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Robust Pose Graph Optimization Without An Accurate Measurement Covariance Model

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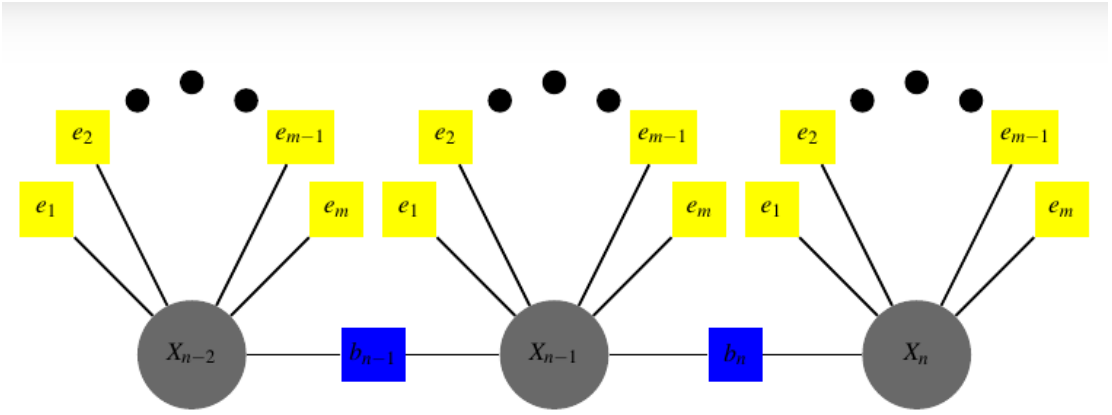
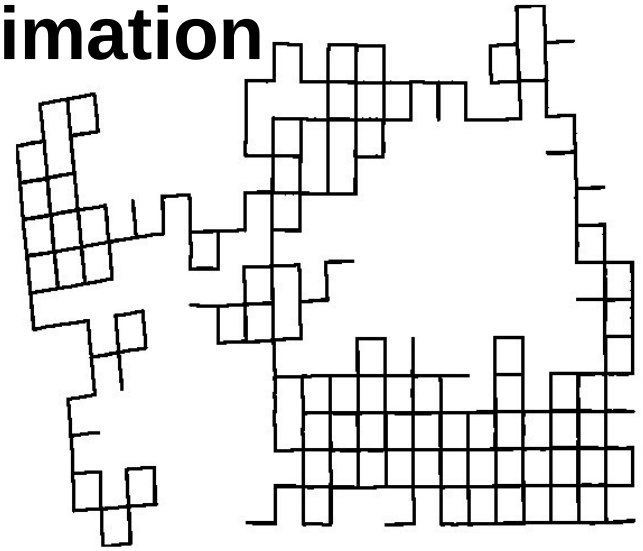
Introduction: What is a F.G.

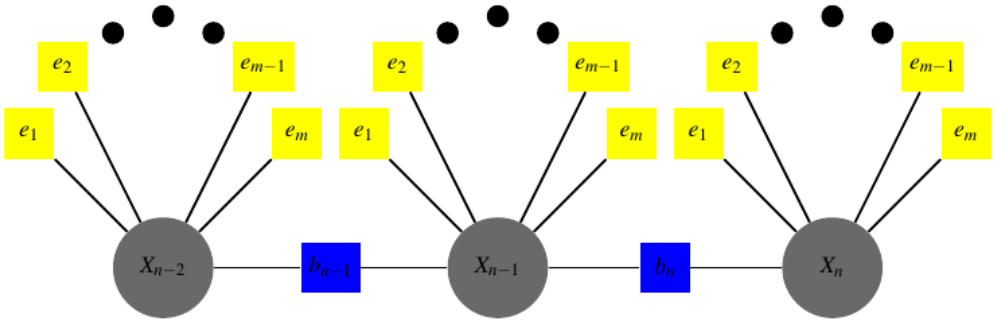
- **What is a factor graph?**
  - **Tool to factorize a function of many variables into a product of smaller subsets**
    - **Factorization represented as a bipartite graph G=(F,X,E)**
  - **Can be applied to MAP estimation**





Introduction: Solving a F.G.

- When The Gaussian Assumption Holds ::



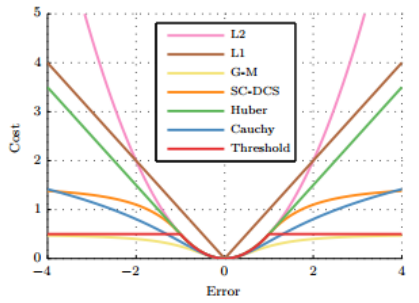
$$e_i = H_i(X_i) - Z_i$$

$$\hat{X} = \text{argmin} \sum_i ||e_i||^2_\Sigma$$

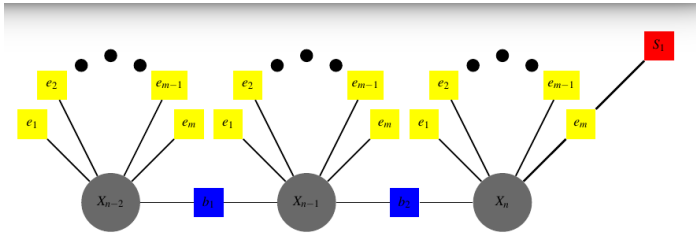
- When The Gaussian Assumption Does Not Hold ::

Previous Robust Methods

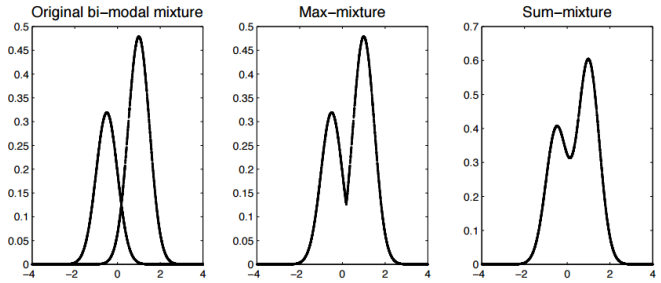
- **M-Estimator**
  - Replace the traditional L^2 cost with a modified cost function



- **Switchable Constraints**
  - The topology of the pose graph should be subject to the optimization.

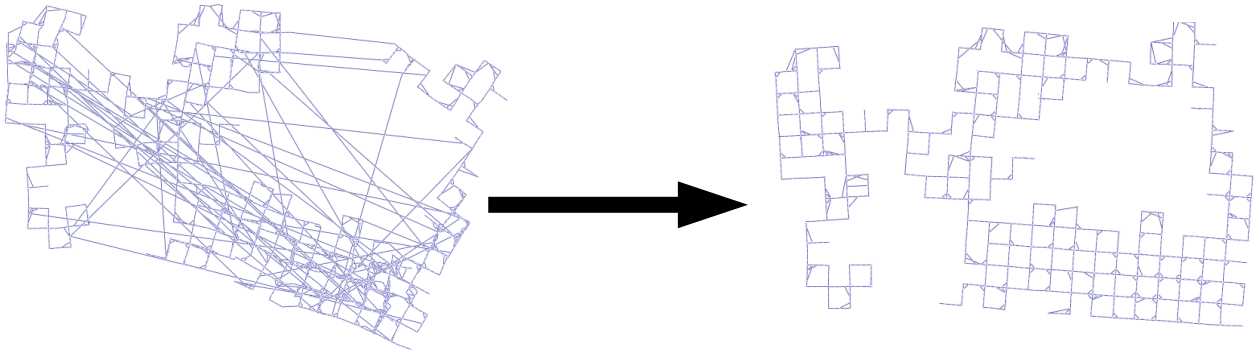


- **Max-Mixtures**
  - Allows for the adoption of more realistic noise models through the max operator

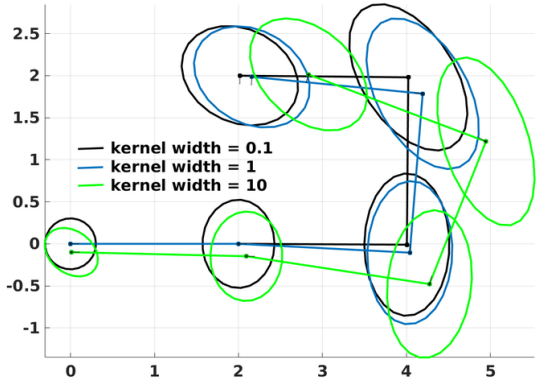


Motivation / Problem Statement

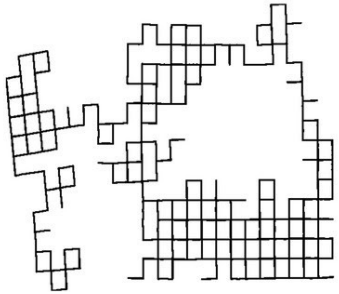
- **Robust**

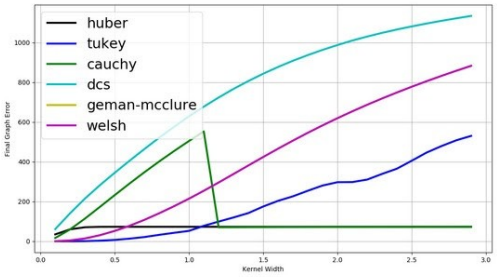


- **Accurate Covariance**

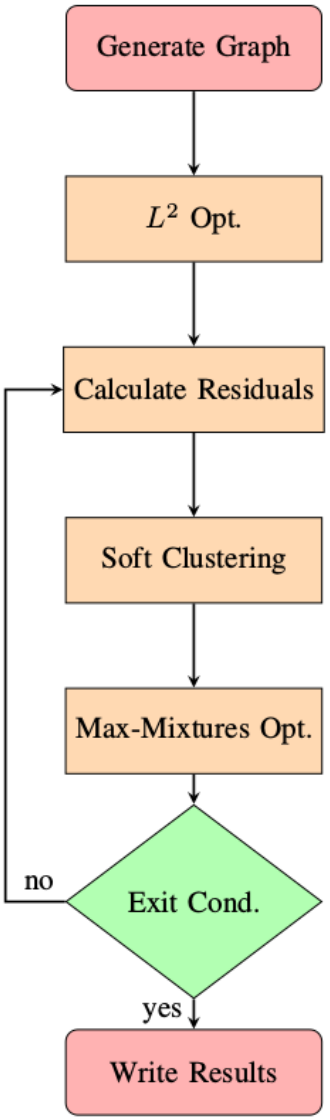


- **Insensitive to Hyper-Parameter**

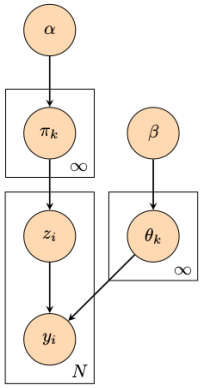




Our Approach



- Using collapsed Gibb's sampling to estimate Gaussian Mixture Model.



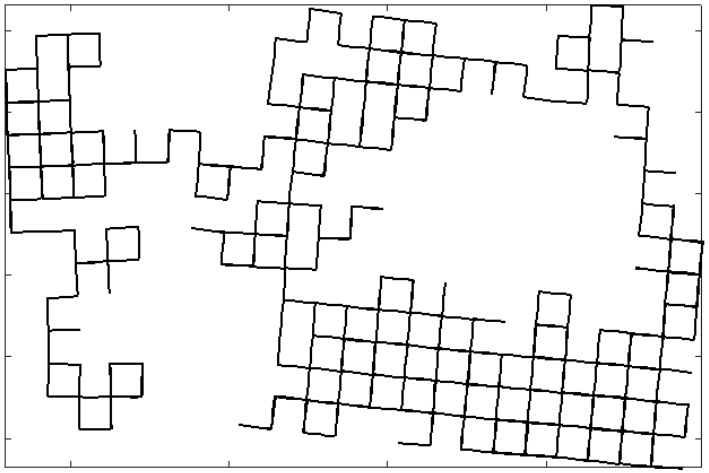
Define $p(\pi|\alpha)$ and $p(\mu_k, \Sigma_k|\beta)$ in such a way that we can analytically integrate out latent variables and only sample parameters of interest through collapsed Gibbs sampling

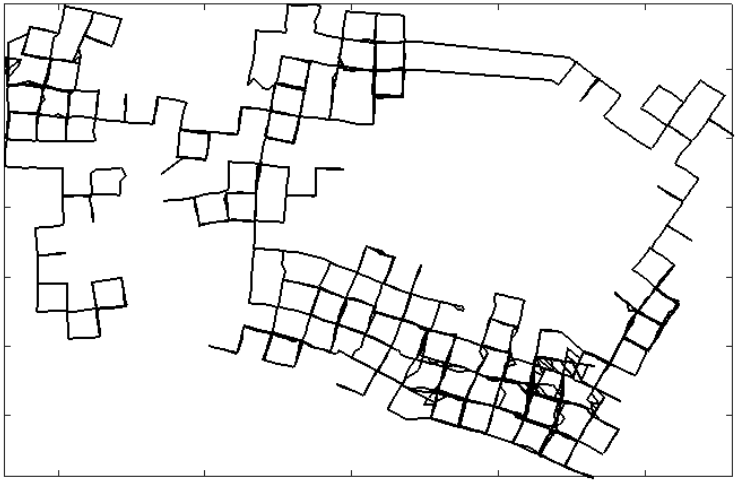
- Now, we have an n-component mixture that characterizes our measurement covariance.
- Now, all constraints are iteratively tested against the model, which allows the information and Jacobian matrices to be scaled accordingly.

Results :: Robust

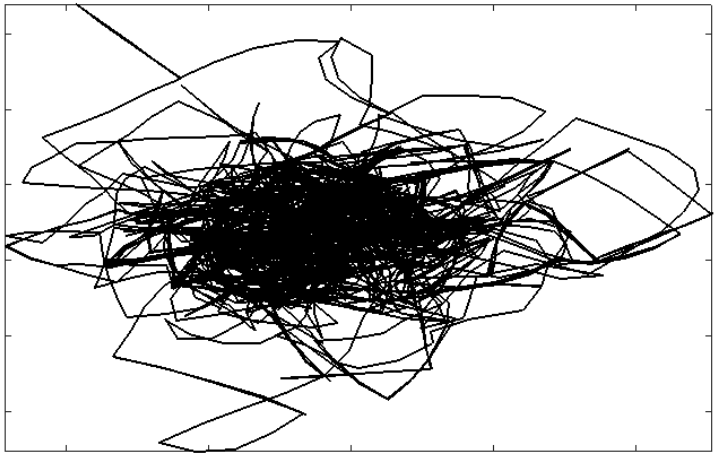
Soft Clustering

Robust Opt.

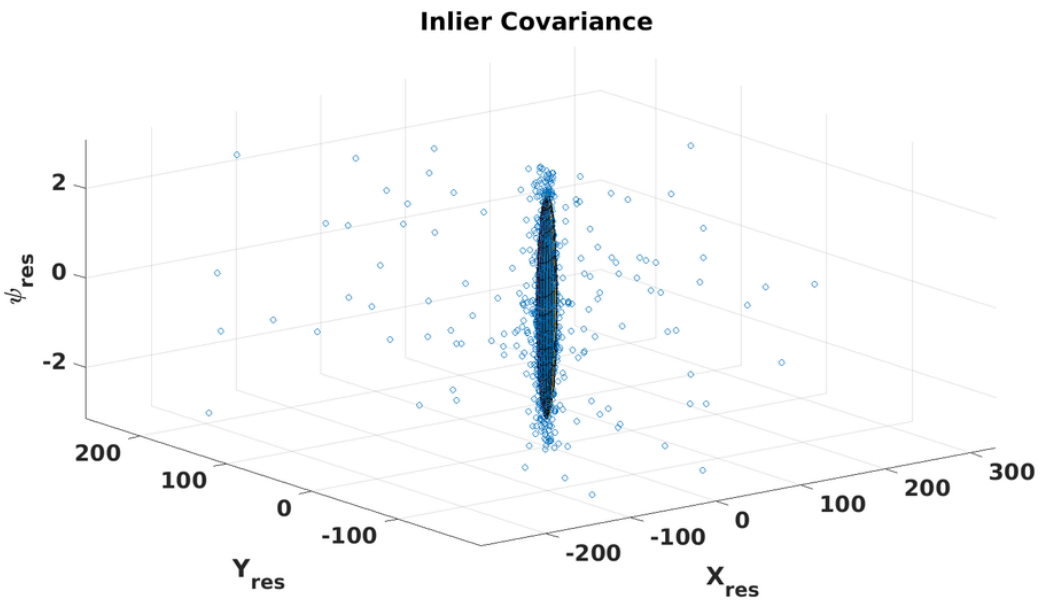


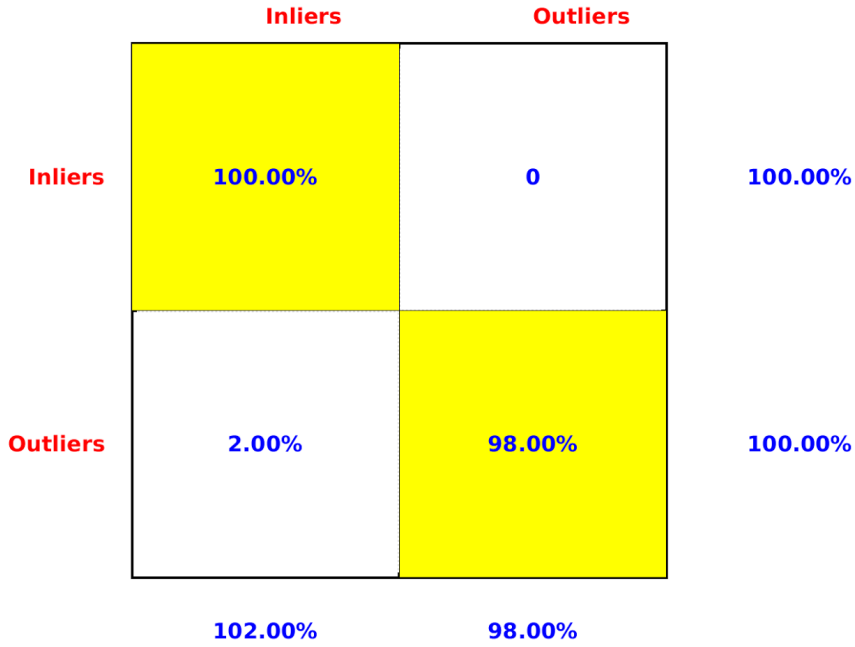


L^2 Opt.

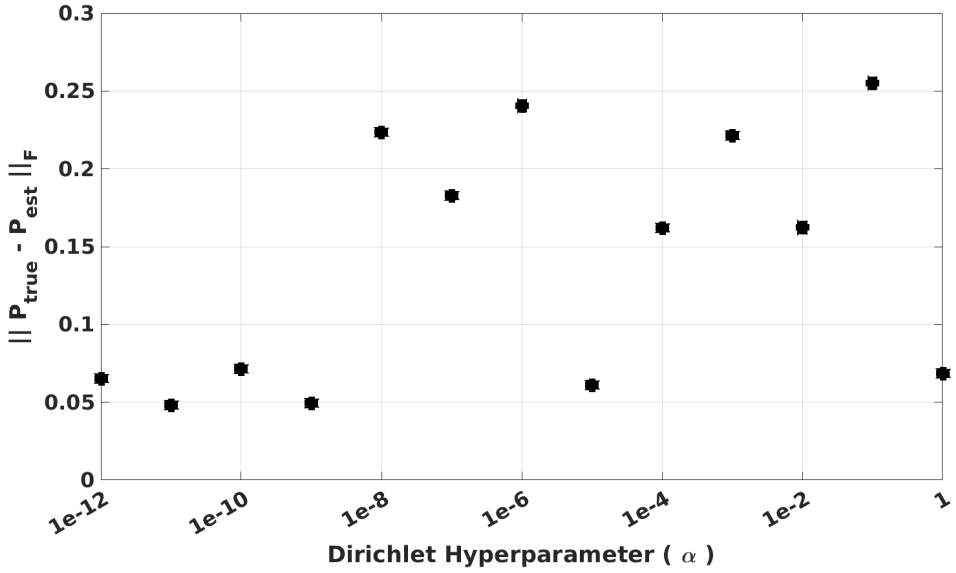


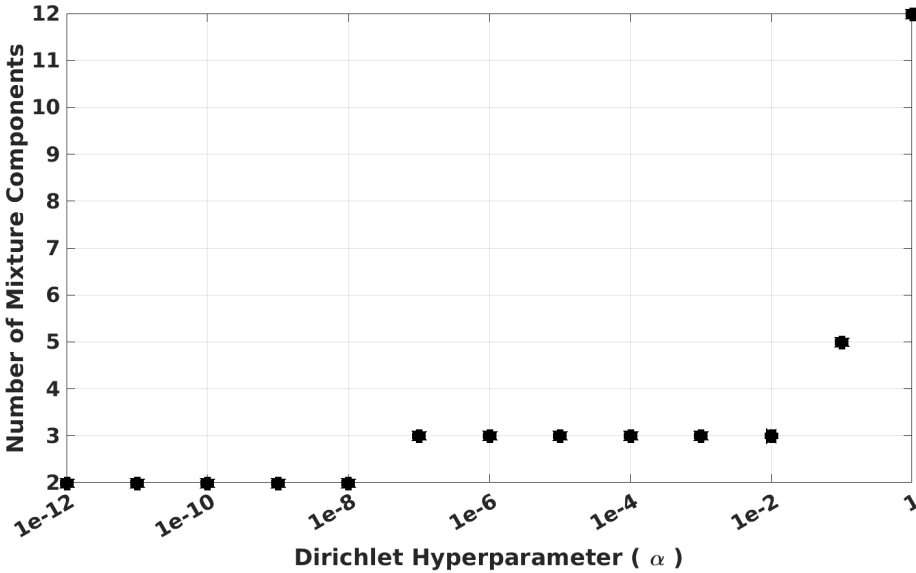
Results :: Accurate Covariance





Results :: Hyper-parameter





Contributions, Future Work

- **Contributions:**
  - **Provided a robust pose-graph optimization routine that provides a reliable estimate of the inlier measurement covariance**
- **Future work:**
  - **Reduce run-time**
    - **Store residuals in a kd-tree**
    - **Replace compressed Gibbs Sampling with variational inference.**
  - **Scale final covariance using Nyman-Pearson lemma.**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