Improve Poor GPS Area Localization for Intelligent Vehicles

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Dinh Van Nguyen, Fawzi Nashashibi, Trung-Kien Dao, Eric Castelli. Improving Poor GPS Area Localization for Intelligent Vehicles. MFI 2017 - IEEE International Conference on Multisensor Fusion and Integration for Intelligent Systems, Nov 2017, Daegu, South Korea. pp.1-5. <hal-01613132>

Abstract

- Introduction - Fusion of Laser-SLAM and GPS
- WiFi Fingerprinting Method
- Experiment and Results
- Conclusion and Limitation
- Q & A

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Laser-SLAM + GPS Fusion

- GPS is required to:
  - Map SLAM local coordinates to a global one
  - Correct SLAM accumulated error
  - Solve loop closure
- Need alternative in area with low/no GPS signal:
  - Parking structure, tunnel, urban area

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Other approaches

Studies:

- Environment static map [2], [4], [5]
- Network of cooperating vehicle [6], [7]
- GPS + radio freq identification + vehicle to vehicle + vehicle to infrastructure [8]

Problem:

- Fusing different sensors data
- Complicated system

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Wifi Fingerprinting Localization

- Training Phase:
  - Learn WiFi map of targeted environment
  - RSSI scanning + coordinates, at reference positions
  - Deterministic or probabilistic
- Prediction Phase:
  - Compare current signal with radio map

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Wifi Fingerprinting Localization

- Pro:
    - Less effort, data than HD map
    - Capable of mimicking GPS in fusing, smooth switching
- Con:
    - Indoor positioning
    - RSSI noise (interference, multipath propagation)
    - Prone to environment (AP, furniture) change
    - Low accuracy & speed

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Learning - RSSI recording

- Record Vector:

$$\{x_{i,1}, x_{i,2}, x_{i,3}, \dots, x_{i,n}, \rho_l\} \quad (1)$$

- Normalized in the range of [-1,1)

$$x_i = \begin{cases} -1, & AP_i \; undetected \\ 1 - \frac{(-1)\times RSSI}{100}, & AP_i \; detected \end{cases} \quad (2)$$

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Learning - training data

- Training Data are high variant
  - RSSI are noisy
  - Scanning frequency is low (vs movement speed)
- Method:
  - Ensemble Bagging (Bootstrap Aggregating) Neural Network

[9] L. Breiman, “Bagging Predictors,” *Mach. Learn.*, vol. 24, pp. 123–140, 1996.

[10] T. G. Dietterich, “Ensemble Methods in Machine Learning,” *Mult. Classif. Syst.*, vol. 1857, pp. 1–15, 2000.

  - Can overcome high variant and noisy data

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Experiment - environment

Experiment - System

- IbeoLux LIDAR
- Credibilist SLAM
- Standard 2.4GHz Wifi antenna
- IMU
- RTK GPS for ground truth

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Experiment - radio map

- 15 reference points
- Training data: 30 scans/point of WiFi signal collected
- ensemble of 50 neural networks, 170 input neurons each, 90 nodes at hidden layer, 15 outputs trained

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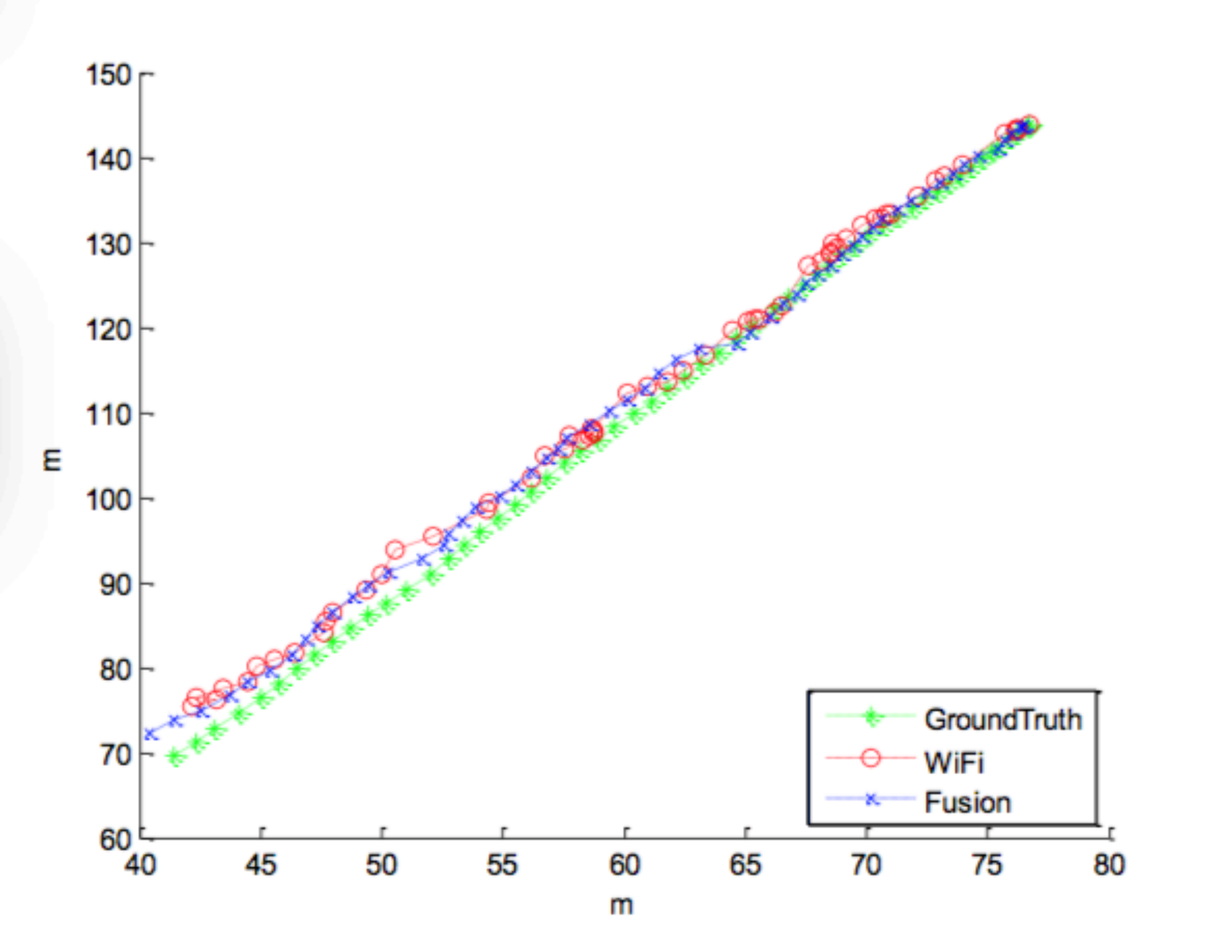
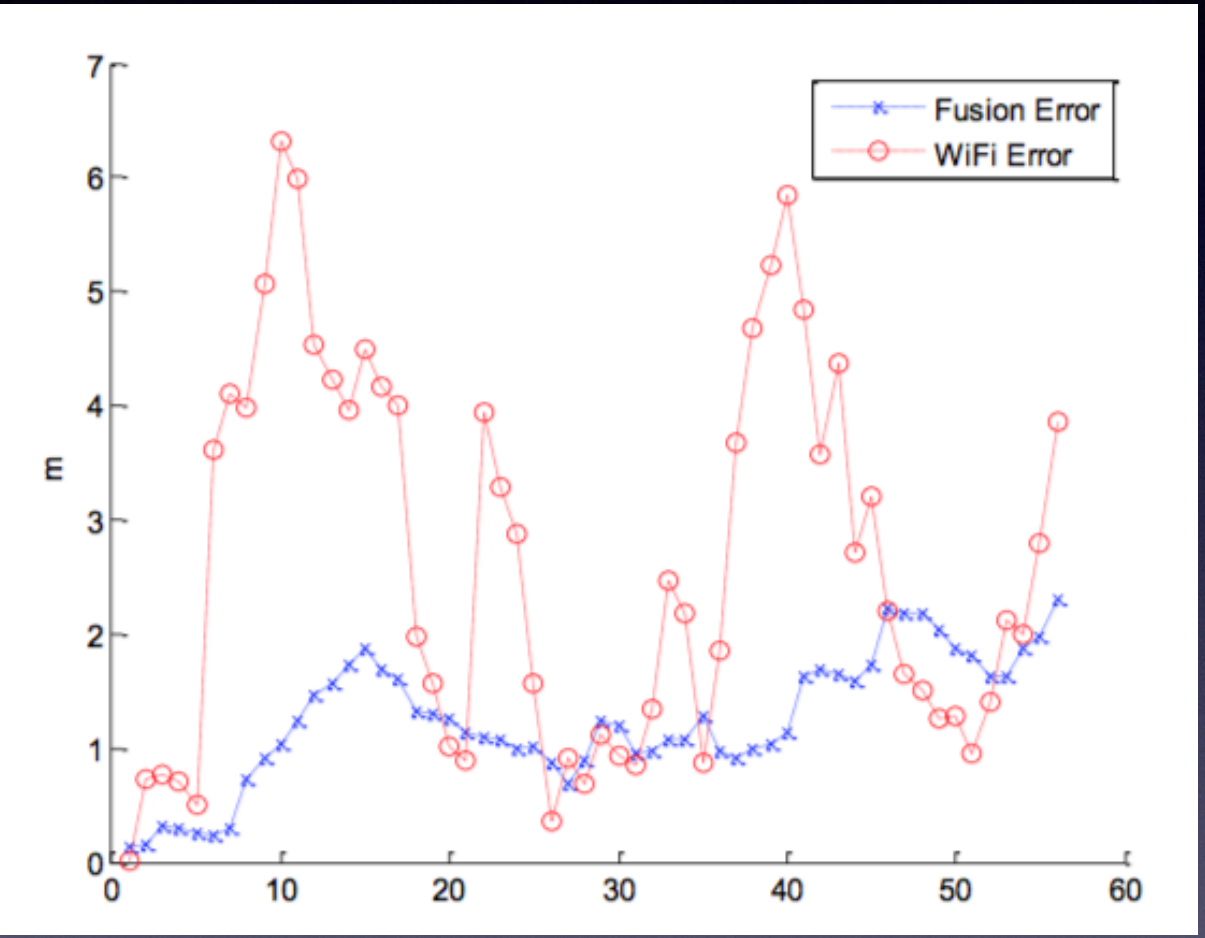
Wifi Localization vs SLAM





- average error = 3.328m, 98% errors < 6m

$\sigma_{Wifi} = 6m$

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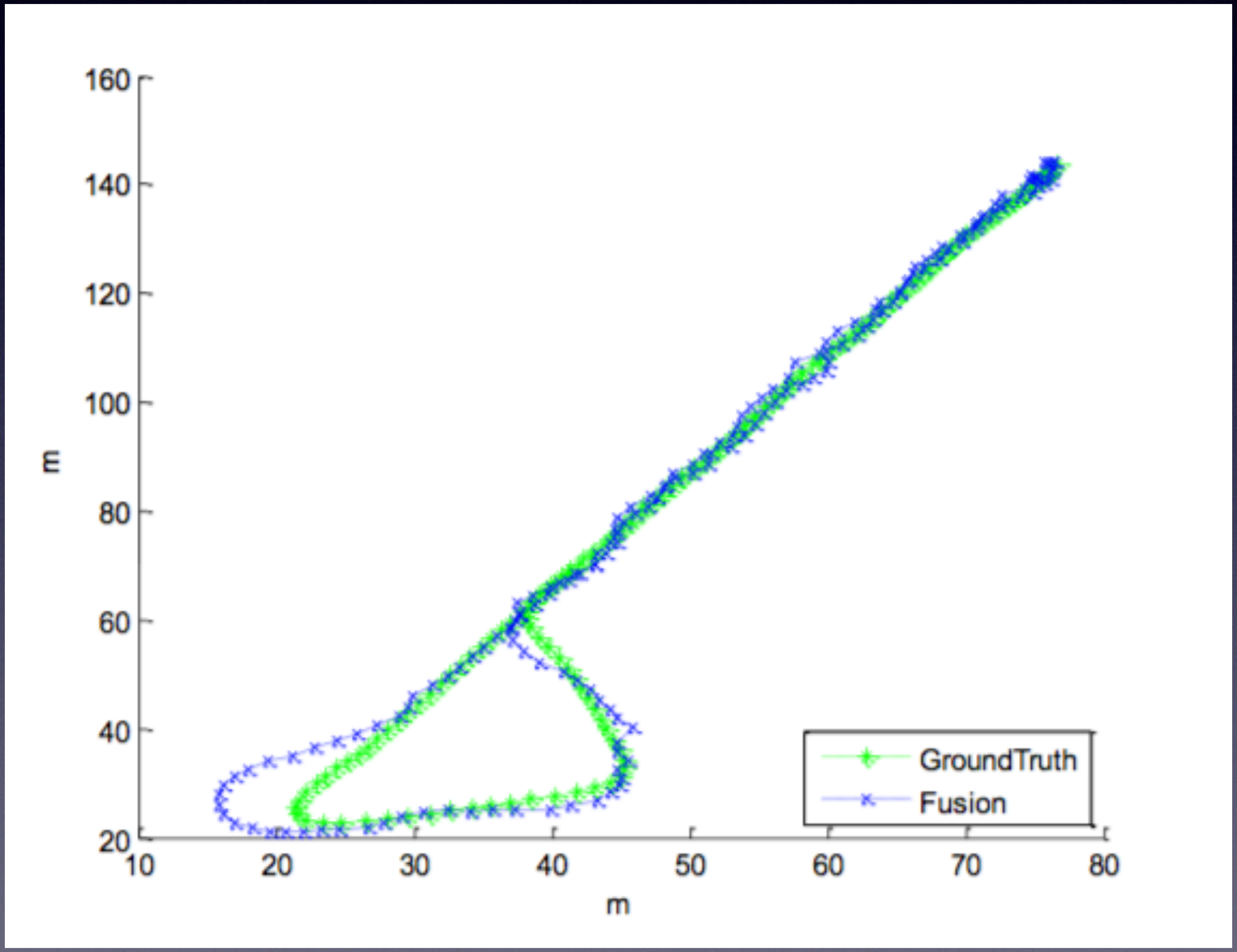
Fusion of GPS and SLAM (σ_{GPS} = 6)



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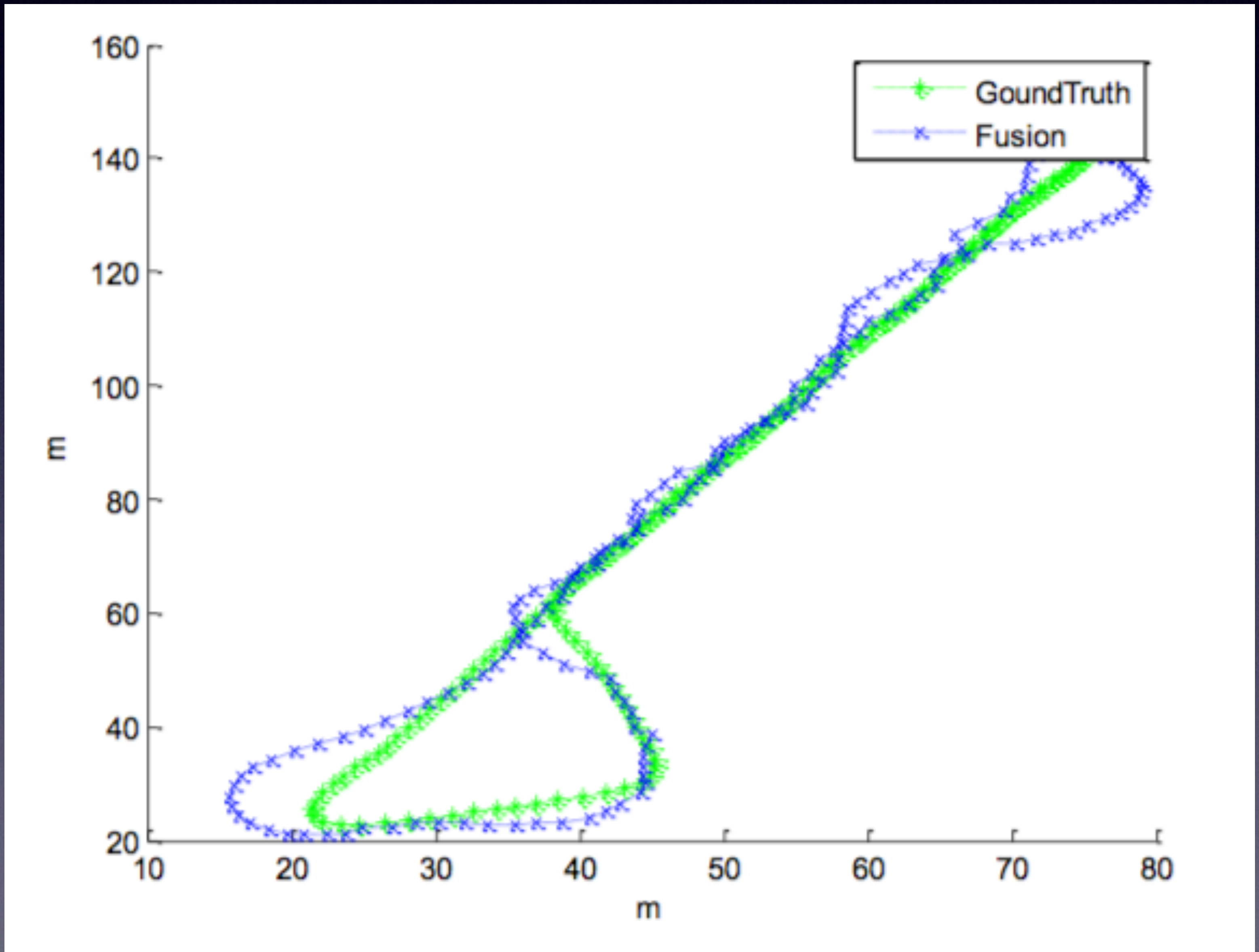
Fusion of GPS and SLAM (σ_{GPS} = 10)



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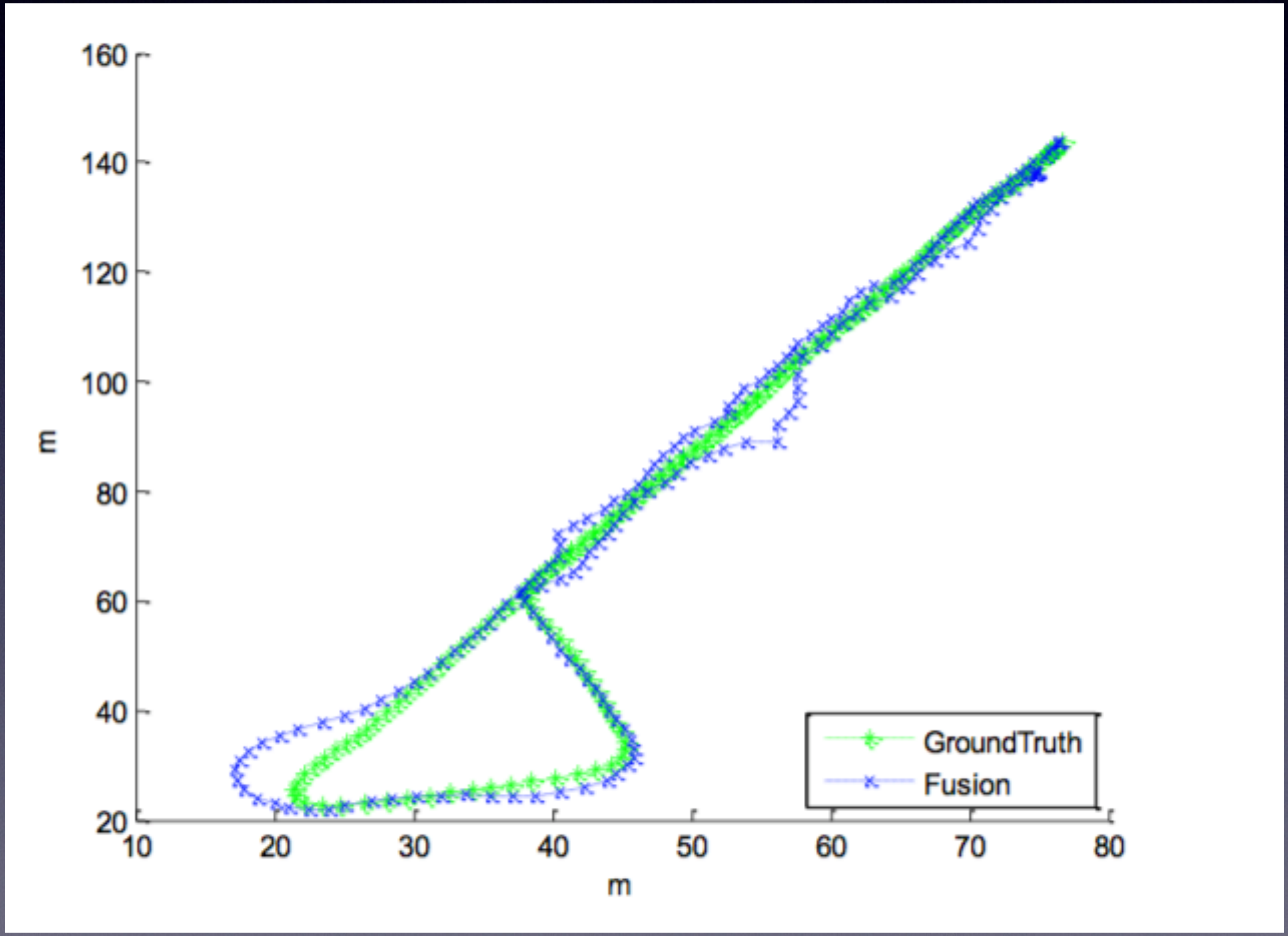
Fusion of Wifi, GPS and SLAM ($\sigma_{GPS} = 6$, $\sigma_{WiFi} = 6$)



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Conclusion

- “alternative solution for weak GPS area with WiFi Fingerprinting localization technique”
- future improvement: “deep learning… mutli-receiver”

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