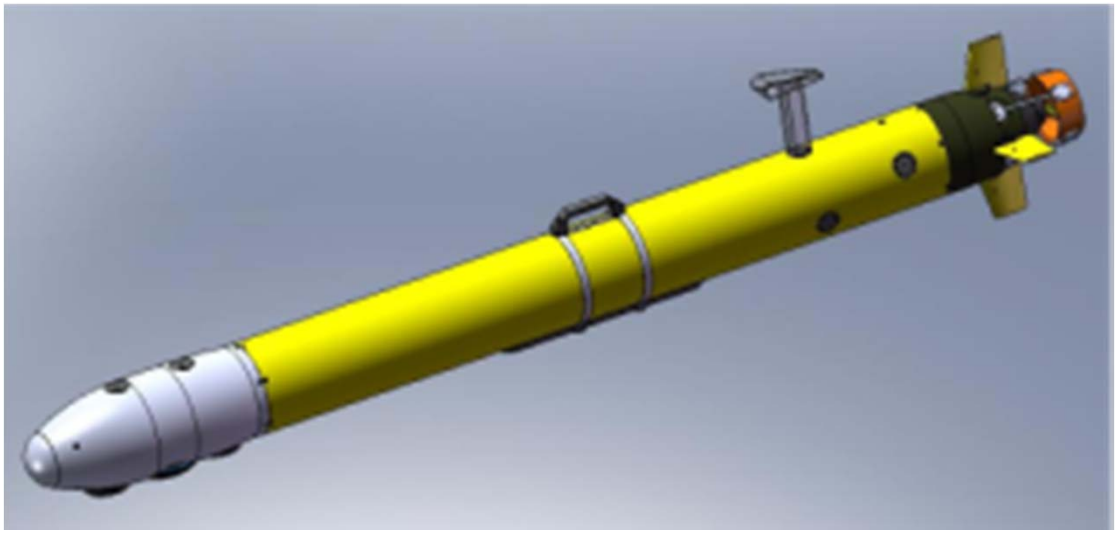
Efficient Real-Time Long Baseline (LBL) Beacon Survey

Vittorio Bichucher
Chien-Wen Recipient Summer ’13

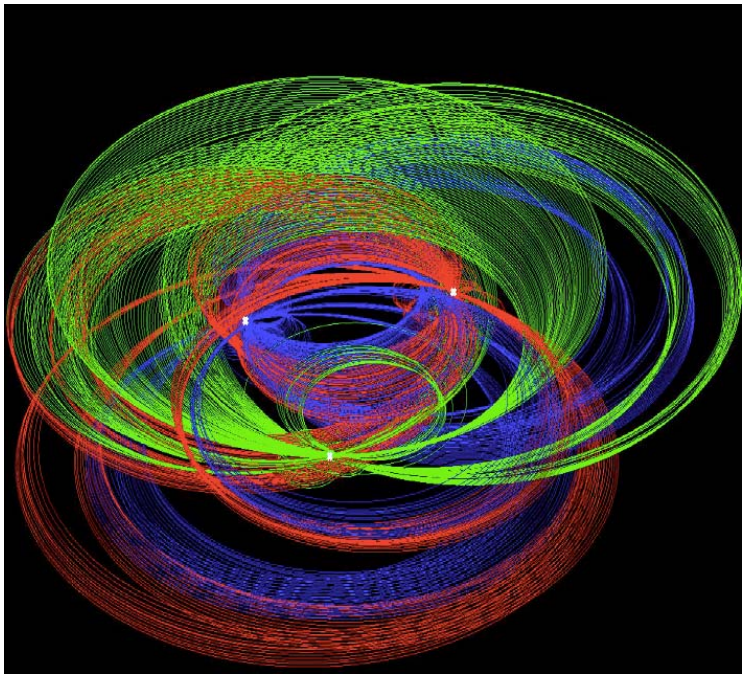


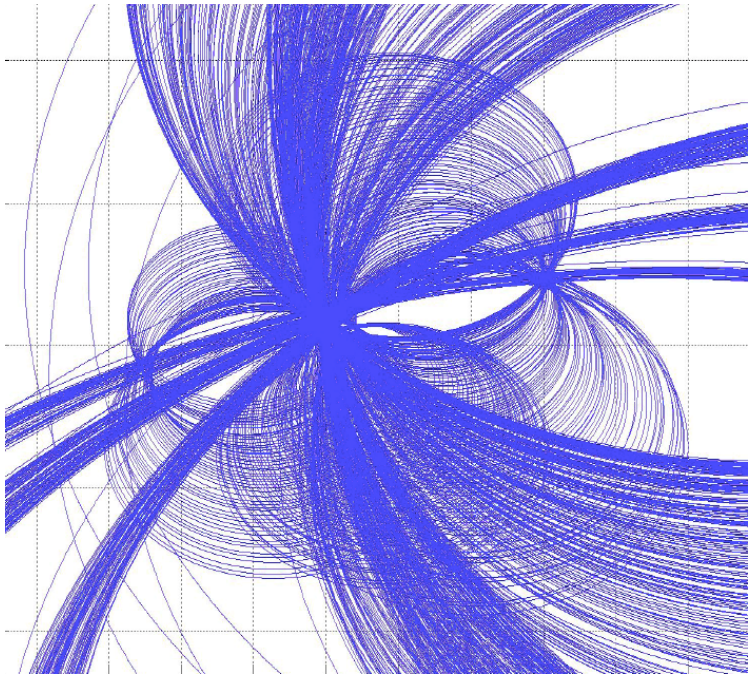
Motivation

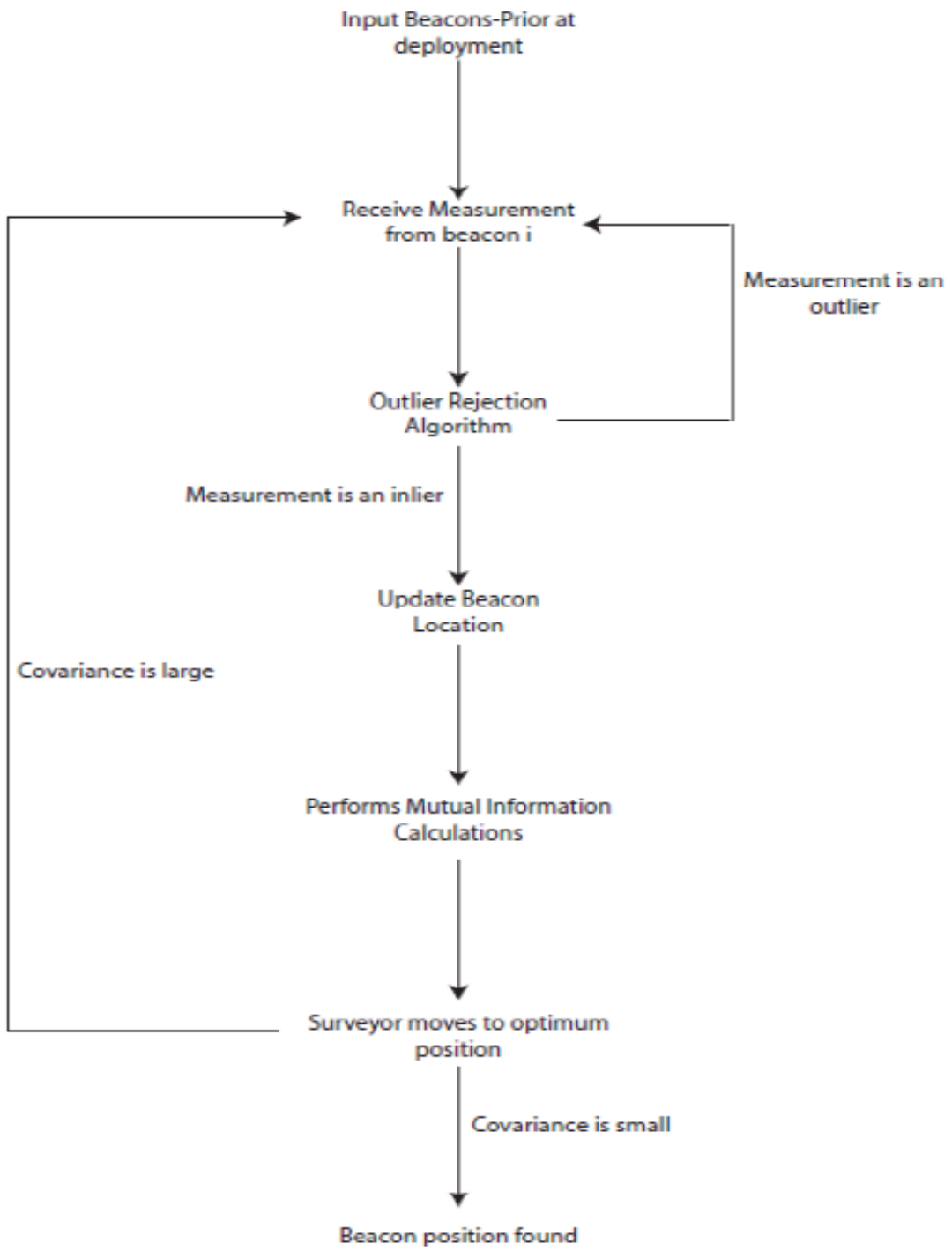
- Underwater Research
  - Scientific Data
  - Localization and Mapping
- Autonomous Underwater Vehicles
- Underwater Navigation
  - No GPS!
  - Long Baseline Navigation
  - Beacon Survey

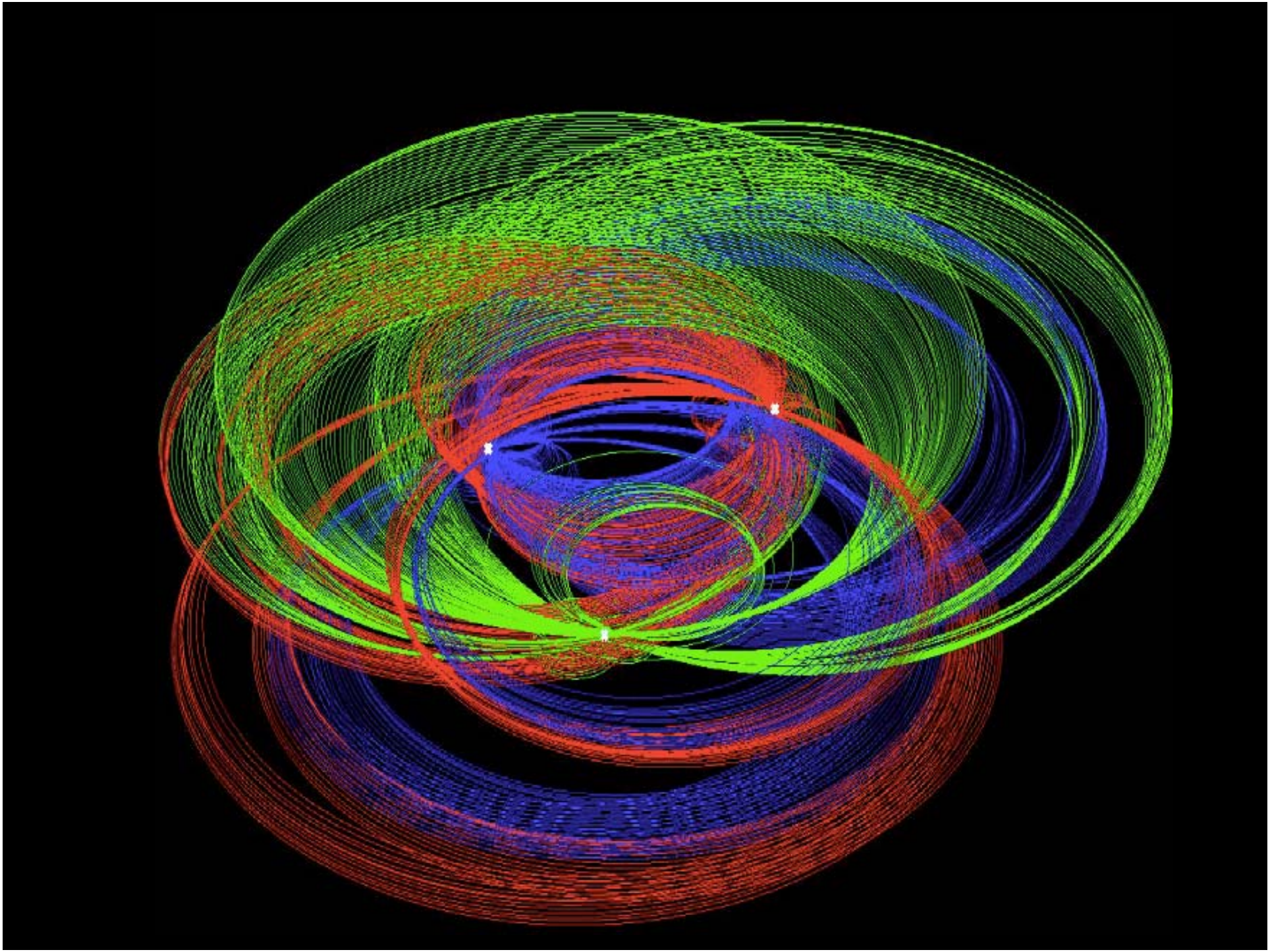
Summary

- Post-Processed vs. Real Time Long Baseline (LBL) Survey
- Non-Linear Least Square Optimization
- Outlier Rejection
- Mutual Information Computation






Input Beacons-Prior at deployment
Receive Measurement from beacon i
Measurement is an outlier
Outlier Rejection Algorithm
Measurement is an inlier
Update Beacon Location
Covariance is large
Performs Mutual Information Calculations
Surveyor moves to optimum position
Covariance is small
Beacon position found



Real-time LBL Survey

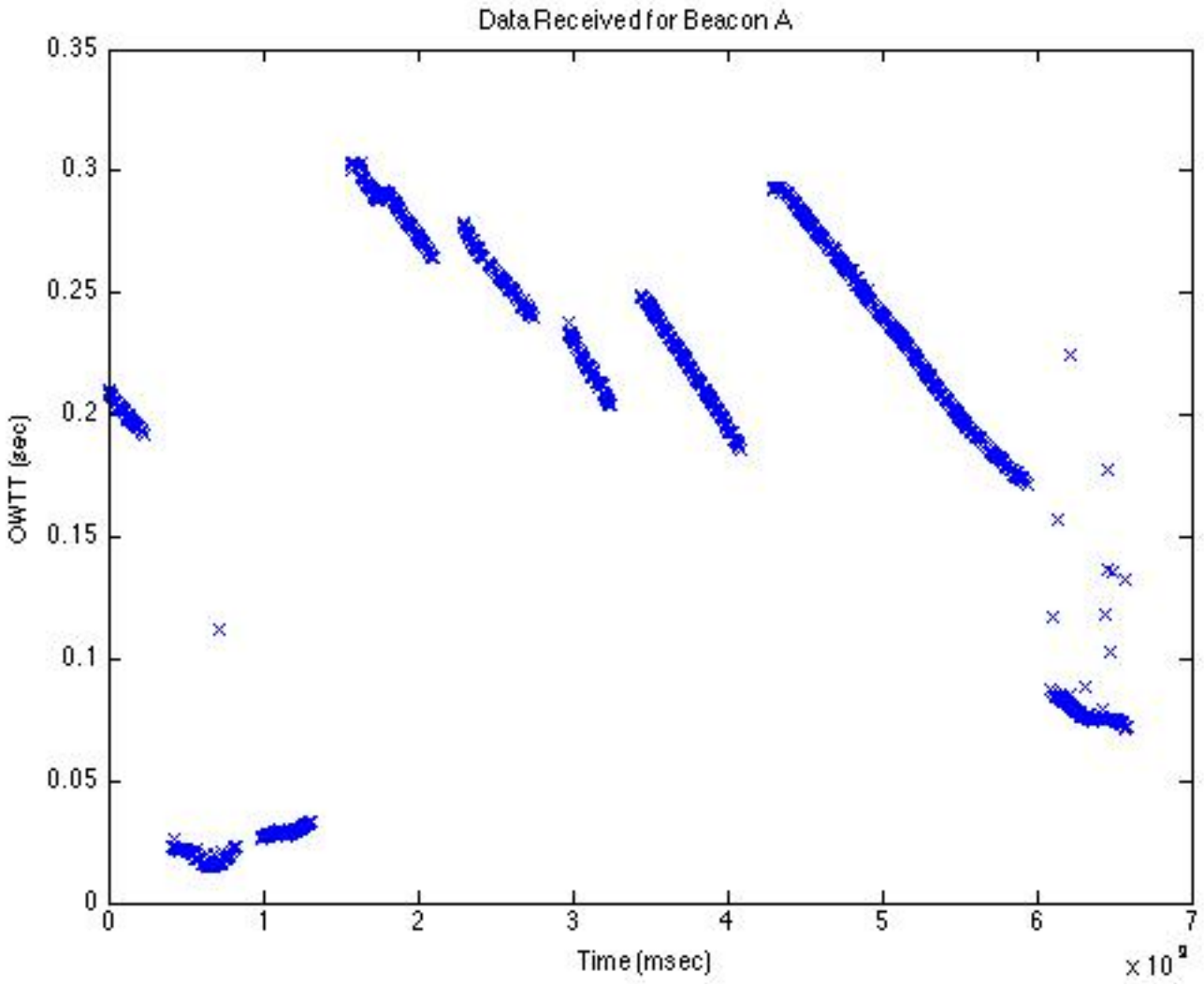
- Non-Linear Least Square
  - Regression analysis method of solving a non-linear system of *k* equations and *n* unknowns, where *k>n.*

$$A = \begin{bmatrix} id_1 & x_1(m) & y_1(m) & z_1(m) & owtt_1(\text{sec}) \\ & & & \vdots & \\ id_k & x_k(m) & y_k(m) & z_k(m) & owtt_k(\text{sec}) \end{bmatrix}$$

$$residual_k = (speed\ of\ sound)(owtt_k) - \sqrt{(x_k - x_b)^2 + (y_k - y_b)^2 + (z_k + z_b)^2}$$

$$[x_b, y_b, z_b] = \ argmin \ \sum_{i=1}^{k} r_k^2$$

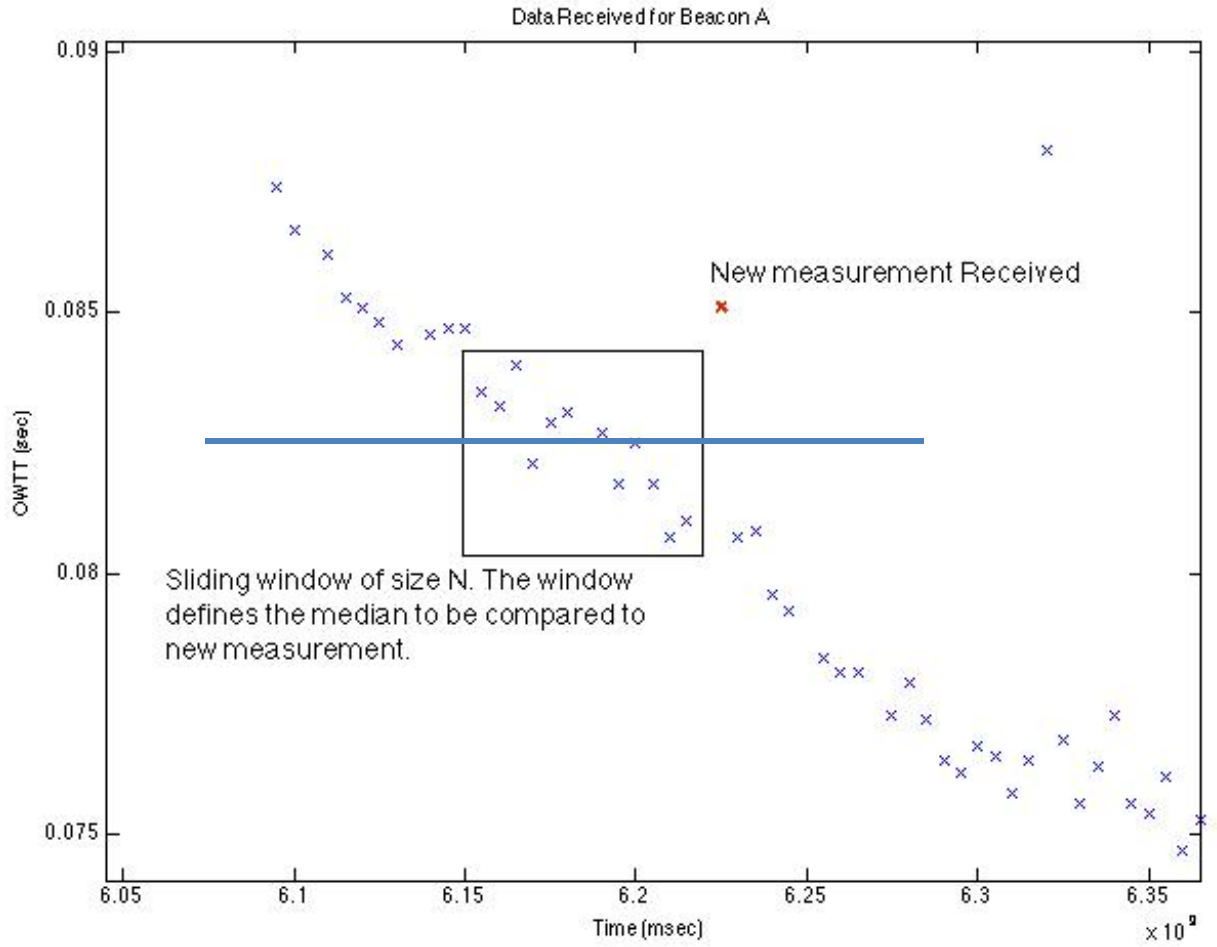
Outlier Rejection



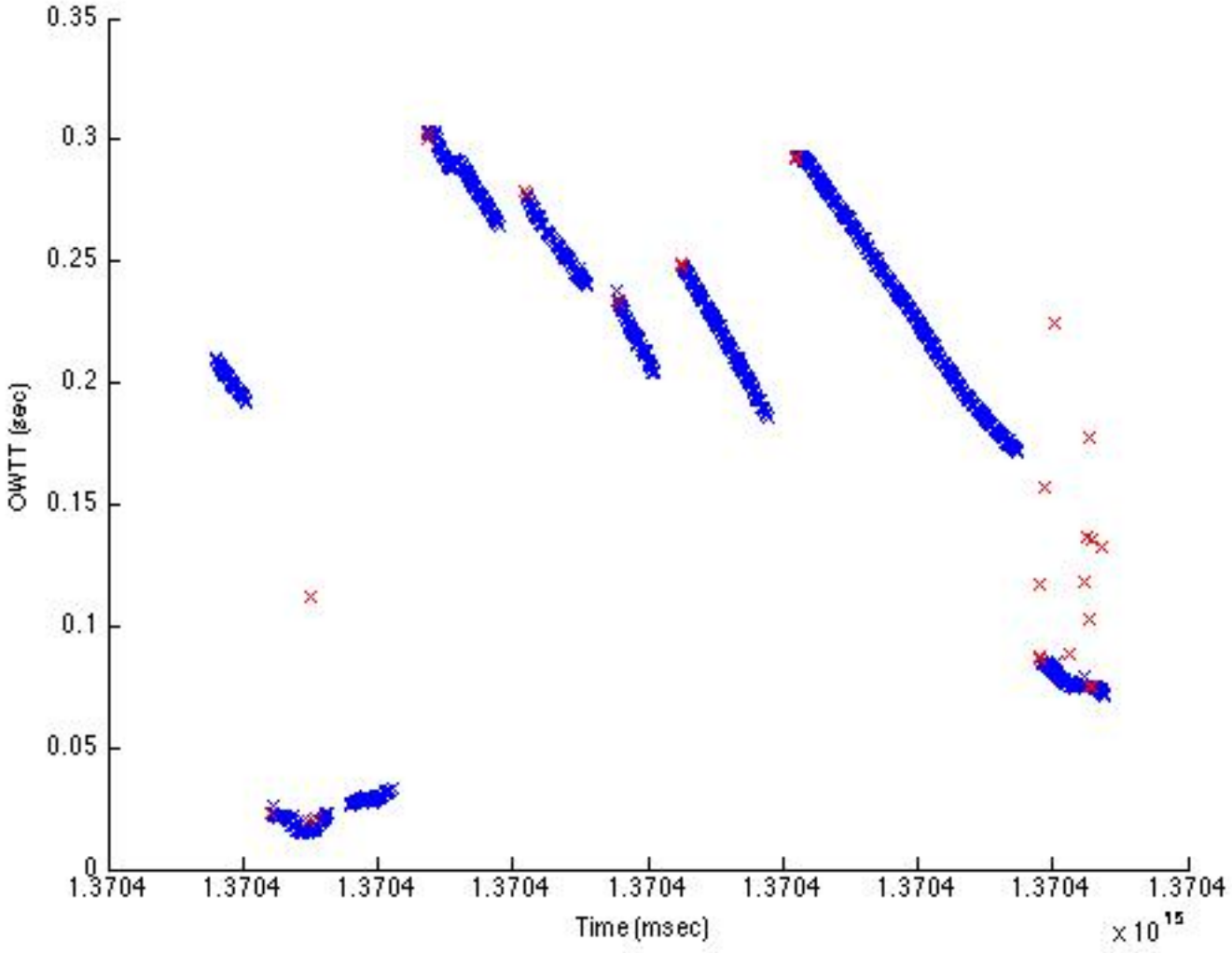
Outlier Rejection

Median Filter Outlier Rejection Algorithm

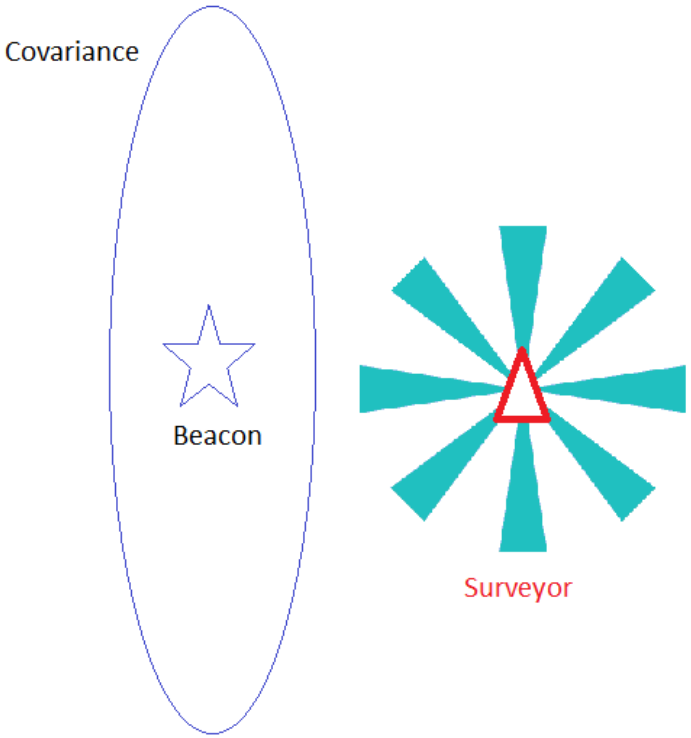
Yoerger, et al (2007)



Outlier Rejection – Results – Beacon A



Mutual Information



- Find optimum path!
- Charrow, *et al:* Compute increase in information by a future path in a single direction.

$$MI[x,y] = \int_x \int_y p(x,y) * \log\left(\frac{p(x,y)}{p(x)p(y)}\right) dydx$$

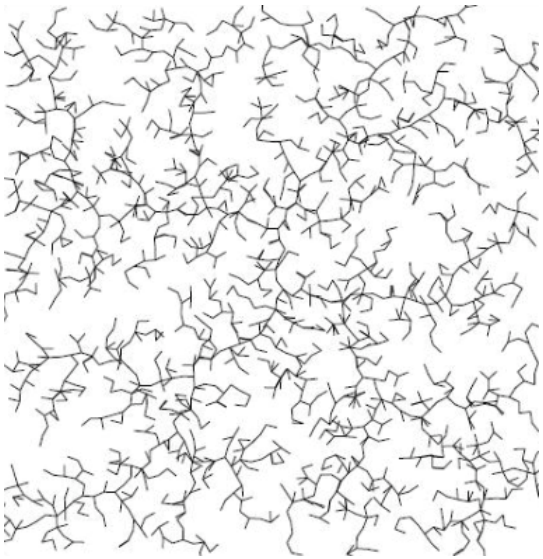
- Compute information gain for all possible paths.

Conclusion

- Algorithm decreases time spent surveying beacons, therefore it can decrease overhead cost.
- Algorithm also helps when making decision about where to deploy the beacons.
- The Algorithm is robust and useful for a network on *n* beacons.

Future Work

- **Robustness**
  - Implement the survey as surface mission for the AUVs:
    - Change Transducer Location on Iver AUVs;
    - Path-Planning Algorithm



Future Work

- **Robustness**
  - Implement the survey as surface mission for the AUVs:
    - Change Transducer Location on Iver AUVs;
    - Path-Planning Algorithm
  - Outlier Rejection: Single Cluster Graph Partitioning
    E. Olson, J. Leonard, S. Teller

Acknowledgements

- Mr. Tony K. Wang
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