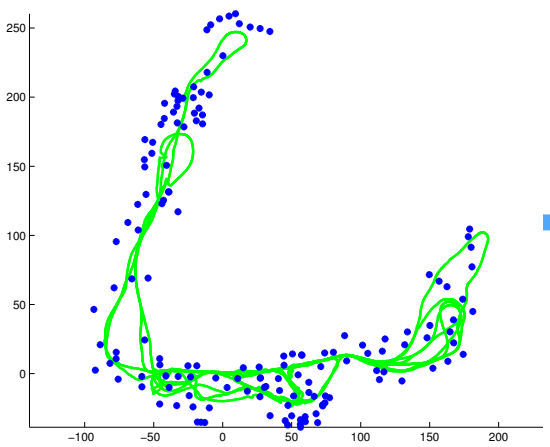
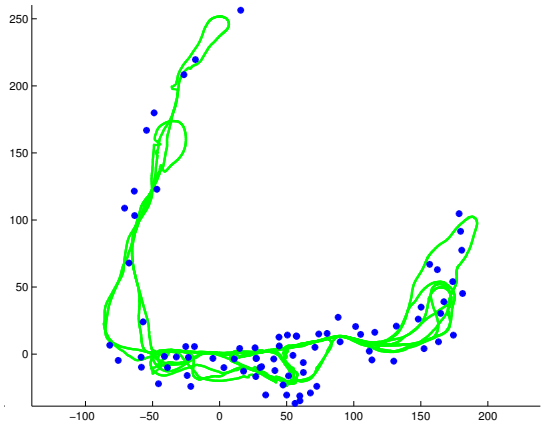


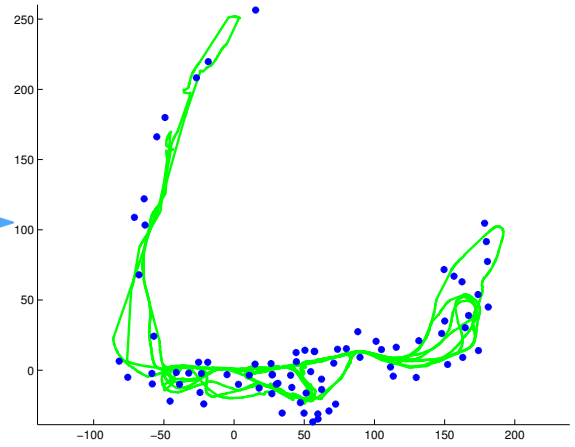
Full SLAM

151 Landmarks, 6968 Poses



After removing landmarks

74 Landmarks, 6968 Poses



After removing poses

74 Landmarks, 2971 Poses

Information based Reduced Landmark SLAM

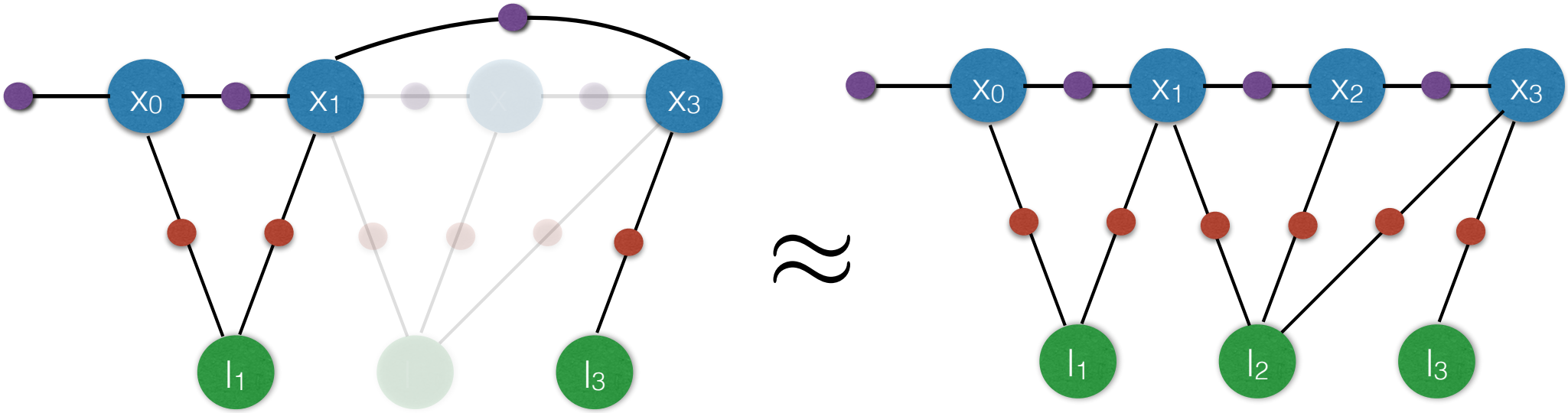
Siddharth Choudhary[1], Vadim Indelman[2], Henrik I. Christensen[1], Frank Dellaert[1]

[1] Institute for Robotics and Intelligent Machines, Georgia Tech
[2] Technion - Israel Institute of Technology

Seattle ICRA 2015

Georgia Tech Institute for Robotics and Intelligent Machines

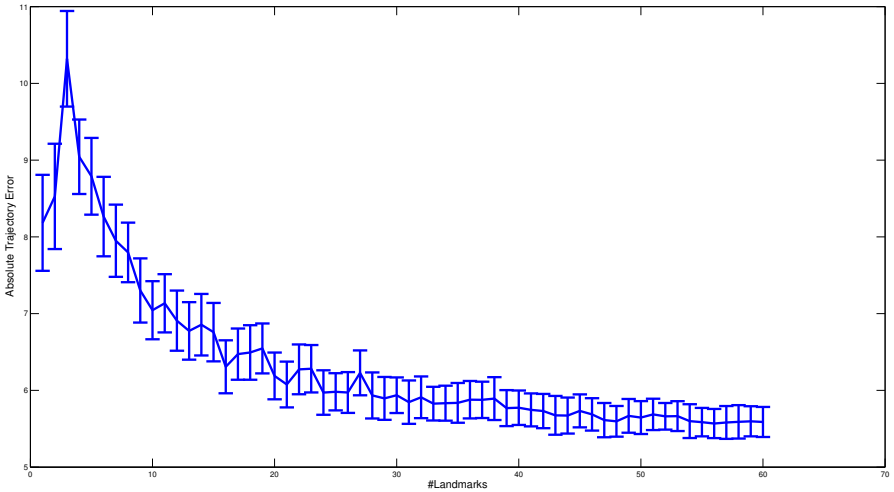
Problem Statement



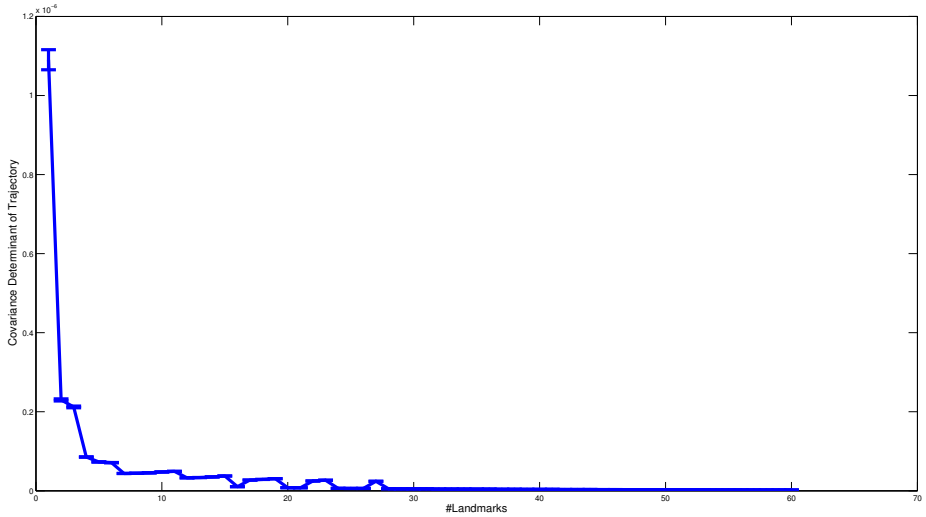
Incrementally finding a reduced subset of landmarks and poses such that the difference between the trajectory estimated using all landmarks and poses and using a subset of landmarks and poses is minimal as well

Motivation

Experiment with random sprinkling of landmarks given known ground truth trajectory



Trajectory Error



Marginal Covariance

Trajectory error and covariance stabilizes after adding a few landmarks

Related Work

Graph Reduction

- Dissanayake et al. Map management for efficient simultaneous localization and mapping (ICRA 2002)
- Strasdat et al. Which landmark is useful? learning selection policies for navigation in unknown environments. (ICRA 2009)
- Ila et al. Information based compact pose SLAM (TRO 2010)
- Eade et al. Monocular graph SLAM with complexity reduction (IROS 2010)
- Kretzschmar and Stachniss. Information theoretic compression of pose graphs for laser based SLAM (IJRR 2012)

Graph Sparsification

- Vial et al. Conservative sparsification for efficient and consistent approximation estimation (IROS 2011)
- Huang et al. Consistent sparsification for graph optimization (ECMR 2013)
- Wang et al. Kullback-leibler divergence based graph pruning in robotic feature mapping (ECMR 2013)
- Carlevaris-Bianco et al. Generic Node removal for Factor Graph SLAM (TRO 2014)
- Mazuran et al. Non linear graph sparsification for SLAM (RSS 2014)

Contributions

- Developed an **information theoretic algorithm** to efficiently **reduce the number** of landmarks and poses **without compromising the accuracy** of the estimated trajectory.

- Proposed an **incremental version** of the algorithm which can be used in a SLAM framework required for online operations.

Objective Function

Change in the uncertainty of the estimated trajectory

Memory consumption of landmarks and poses

$$\rho(L_s, X_s) = (1 - \lambda) d\left(\Theta_s^*\right) + \lambda m(L_s, X_s)$$

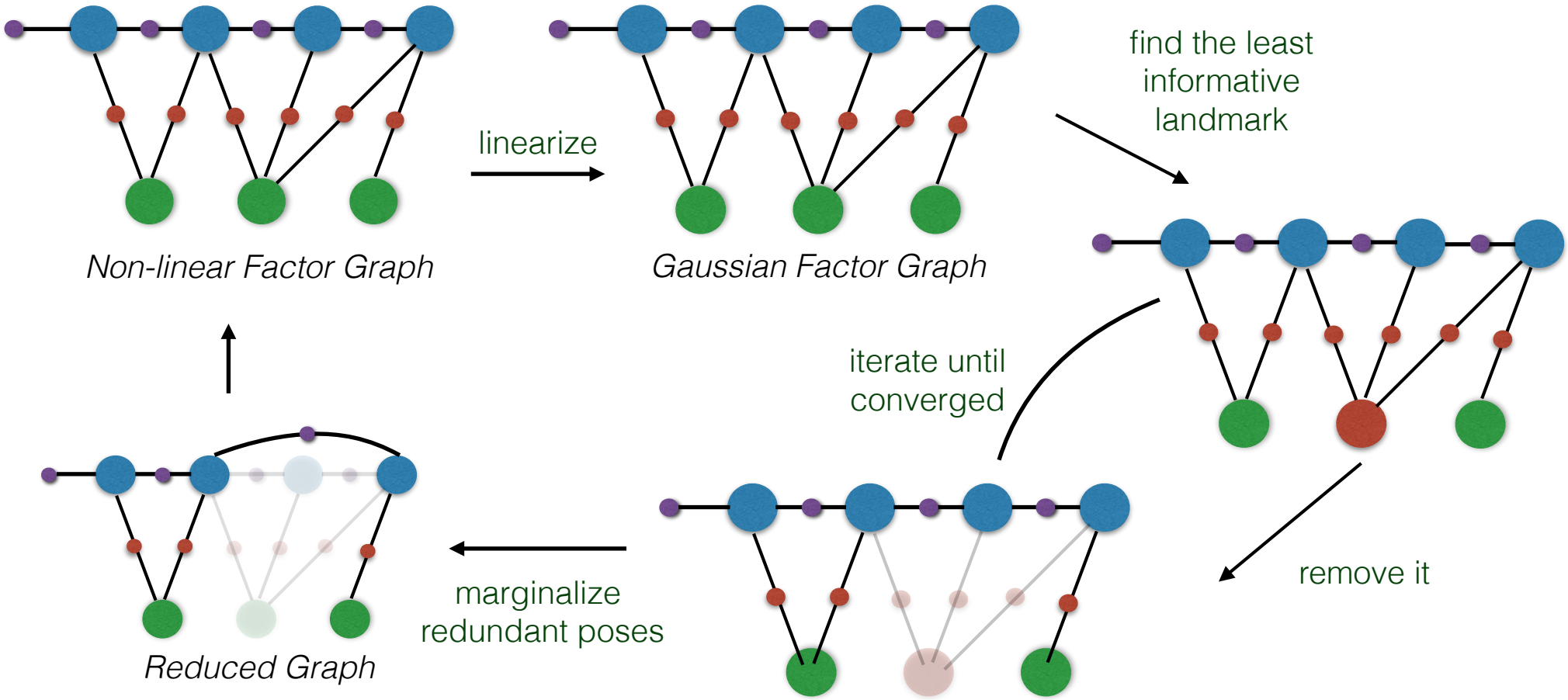
Regularization Parameter

Objective Function

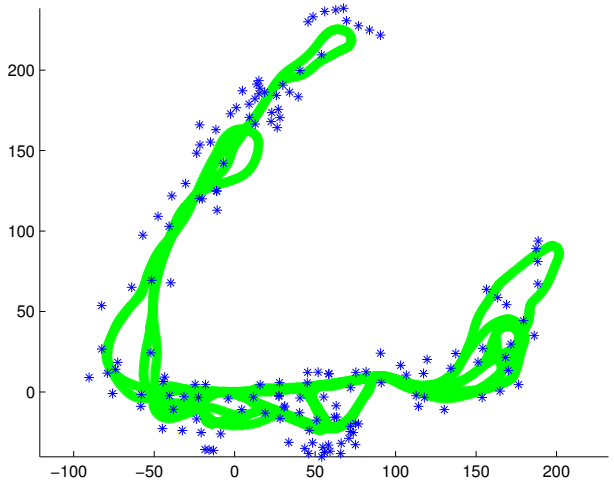
Find a subset of landmarks and poses that minimizes the objective function $\rho(L_s, X_s)$

$$\{L^*, X^*\} = \arg\min_{L_s, X_s} \rho(L_s, X_s)$$

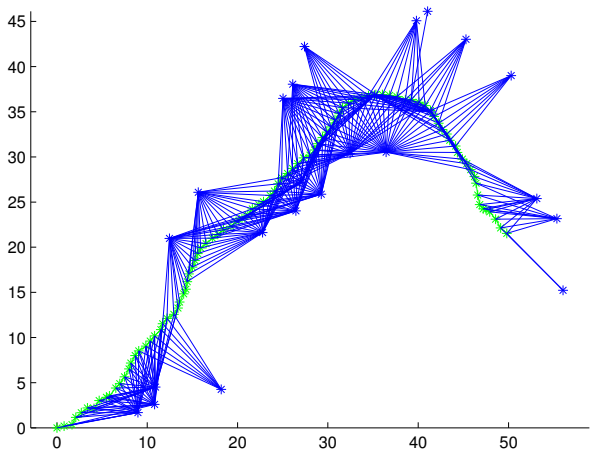
Algorithm


linearize
Non-linear Factor Graph
Gaussian Factor Graph
find the least informative landmark
iterate until converged
remove it
marginalize redundant poses
Reduced Graph

Datasets



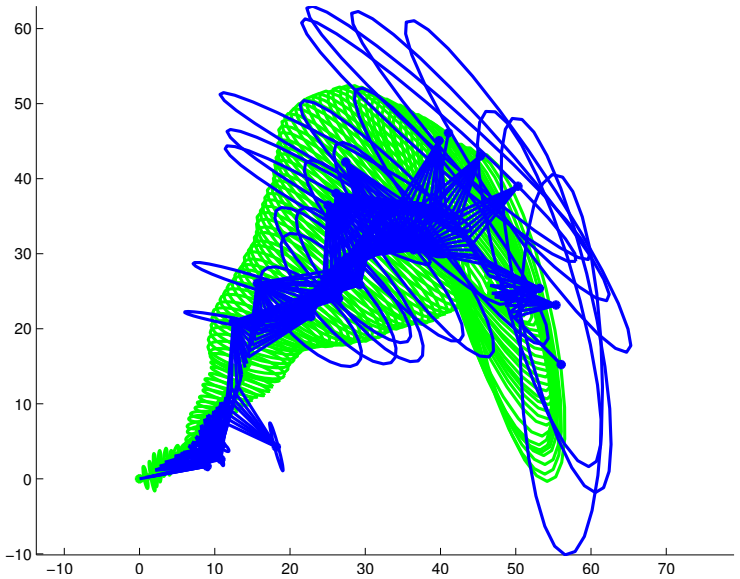
(a) Victoria Park dataset



(b) Synthetic dataset

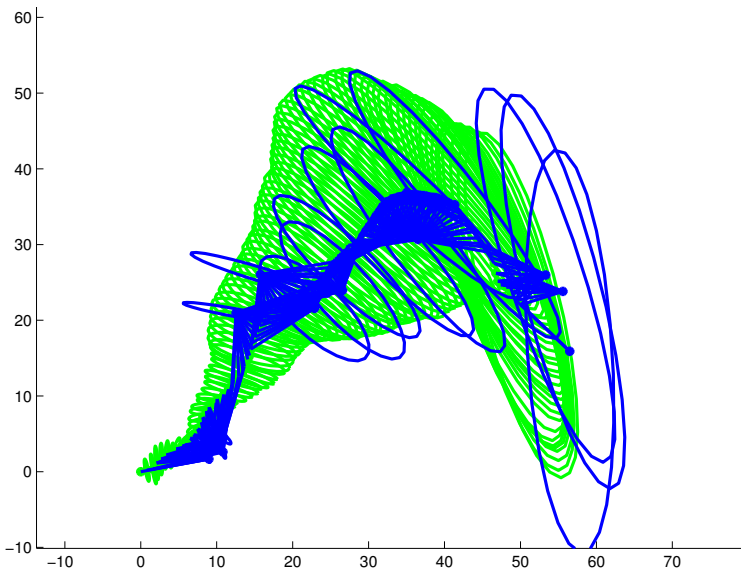
	L	P	Z	Area Covered
Victoria Park dataset	151	6969	10608	200×250 sq. units
Synthetic dataset	24	95	422	50×50 sq. units

Synthetic dataset



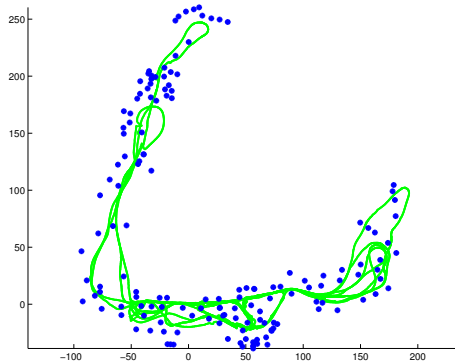
24 Landmarks,
94 Poses

After
Minimization



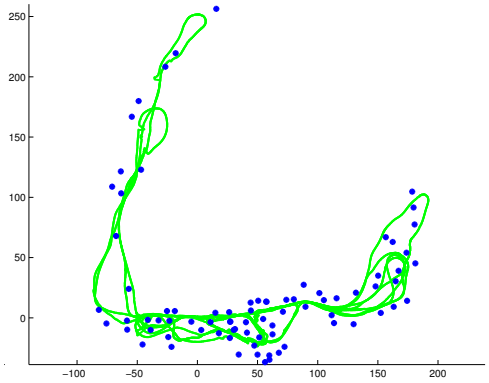
14 Landmarks,
94 Poses

Victoria Park dataset



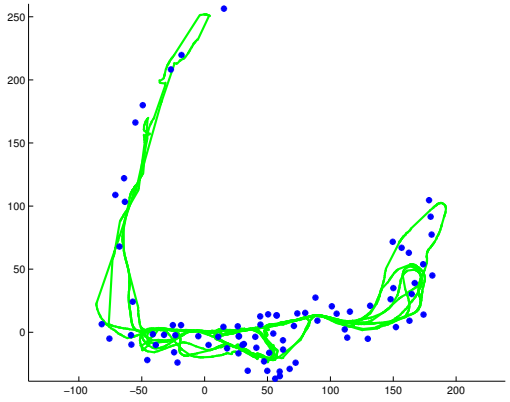
151 Landmarks,
6968 Poses

Removing
redundant
landmarks



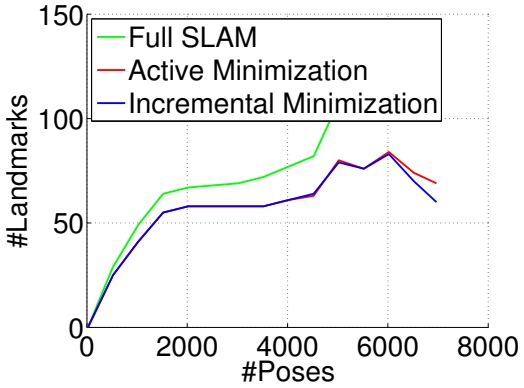
74 Landmarks,
6968 Poses

Removing
redundant
poses

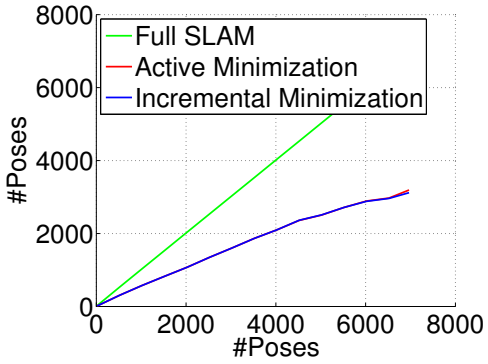


74 Landmarks,
2971 Poses

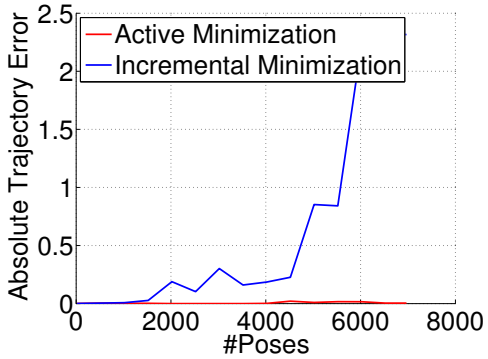
Victoria Park dataset



Number of Landmarks



Number of Poses



Absolute trajectory error

Conclusions

- Proposed an **incremental and active minimization** algorithm that can be used in a SLAM framework resulting in reduced landmark based SLAM.

- Showed a reduction of **40-50%** in the number of landmarks and around **55%** in the number of poses.

Thank You.

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