Simultaneous Localization and Mapping with BLE

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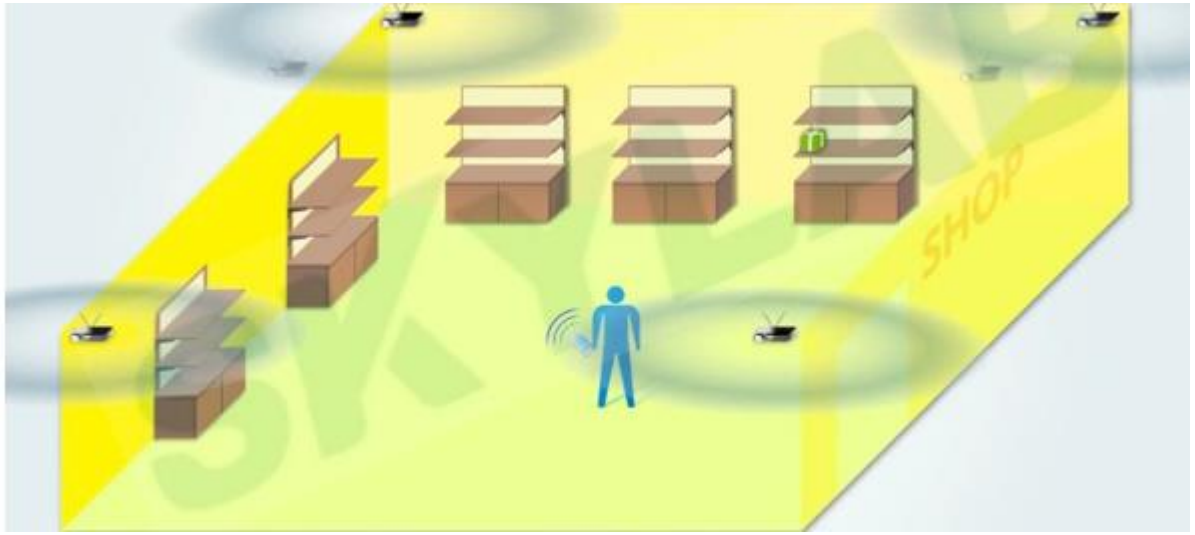
Introduction

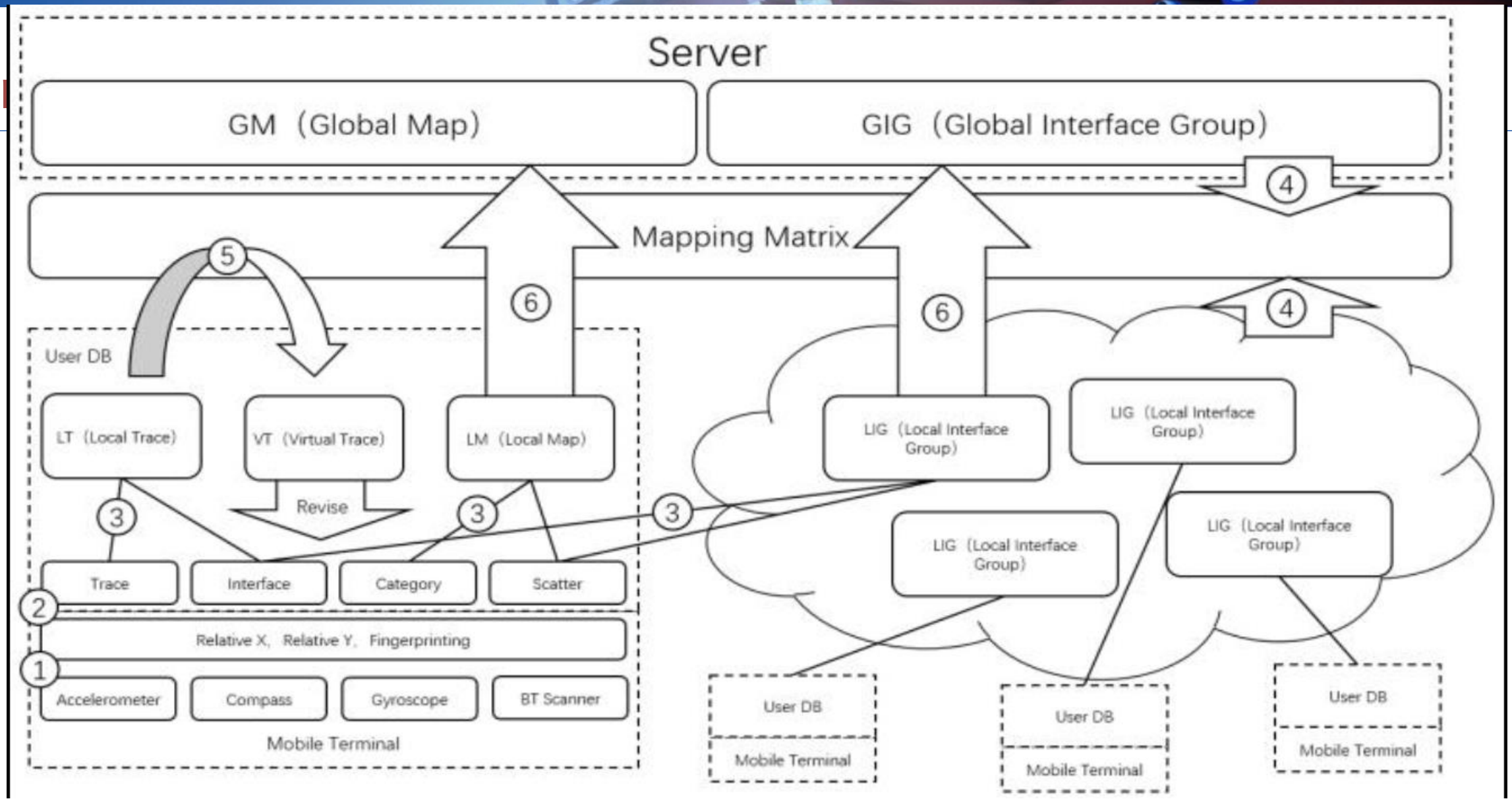


accelerometer → acceleration

magnetometer → Magnetic field strength

gyroscope → Angular Acceleration

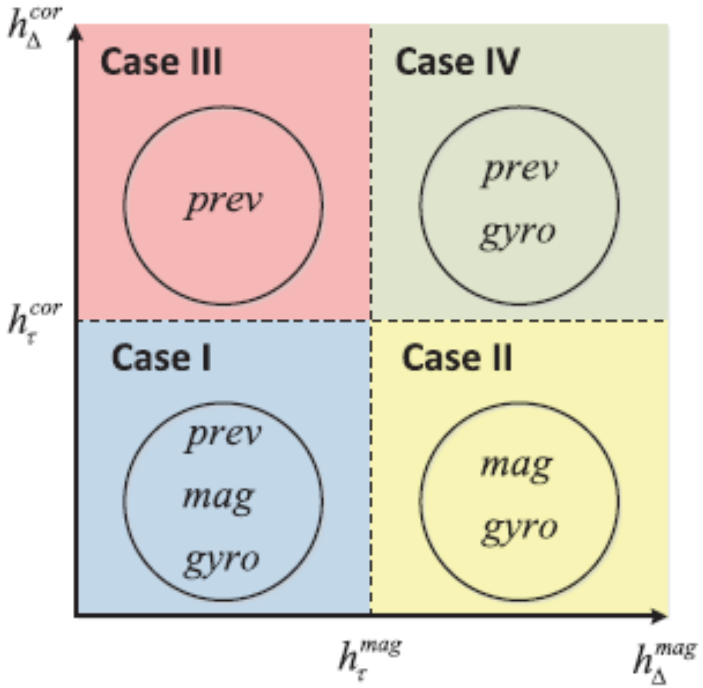
Step Number
Step Length
Direction
→ Movement Trace

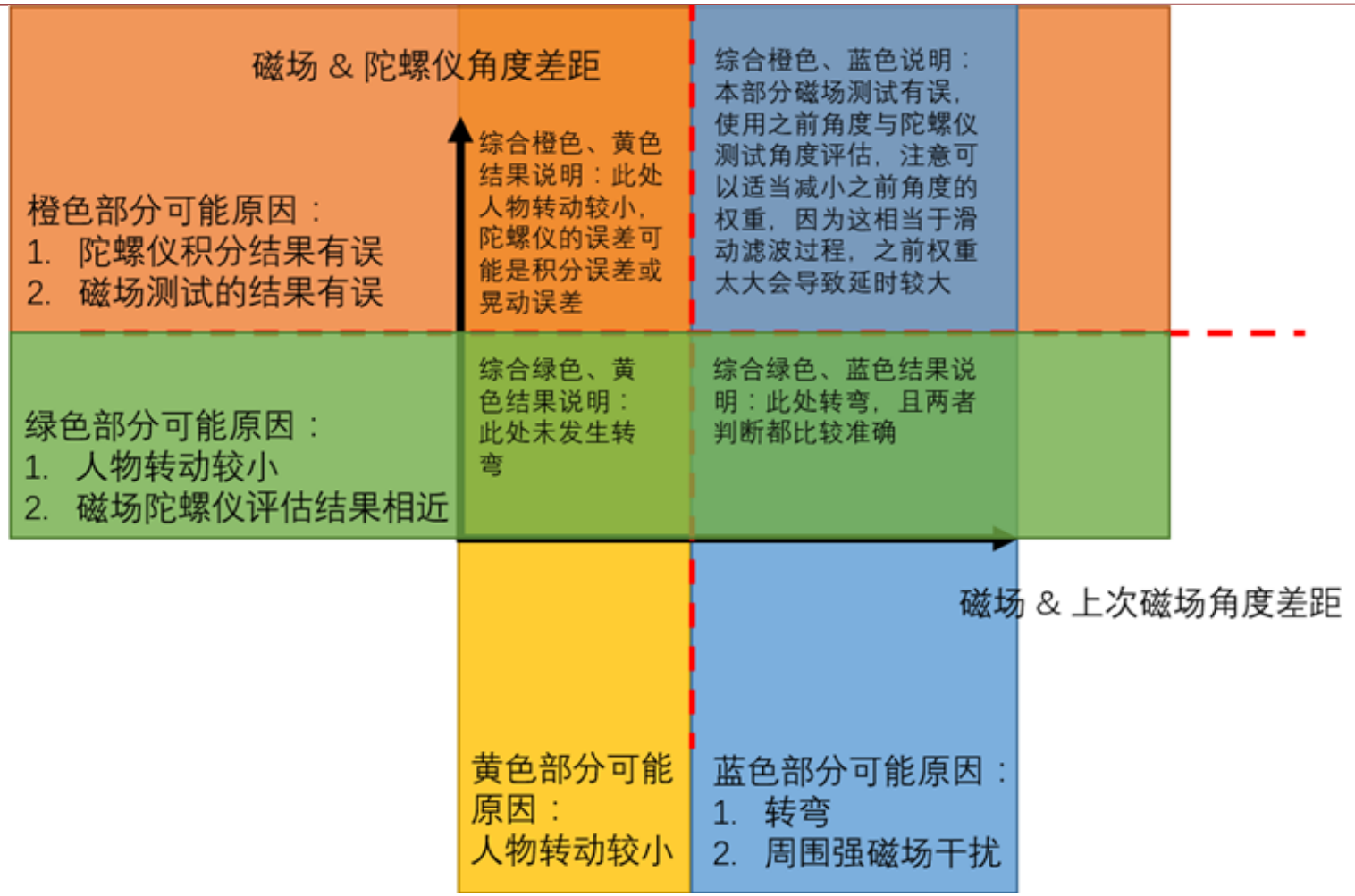

Server
GM (Global Map)
GIG (Global Interface Group)
Mapping Matrix
User DB
LT (Local Trace)
VT (Virtual Trace)
LM (Local Map)
Revise
Trace
Interface
Category
Scatter
Relative X, Relative Y, Fingerprinting
Accelerometer
Compass
Gyroscope
BT Scanner
Mobile Terminal
LIG (Local Interface Group)
LIG (Local Interface Group)
LIG (Local Interface Group)
LIG (Local Interface Group)
User DB
Mobile Terminal
User DB
Mobile Terminal
User DB
Mobile Terminal
1
2
3
4
5
6

Direction Estimation

Magnetometer
Gyroscope

Rotation angle





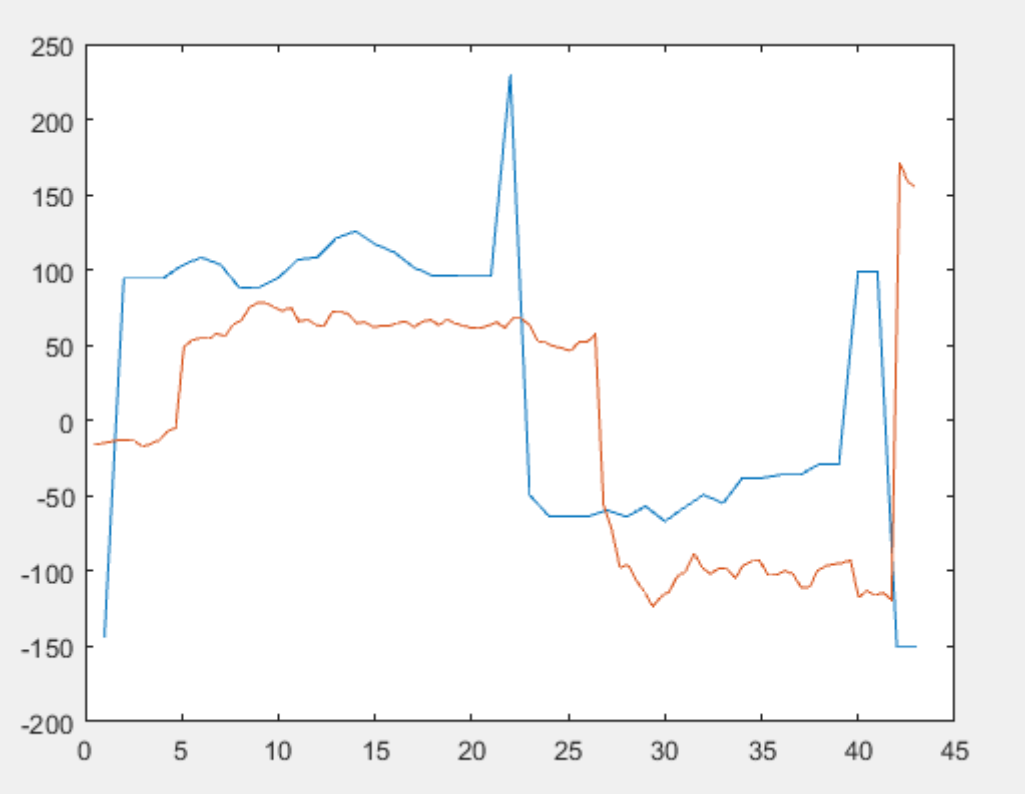
Direction Estimation

$$h_t = \begin{cases} w^{pmg}\left(w^{prev}h_{t-1} + w^{mag}h_t^{mag} + w^{gyro}h_t^{gyro}\right), \\ \qquad \text{for } h_\Delta^{cor} \le h_\tau^{cor},\ h_\Delta^{mag} \le h_\tau^{mag} \\ w^{mg}\left(w^{mag}h_t^{mag} + w^{gyro}h_t^{gyro}\right), \\ \qquad \text{for } h_\Delta^{cor} \le h_\tau^{cor},\ h_\Delta^{mag} > h_\tau^{mag} \\ h_{t-1}, \quad \text{for } h_\Delta^{cor} > h_\tau^{cor},\ h_\Delta^{mag} \le h_\tau^{mag} \\ w^{pg}\left(w^{prev}h_{t-1} + w^{gyro}h_t^{gyro}\right), \\ \qquad \text{for } h_\Delta^{cor} > h_\tau^{cor},\ h_\Delta^{mag} > h_\tau^{mag} \end{cases}$$

$$\begin{aligned} w^{pmg} &= \left(w^{prev} + w^{mag} + w^{gyro}\right)^{-1} \\ w^{mg} &= \left(w^{mag} + w^{gyro}\right)^{-1} \\ w^{pg} &= \left(w^{prev} + w^{gyro}\right)^{-1} \\ h_\Delta^{cor} &= \left|h_t^{mag} - h_t^{gyro}\right| \\ h_\Delta^{mag} &= \left|h_t^{mag} - h_{t-1}^{mag}\right| \end{aligned}$$

w^{prev}: w^{mag}: w^{gyro} *and* threshold h_τ^{cor} and h_τ^{mag} *can be adjusted to find a better result which is closer to the true direction*

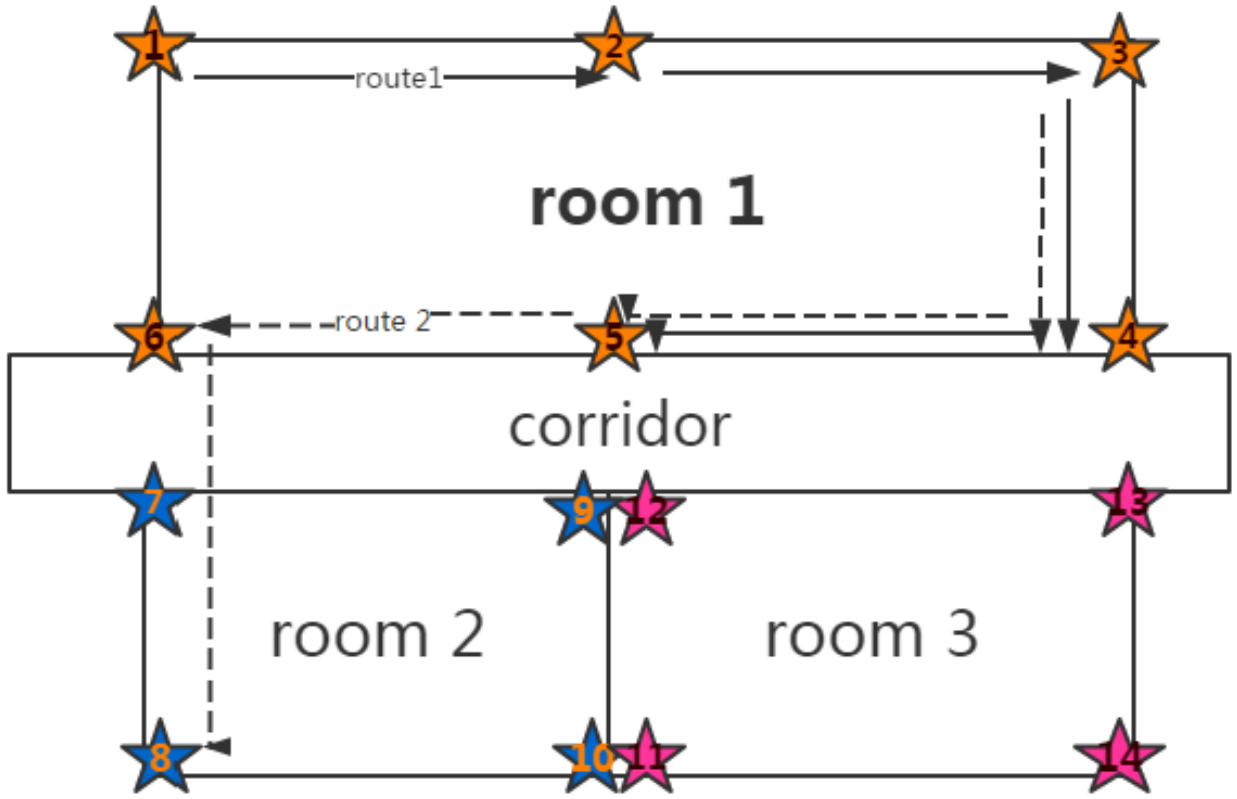
Direction Estimation



$$w^{prev} : w^{mag} : w^{gyro} = 2 : 1 : 2$$

$h_{\tau}^{cor} = 5$ degrees and $h_{\tau}^{mag} = 2$ degrees

Online Matching



Sort out similar Anchors

↓ Larger than 3

Anchor array A, Anchor array B

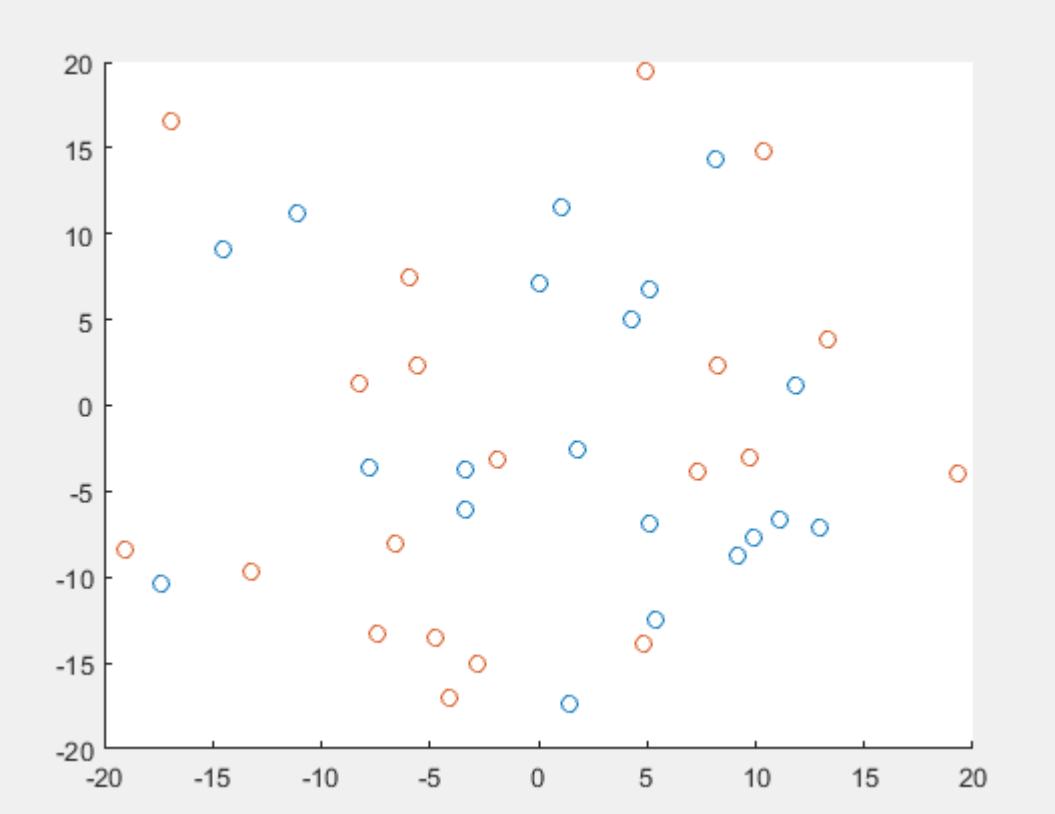
↓ Find scaling factor k and rotation matrix β

$$\mathbf{A^T(k\beta)^T = B^T}$$

↓ other positions also rotate and scale up or down

Combine two LCS to one LCS

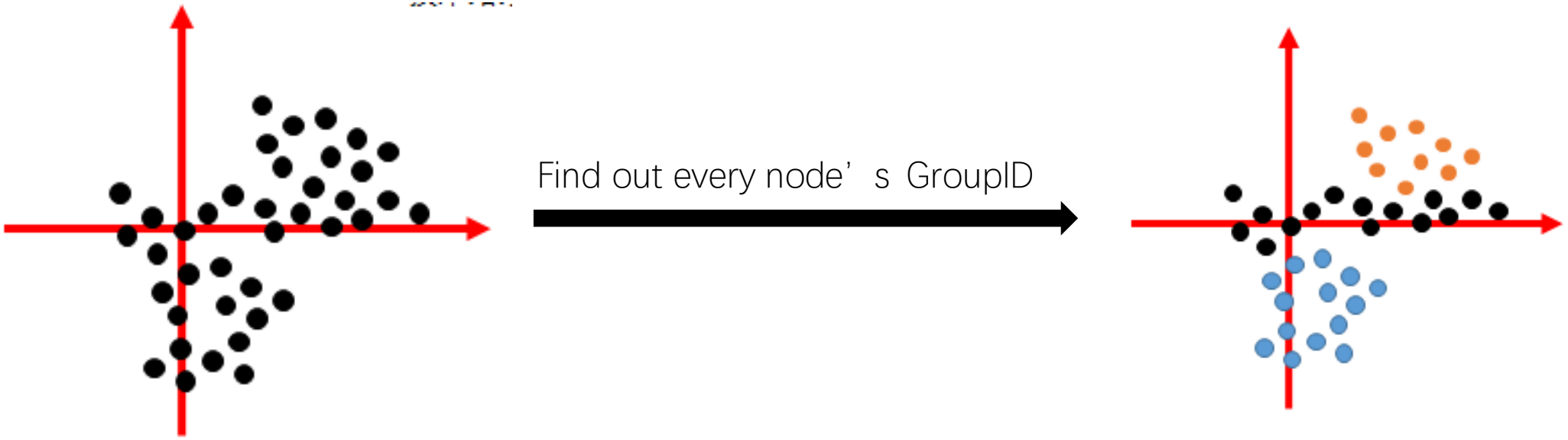
Direction Estimation



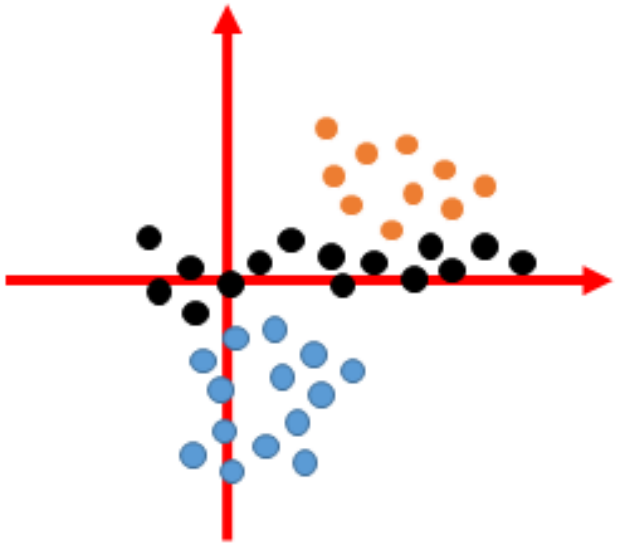
After rotating 100 degrees, the frame of blue one can roughly coincide with the red one

Red circle: original BLE positions
Blue circle:computed result after rotating,scaling and adding noise

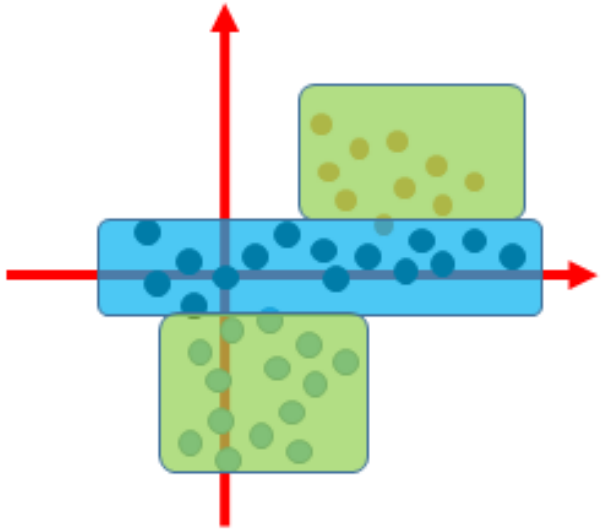
Outline of Rooms



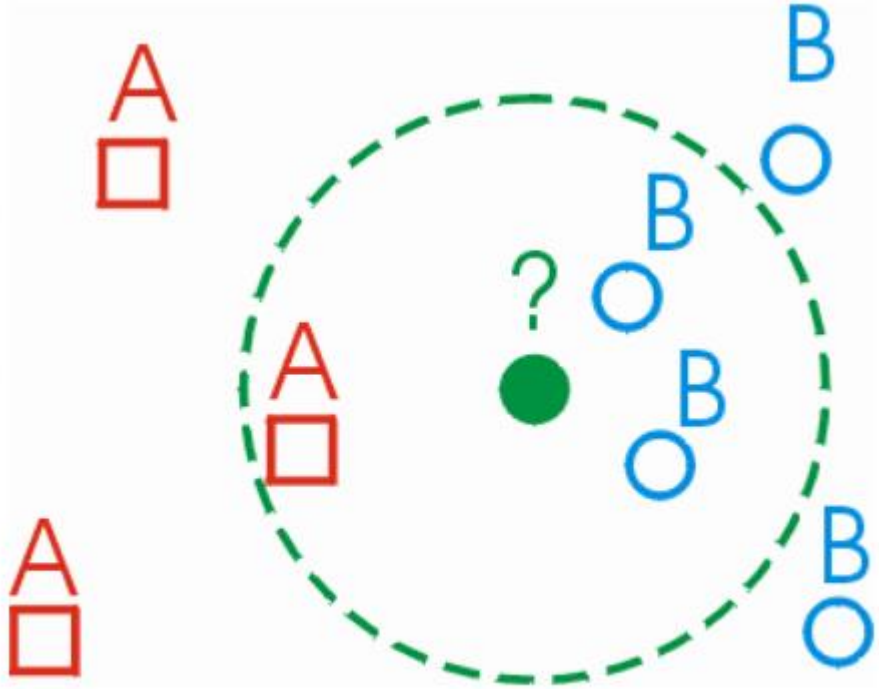
Outline of Rooms



Find out the outline of rooms



Outline of Rooms & Algorithm



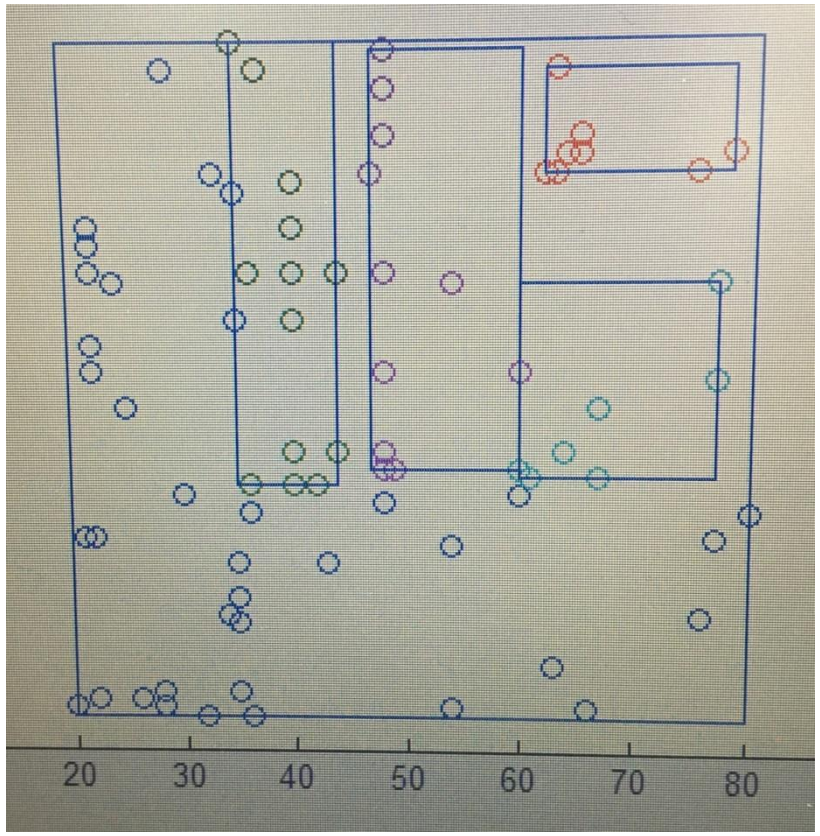
KNN (K nearest neighbors)

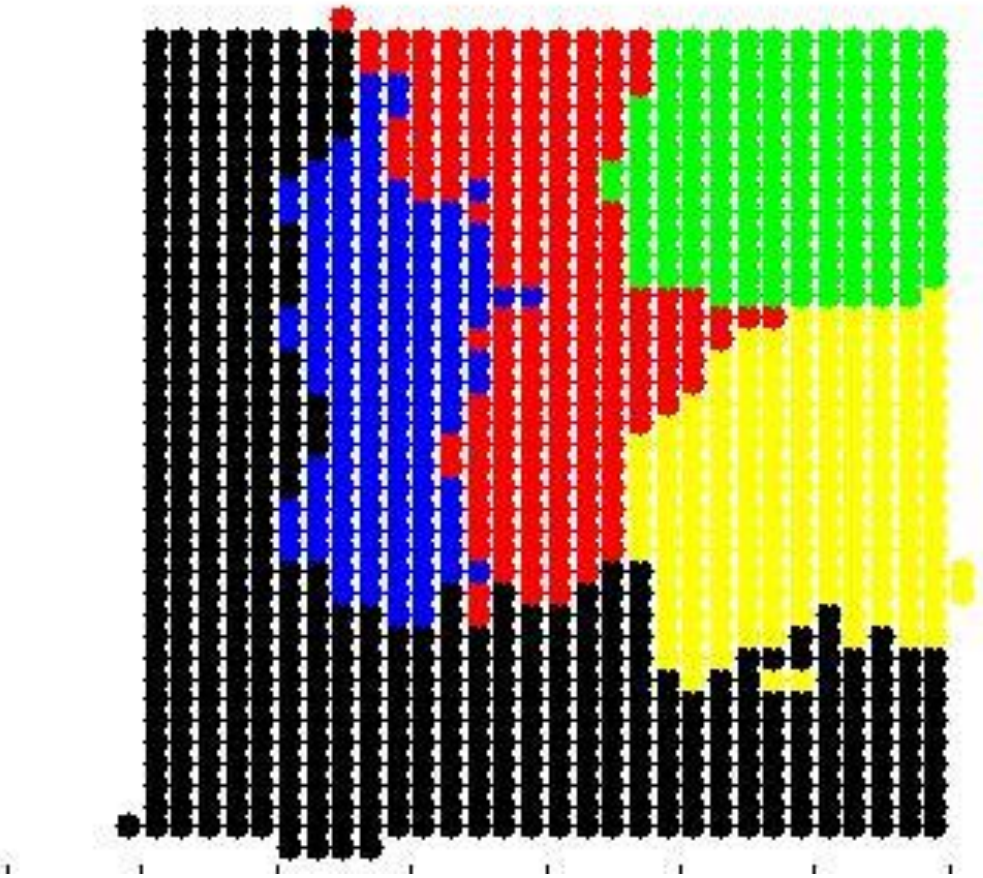
For each pixel in a scenario, we find the nearest K nodes.

And figure out the group that most nodes belong to .

And note this pixel is part of the group.

Outline of Rooms --result





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Further Work

We have deployed the BLE access points in our laboratory, And now we are going to integrate all part of work to realize interface matching.

Q&A