# Improving Position Accuracy Using GPS-ML Method

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# CONCENTS

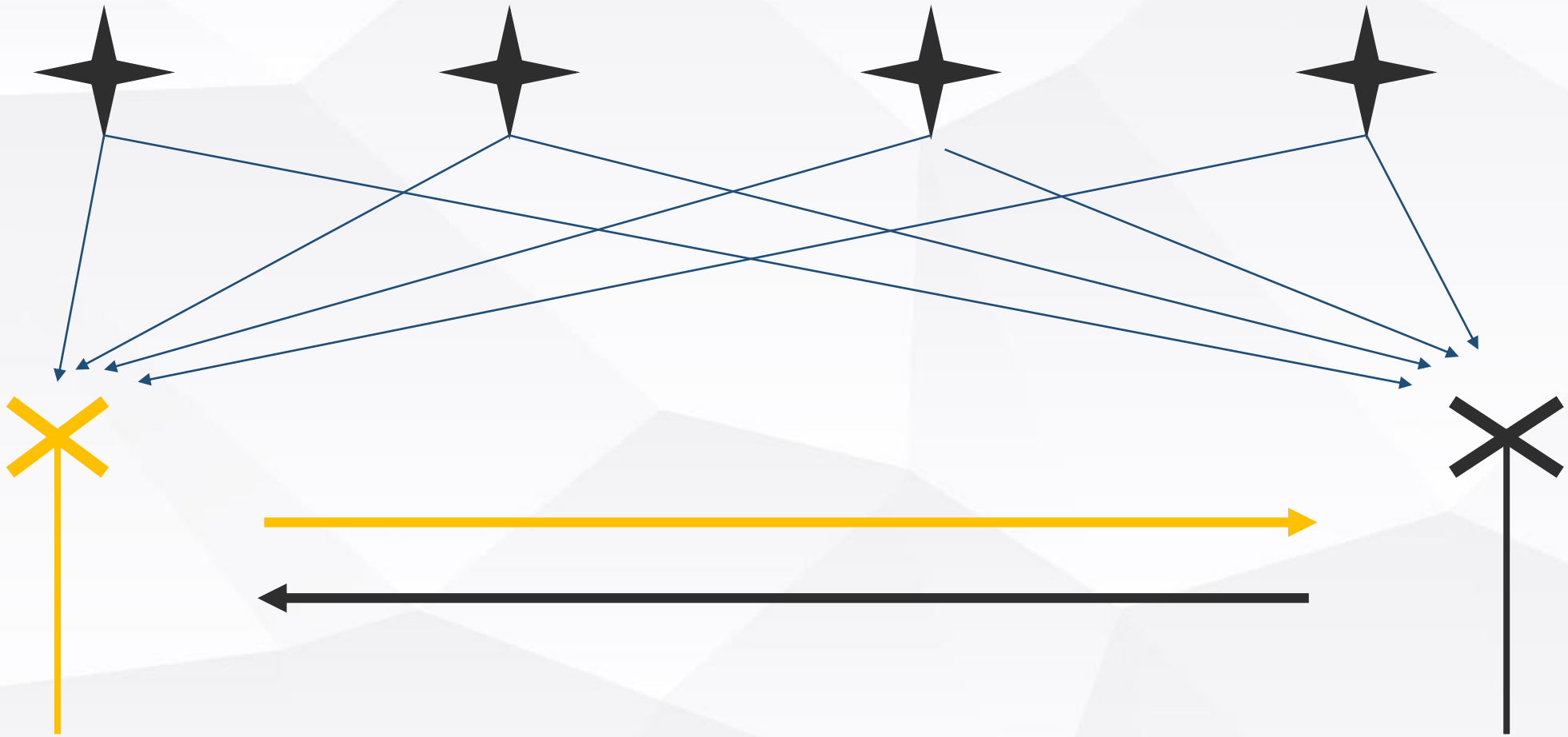
# PART 1

# Background

# 1.1 —— High Accuracy GPS

DRTK =GPS+GLONASS
or GPS+北斗
Centimeter level accuracy
Complex hardware
Low temporal resolution

# 1.2 —— What is RTK



PART 2

# Paper Review

# 2 —— Paper Review

## Improving positioning accuracy of vehicular navigation system during GPS outages utilizing ensemble learning algorithm

Jing Li*, Ningfang Song, Gongliu Yang, Ming Li, Qingzhong Cai

*School of Instrumentation Science and Opto-electronics Engineering, Beihang University, Beijing 100191, PR China*

IMU+GPS as standard

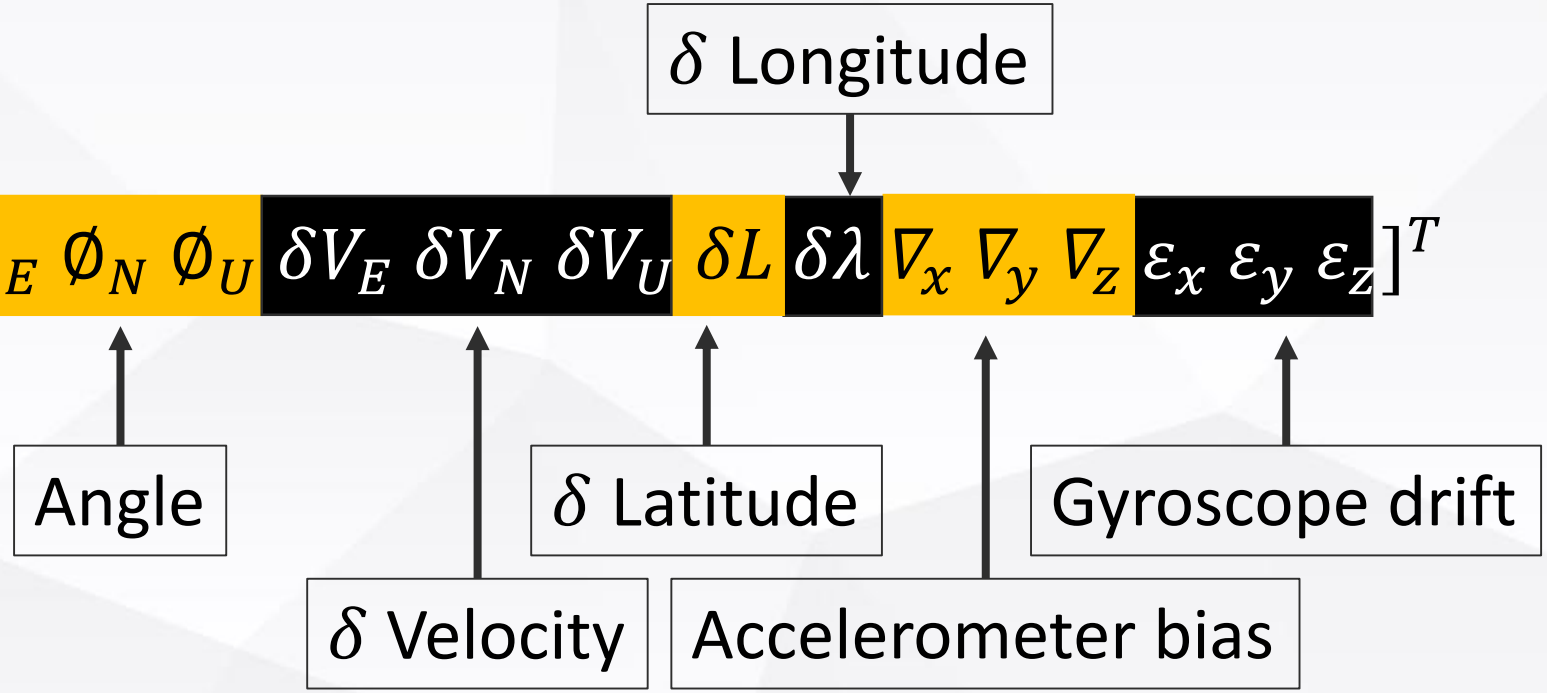
Training and Predicting

≈50% accuracy lifting

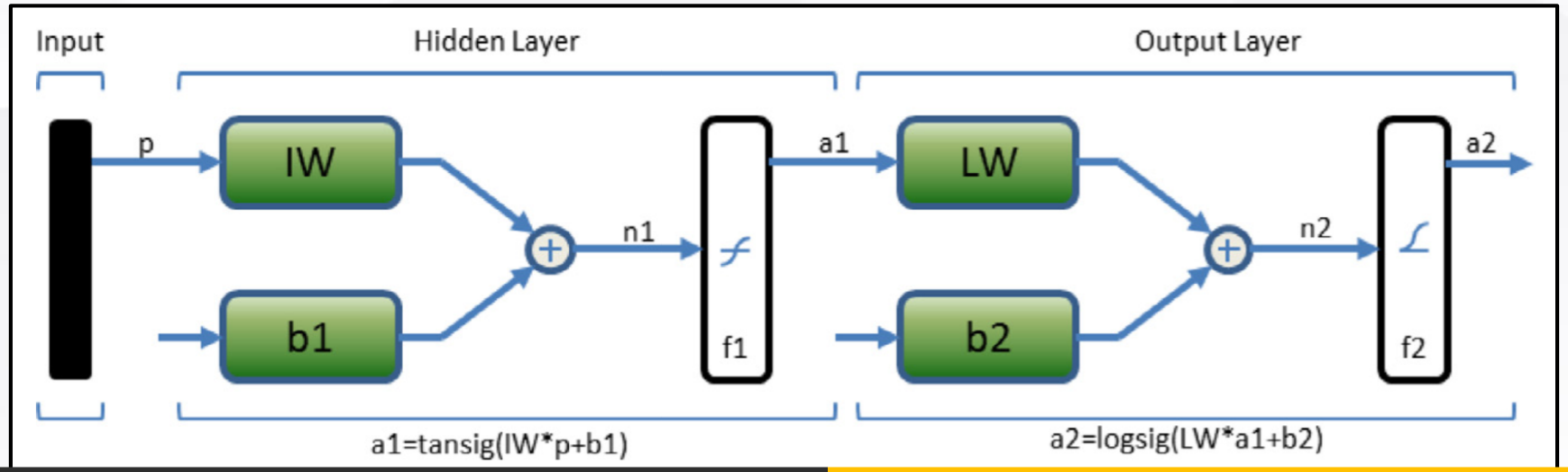

# 2.1 —— GPS+IMU Model

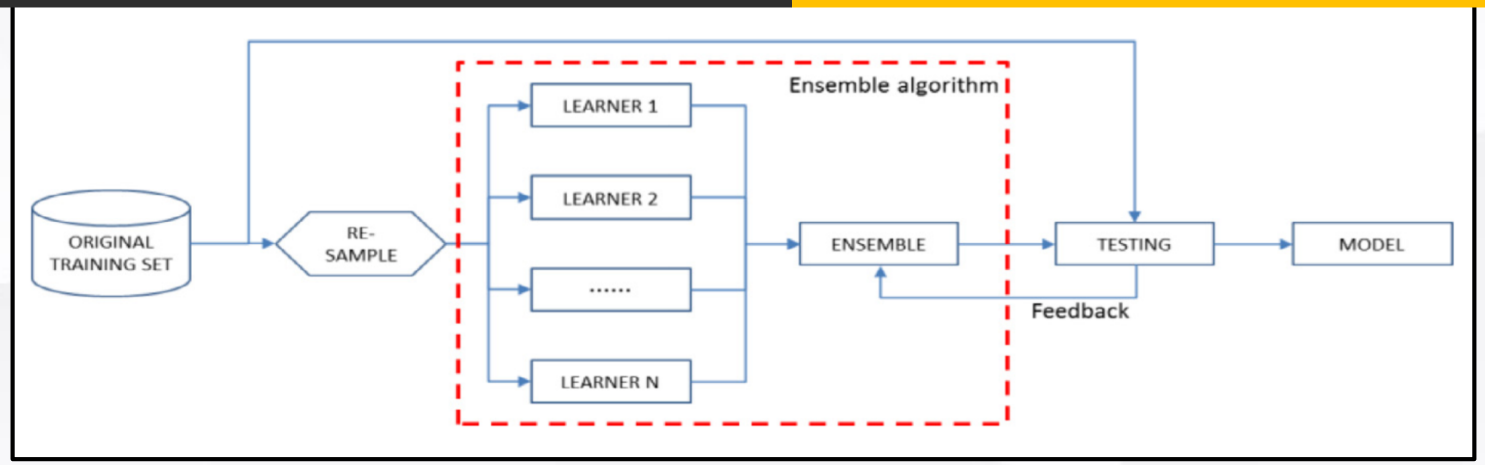
| GPS+IMU : | Classical<br>centimeter level accuracy depending on IMU |
|---|---|

State vector: $X(t) = [\emptyset_E\ \emptyset_N\ \emptyset_U\ \delta V_E\ \delta V_N\ \delta V_U\ \delta L\ \delta\lambda\ \nabla_x\ \nabla_y\ \nabla_z\ \varepsilon_x\ \varepsilon_y\ \varepsilon_z]^T$



# 2.2 —— MLP and Ensemble Learning



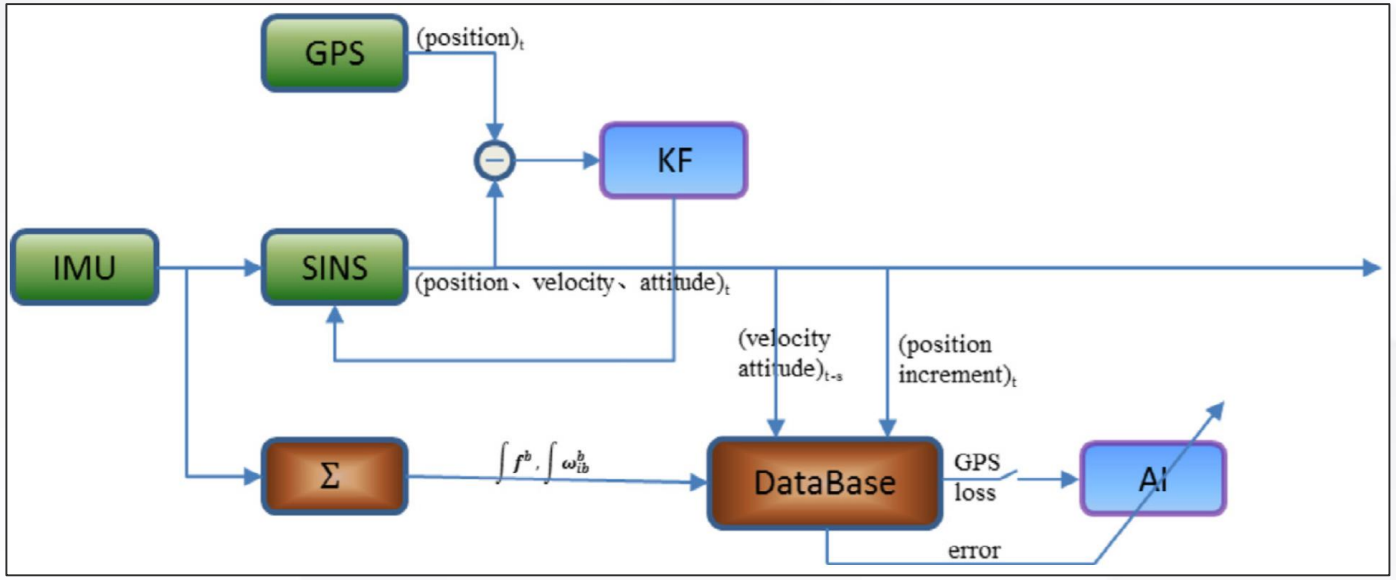
# 2.3 —— Training & Predicting

Input:

$$\left[ve_{t-s}\ vn_{t-s}\ vu_{t-s}\ \gamma_{t-s}\ \theta_{t-s}\ \psi_{t-s}\ \sum_{t-s}^{t}\omega\ \sum_{t-s}^{t}f\right]$$

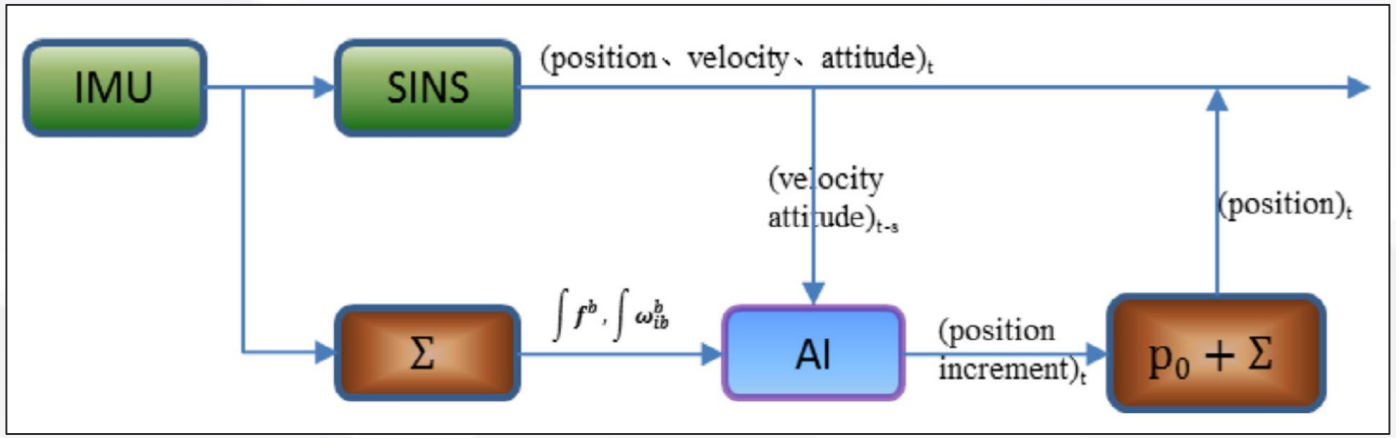
Output:

$$\Delta p_t = [\Delta pe_t\ \Delta pn_t]$$

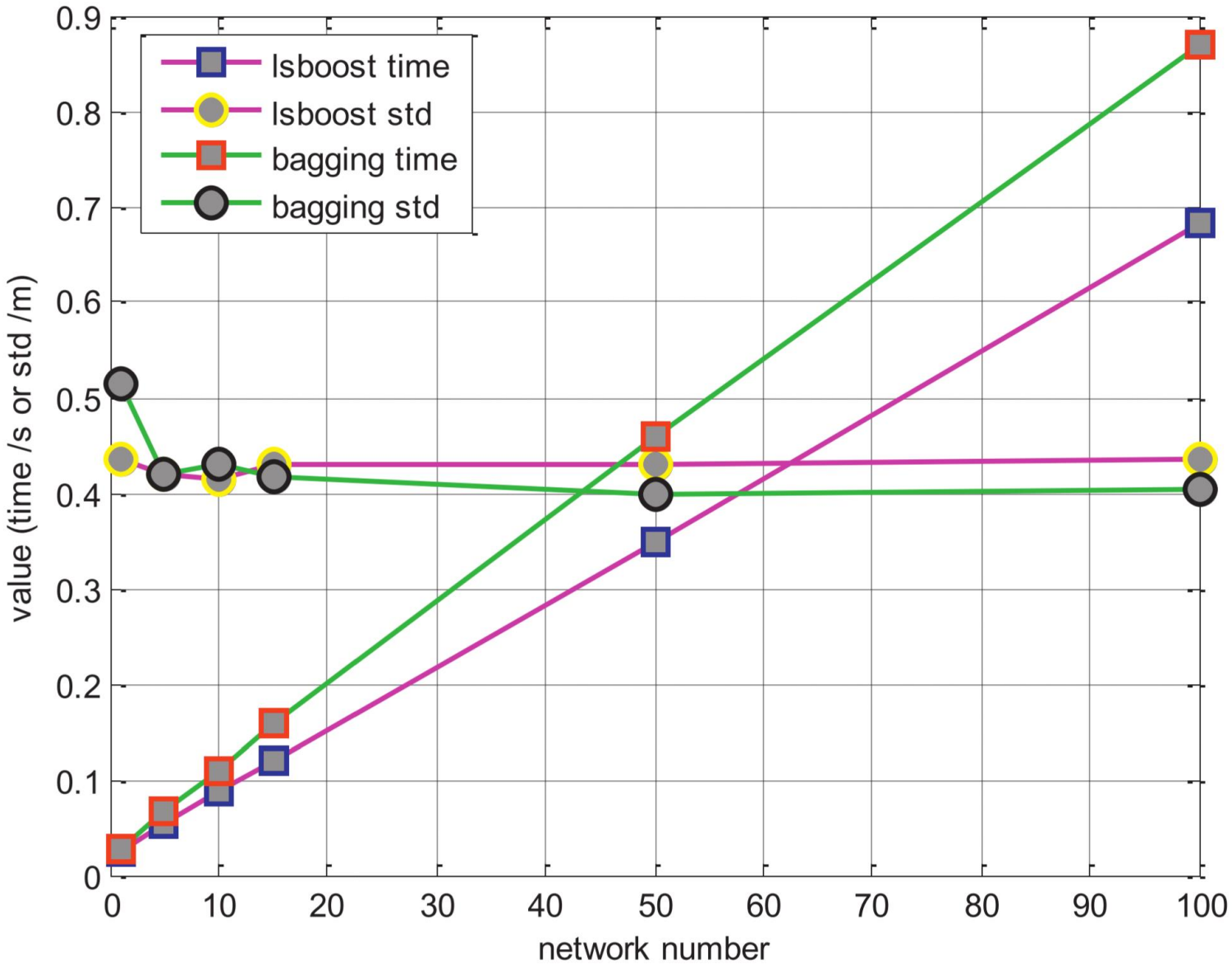



Predicting:

$$p(k) = p_0 + \sum_{i=0}^{k}\Delta p_i$$



# 2.4 —— Ensemble testing




500s training
400s predicting
Performance test

Balancing the network number & the training time

# 2.5 —— Results

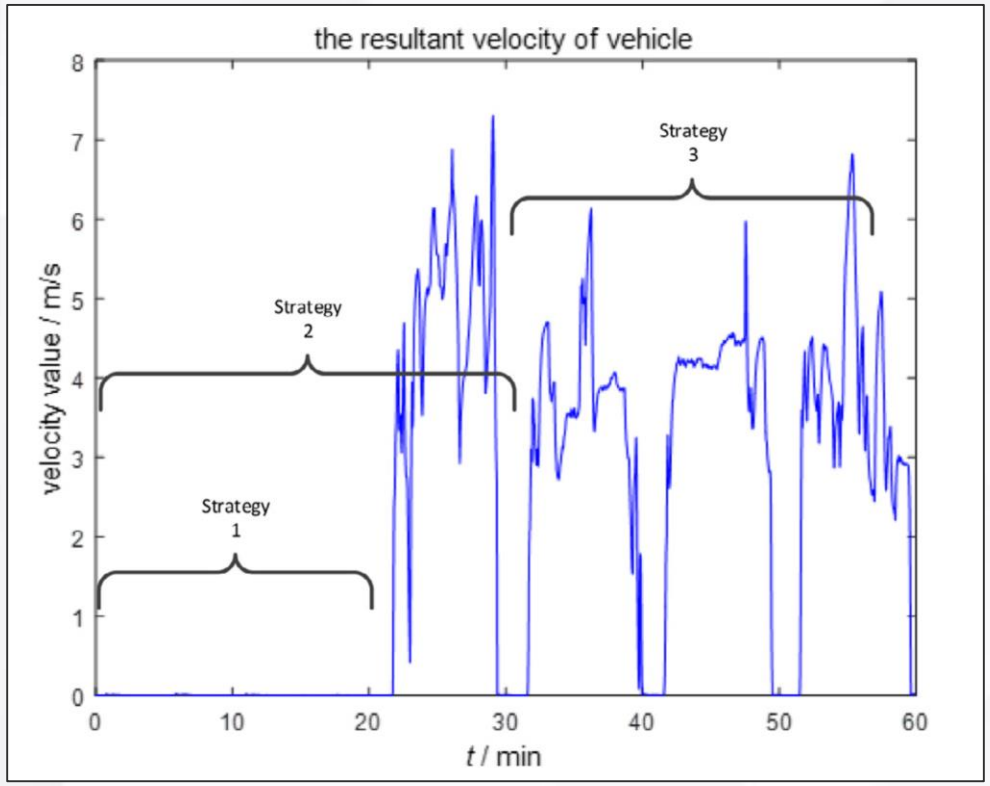
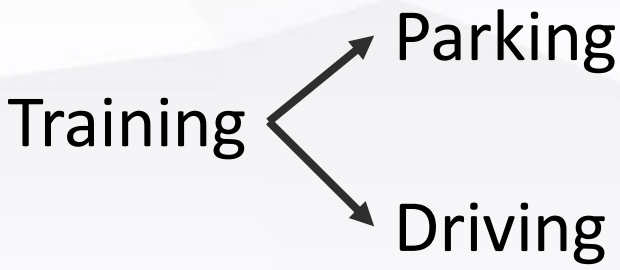
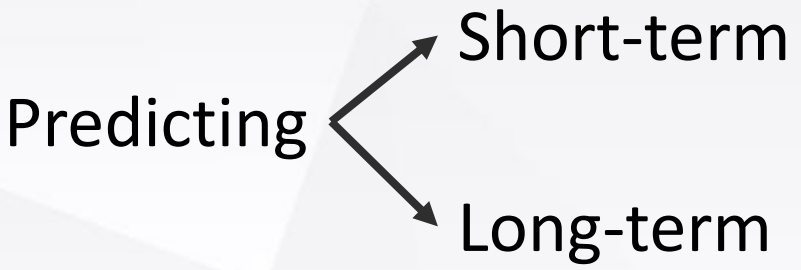


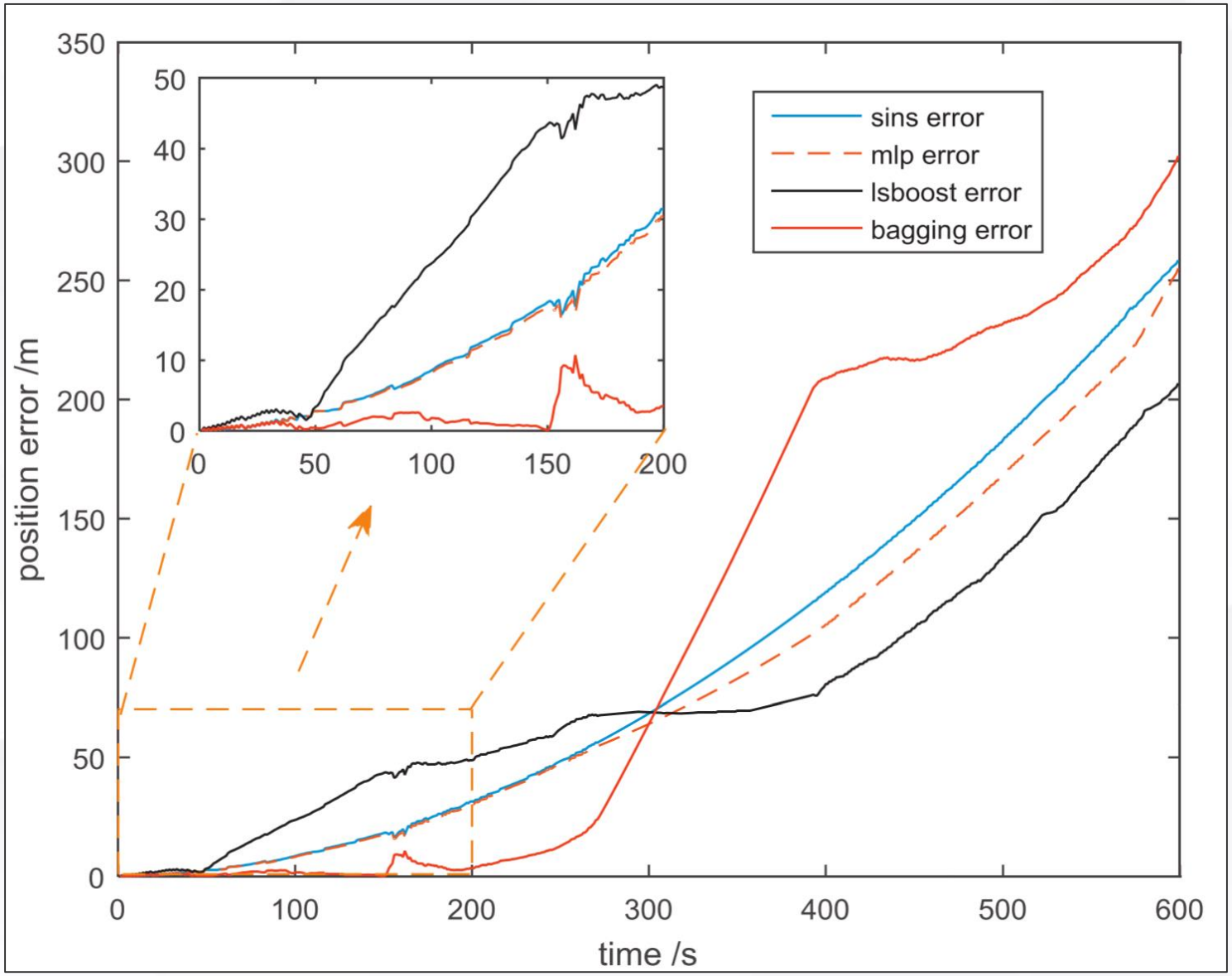

**Table 5**
Time allocation of different independent strategy.

| | Total time | GPS on (training time) | GPS loss (prediction time) |
|---|---|---|---|
| Strategy 1 | 0s-1200s | 0s-600s | 600s-1200s |
| Strategy 2 | 0s-1800s | 0s-1200s | 1200s-1800s |
| Strategy 3 | 1800s-3300s | 1800s-2700s | 2700s-3300s |



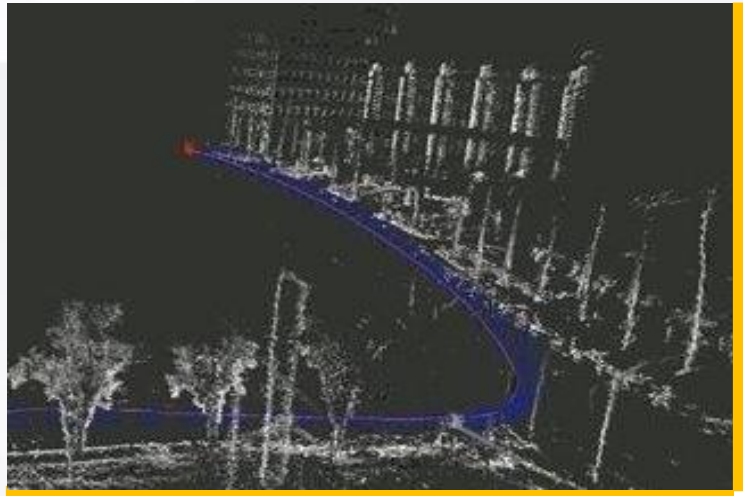
# 2.6 —— Results


sins error
mlp error
lsboost error
bagging error
position error /m
time /s
0
50
100
150
200
250
300
350
0
100
200
300
400
500
600
0
10
20
30
40
50
0
50
100
150
200

PART 3

# Discussion

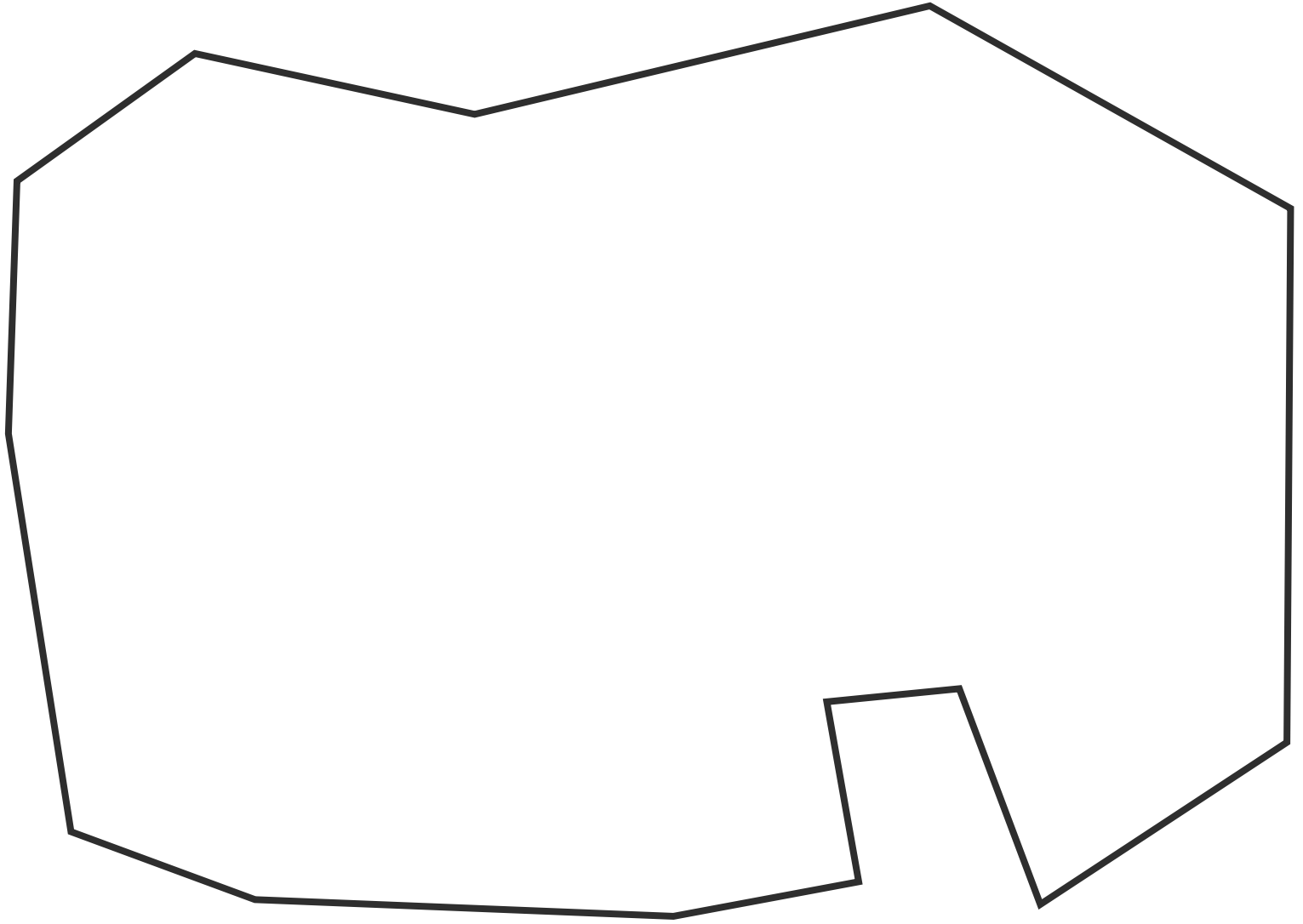
# 3 —— Project Structure



GPS + Map binding
Using machine
learning method

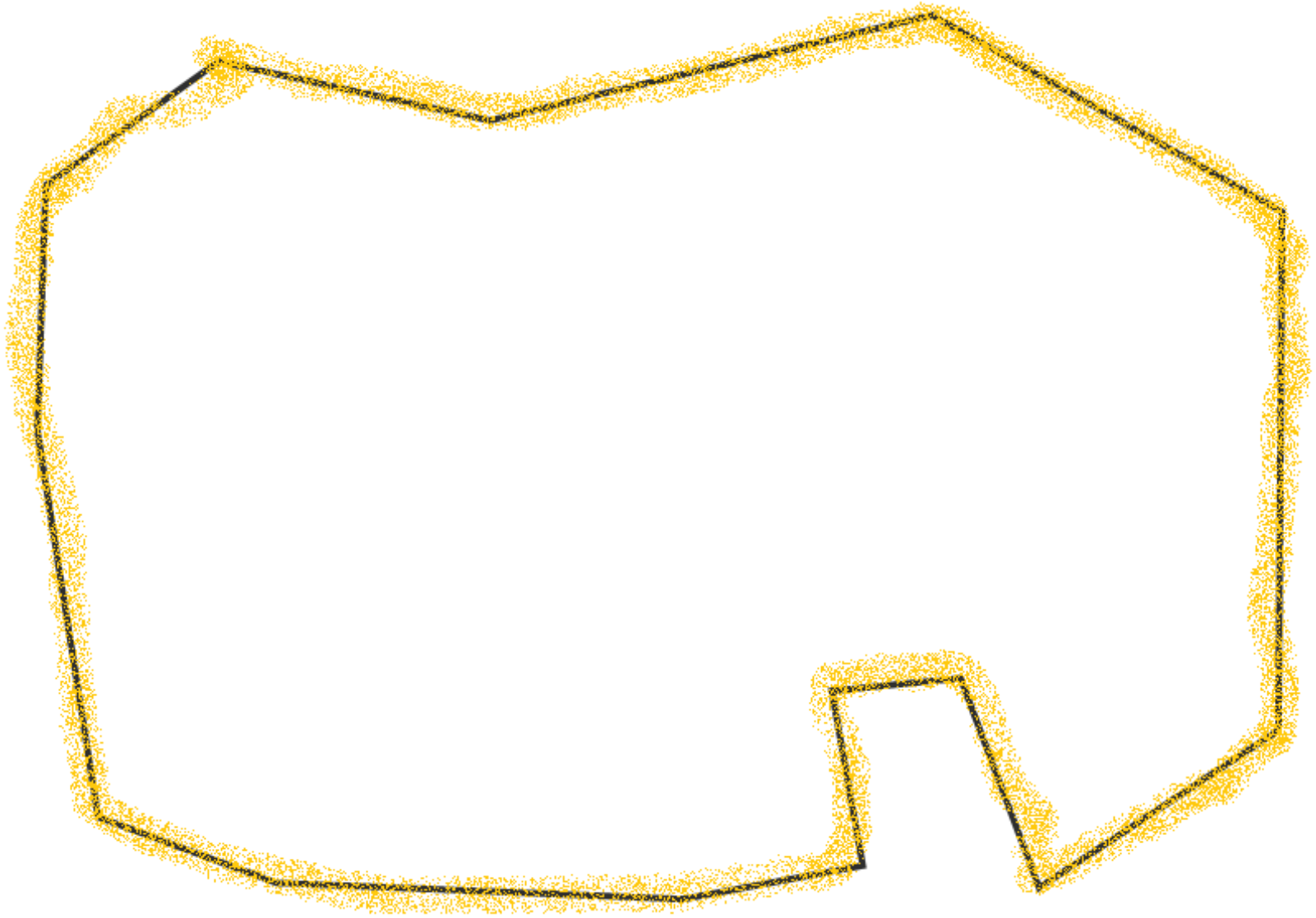
SLAM + Feature
Extraction
Compressing data &
Location matching

# 3 —— Discussion



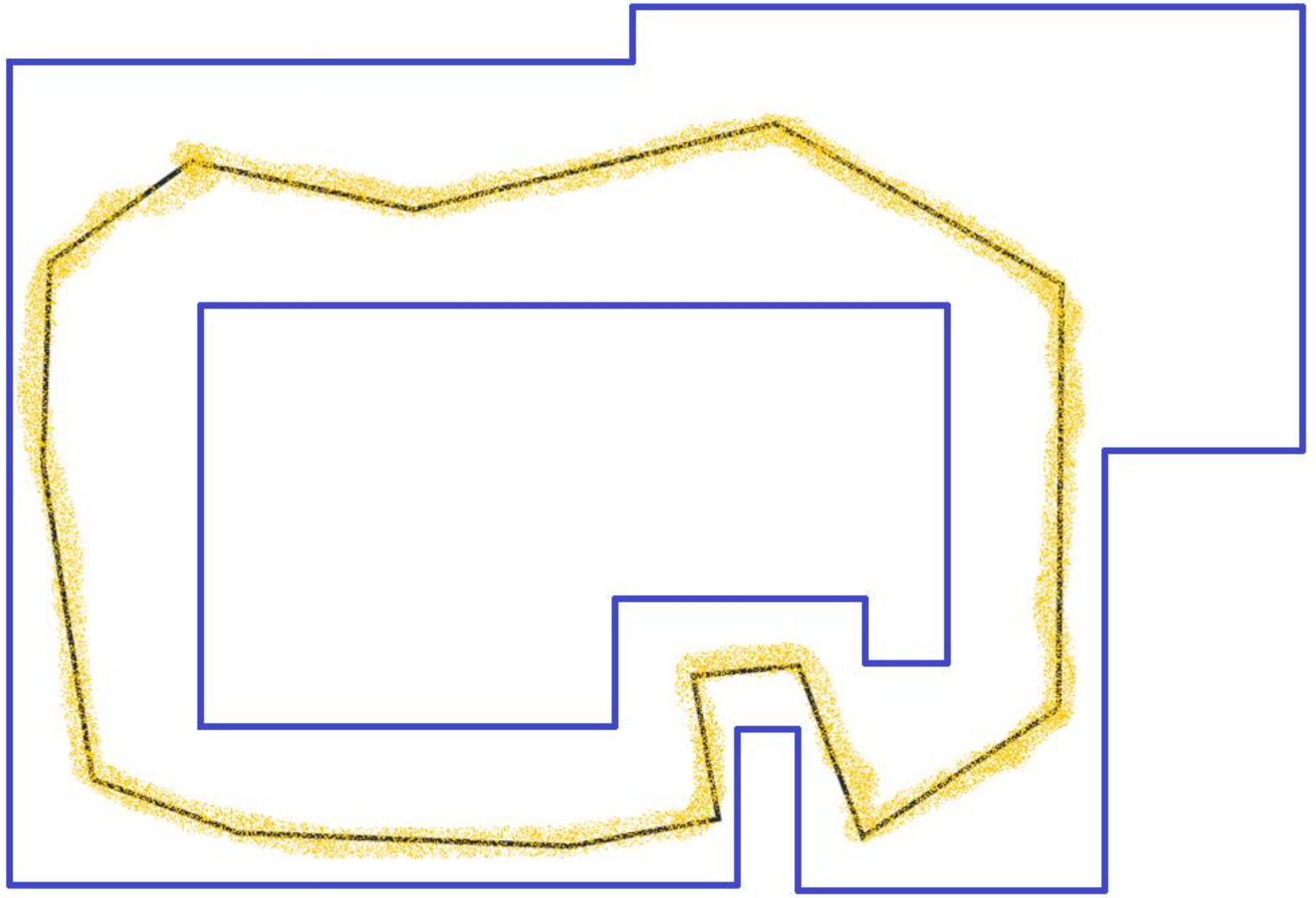
Route

# 3 —— Discussion



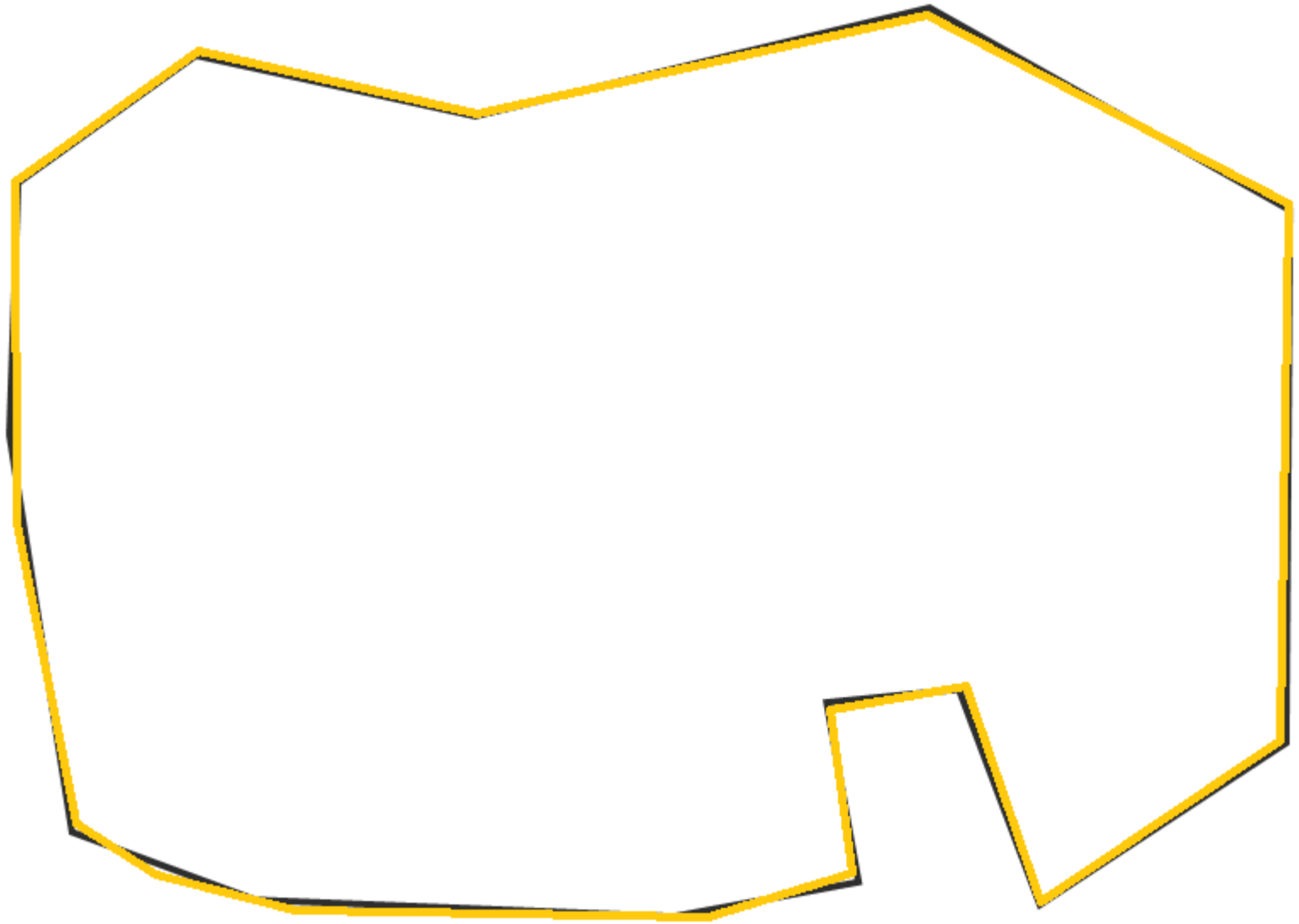
GPS

# 3 —— Discussion



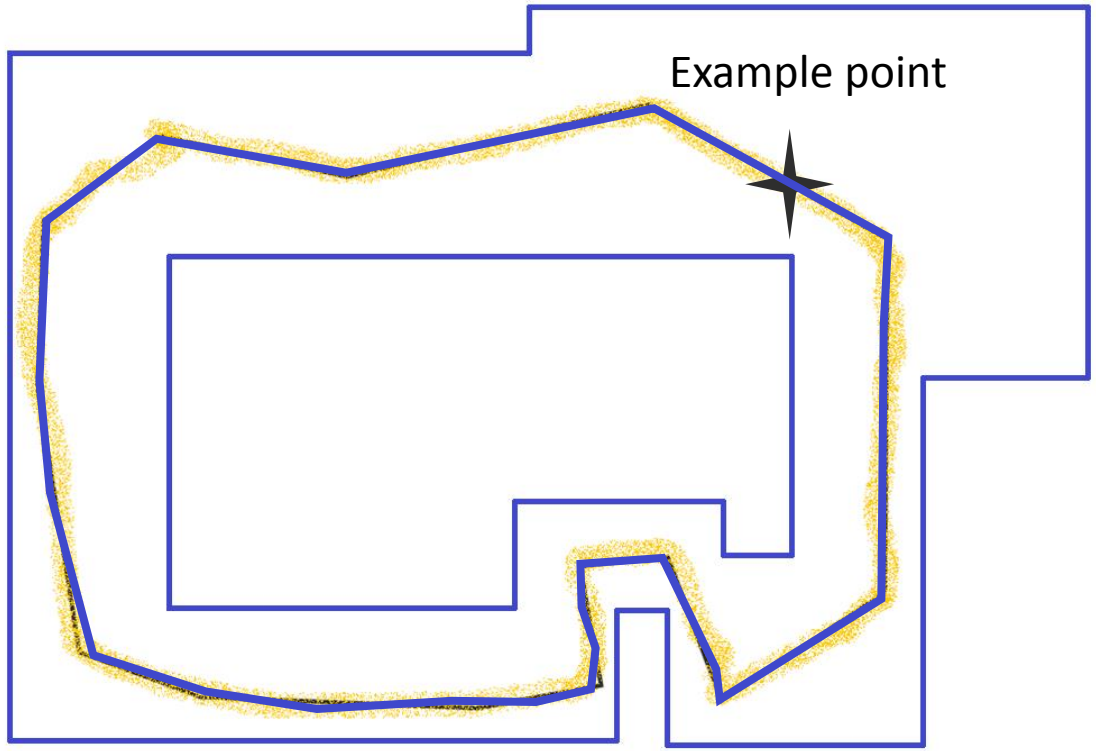
SLAM

# 3 —— Target



Centimeter level GPS

# 3 —— Roadmap 1



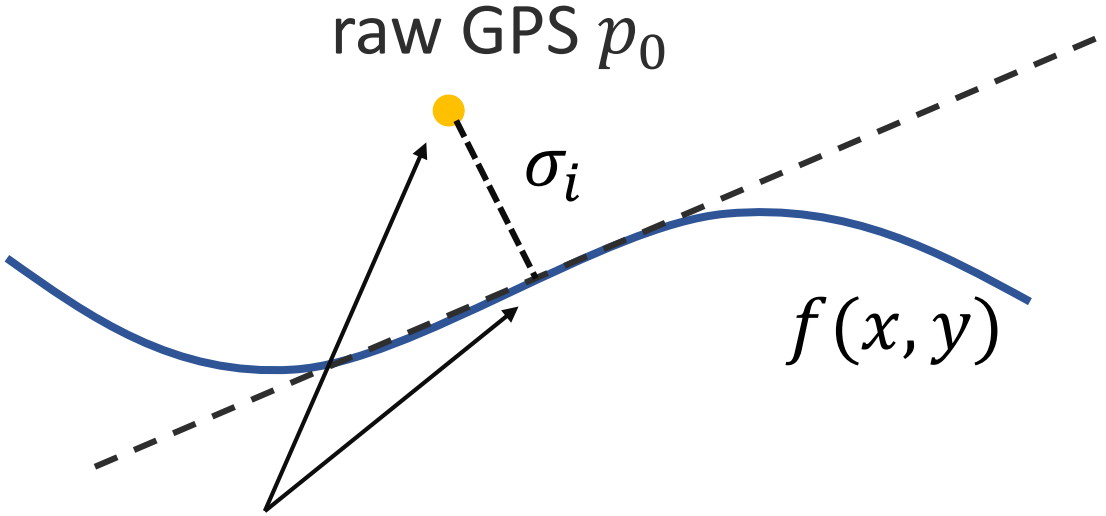

Calibration

1. All GPS data
   + Route path data
   + feature extracted SLAM data
   + timestamp
2. ML Training & Binding

Application

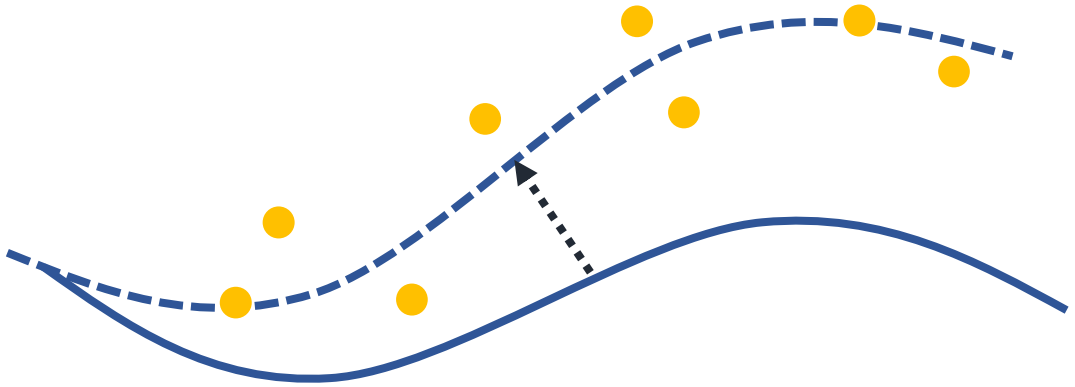
1. Estimate the location using GPS
2. Calculate the accurate position through feature extraction

# 3 —— Roadmap 1: Binding




same timestamp

Set $\Delta p$ & $\Delta r$ then iterate

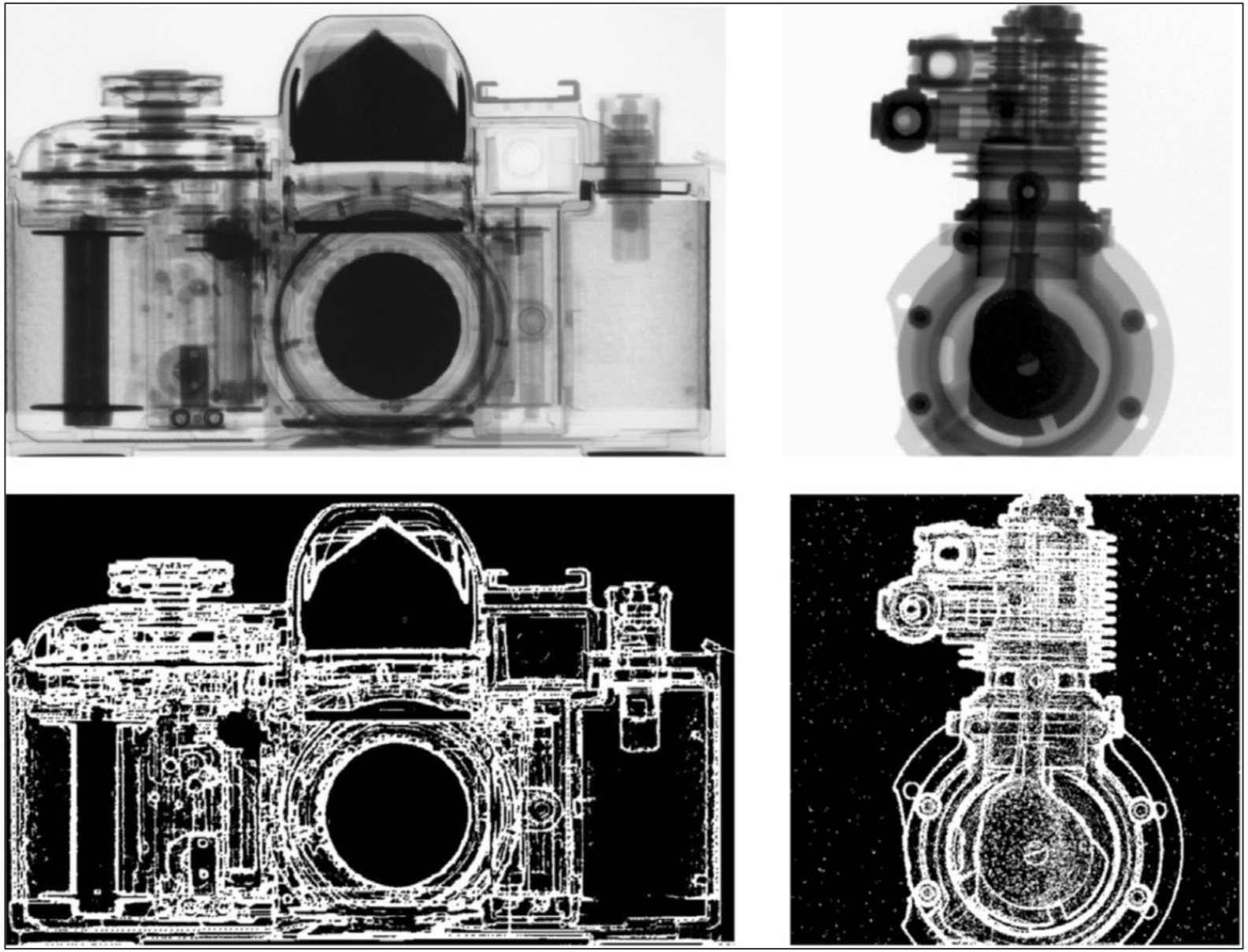


Translation & Rotation

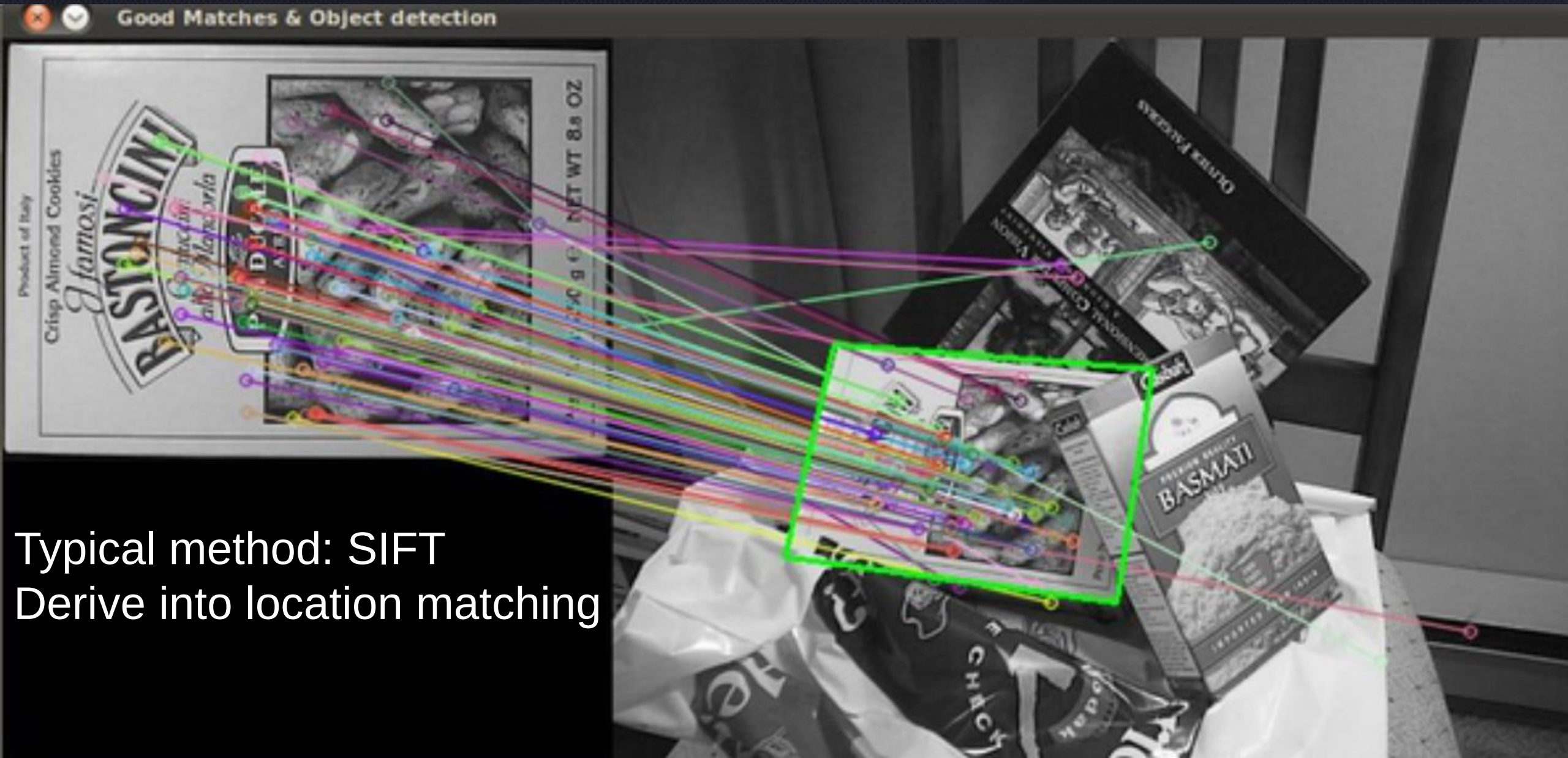
$$p = argmin\left\{\sqrt{\frac{1}{n}\sum_{i=1}^{n}\sigma_i^2}\right\} \quad s.t.\ p = f(x,y)$$

Typical method: ACO PSO IRLS

# 3 —— Roadmap 1: ACO

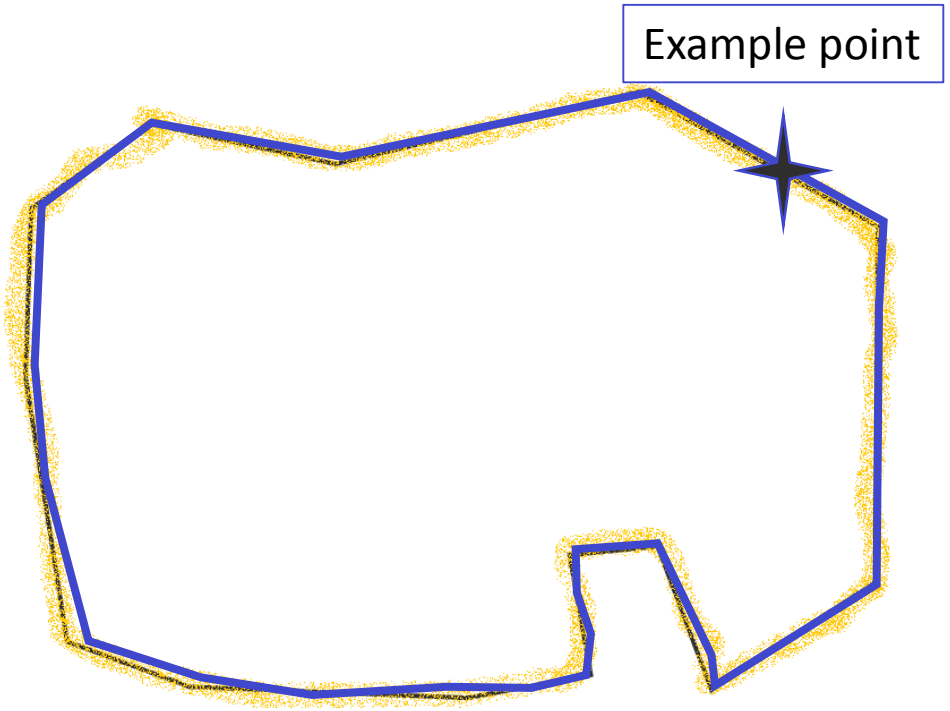


# 3 —— Roadmap 1: feature matching




Typical method: SIFT
Derive into location matching

# 3 —— Roadmap 2

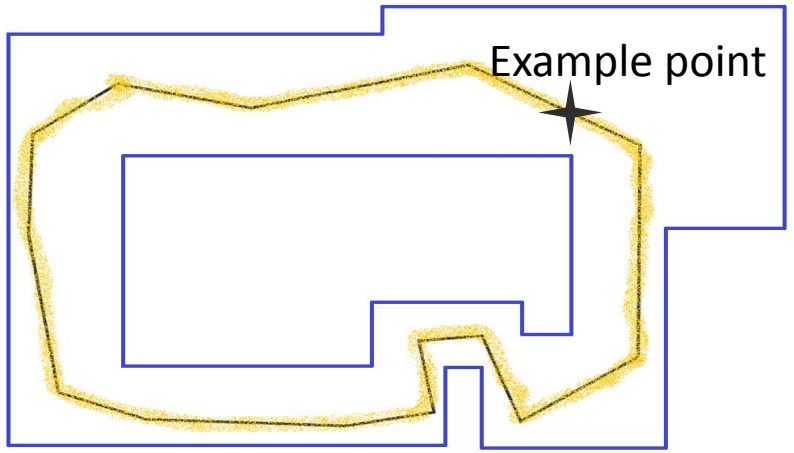


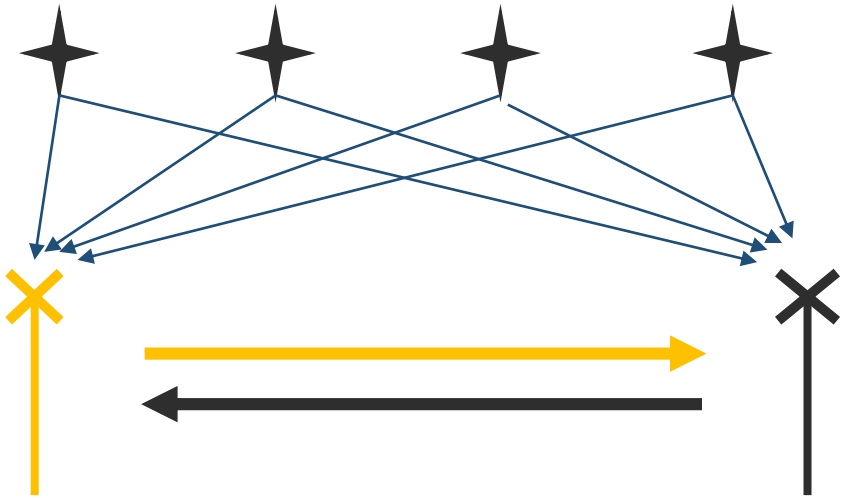

Calibration
1. All GPS data + Route path data
2. ML Training & Binding

Application
1. GPS data
2. Location correction

Simulation
Fabricate points & route data

# 3 —— V.S. RTK



Advantage:

1. Automation
2. Simple hardware
3. Easy development

Disadvantage

Uncontrollability

2017

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# Thanks