Evaluating Lateration-Based Positioning Algorithms for Fine-Grained Tracking

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Introduction

- Fine-grained location information has many uses
  - new user interfaces
  - contextual inferences
  - location correlated sensing
  - routing
- We look at the performance of a number of lateration algorithms using real-world data in multipath environments

Algorithms

- **Non-linear Regression** (NLR) – minimize error across entire dataset
- **Iterative NLR** (INLR) – repeatedly remove outliers until fit is good enough
- **Linear Least Squares** (LLS) – linearise problem for direct solution
- **RANSAC** – Trilaterate a random triple and look for supporting data
- **Trilaterate on Minima** (ToM) – Trilaterate the shortest distances

Data Collection

- Ultrasonic sensor system (Bat system)
  - sensors in ceiling approx 2 per square metre
  - produces time-of-flight readings
- No reliable fine-grained simulation of an indoor environment and occupants exists
  - Cannot evaluate algorithms using simulated data
- Bat transmitters left in fixed position for 4 months
  - ground-truth position from laser survey equipment

Results

- Between 5% and 20% of sightings are multipath signals – this is not correlated with position
- Location error **is** correlated with position

	Error Middle	Error Wall
INLR	0.03	0.05
RANSAC	0.05	0.1
NLR	0.24	0.41
LLS	9.57	24.69
ToM	0.63	0.63

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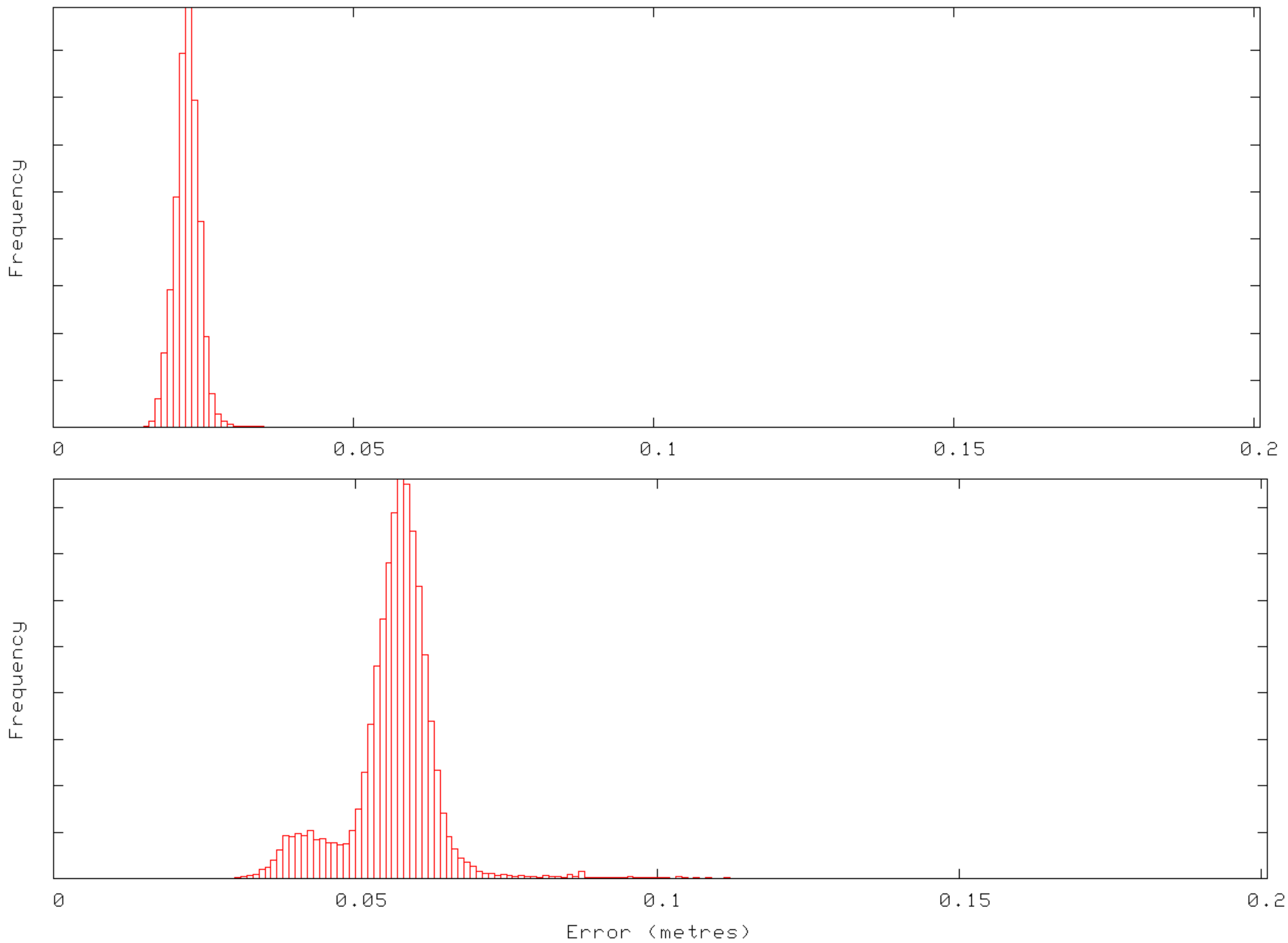
Iterative Non-Linear Regression Error



Middle of room

Against wall

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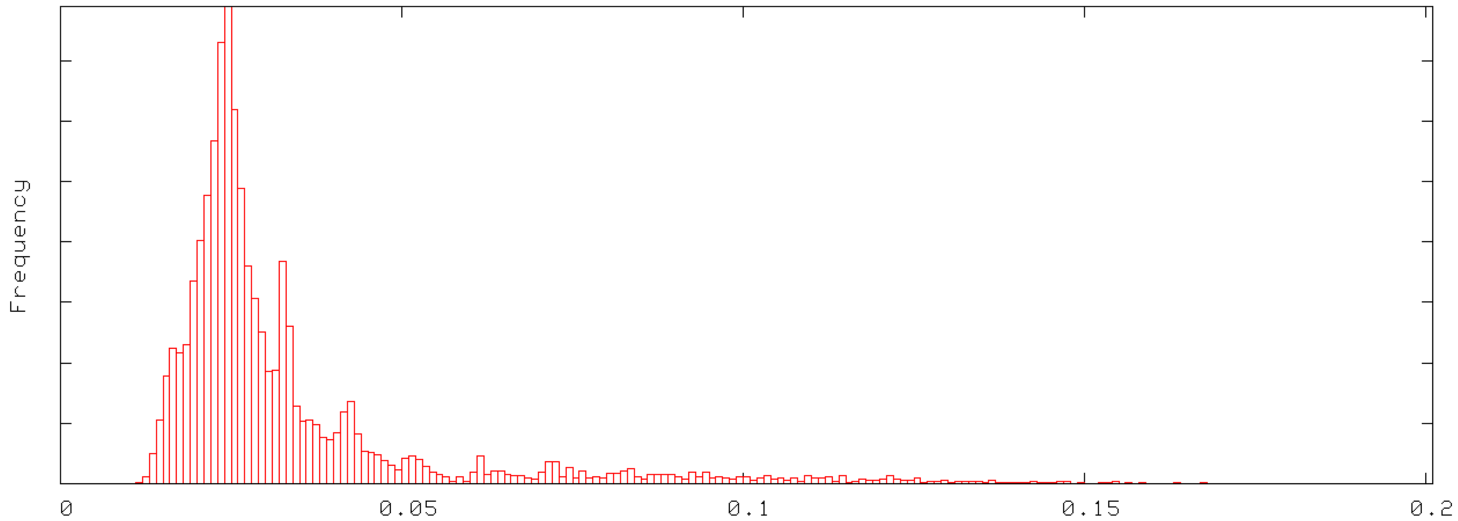
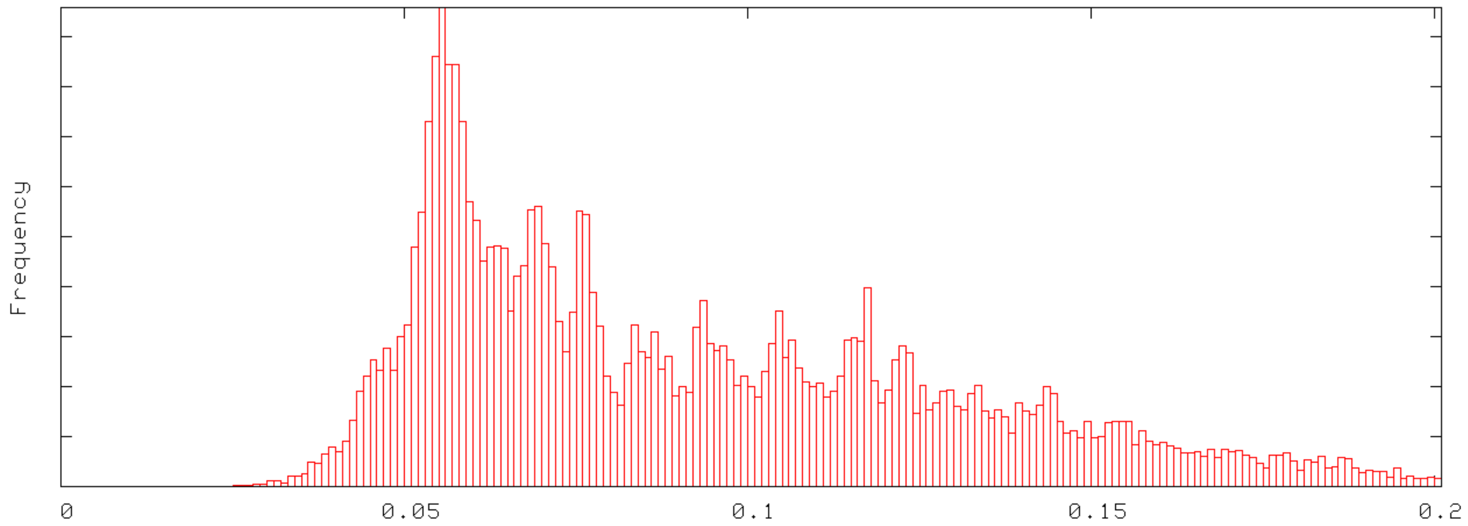
RANSAC Error



Middle of room

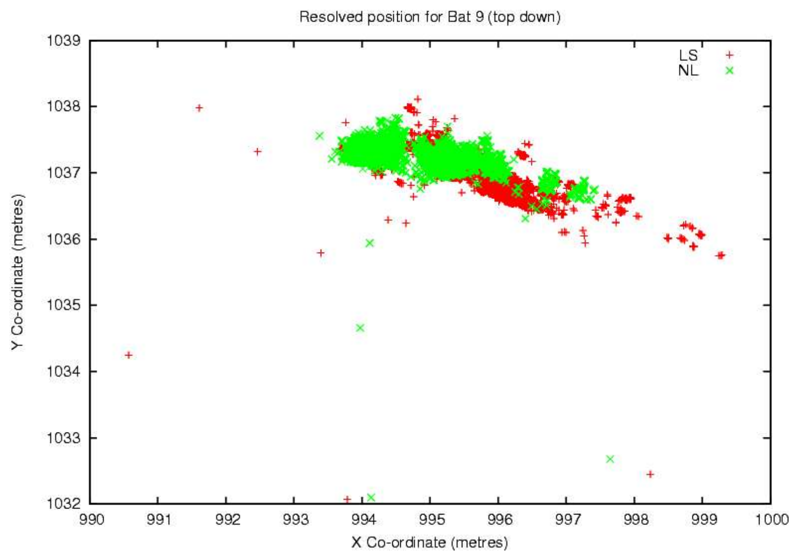


Against wall

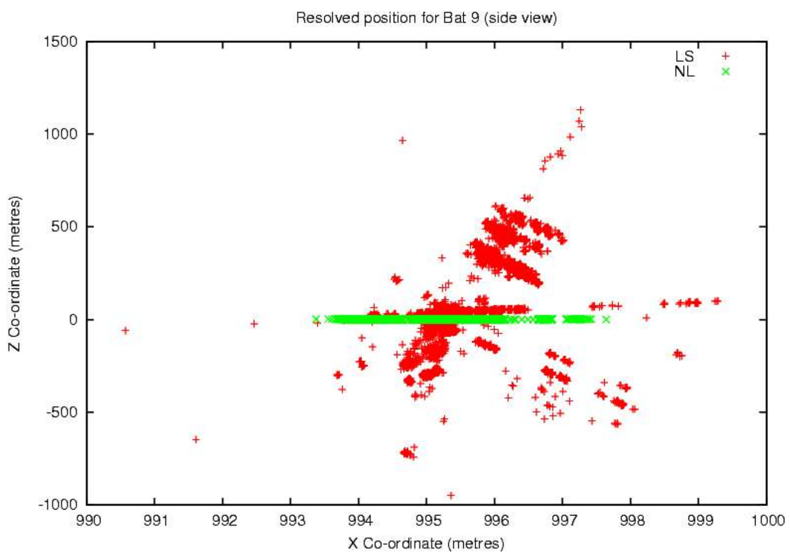
LLS Vertical Error

- Planar sensor array interacts badly with linearization for vertical information

Top-down view



Side view



LLS NLR

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Dependability

- Algorithm specific estimate of location error
- Dependability (d) = % of time that estimated error is less than actual error
- Dependability strength (d_s)= actual error minus estimated error

	d (%)	d_s (m)
INLR	91.99	0.05
RANSAC	99.44	1.16
NLR	99.99	4.06
LLS	22.31	0.79

Conclusions

- INLR best accuracy but computationally expensive
- LLS is fast but suffers from outliers and is geometrically weak when using a planar sensor array
- INLR and RANSAC good at rejecting multipath signals
  - sensor geometry plays a more significant rôle

Finally

- NLMaP
  - implementation of all the investigated algorithms
  - open source, freely available
- http://www.cl.cam.ac.uk/Research/DTG