Indoor Localization using Ultra-wideband

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Dr. Rüdiger Quay

Outline

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- Motivation
- Scope of Work
- Result
- Conclusion

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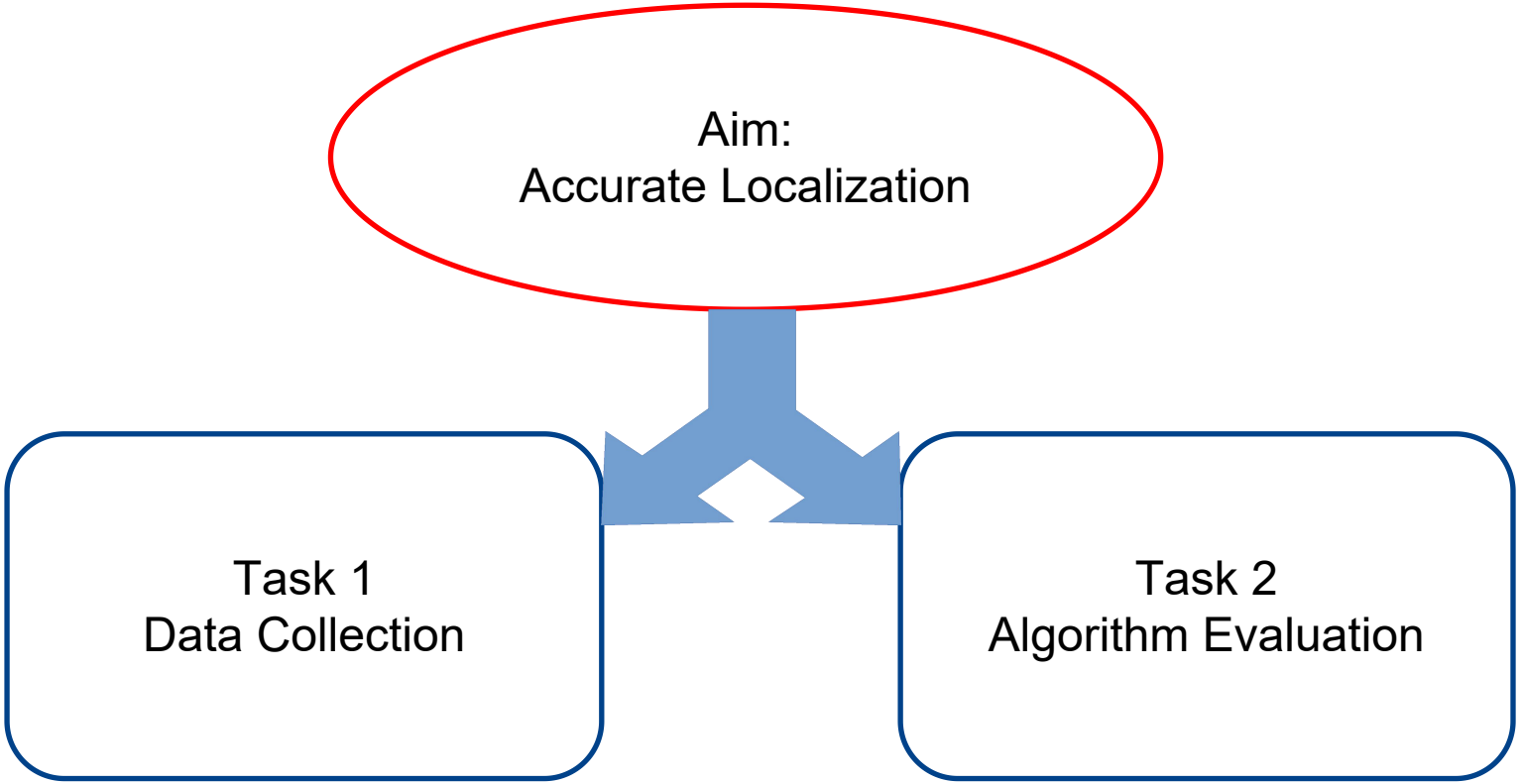
Motivation


Aim:
Accurate Localization
Task 1
Data Collection
Task 2
Algorithm Evaluation

Motivation

- **GPS**
  - \- Outdoor
- **Utral-Sound**
  - \+ Indoor
  - \- Multipath(NLOS)
- **UWB**
  - \+ Indoor
  - \+ Penetrating through((NLOS))
  - \+ High bandwidth

Motivation - algorithm development

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- more robust: random noise, multipath, system error, data missing
- less information needed: nodes positions

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- ***Scope of Work***
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Scope of Work

- **Hardware Improvement**

- 1, sampling rate
- 2, date obtained rate

- **Algorithm Development**

- 1, EKF
- 2, EKF seperation form
- 3, self-calibration localization

Scope of Work

- ***Hardware Improvement***
  - ***1, sampling rate***
  - ***2, date obtained rate***

- **Algorithm Development**
  - 1, EKF
  - 2, EKF seperation form
  - 3, self-calibration localization

Scope of Work - Hardware Improvement

improvement achieved by

- ***loop end condition added***
- Energy mode changed
- mutex(mutual exclusion) added

Scope of Work - Hardware Improvement

loop end condition added

- before
- only RTC

- after
- RTC
- **boolean** to detect the tasks accomplishment

Scope of Work - Hardware Improvement

improvement achieved by

- loop end condition added
- ***Energy mode changed***
- mutex(mutual exclusion) added

Scope of Work - Hardware Improvement

Energy mode changed

before

- EM3 (Energy Mode)

after

- EM2 (Energy Mode)

	EM3	EM2
low-frequency oscillator	off	on
RTC	off	on
WDOG	off	on
consumption	0.5 µA	0.9 µA

Scope of Work - Hardware Improvement

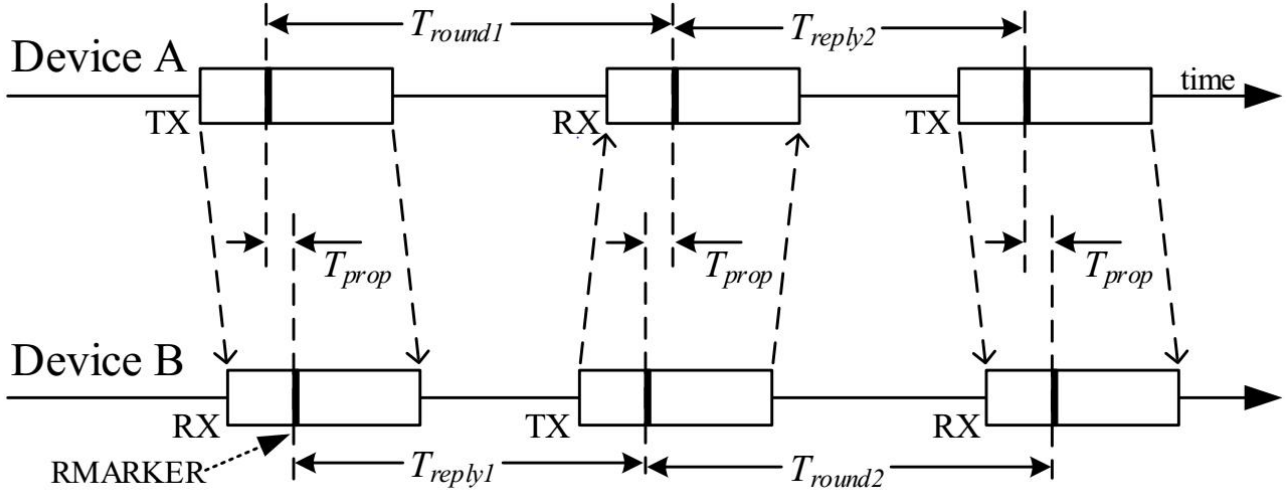
improvement achieved by

- loop end condition added
- Energy mode changed
- ***mutex(mutual exclusion) added***

Scope of Work - Hardware Improvement

mutex(mutual exclusion) added

- lDouble Sided Two Way Ranging



[1]

Scope of Work - Hardware Improvement

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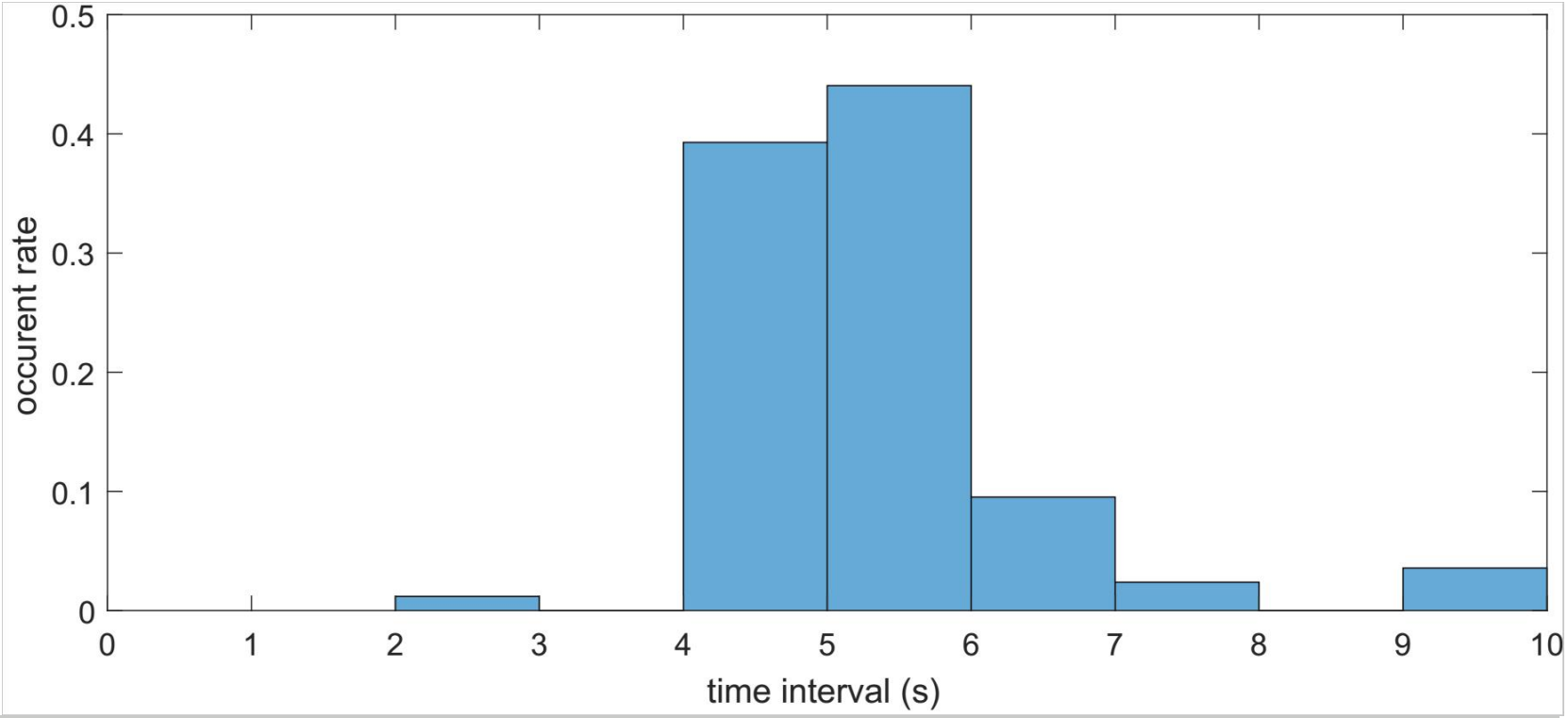
mutex(mutual exclusion) added

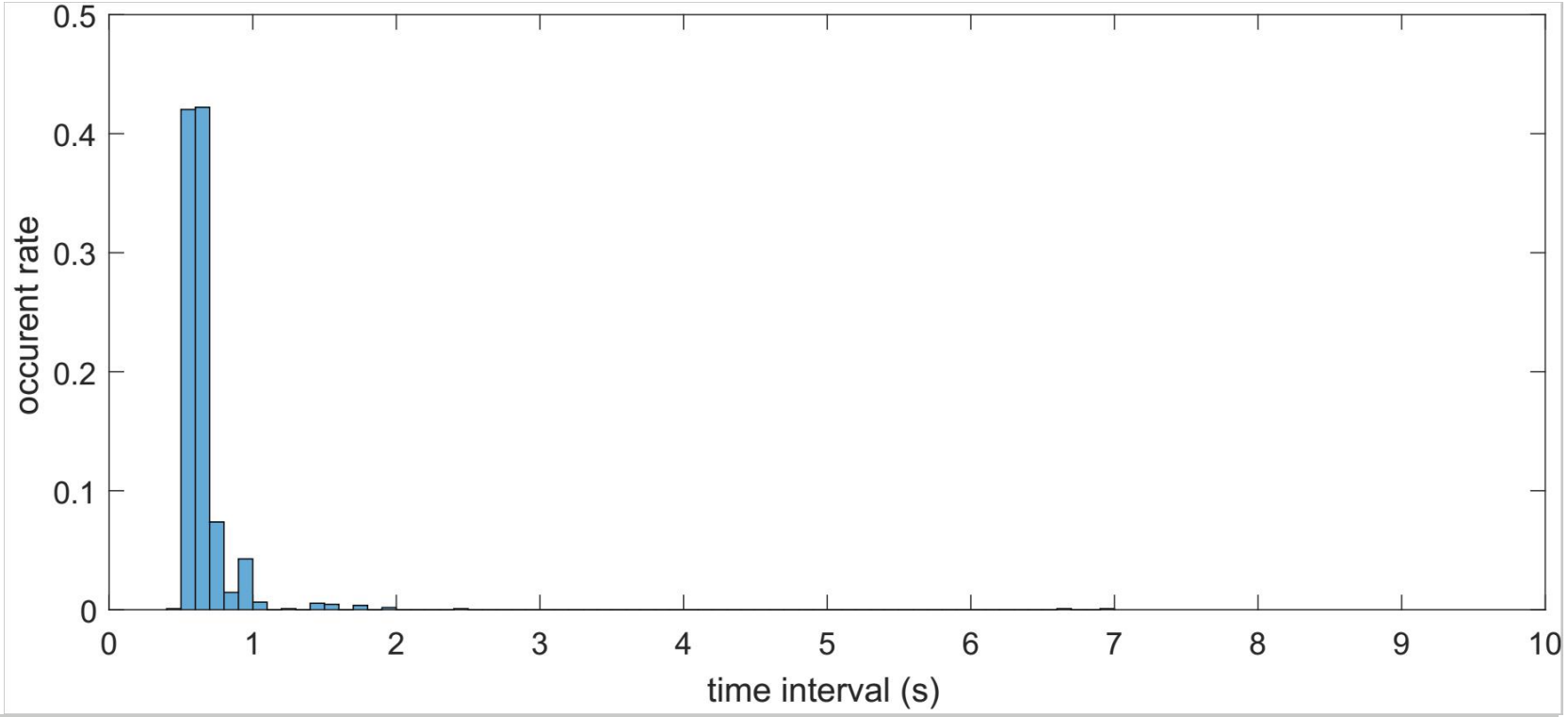
Scope of Work - Hardware Improvement - sampling rate

time interval of each sampling cycle (before)
mean: 5.2s 0.2Hz



Scope of Work - Hardware Improvement - sampling rate

time interval of each sampling cycle (after)
mean: 0.7s 1.5Hz



Scope of Work - Hardware Improvement - date obtained rate

Due to error, scattering, blocking, measurement data missed

Each measurements set contains

ideal case: 5 measurements data

realistically : 5, 4, 3, 2, 1, 0 happens

Scope of Work - Hardware Improvement - date obtained rate

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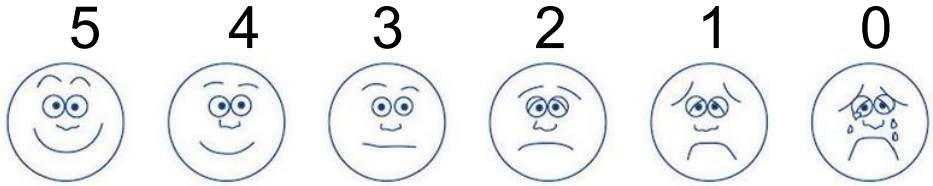
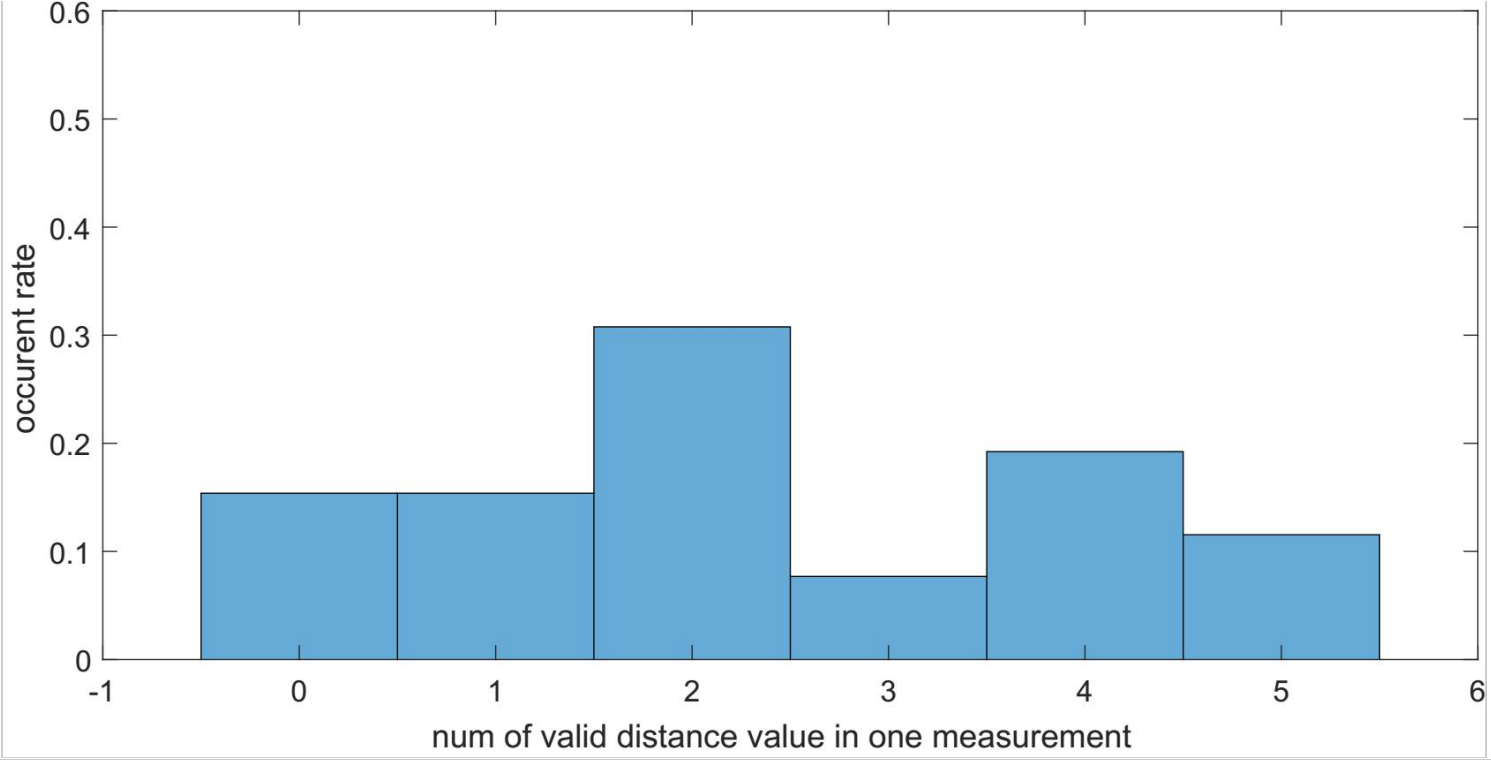


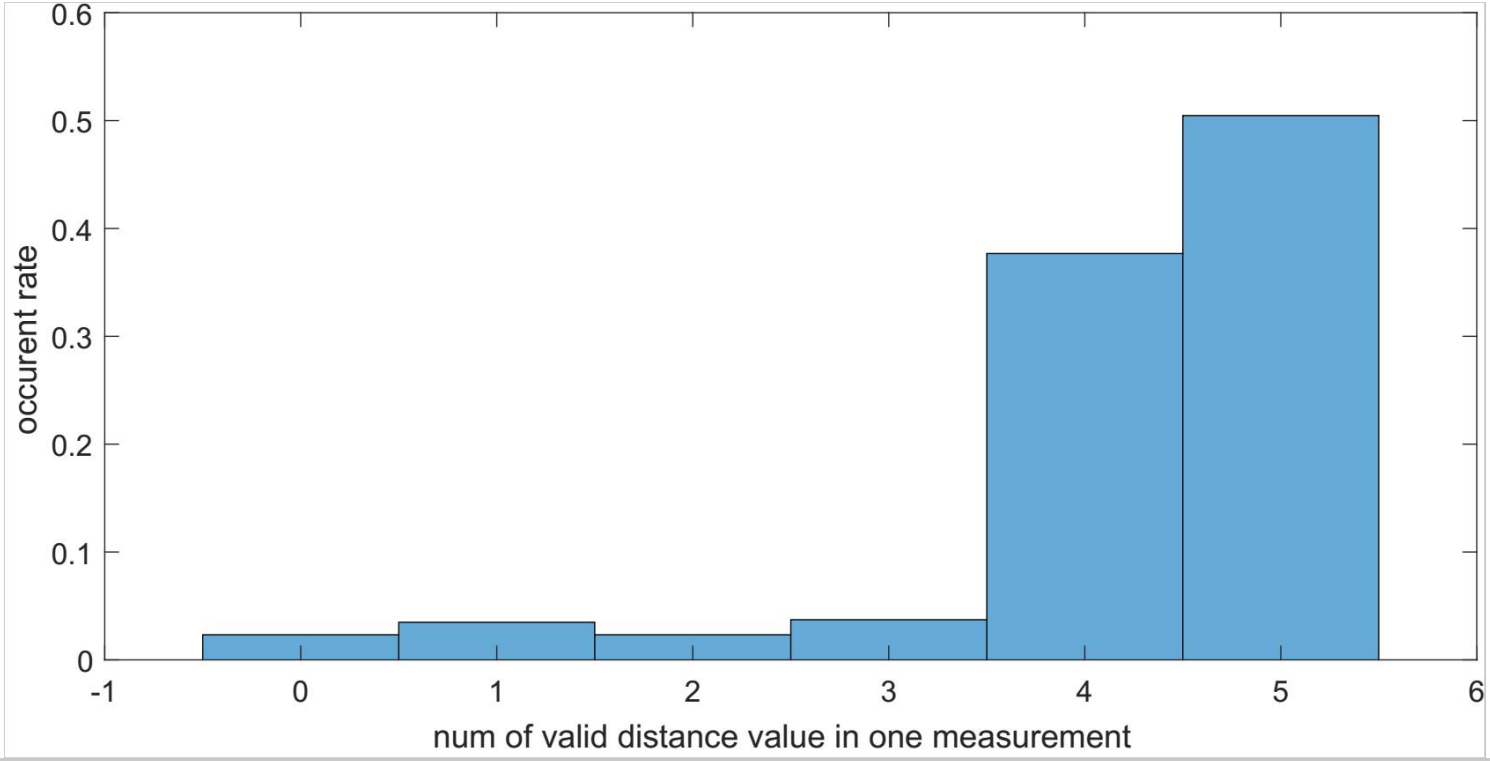
Scope of Work - Hardware Improvement - date obtained rate

date obtained rate comparision (before)



Scope of Work - Hardware Improvement - sampling rate

date obtained rate comparision (after)



Scope of Work - Algorithm Development

- Algorithm Development

- 1, ***EKF***
- 2, EKF seperation form
- 3, self-calib

Scope of Work - Algorithm Development - EKF

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- state vactor $\mathbf{x} = [p_x, p_y, \dot{p}_x, \dot{p}_y]^T$
- state transition model $\mathbf{x}_k = f(\mathbf{x}_{k-1}, \mathbf{u}_k) + \mathbf{w}_k$
- observation model $\mathbf{z}_k = h(\mathbf{x}_k) + \mathbf{v}_k$

Scope of Work - Algorithm Development

state transition model

$$\mathbf{x}_k = f(\mathbf{x}_{k-1}, \mathbf{u}_k) + \mathbf{G} * \mathbf{w}_k$$

$$= \begin{bmatrix} 1 & 0 & dt & 0 \\ 0 & 1 & 0 & dt \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} * \mathbf{x}_{k-1} + \begin{bmatrix} \frac{1}{2} \cdot dt^2 & 0 \\ 0 & \frac{1}{2} \cdot dt^2 \\ dt & 0 \\ 0 & dt \end{bmatrix} * \begin{bmatrix} \ddot{p}_x \\ \ddot{p}_y \end{bmatrix}$$

Scope of Work - Algorithm Development

observation model

$$\begin{aligned}\mathbf{z}_k &= h(\mathbf{x}_k) + \mathbf{v}_k \\ &= \mathbf{H}\mathbf{x}_k + \mathbf{v}_k\end{aligned}$$

$$\mathbf{H} = \left.\frac{\partial h}{\partial \mathbf{x}}\right|_{\mathbf{x}_k} = \begin{bmatrix} \frac{p_x - n_{1x}}{\sqrt{(n_{1x}-p_x)^2+(n_{1y}-p_y)^2}} & \frac{p_y - n_{1y}}{\sqrt{(n_{1x}-p_x)^2+(n_{1y}-p_y)^2}} & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots \\ \frac{p_x - n_{ix}}{\sqrt{(n_{ix}-p_x)^2+(n_{iy}-p_y)^2}} & \frac{p_y - n_{iy}}{\sqrt{(n_{ix}-p_x)^2+(n_{iy}-p_y)^2}} & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots \end{bmatrix}$$

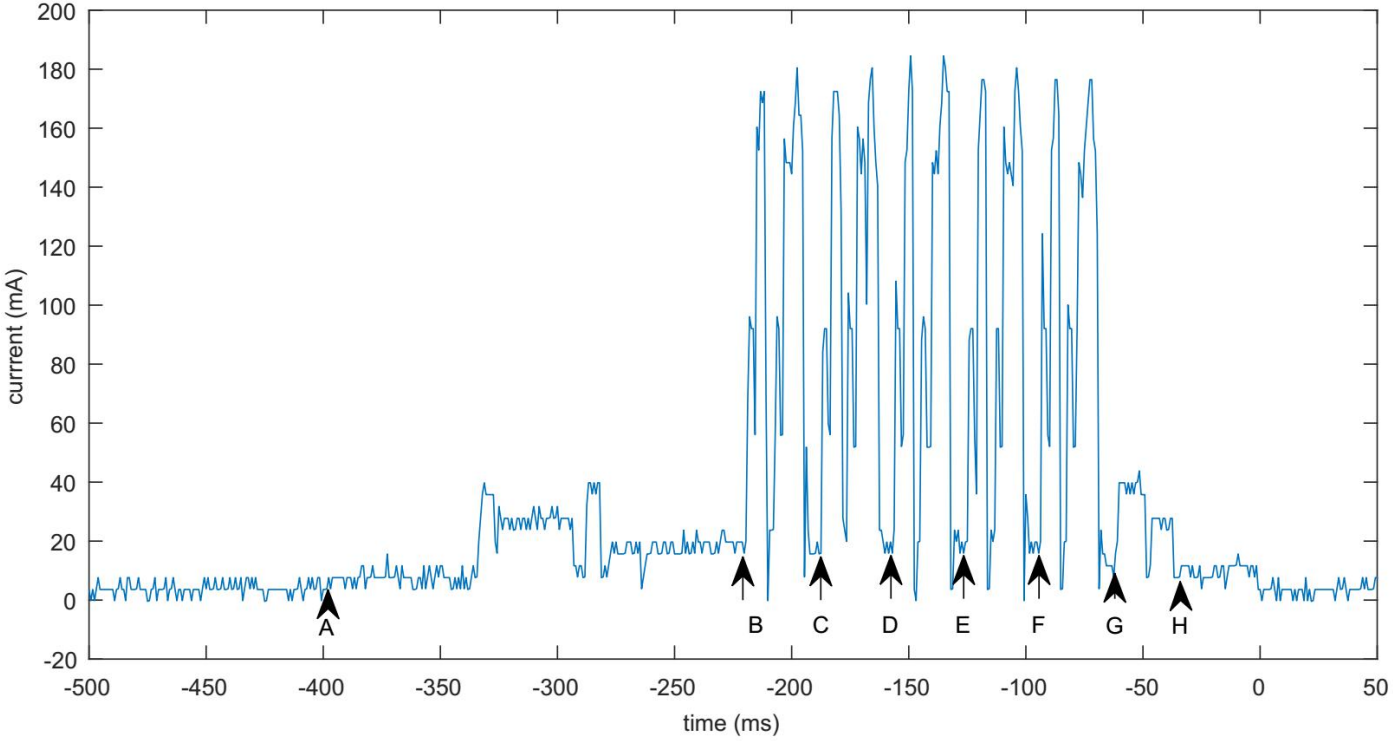
Scope of Work - Algorithm Development

- Algorithm Development

- 1, EKF
- ***2, EKF seperation form***
- 3, self-calib

Scope of Work - Algorithm Development

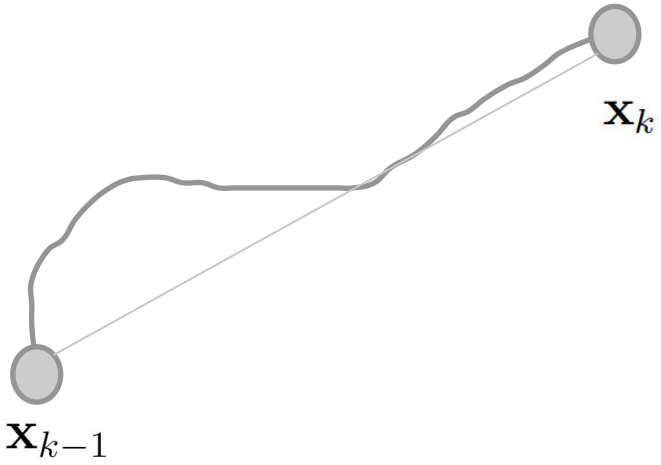
sampling cycle of mobile tag (with 5 anchor nodes)



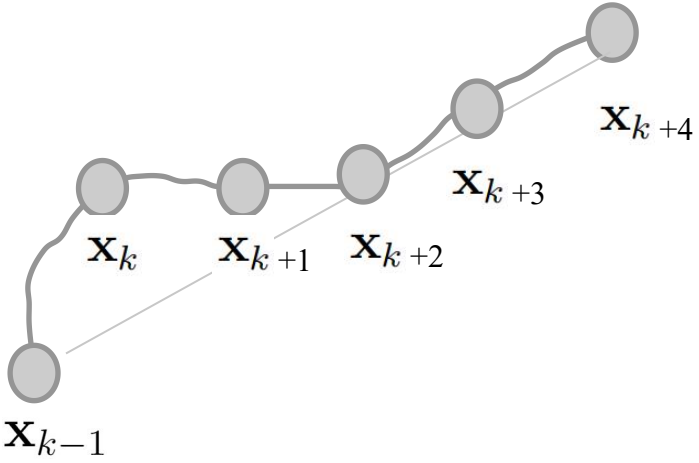
Scope of Work - Algorithm Development

update using one measurements set (contains 5 measurements)

normal EKF



EKF seperation form



Scope of Work - Algorithm Development - self-calibration

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- localize the nodes and tag simultaneous
- allow the absent of the positions of the node

Scope of Work - Algorithm Development - self-calibration

unknow: n anchor nodes

$$N = (n_{1x}, n_{1y}, n_{2x}, n_{2y} \ldots n_{nx}, n_{ny})$$

m samples from tag's trajectory

$$M = (m_{1x}, m_{1y}, m_{2x}, m_{2y} \ldots m_{mx}, m_{my})$$

in total $2*(m+n)$ variables

known: $m*n$ distace values

equation system can be solved when $2*(m+n) \leq m*n$

Scope of Work - Algorithm Development - self-calibration

- optimization method (Levenberg-Marquardt algorithm)

$$\arg\min \sum_{i=1}^{n} \sum_{j=1}^{m} (f_{ij})^2$$

$$f_{ij} = \left\| n_i - m_j \right\| - d_{ij}$$

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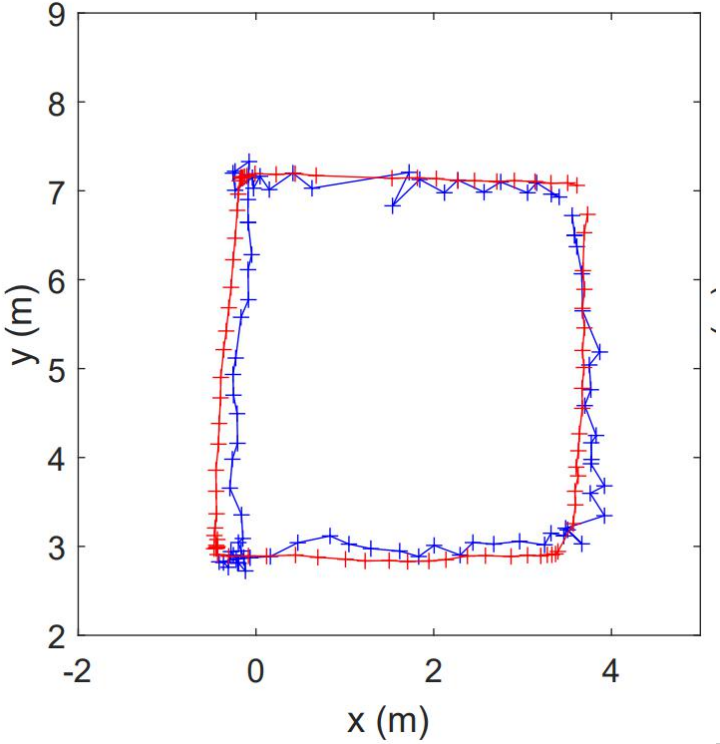
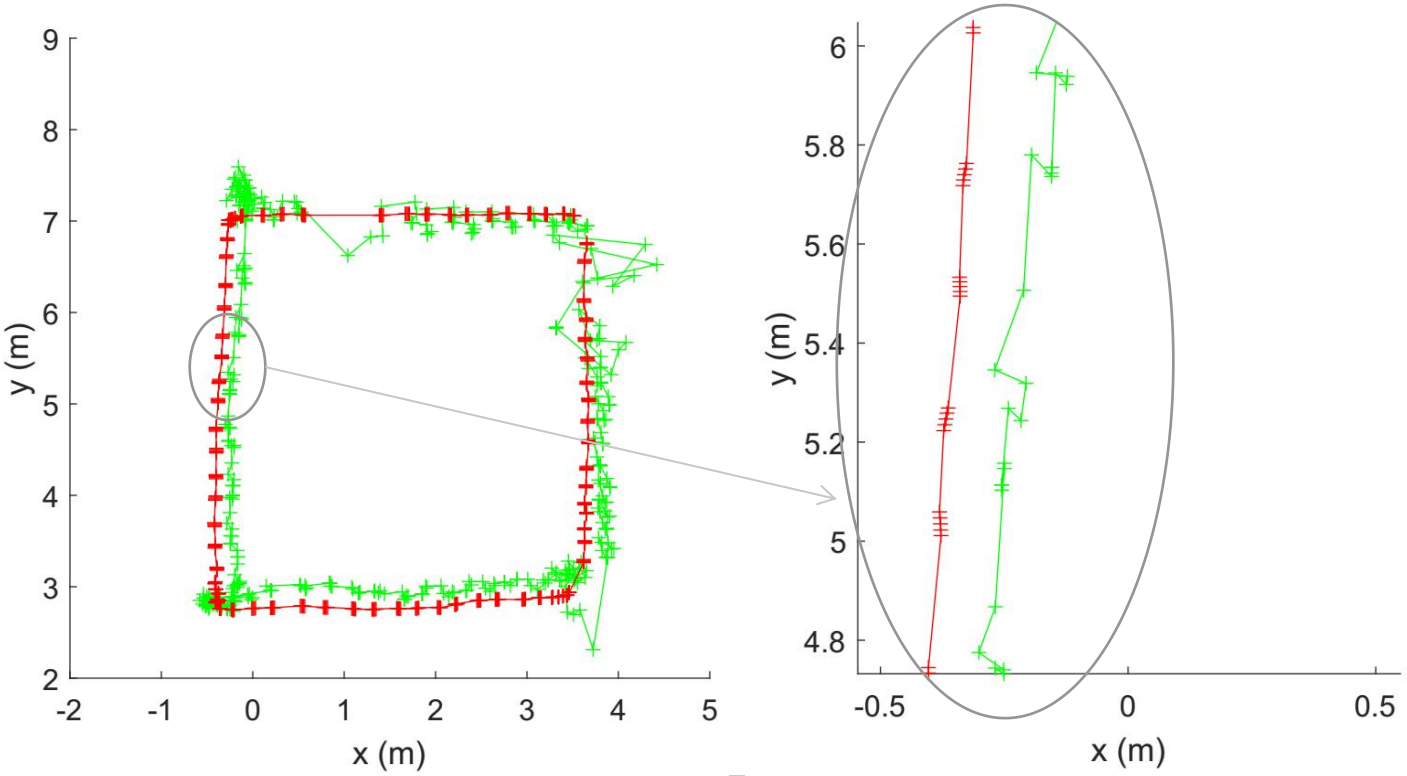
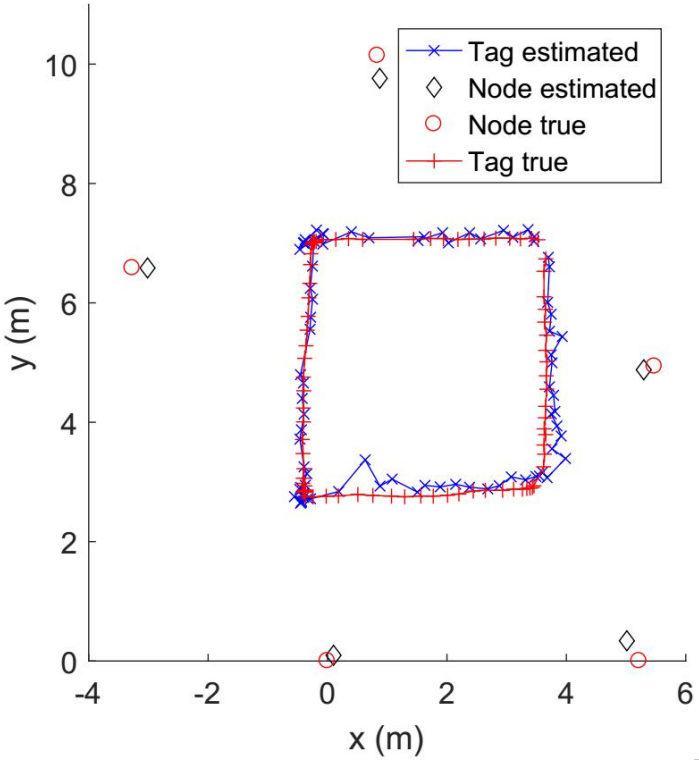
Result - EKF



Result - EKF seperation form

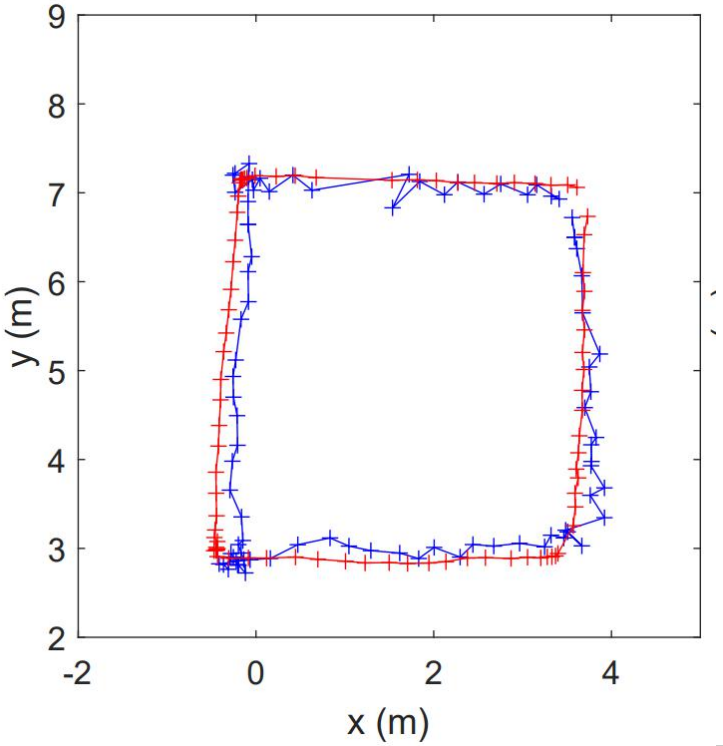


Result - self-calibration

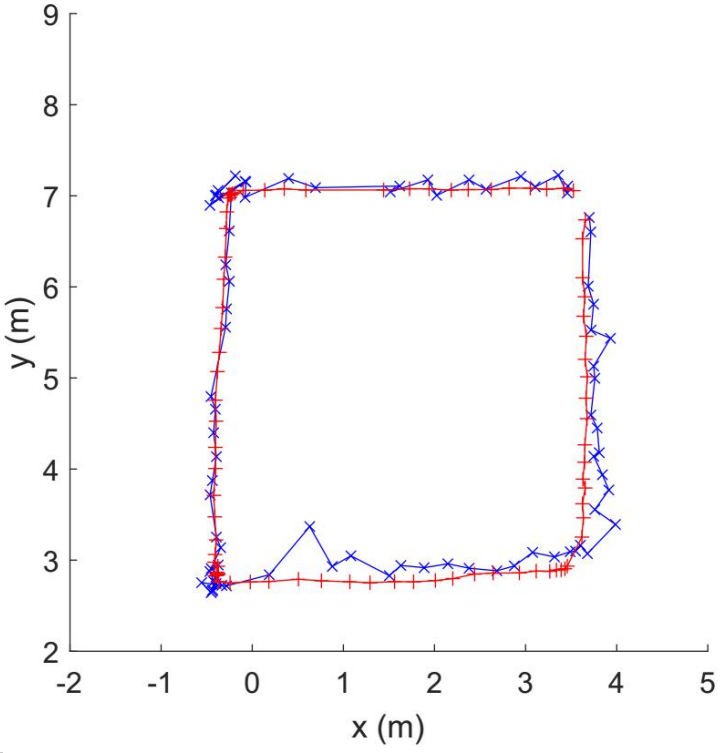


Result - comparision

EKF



self-calibration



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Conclusion

- Hardware: sampling rate increased

  data obtained rate increased

- Algorithm: 3 algorithms built

  recover trajectory succeed

The End

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- **Thank you for your attention!**

needed to be done PPT

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- 页尾》 时间。标题
- rename EKF seperation form

请在此处添加标题

sdadsa	asda	asd
• a	• a	• a

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Outline

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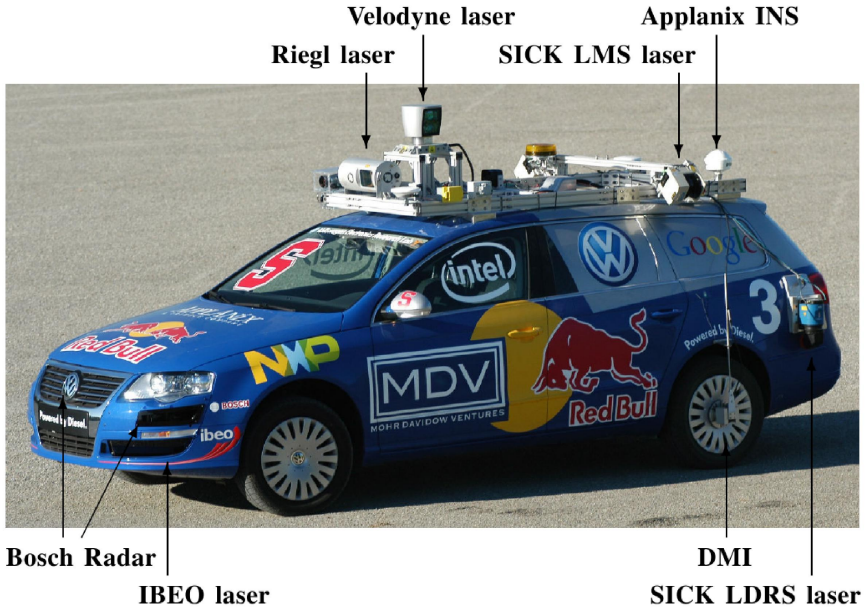
- Motivation
- ***Approach***
- Result
- Path Planning
- Conclusion



g. 2. Stanford Racing Team's robotic vehicle, Junior. The results presented this work were obtained using the Applanix GPS+IMU system and the lodyne 3D LIDAR.

Conclusion

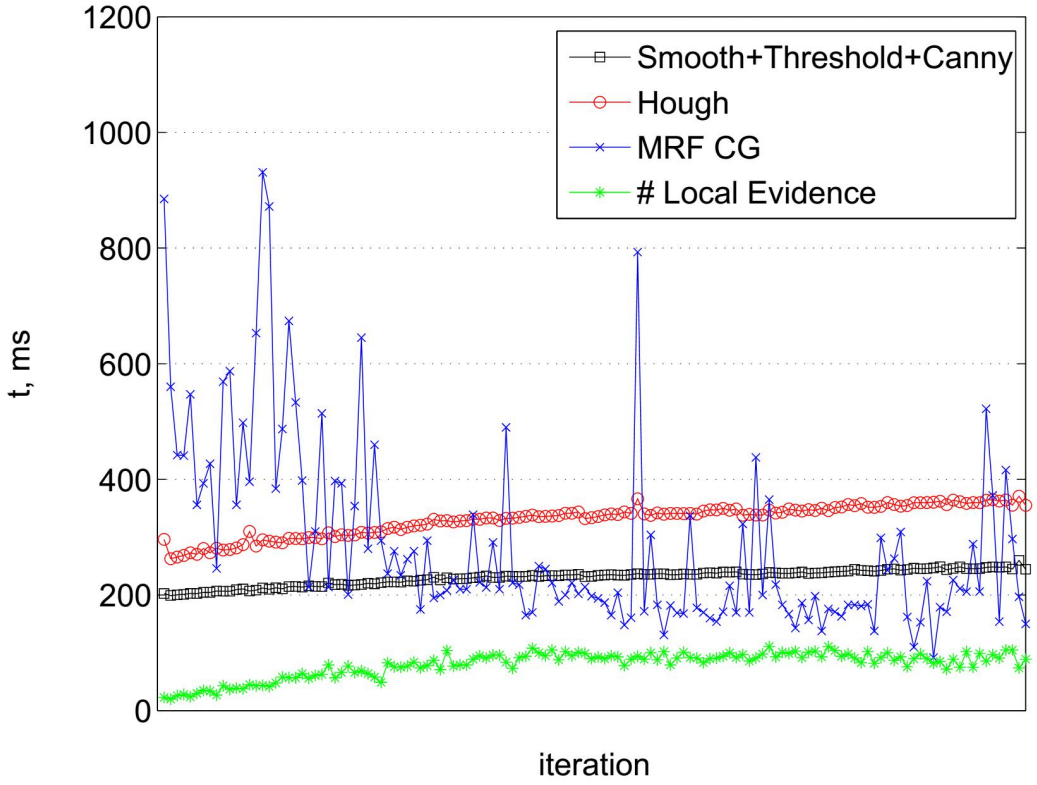
- current and future work:

  Combination of

  - obstacle data with visual camera data
  - surface-reflectivity data from LIDARs for detecting

  to recognize more advanced features in unknown environments and their use in path planning.

WHAT IS LIDAR SENSOR


1200
1000
800
600
400
200
0
t, ms
iteration
Smooth+Threshold+Canny
Hough
MRF CG
Local Evidence