A brief description of a hybrid approach for feature based-SLAM in large environments

Acción Integrada –'Visual-based interface for robots and intelligent environments'. First Meeting, Coimbra (Portugal) - 04/02/2008

Ingeniería de Sistemas Integrados
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Contents

- Introduction
- EKF based SLAM framework
- Scaling Problem
- Introduction to Hybrid Mapping

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Motivation

- Fundamental abilities for autonomous mobile robotics: localization and mapping
- Localization: accurate estimation using relative observations and a previous map
- Mapping: autonomous acquisition of a spatial model

Simultaneous Localization and Mapping

- EKF-based SLAM: statistical formalism approach

- Advantages: recursive solution, consistent estimates, a broad experience in navigation applications, a proof of existence and convergence for a solution

- Drawbacks: High computation and storage cost (CEKF, NCFM), accurate vehicle and observation models

Environment Representation: feature maps

- Different models to describe different features of the environment
- Suitable to describe uncertainty

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EKF based SLAM framework

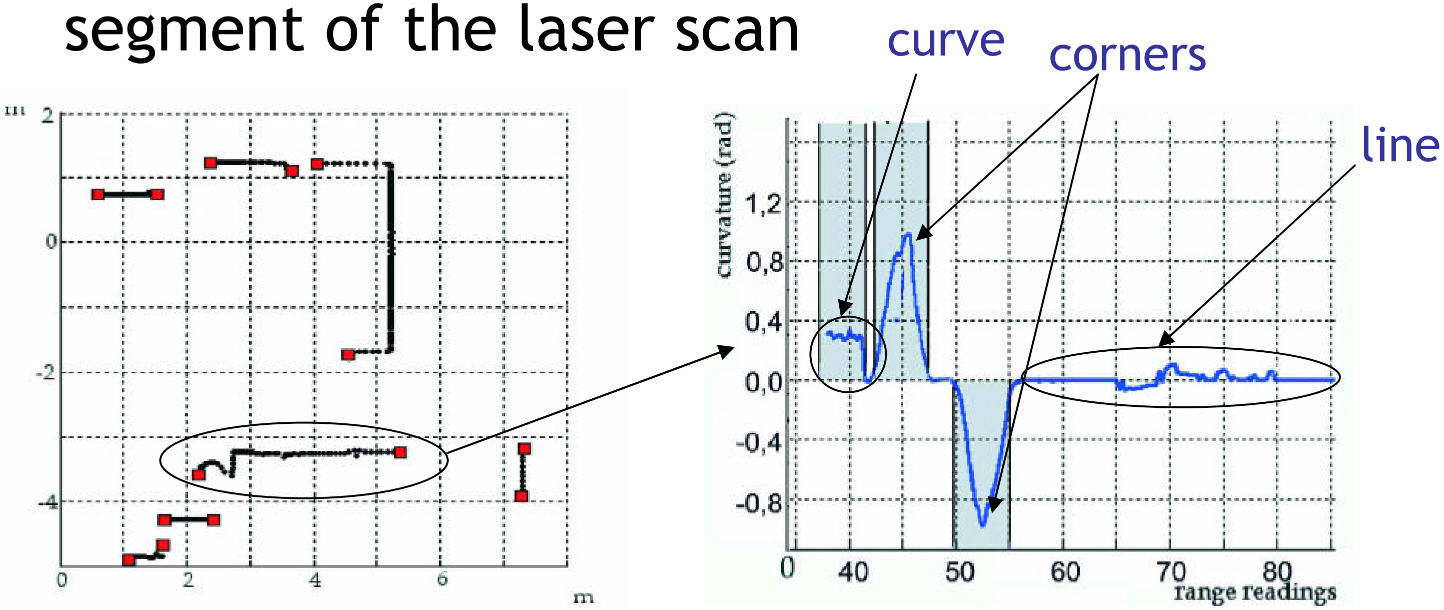
Basic SLAM loop:

- Prediction: robot motion
- Get observations
- Data Association: match observed and stored features
- Update: observation of known landmarks
- State Augmentation: include new landmarks (unknown observations)

EKF based SLAM framework

Observations: Laser range finder – 180º

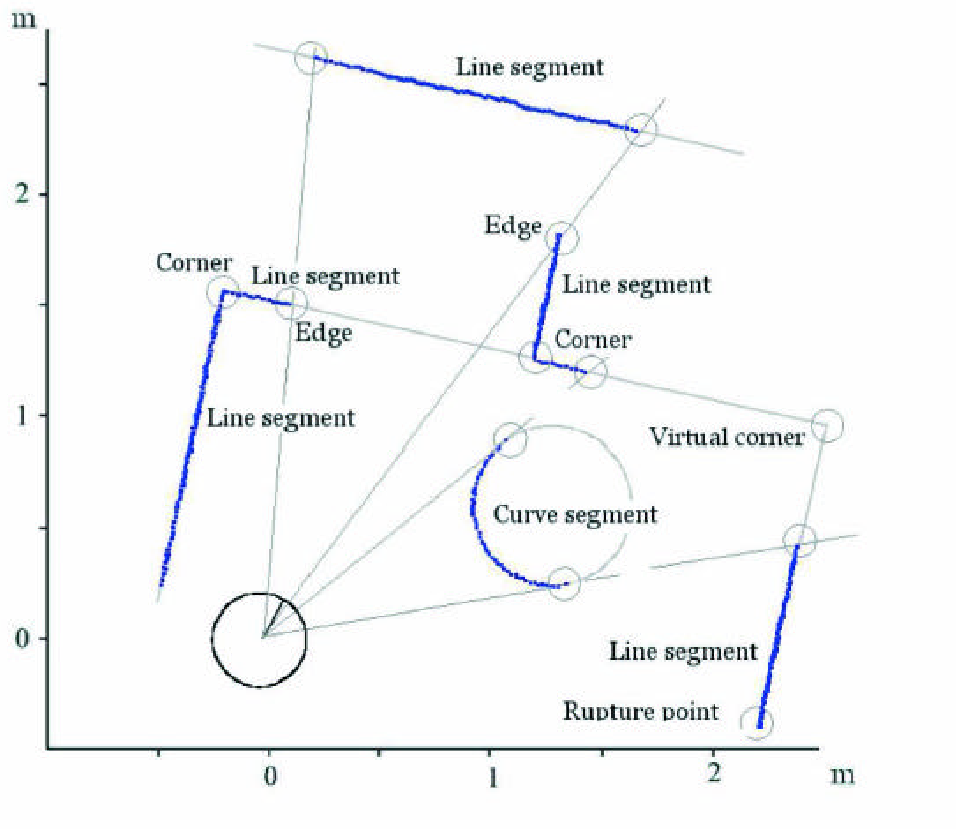
- Adaptive curvature function associated to each segment of the laser scan



- P. Núñez et al, "Natural landmark extraction for mobile robot navigation based on an adaptive curvature estimation", RAS 2008

EKF based SLAM framework

Observations: Laser range finder – 180º



EKF based SLAM framework

Observations: Vision Systems

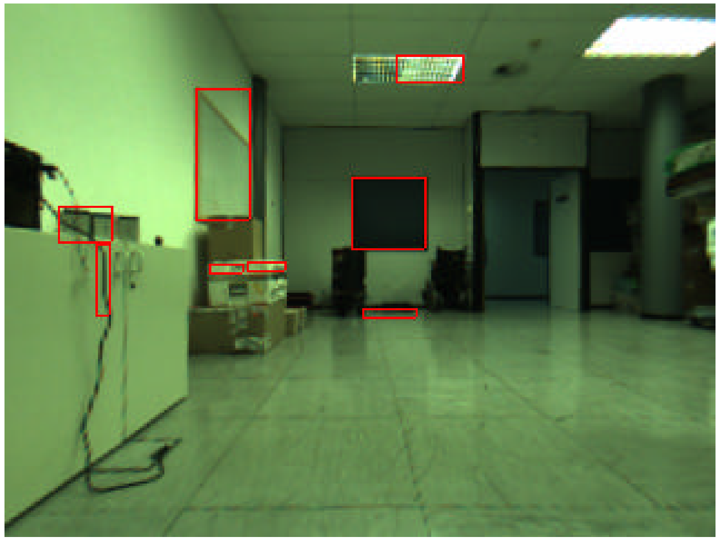
- Scale Invariant Feature Transform (SIFT)

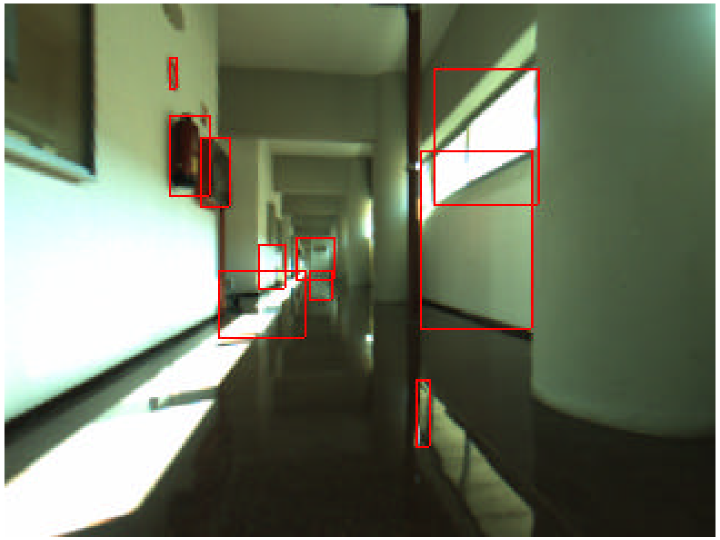
•D. Lowe, “Object Recognition from Scale-Invariant Features”, Proc. of the Int. Conf. in Computer Vision, 1999

EKF based SLAM framework

Observations: Vision Systems

- Perception-based grouping mechanism

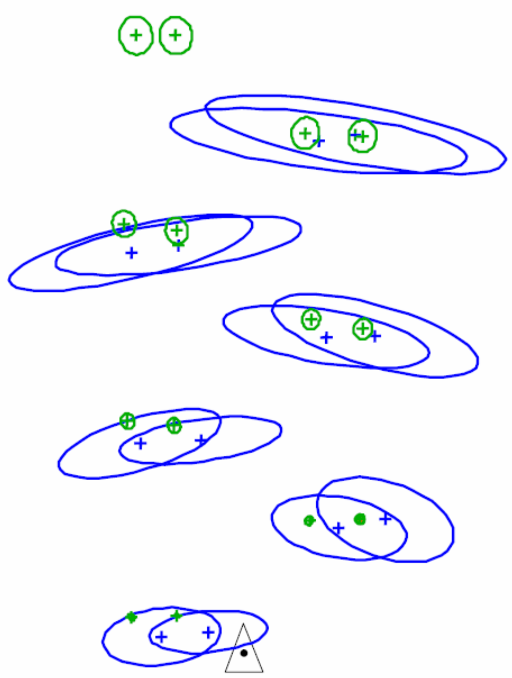




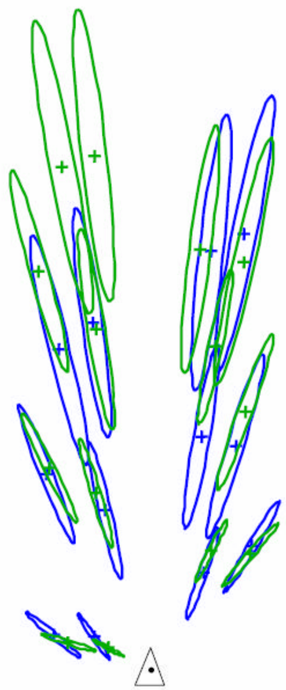
EKF based SLAM framework

Data Association: Combined Constraint DA

- High odometry error



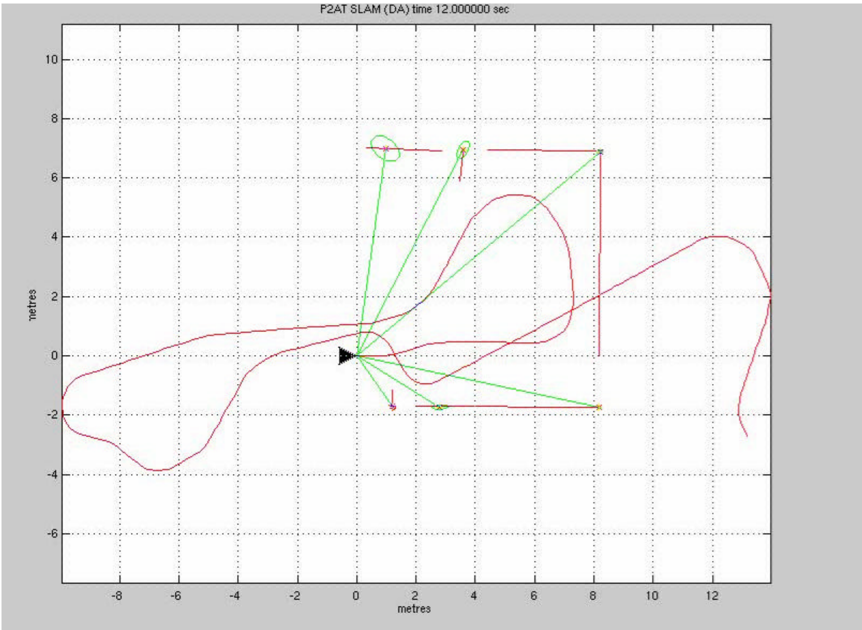
- High sensor error

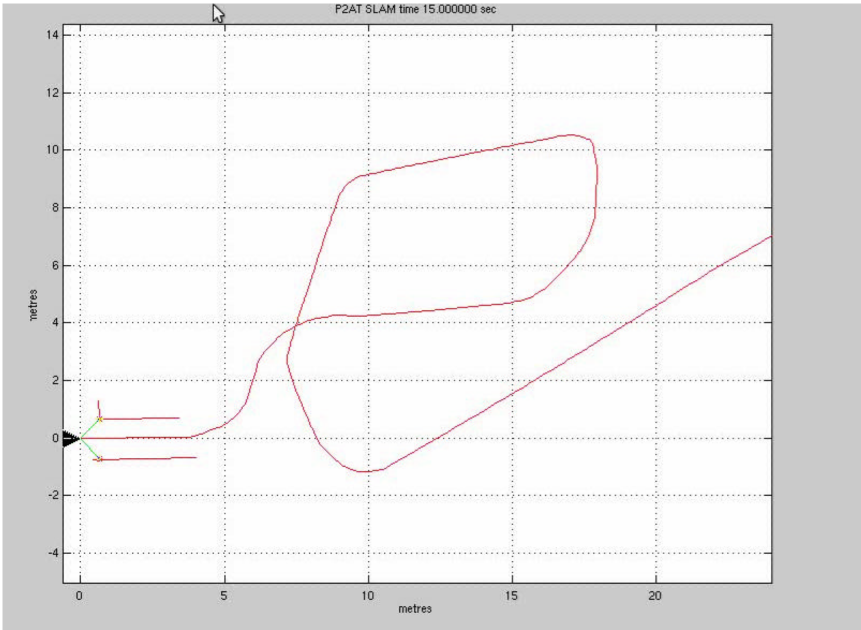


•T. Bailey, “Mobile robot localization and mapping in extensive outdoor environments”, PhD Thesis, University of Sidney

EKF based SLAM framework

EKF-SLAM in real indoor environments using laser



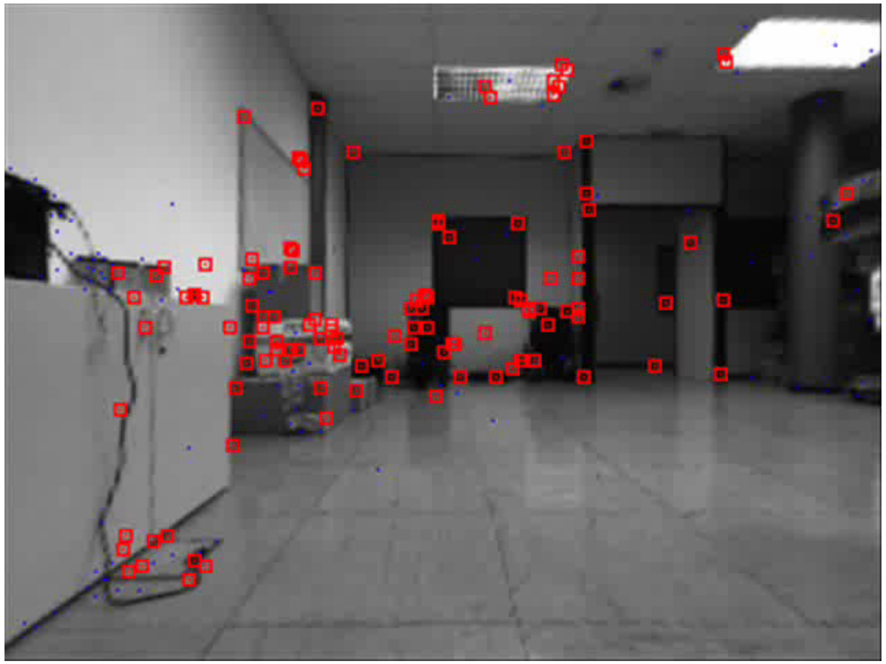


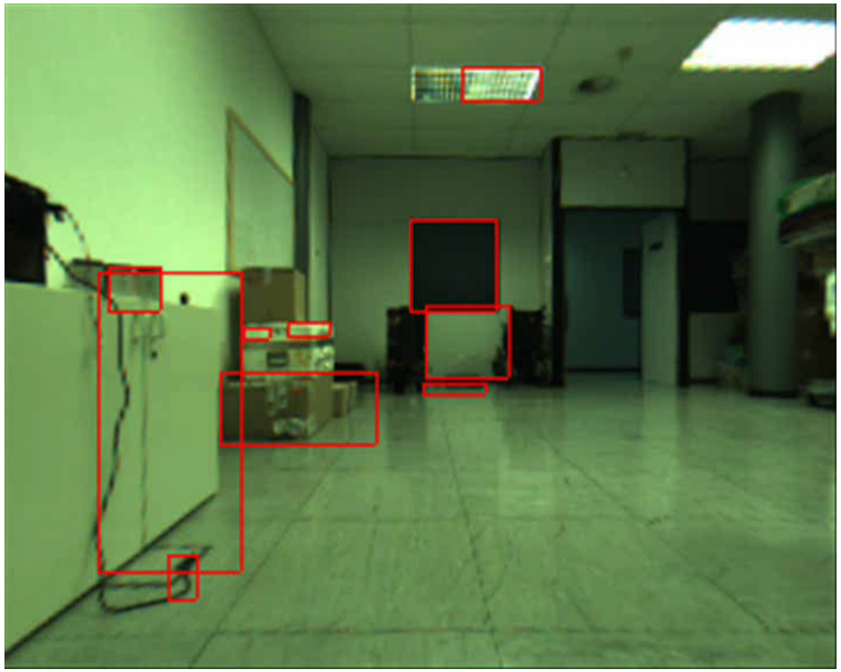
EKF based SLAM framework

EKF-SLAM in real indoor environments using laser

EKF based SLAM framework

EKF-SLAM using visual landmarks: forthcoming





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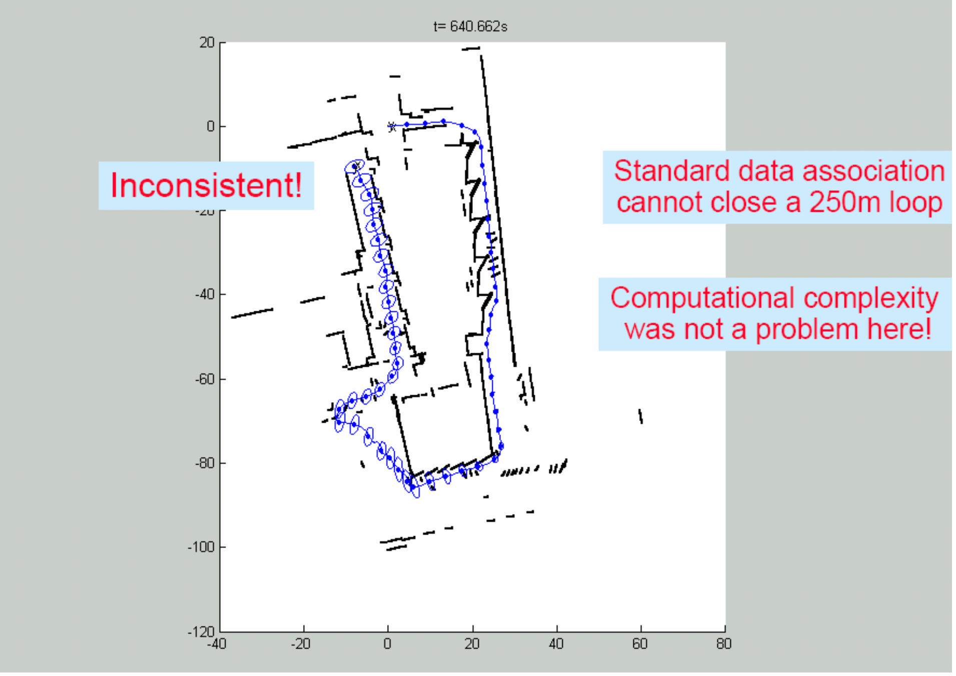
Scaling Problem in SLAM

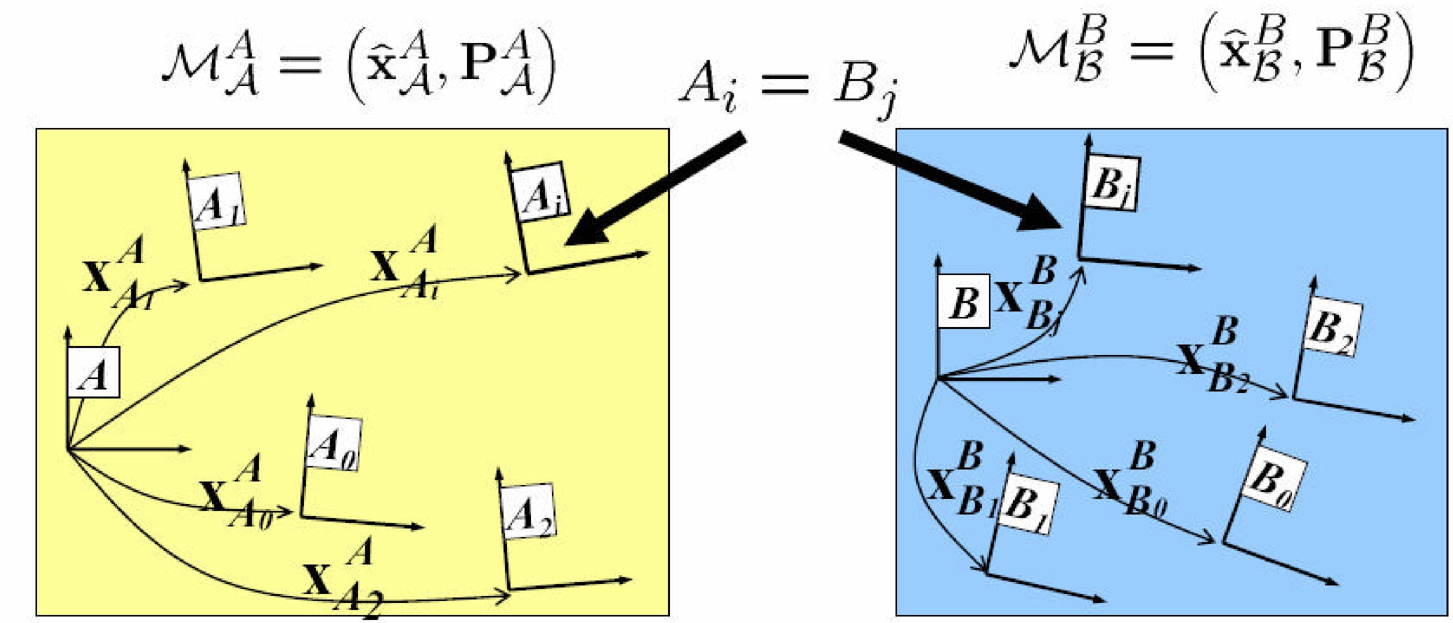
- High computational cost and storage
- Linearization errors: inconsistent uncertainty estimation



Scaling Problem

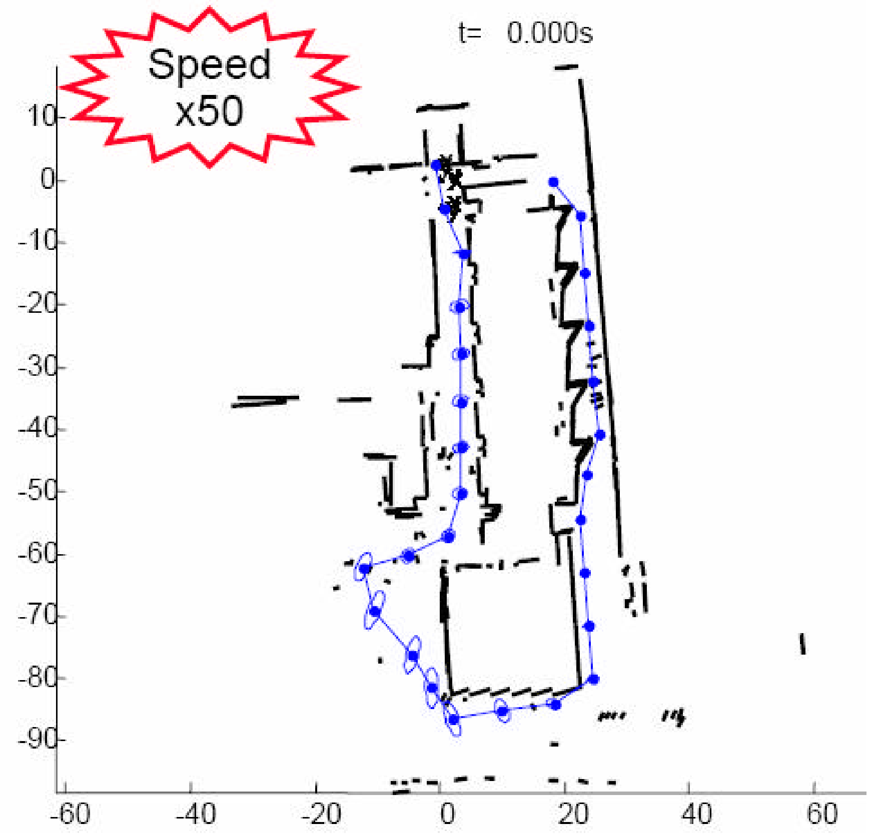
Local map sequencing

- Independent stochastic maps
- Local maps related by spatial relationships



Scaling Problem

Local maps bound linearization errors effects



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Introduction to Hybrid Mapping

Motivation

- Difficult global consistency for large maps

Advantages using topological maps

- Representation of the natural structure of the environment: topology
- Advantages imposing loop-closure in topological maps: computational complexity, multiple hypotheses

Introduction to Hybrid Mapping

Mapping in two levels

- Local or Metric Map: built as a stochastic independent map using EKF-SLAM
- Topological Map: natural structure of the environment composed by nodes and edges
- Relationships:
    - Local maps are nodes of the topological map
    - Edges represent spatial relationships between nodes

Local map partitioning

- Decision at metric level (internal state): vehicle or landmarks uncertainty, number of landmarks, size of local maps
- Dividing maps according to the environment structure: cut in graphs (Ncut, Voronoi graphs), covisibility, image retrieval.

Introduction to Hybrid Mapping

Mapping in two levels

Introduction to Hybrid Mapping

Relocation

- Detect when the robot revisit a known area

Applying loop closing constraints

- Bayesian Inference in topological maps (PTM)
- Hidden Markov Models (HMM)
- Partially Observable Markov Decision Process (POMDP)

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- **Thanks for your attention!!**
- **Any questions/advise?**

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