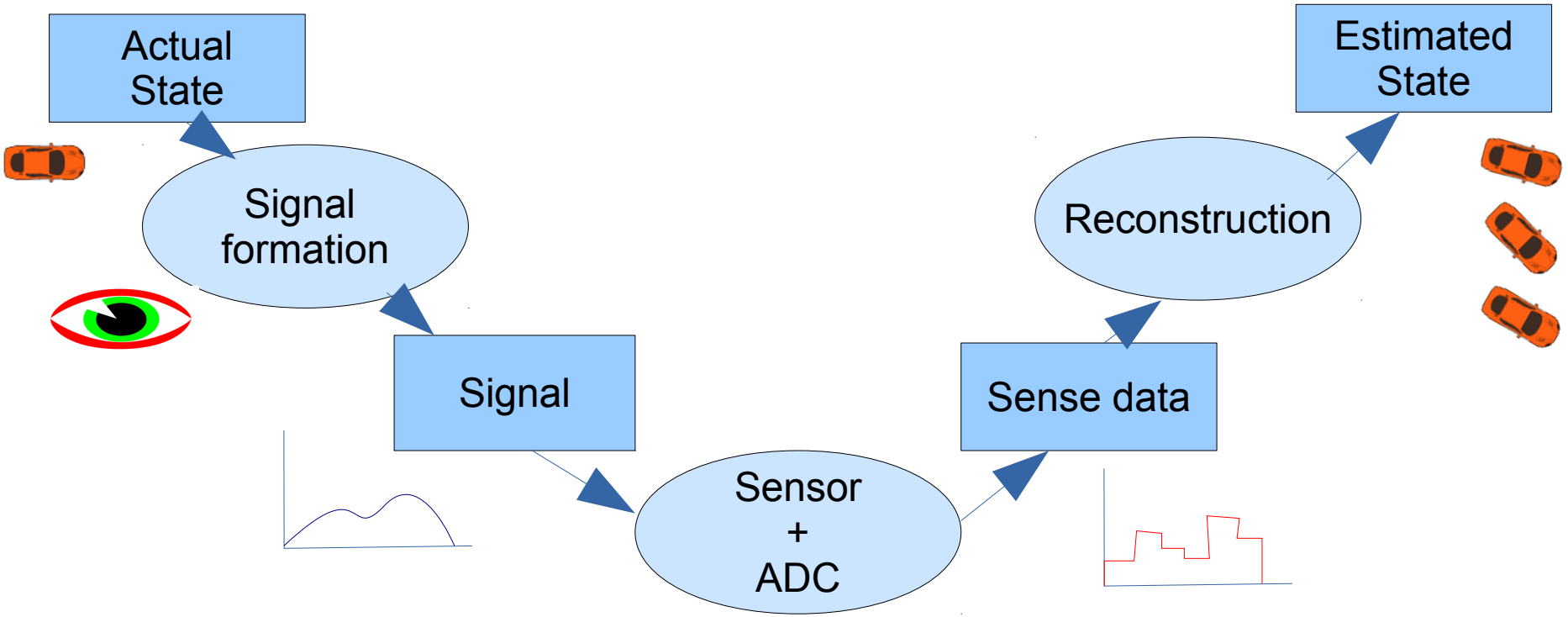
- Learning.
- Evolving.
- ...

Cognitive robotics is a good engineering shortcut.

- Representing world information and computing on it → engineering solution.
- BUT:
  - Be careful about *reification*.
  - The world is still *out there*.
  - Don't be fooled by false introspection.

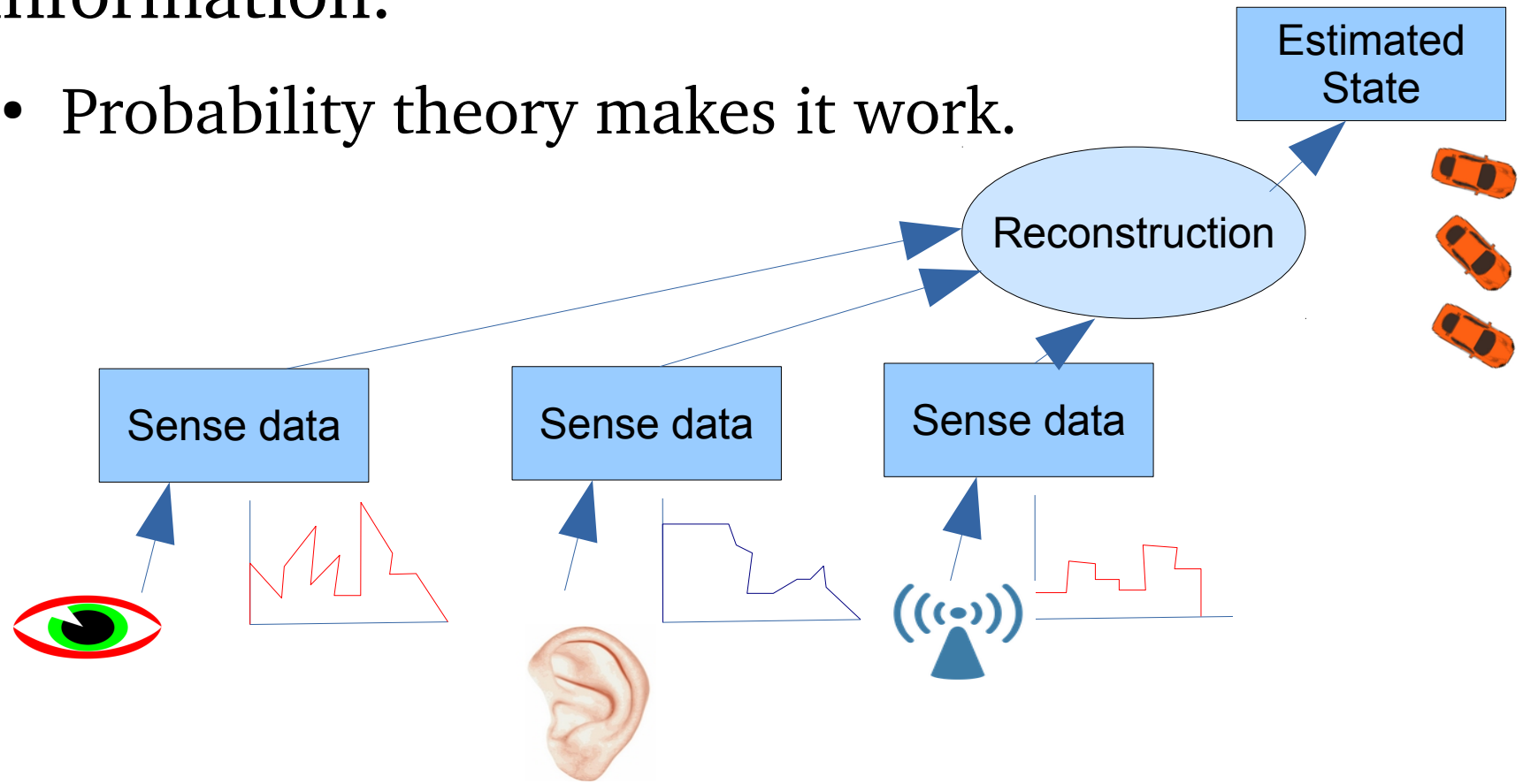
Reconstruction from sense data

"What must the world be like to get these readings?"



Sensor fusion

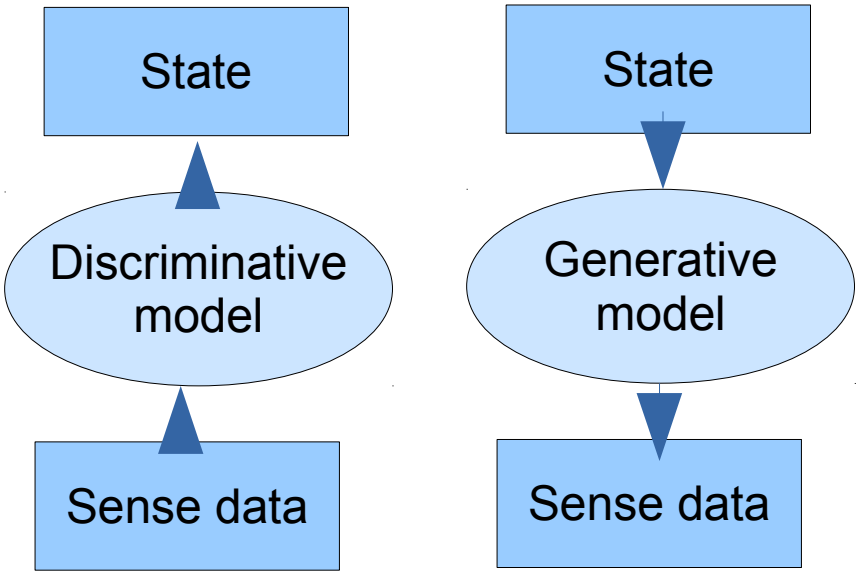
- Combine multiple sources of (sense) information.
  - Probability theory makes it work.



https://openclipart.org/detail/63247/eye-sign-by-dbdeveloper
https://openclipart.org/detail/21326/human-ear-by-bionet
https://openclipart.org/detail/177491/pointing-finger-by-sumitomohiko-177491

Discriminative vs. generative models

- Reconstruction usually uses **observation model**.
- **Discriminative model**: How to reconstruct state from sense data.
- **Generative model**: How sense data generated.
  - Extra step to get discriminative model.
  - Easier to understand (e.g. causal models, optic models).



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Localisation Problem

- Determine robot pose.
- With respect to environment representation (s).
  - e.g. 2D v. 3D.
  - e.g. Coordinates v. grid entry v. location label.
  - e.g. Workspace coordinates v. configuration.
- Use sensors + prediction.

Open loop localisation

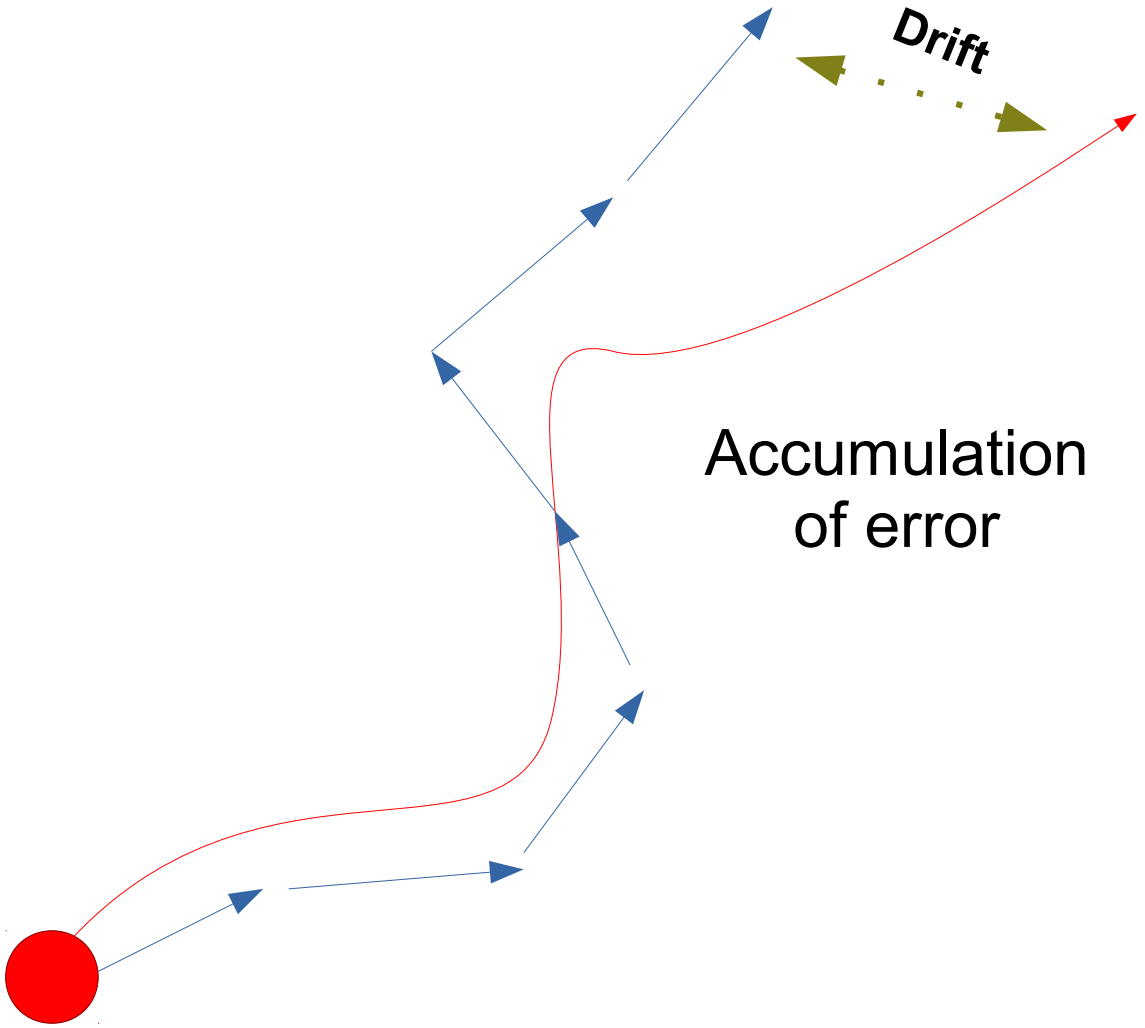
1. Send motor command.
2. Guess new position.

- Simplest approach.
- No sensing!

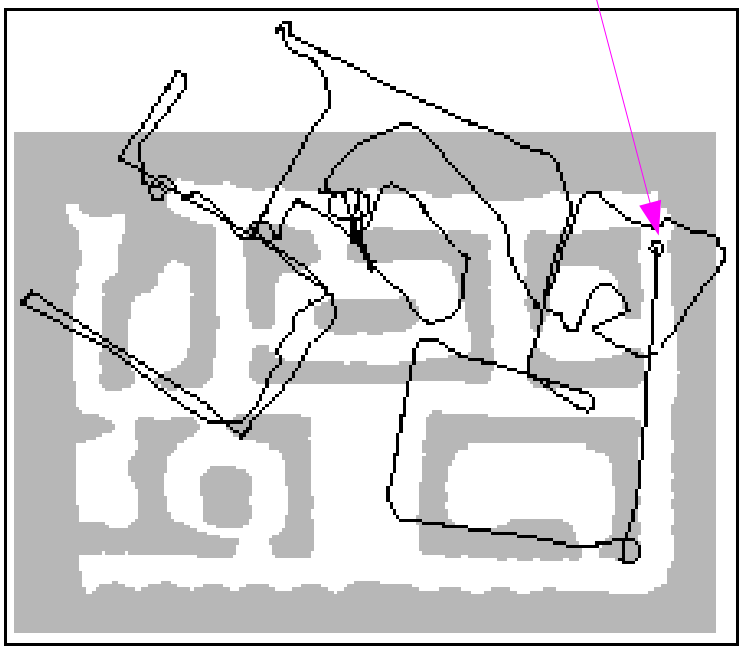
Dead reckoning

- Only standard odometry (proprioceptive).
- Can estimate change in location.
- Many error sources:
  - Slip, inaccuracy, noise, quantisation errors, kidnapping, etc.
- Error accumulates:
  - Range error.
  - Turn error.

Dead reckoning



Accumulation
of error

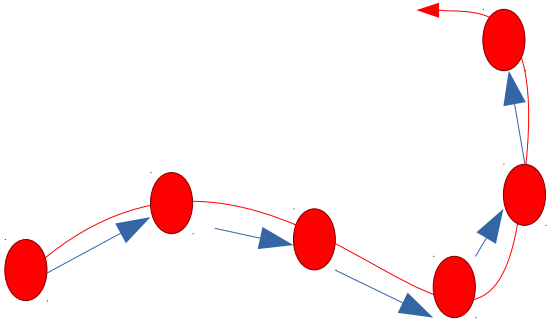


—— Actual position
—— Estimated position

Localisation sub-problems

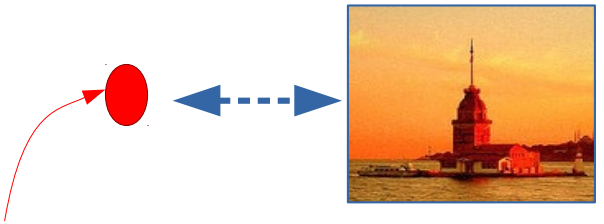
Position tracking:

- Pose wrt last known point.
- Also "odometry" (e.g. visual odometry).



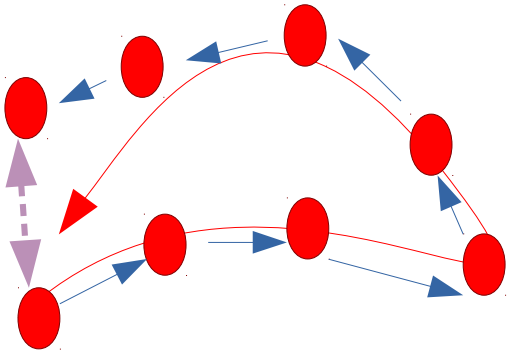
Global localisation:

- Pose wrt known locations.
- (see "robot kidnapping problem")



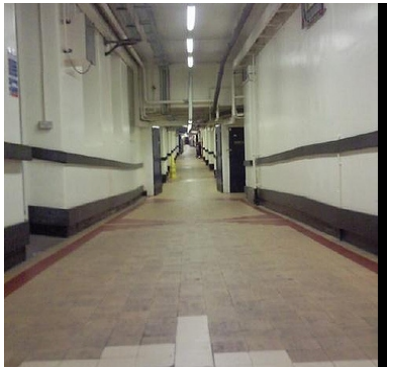
Loop closing:

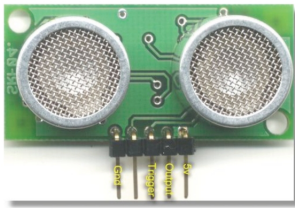
- Fixing position track when re-reaching known location.
- Solve “drift”.

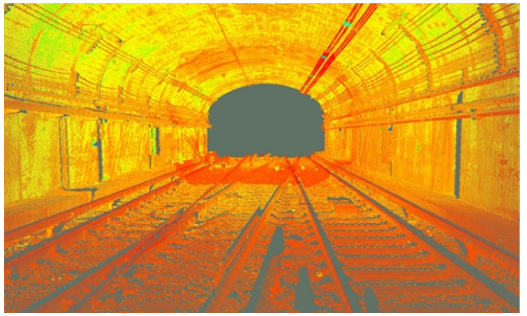


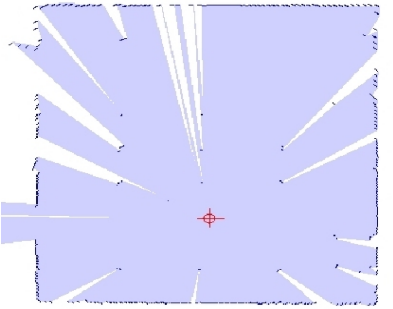
Localisation sensors: examples

- Vision.
- Sonar distance.
- Laser distance scans.
- GPS.
- Compass.
- WLAN signal strength.
- Depth and RGBD cameras.









Active v. Passive Localisation

Passive:

In parallel:

- Complete task.
- Localise from sensors.

Active:

Simultaneously:

- Complete task.
- Localise from sensors.
- **Act** to localise.

Acting must satisfy both immediate task and perceptual needs

Considerations

- Map representation?
  - E.g. occupancy grid, polygonal, landmark-based.
- Data used.
  - E.g. optical flow, wi-fi signal, odometry.
- Map-data mapping.
  - E.g. Prediction/likelihood, RANSAC.
- Position prediction.
  - E.g. velocity based.
- Data expectations.
  - E.g. predicted feature locations.

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Map representation

Continuous metric.

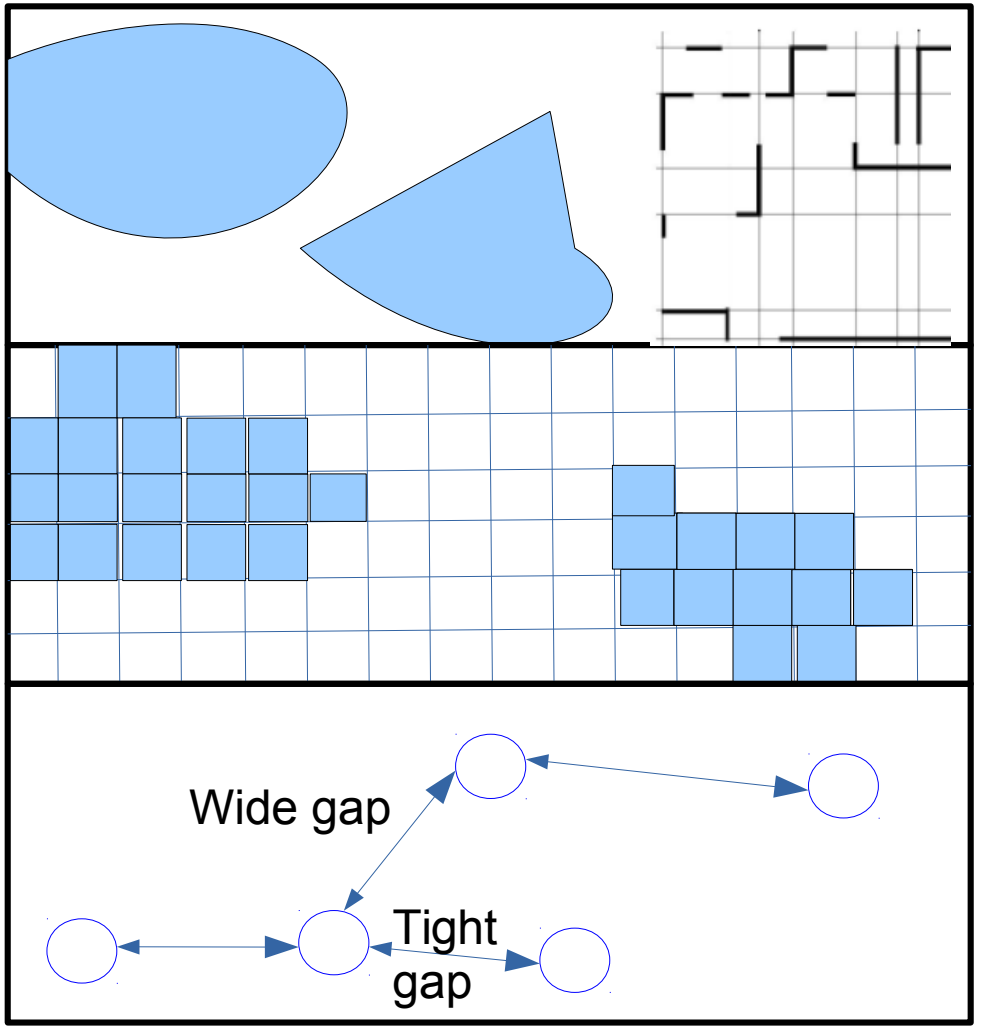
- Parametric curves/lines/surfaces.
- O(primitives)

Discrete metric.

- Grids/adaptive occupancy grids.
- O(size^2)

Topological.

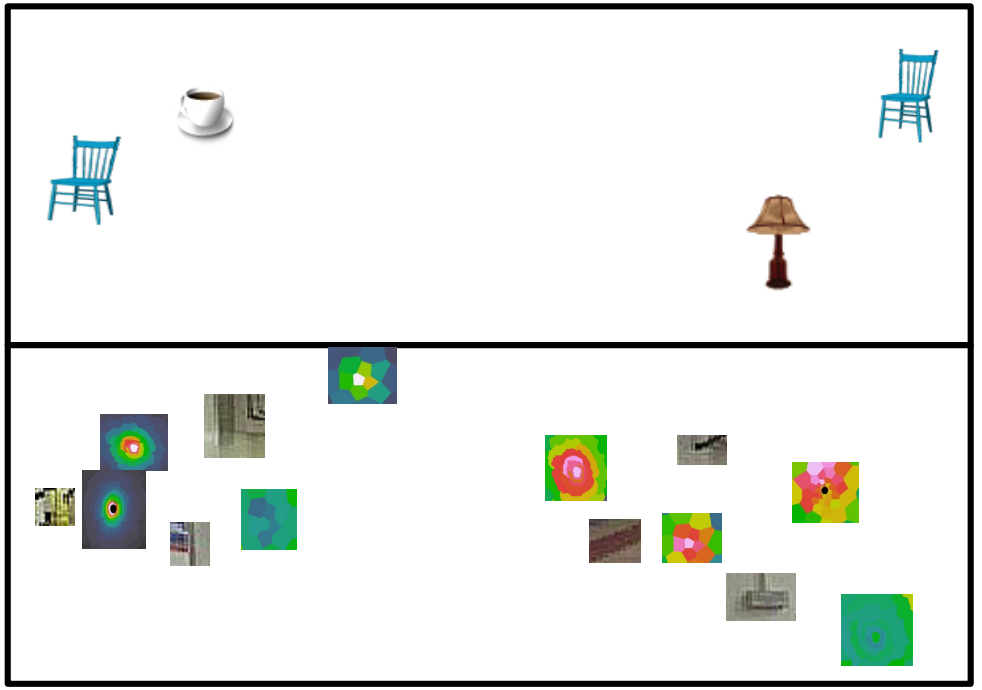
- Waypoints and edges.
- O(places+ways)



Map representation

Landmarks/feature maps.

- Known locations/visual elements.
- O(features)



Mixed maps.

- Topology + metric + etc.
- More tractable, more complicated.

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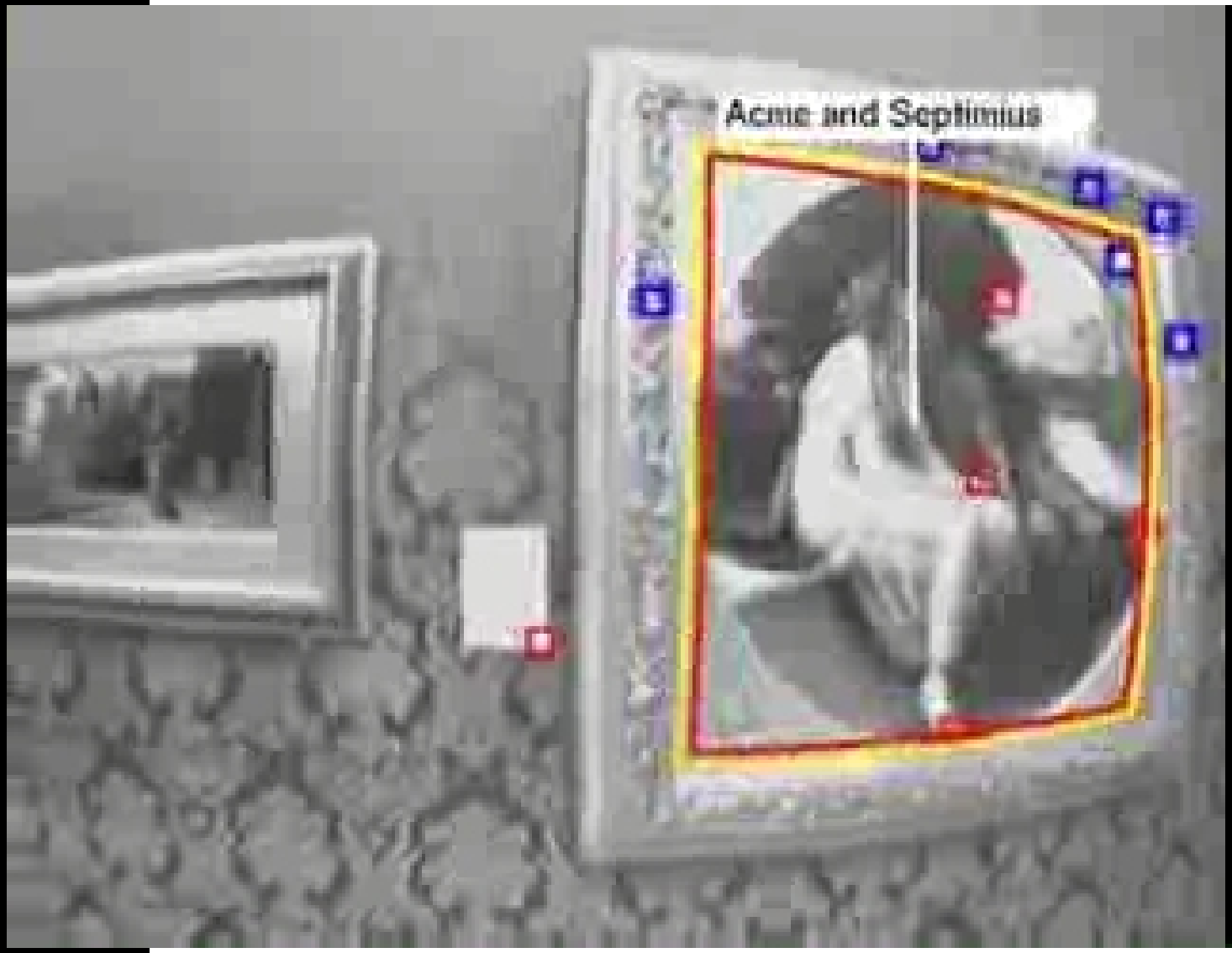
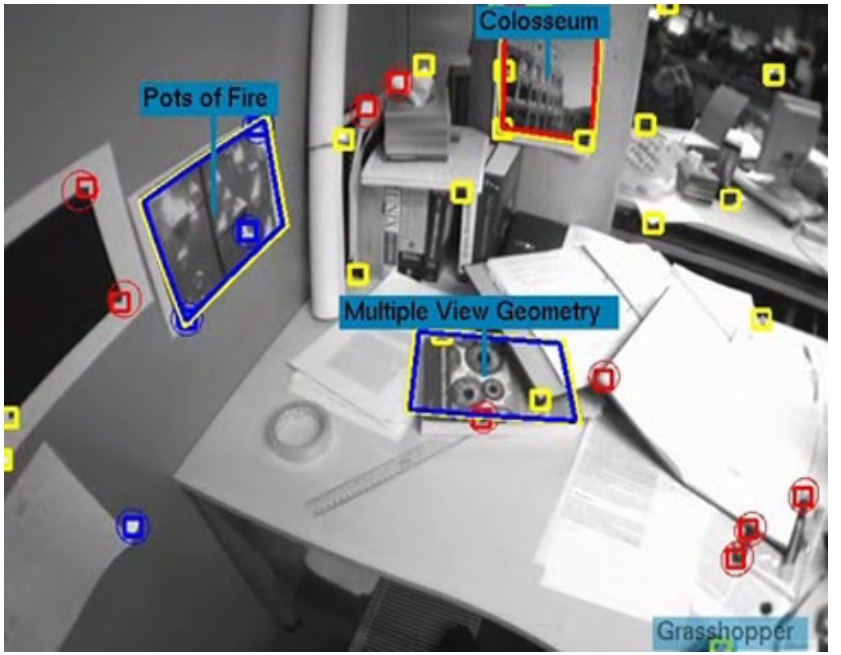
Features: image features

"Monoslam"



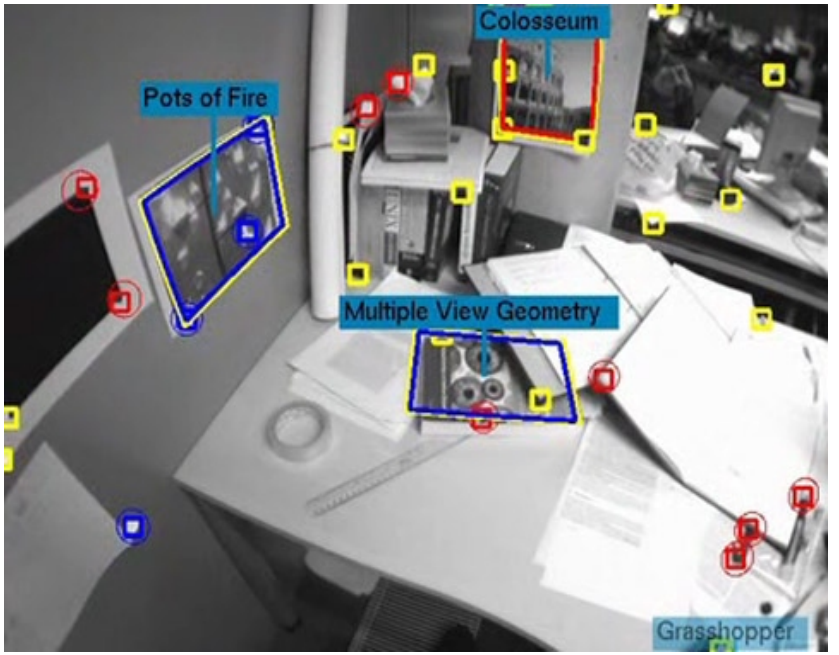
Qualities of good features

- Detectable.
  - Looks different from background.
    - E.g. `corner detection`.
- Repeatably detectable.
  - Same features detected reliably.
    - E.g. the same points tend to be detected as corners.



Qualities of good features

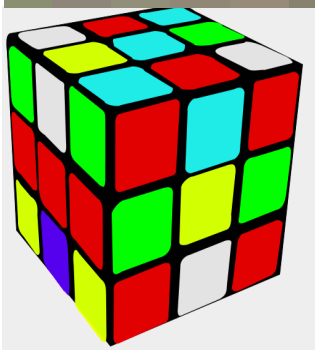
- Identifiable.
  - Can recognize it again.
    - E.g. Invariant to angle.
    - E.g. A human face, specific pattern of grays.
- Fusable.
  - Suitable for combining.
    - E.g. Audio source + visual have direction in common?

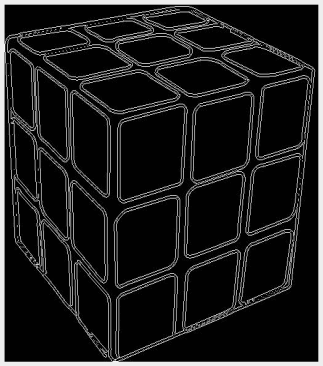


Levels of features

Raw data / templates.

- Low level features.





High level features.

Levels of features

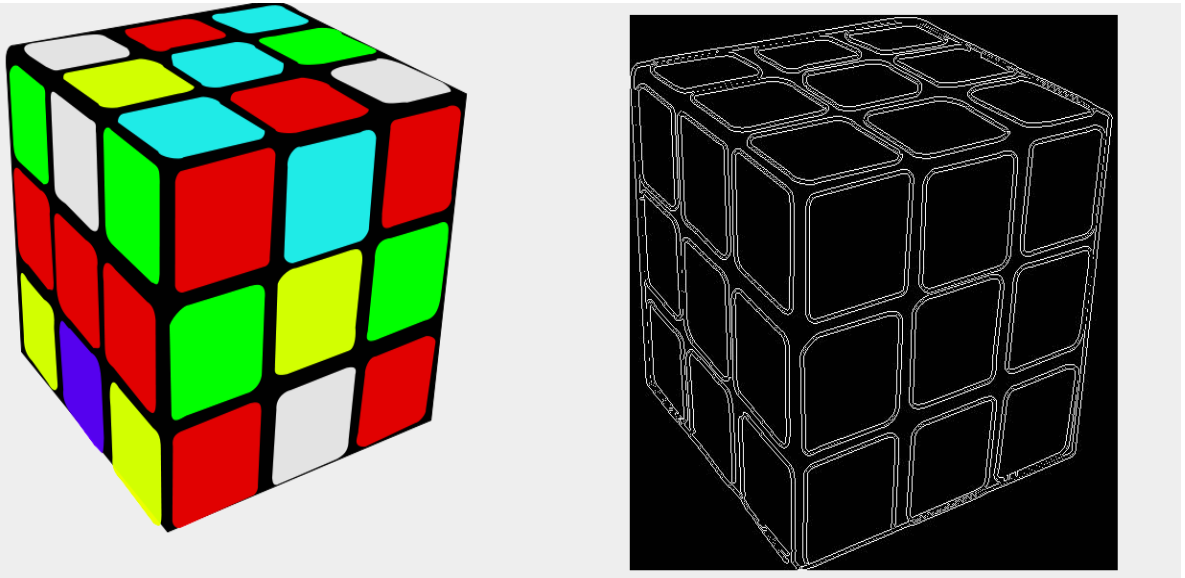
Raw data / templates.

- e.g. laser data, image pixel regions.
- Makes use of all info.
- Lots of extra info → low distinctiveness.
- Usually not invariant (to e.g. angle).

Levels of features

Low level features.

- e.g. lines, edges, corners, NARF, SIFT, FPH.
- Aim is discriminability, tractable ambiguity.

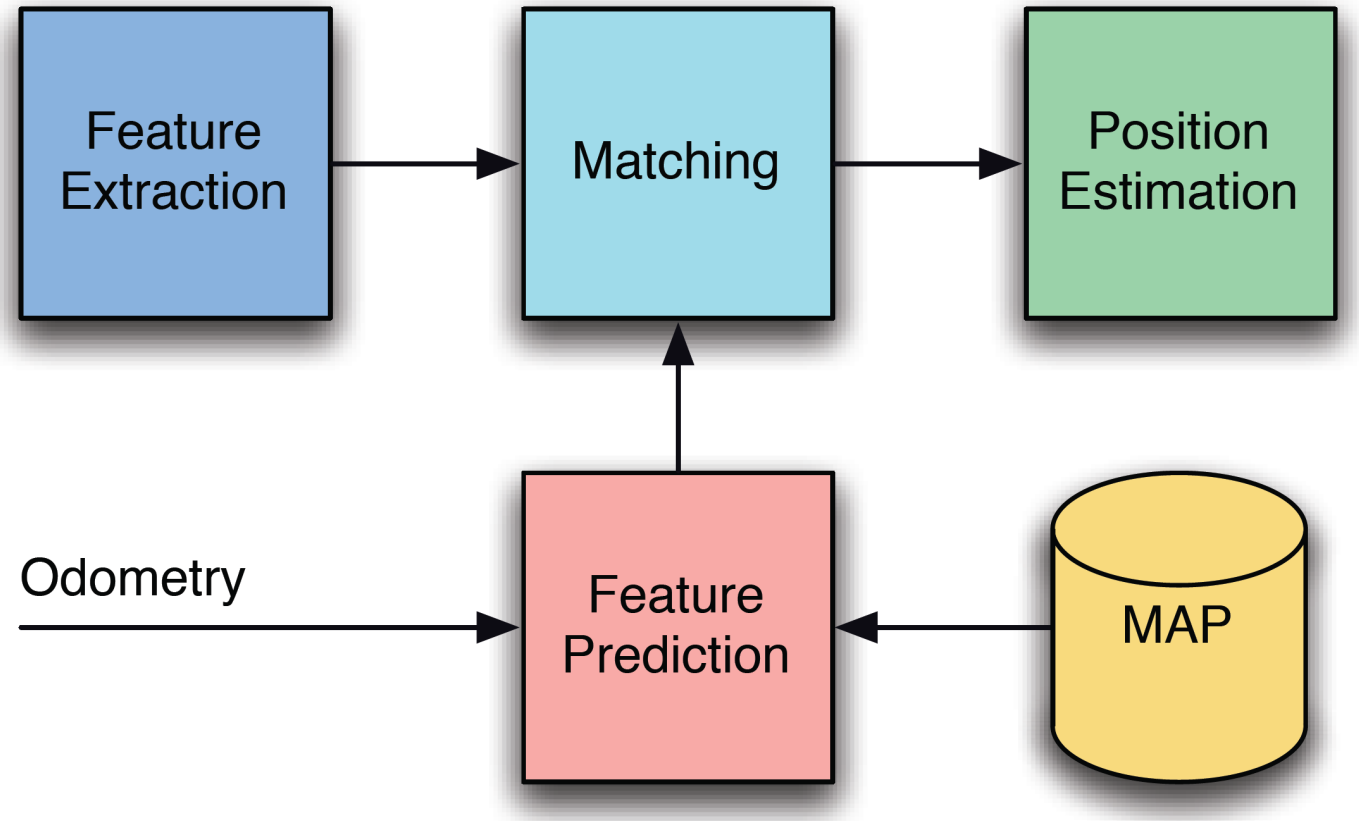


Levels of features

High level features.

- e.g. faces, objects.
- Semantic level or full object surfaces.
- Much information removed.
- Discriminability is low.

A landmark-based localisation framework



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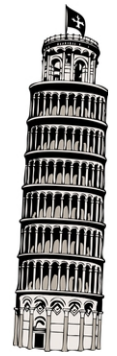
Triangulation from landmarks/features

- From multiple features:
  - Range → location.
  - Bearing → location.
  - Range + bearing → location.



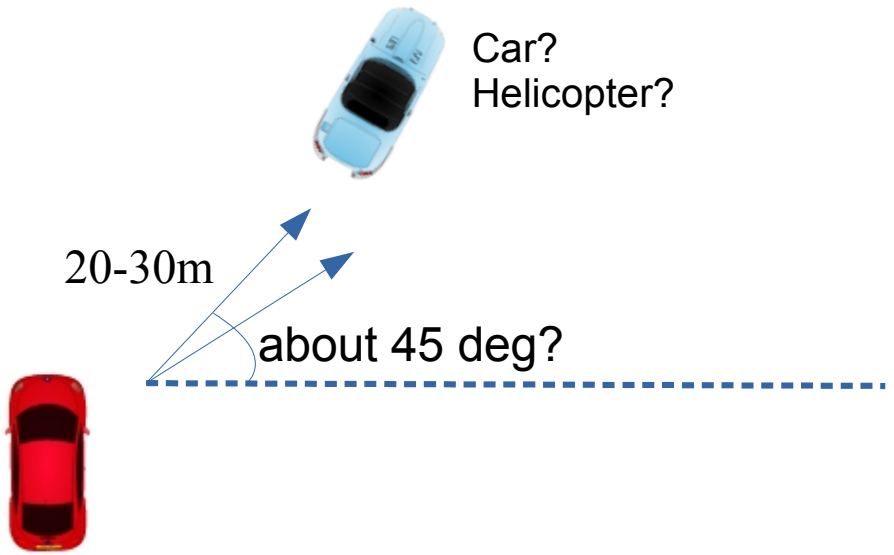
500m

1000m

45 degrees
(North by North East)

Note on partial observability

- World is partially observable.
- Features are partially observable:
  - Range.
  - Bearing.
  - Semantics.
  - …

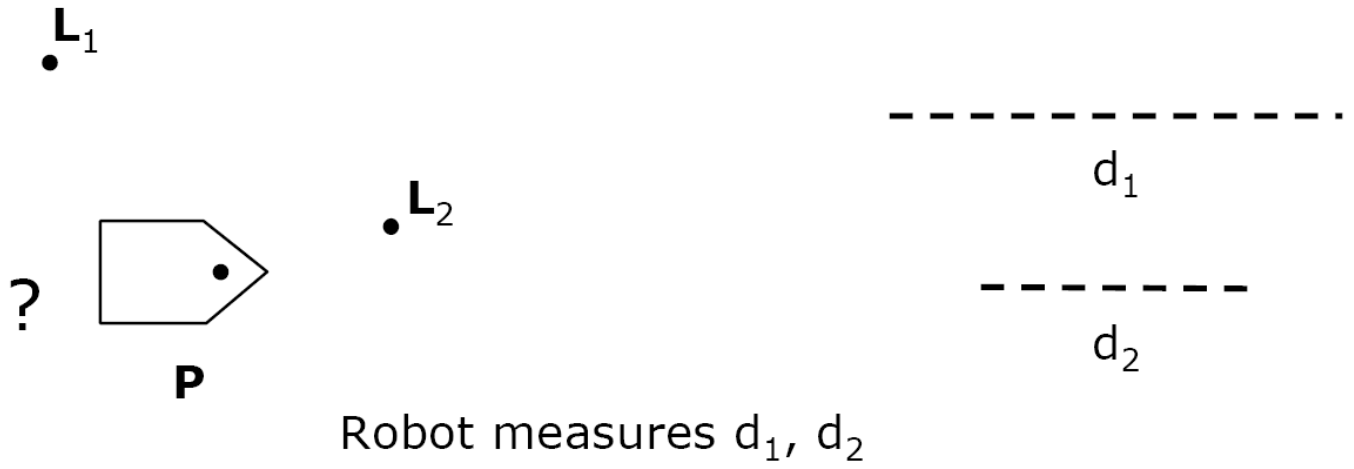


This lecture does not utilise probability for dealing with this – that is the topic of “estimation”.

Triangulation from ranges

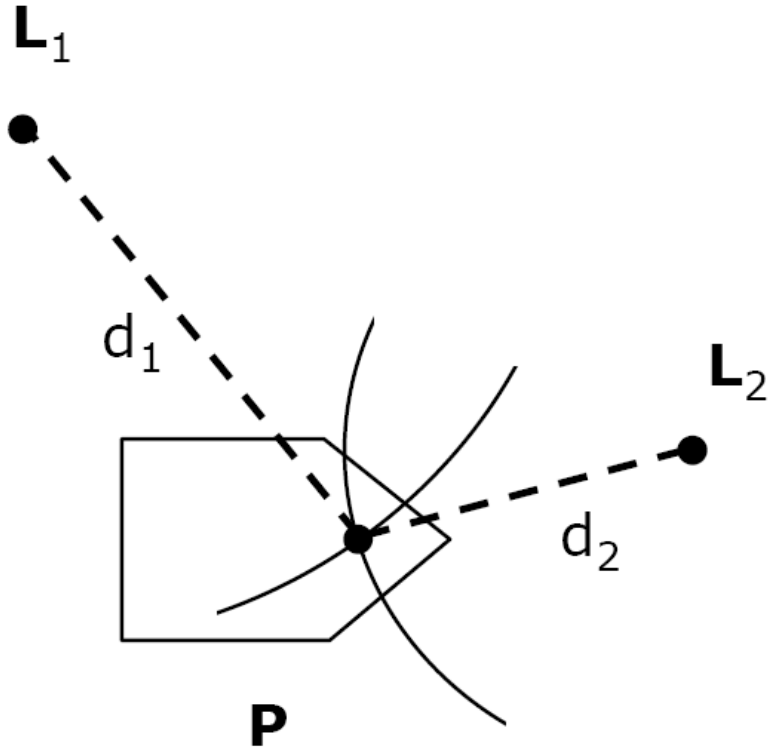
Robot at P.

Measures distances d_1 and d_2 to L_1 and L_2.



Triangulation from ranges

Robot must be on circles from L_1, L_2, radii d_1 and d_2.

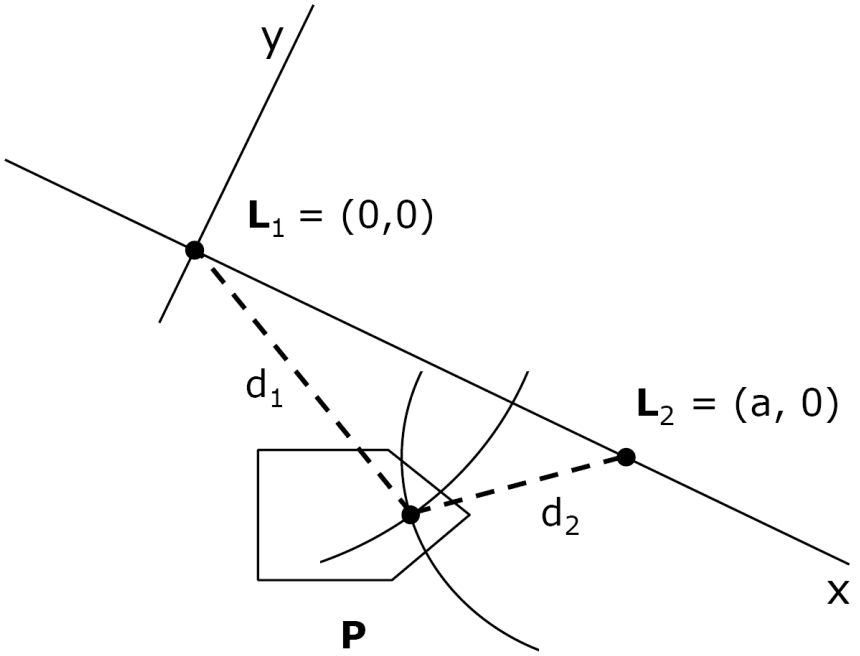


Triangulation from ranges

Make a coordinate frame from landmarks.

L_1 at origin.

L_2 at (a,0) (a is L_1-L_2 distance).



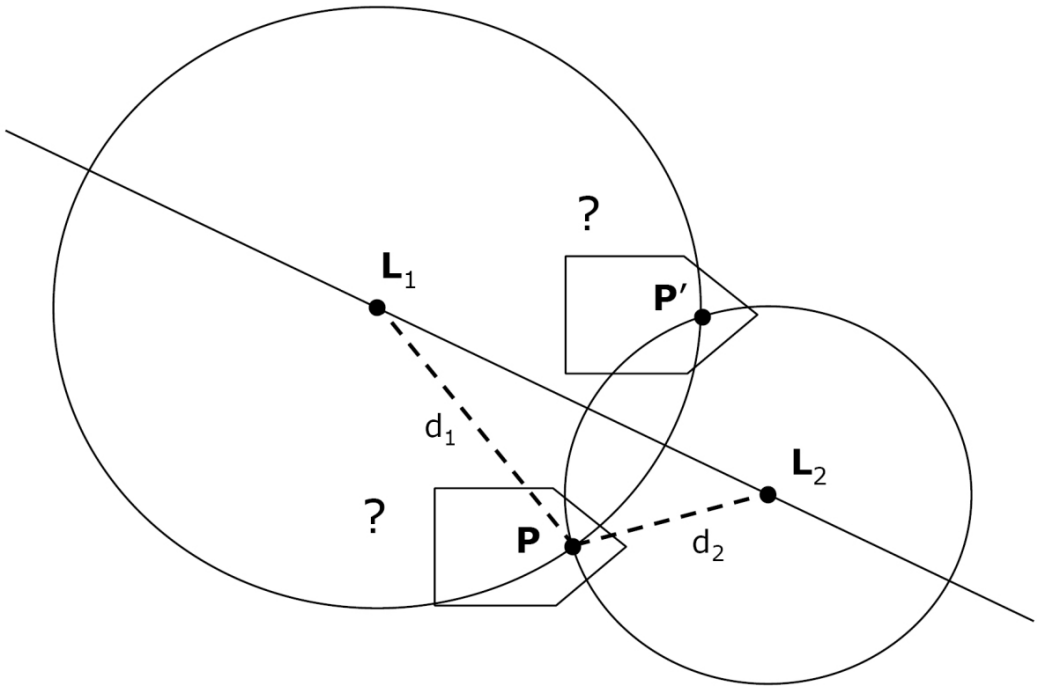
$$x = (a^2 + d_1^2 - d_2^2) / 2a$$

$$y = \pm\sqrt{(d_1^2 - x^2)}$$

(Try e.g. setting $d_1 = a$, $d_2 = 0$)

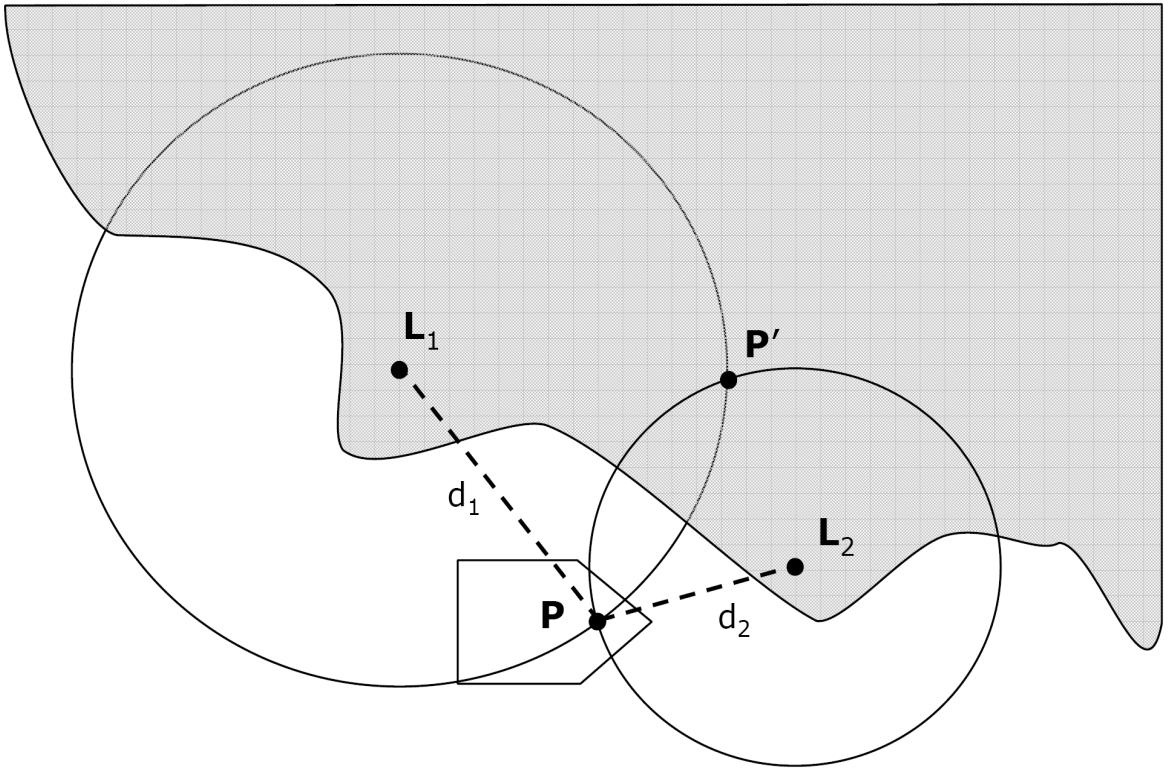
Disambiguating between solution candidates

Two possible solutions.



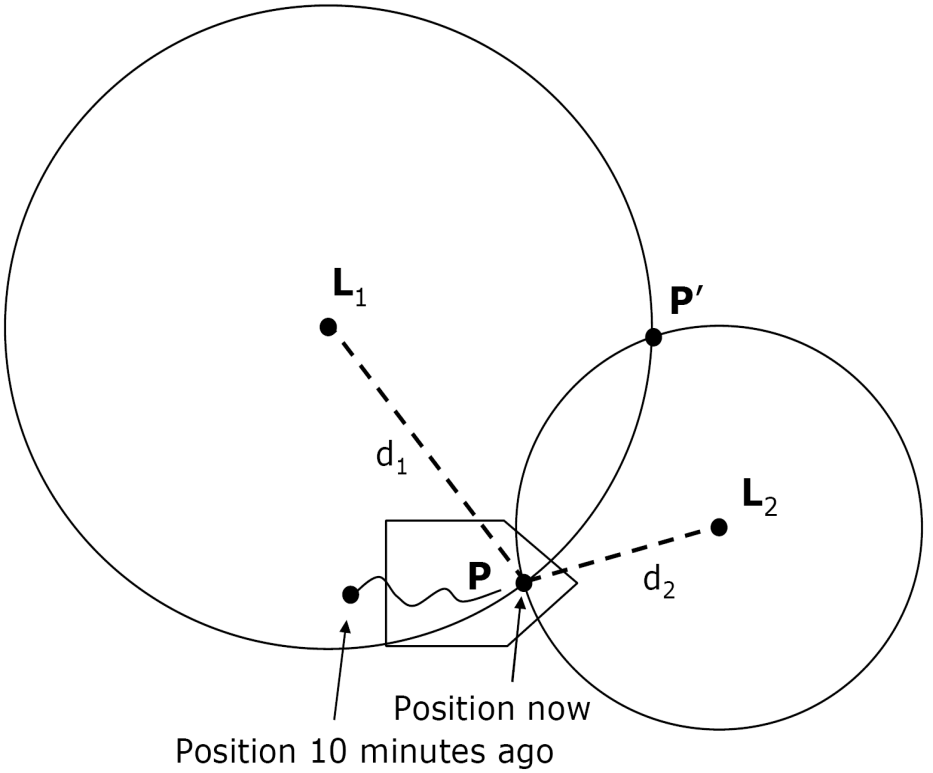
Disambiguating between solution candidates

A priori/known information.



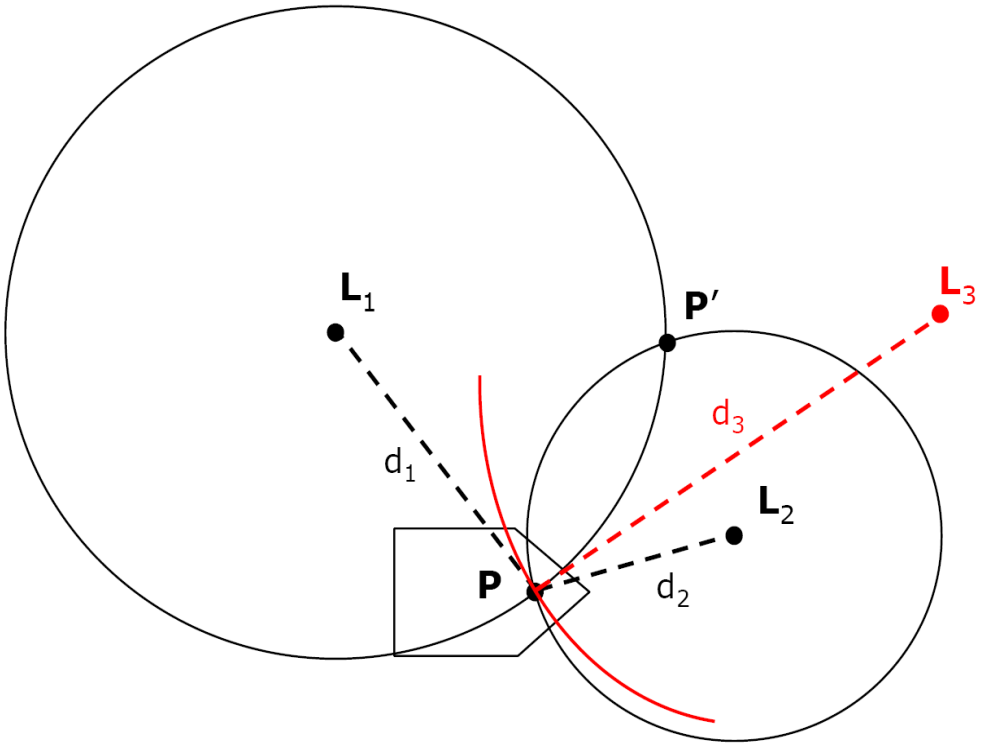
Disambiguating between solution candidates

Continuity (spatio-temporal info).



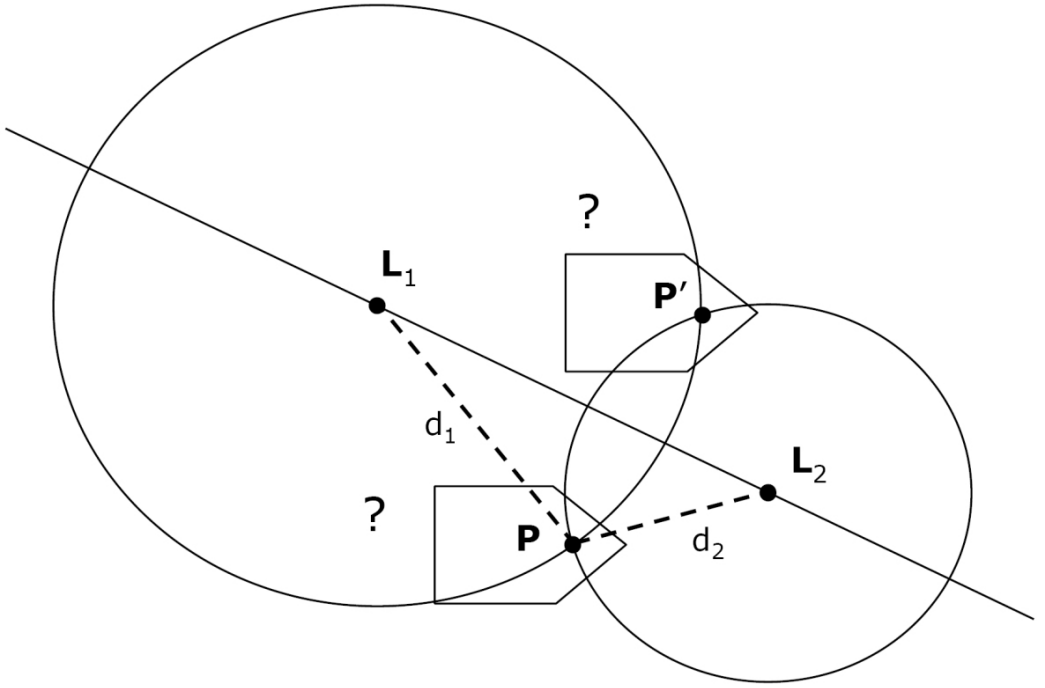
Disambiguating between solution candidates

Additional landmarks.



Disambiguating between solution candidates

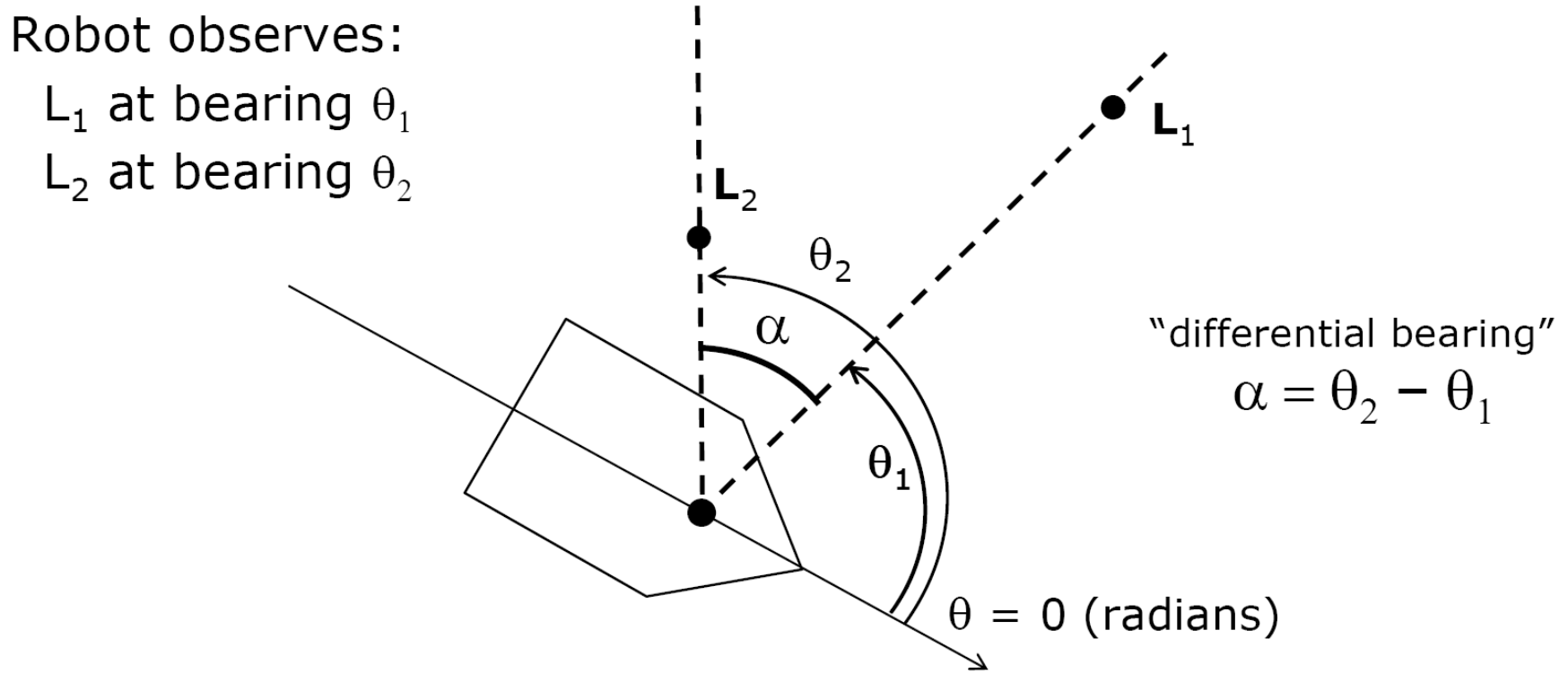
Can you think of any other information that might disambiguate P from P'?



Triangulation from bearings

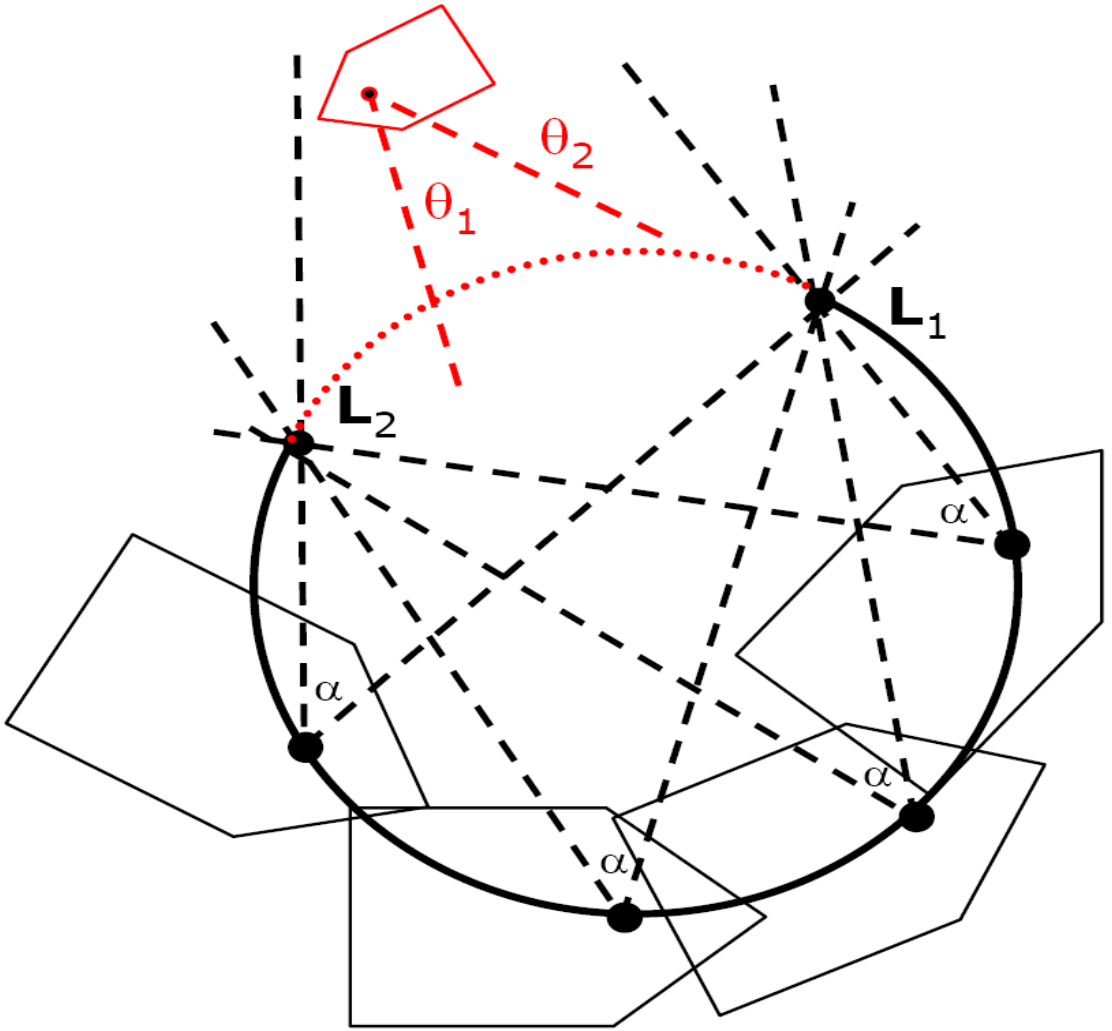
2 bearings: restrict pose to an arc.

3 bearings: restrict pose to a point.



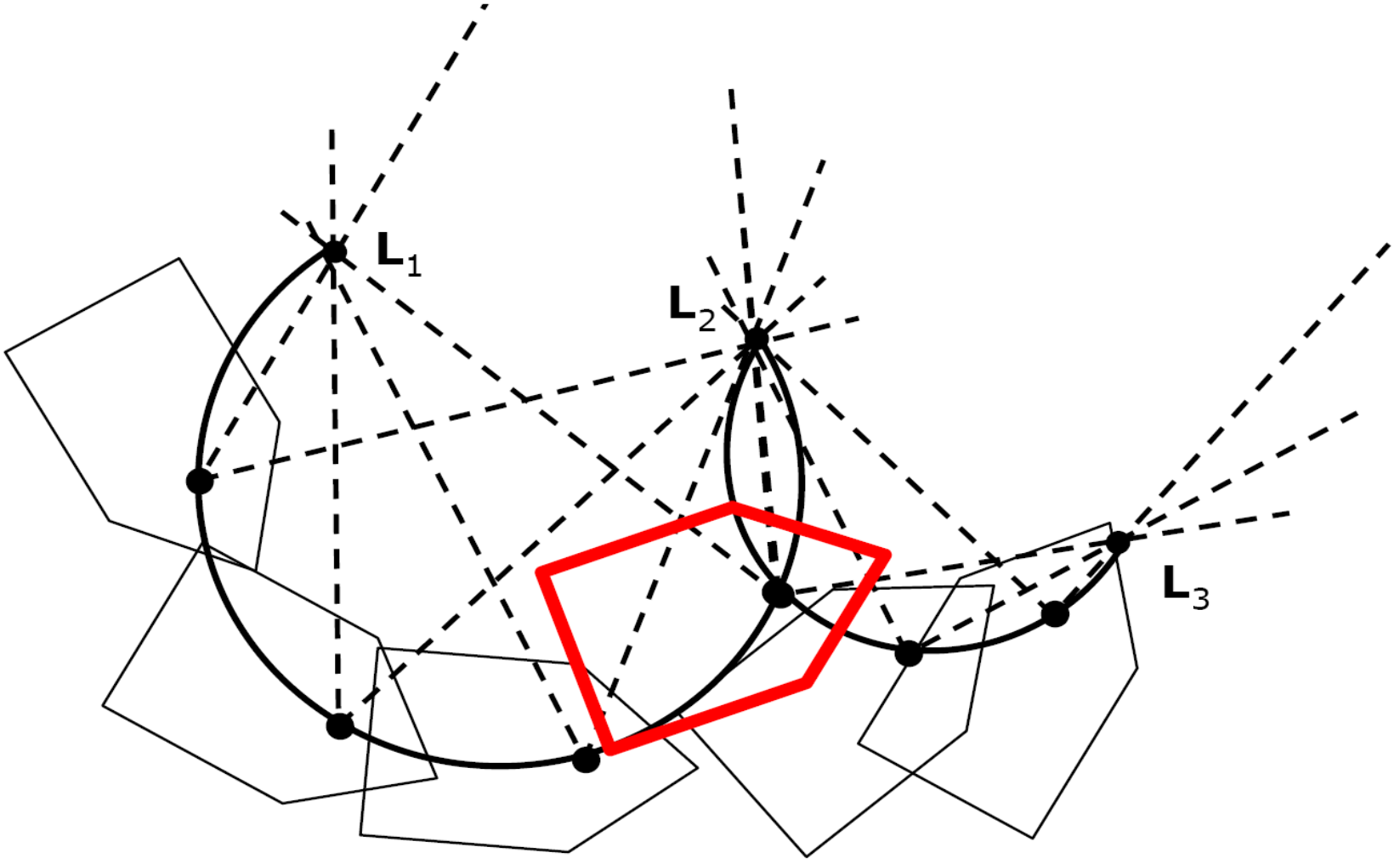
Triangulation from bearings

2 bearings disambiguate to an arc:



Triangulation from bearings

3 bearings disambiguate to a pose:



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Reading

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