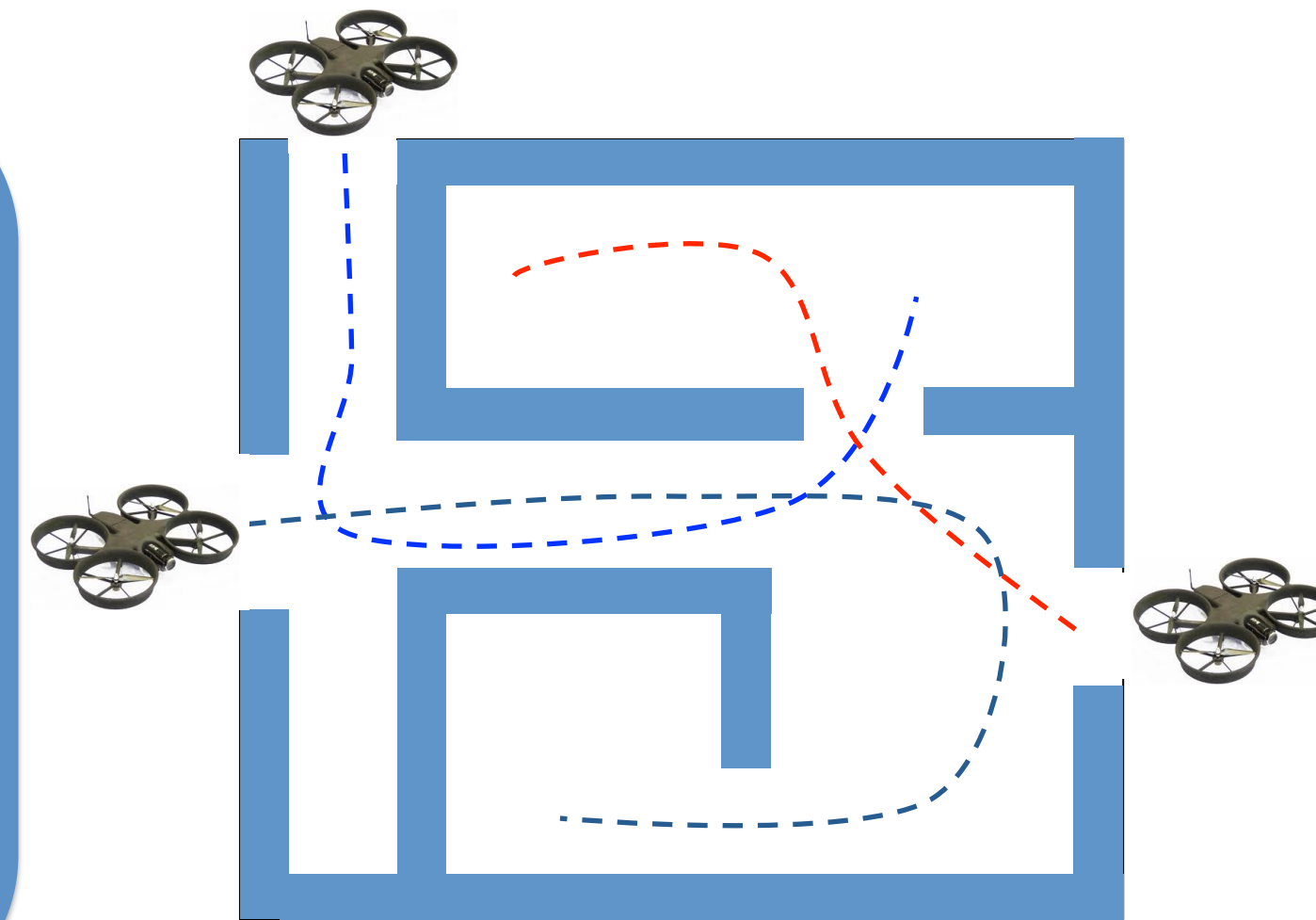# Incremental Distributed Robust Inference from Arbitrary Poses via EM and Model Selection

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Problem Statement

- Robots operate in the same environment (e.g. building),
- Initially unaware of each others' location
- How to establish collaboration and perform multi-robot localization?
  - Unknown multi-robot data association
  - Unknown initial relative poses between robots

Approach

- Robots share informative (laser) measurements
- Calculate multi-robot relative-pose constraints (e.g. ICP)
  - includes outliers
- Initial relative pose is unknown and set to **arbitrary** value
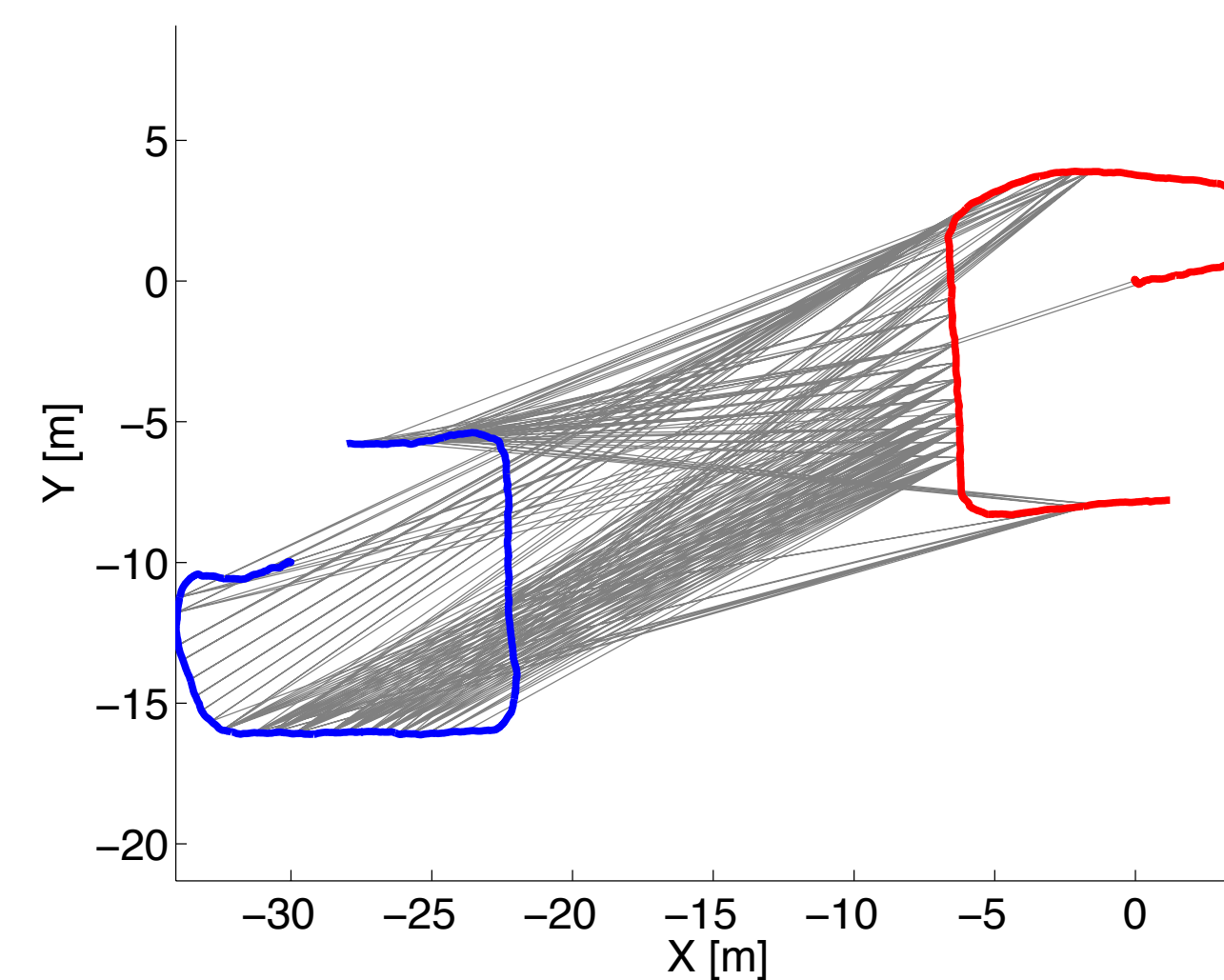- Joint pdf over robot poses and multi-robot data association:

$$p\left(X, \mathcal{J}|Z\right) \propto \prod_r p\left(X^r|Z^r\right) \prod_{(r_1, r_2, k, l) \in \mathcal{F}} p\left(j_{k,l}^{r_1, r_2}\right) p\left(u_{k,l}^{r_1, r_2}|x_k^{r_1}, x_l^{r_2}, j_{k,l}^{r_1, r_2}\right)$$

local measurements   **Multi-robot correspondence**   **Data association**   **Measurement likelihood**
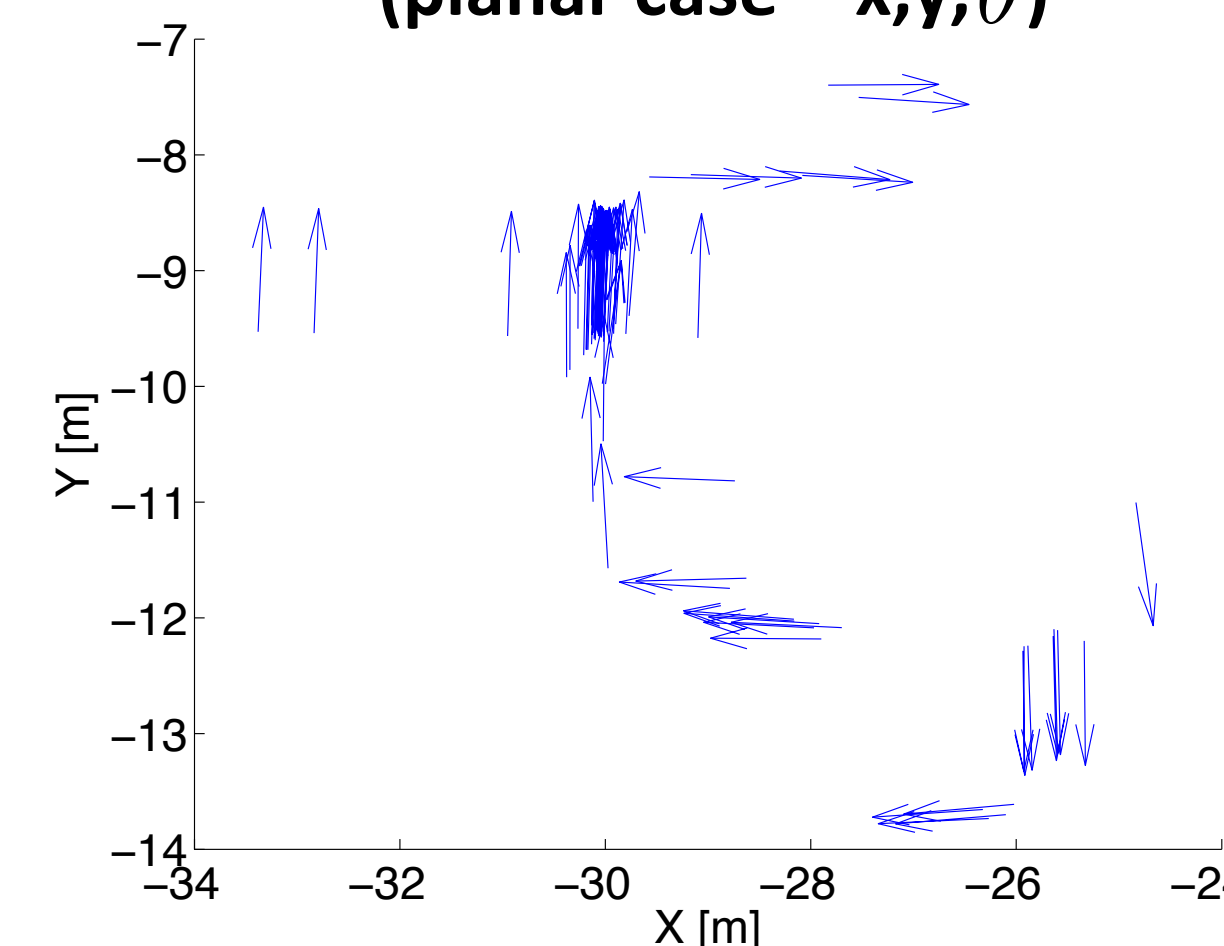
Key Observation

- **Must** first infer initial relative pose
- Given robot local trajectories, each multi-robot constraint determines initial relative pose transformation between robots
- Transformation is consistent **only for inlier correspondences**
- Therefore: **identify cluster via EM**
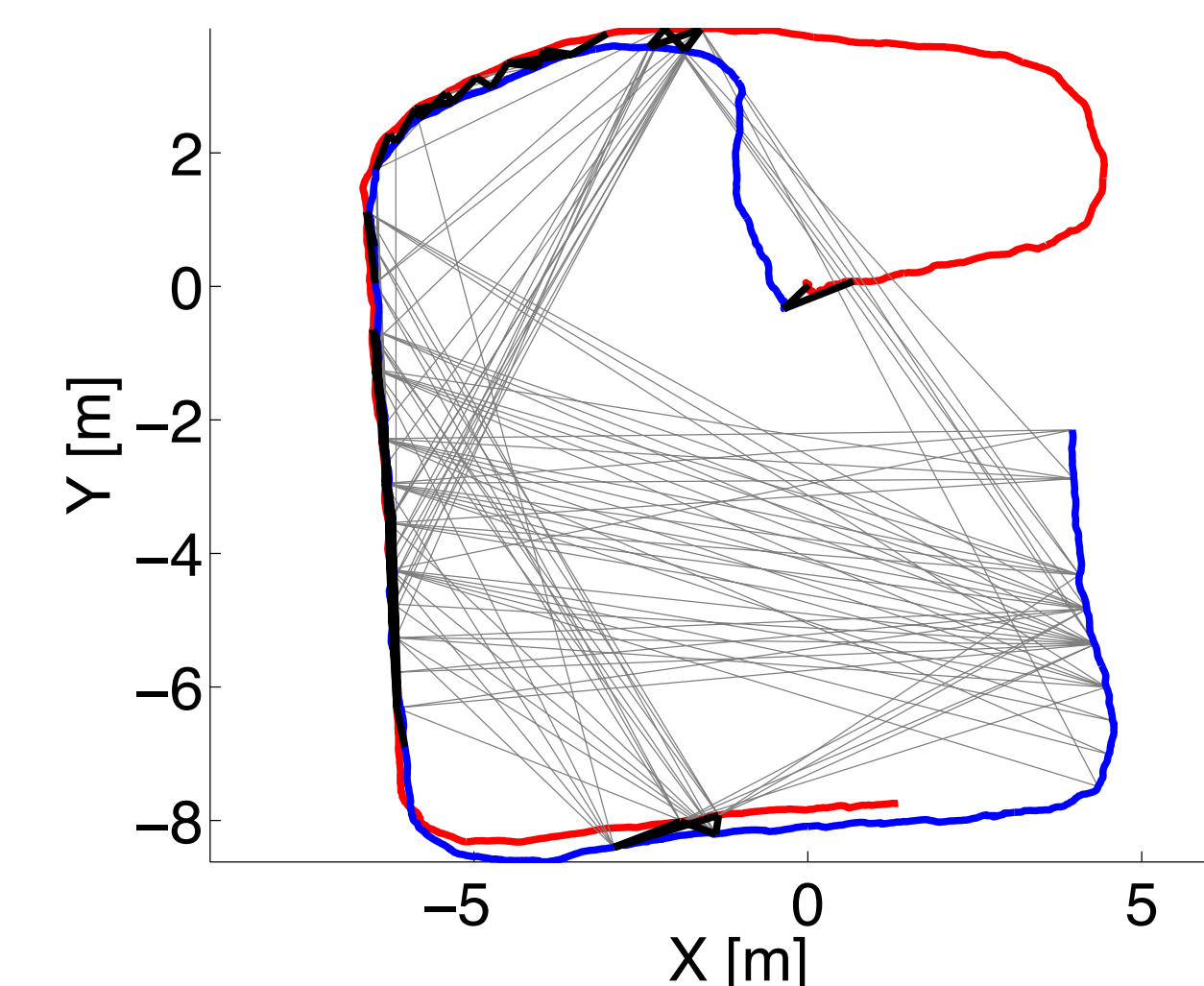
Multi-robot correspondences

Distribution of transformations (planar case – x,y,θ)

Challenges

- **Perceptual aliasing** → multiple clusters (**hypotheses**)
  - including consistent-outliers cluster(s)
- Which one to choose?
- How to know sufficient data exists for making decision?
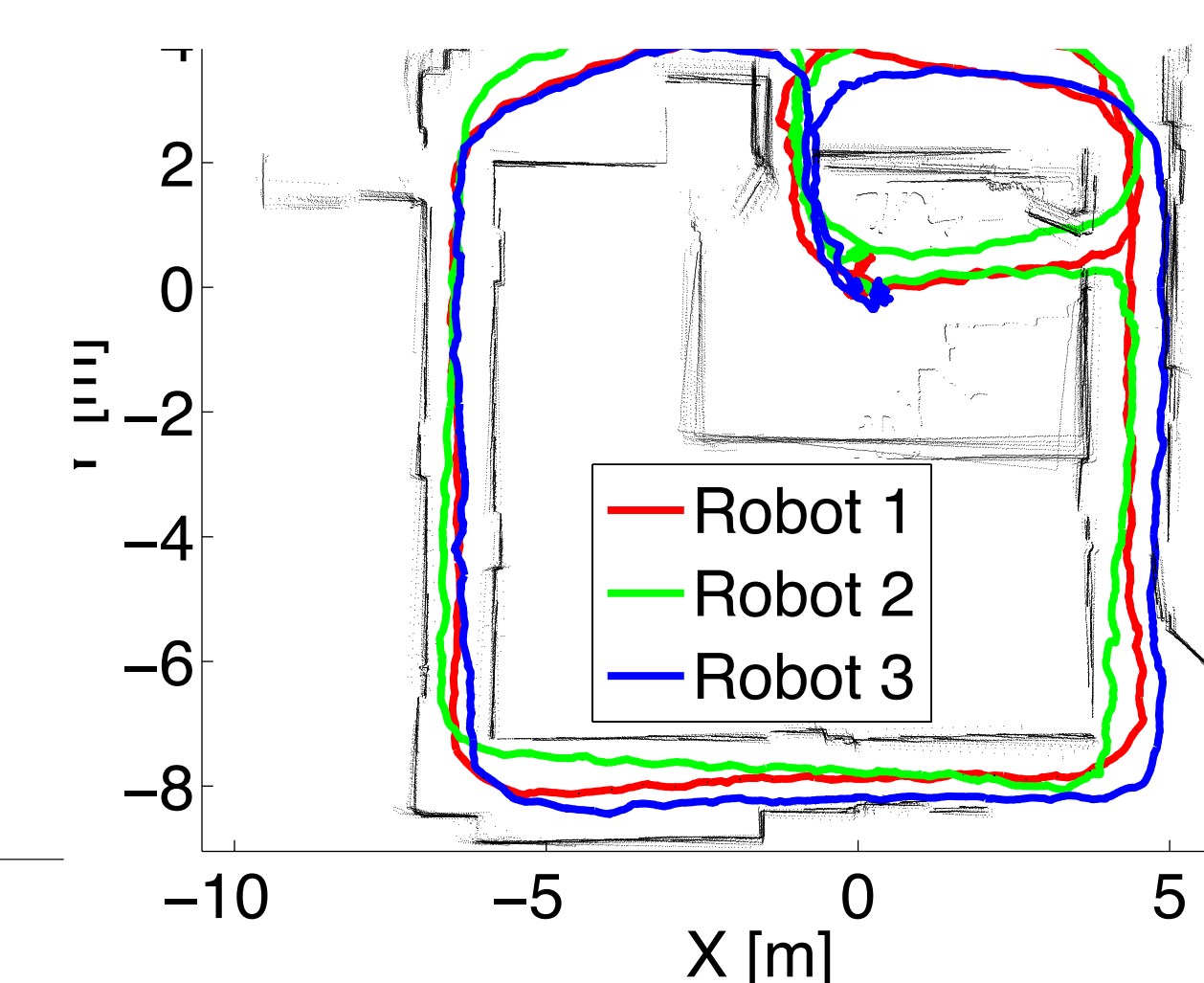
Approach - Incremental Framework

- Model selection – calculate probability of each hypothesis
- Use Chinese restaurant process for Hypothesis prior
- Discriminates between hypotheses as more data comes in

Result (incremental framework)   **Ground truth (full dataset)**

Robot 1
Robot 2
Robot 3

References

[1] "Multi-Robot Pose Graph Localization and Data Association from Unknown Initial Relative Poses via Expectation Maximization", ICRA 2014
[2] "An Experimental Study of Robust Distributed Multi-Robot Data Association from Arbitrary Poses", ISER 2014

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