A Method of Map Matching for Personal Positioning System

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Needs for accurate positioning

Information services which
depend on one's location

the nearest Parking

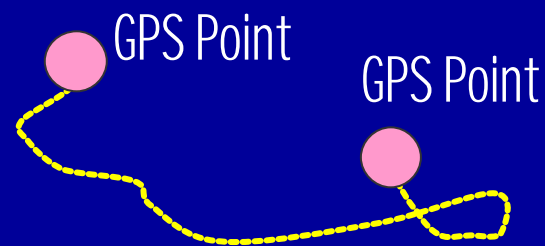Full or any vacancy ?

accurate positioning
technology is needed

You are here

P

P

P

P

GPS
receiver

Platform

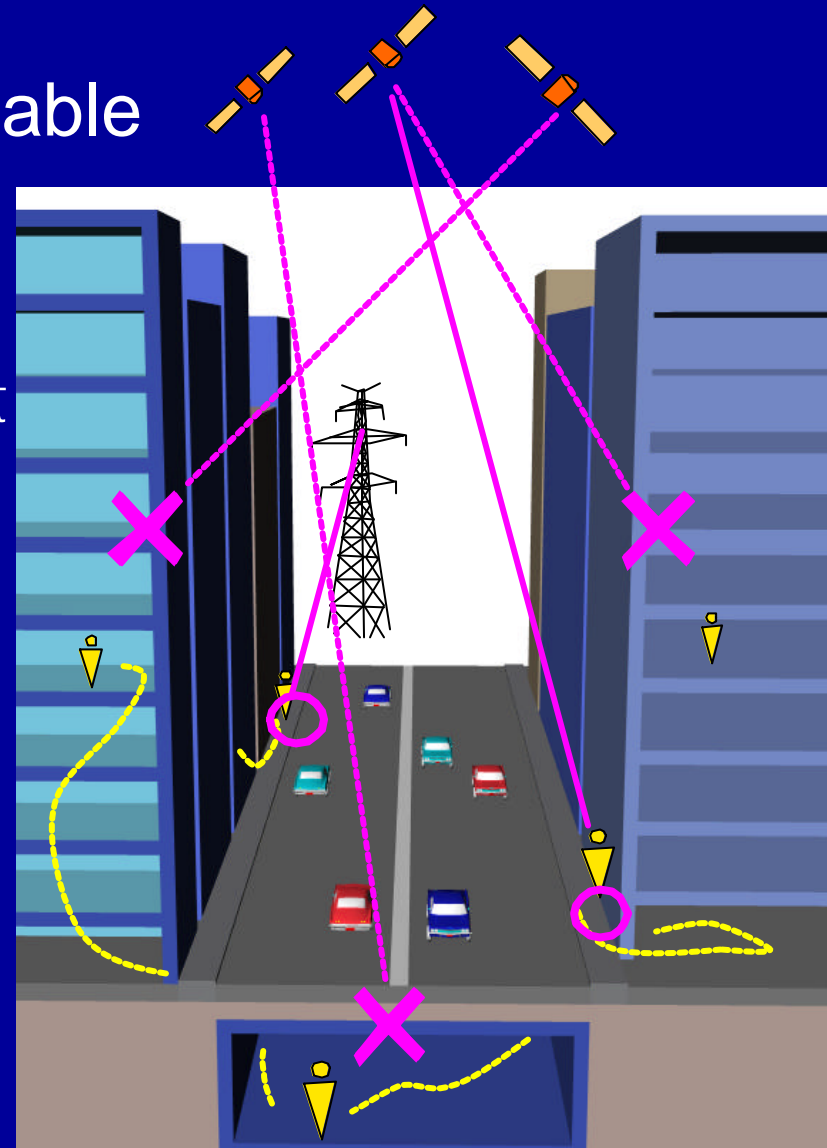Mobile phone (e.g i- mode)   PDA

Problems with current positioning services

GPS system is not always available

In the valley between high-rise buildings
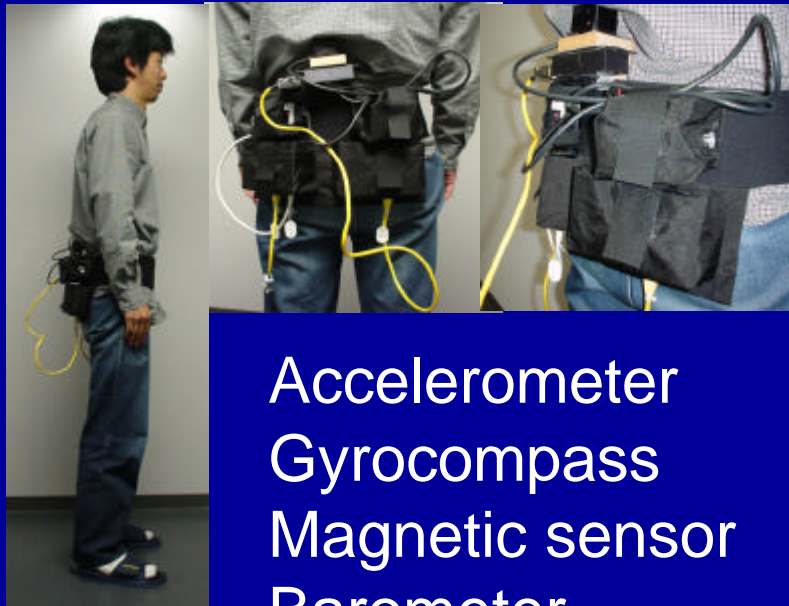Underground passage
Inside of buildings

GPS Point

GPS Point

We have to get trajectory between GPS points
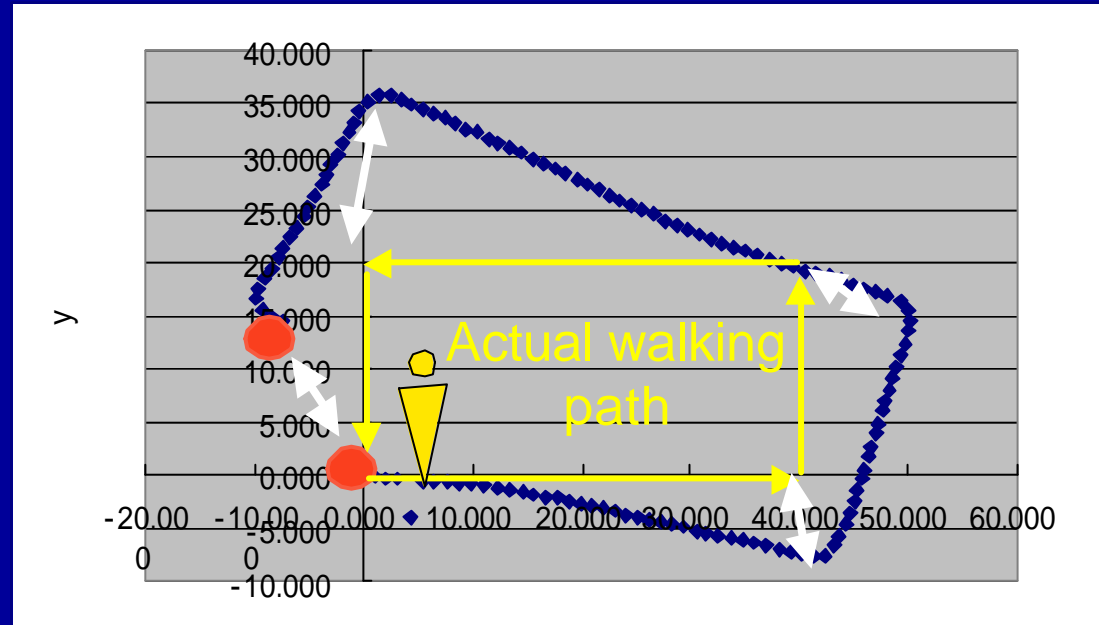
Complementary method is necessary

Complementary method

Personal Positioning System (PPS)
developed by Mr.Yusuke Konishi

Observed tracks

Accelerometer
Gyrocompass
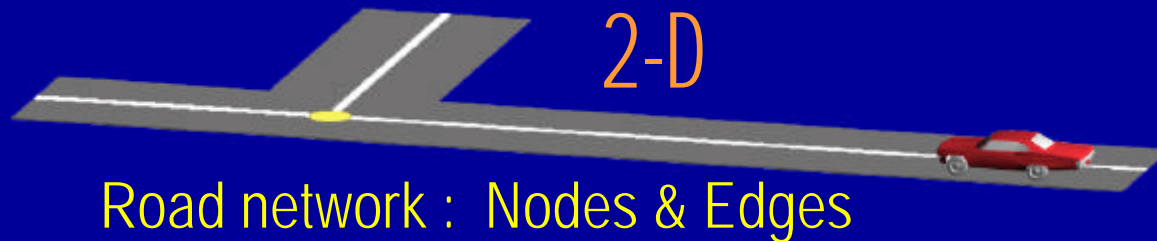Magnetic sensor
Barometer

Actual walking path

Accumulation of errors is inevitable

Map matching

Map Matching

Map matching methods for car navigation

2-D

<u>cars always run</u>

Road network : Nodes & Edges

<u>along with network</u>

Map matching methods for PPS (Personal Positioning System)
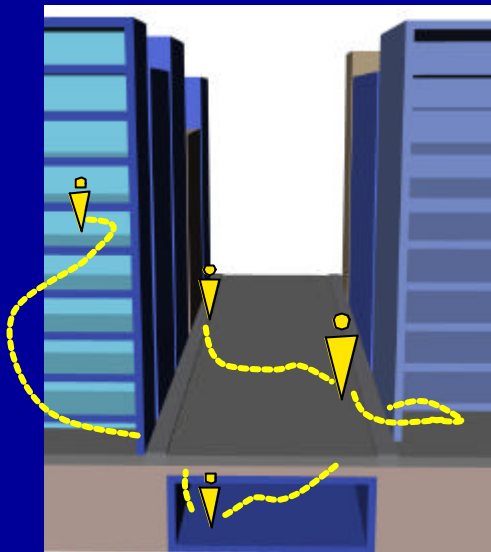
<u>Human can move more freely</u>

A new matching algorithm

3-D database

Objective

Development of a new method of "Map matching"

track human's movement

Matching in 3-D space $\longrightarrow$ 3-D database

Position (x, y, z)

Combination of algorithm $\longrightarrow$ Local matching

Global matching

Local matching

Obstacle boundaries

Boundaries and polygons

Intersect boundaries or not ?
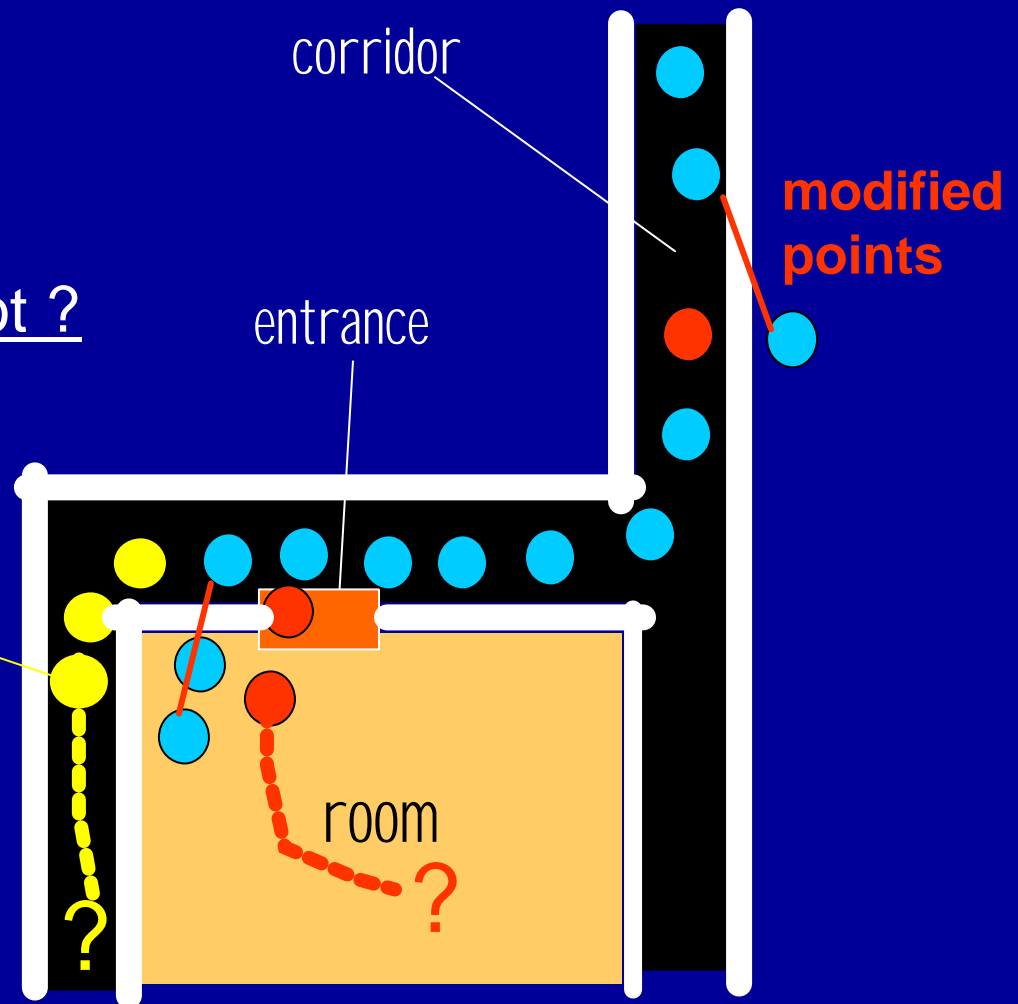
Merit : Frequent modification

Possible tracks

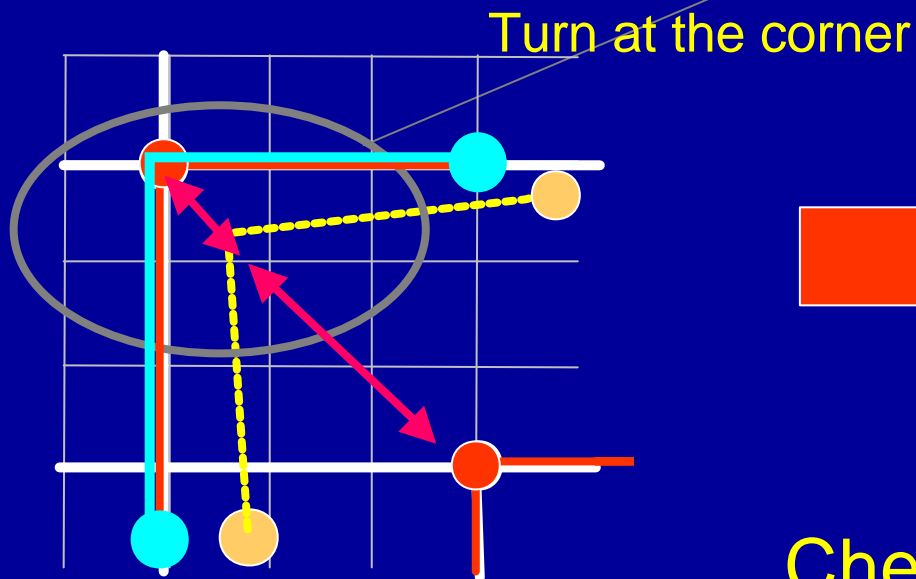Demerit : Hard to correct once mismatching happened

⬇

Global information is needed

corridor

modified points

entrance

room

?

?

Global matching

Road Network

Nodes and edges

Turn at the corner

Distinct characteristics

90° turn in between long straight paths
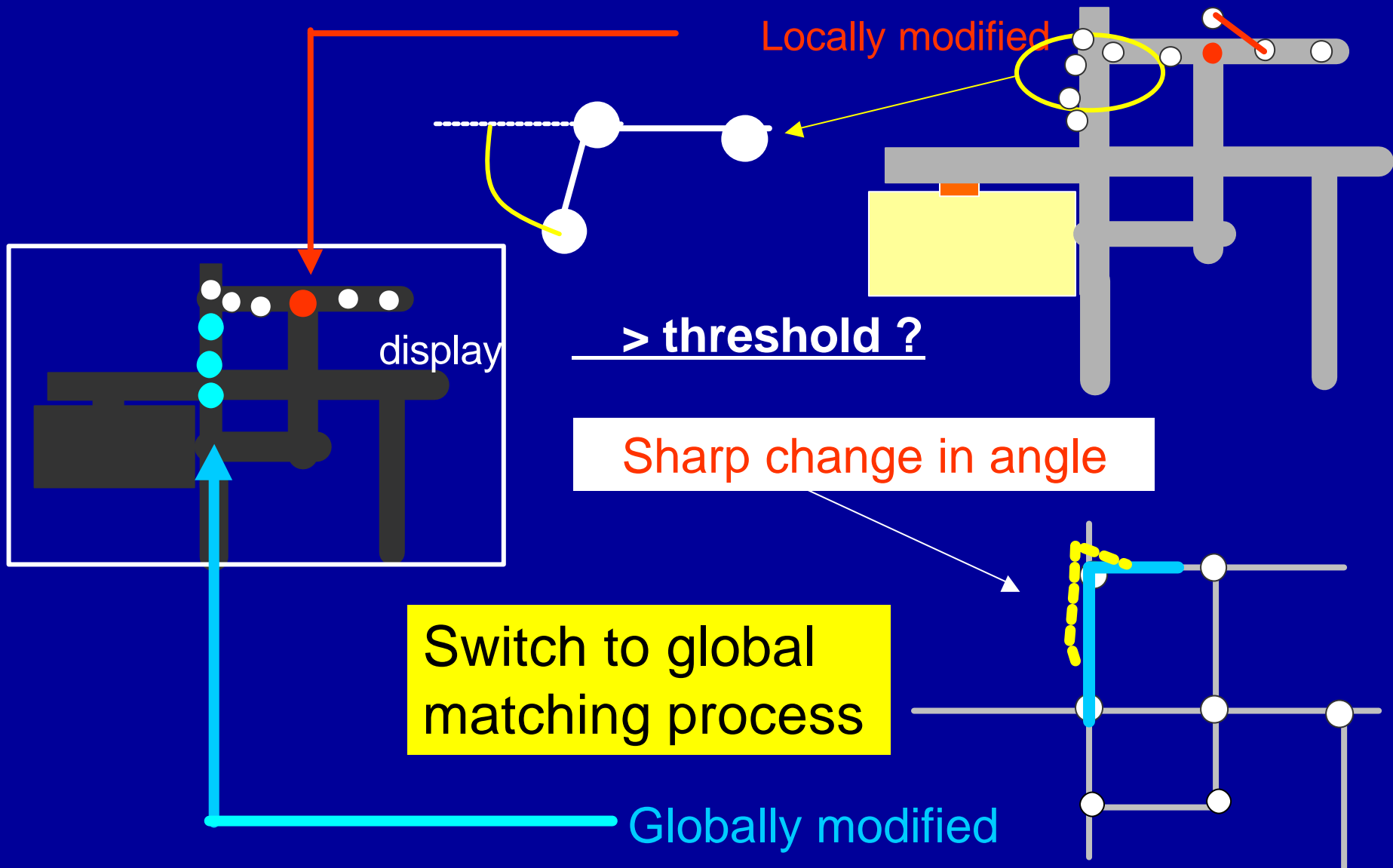
Candidates

Distance

Orientation

Check the fitness

Merit : Global consistency

Demerit : Long interval between processes

Combine and "switch" two matching algorithms

"Switch" matching algorithm

Locally modified

display

> threshold ?

Sharp change in angle

Switch to global matching process

Globally modified

Place of experiments

View from the East side

Institute of Industrial Science,The University of Tokyo
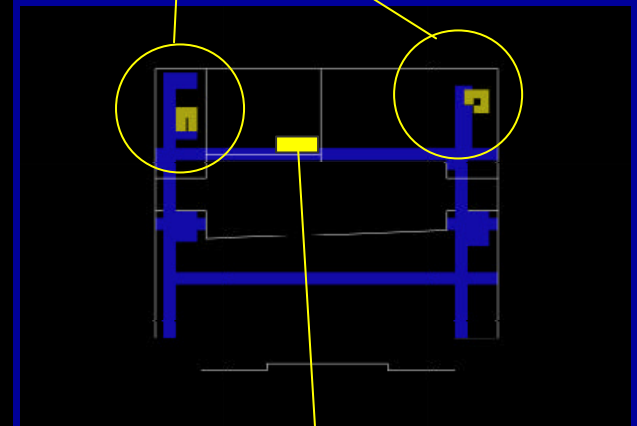
10th floor
9th floor
8th floor
7th floor

6th floor

5th floor

4th floor

3rd floor

2nd floor

Ground floor

Subjective area

staircases

Entrance

Corrected data

Raw data

Result : enter the room (2-D)

Corrected data

Raw data

Entrance

Result : go downstairs (3-D)

Raw data

matching nodes
of the entrance
of staircases

Corrected data
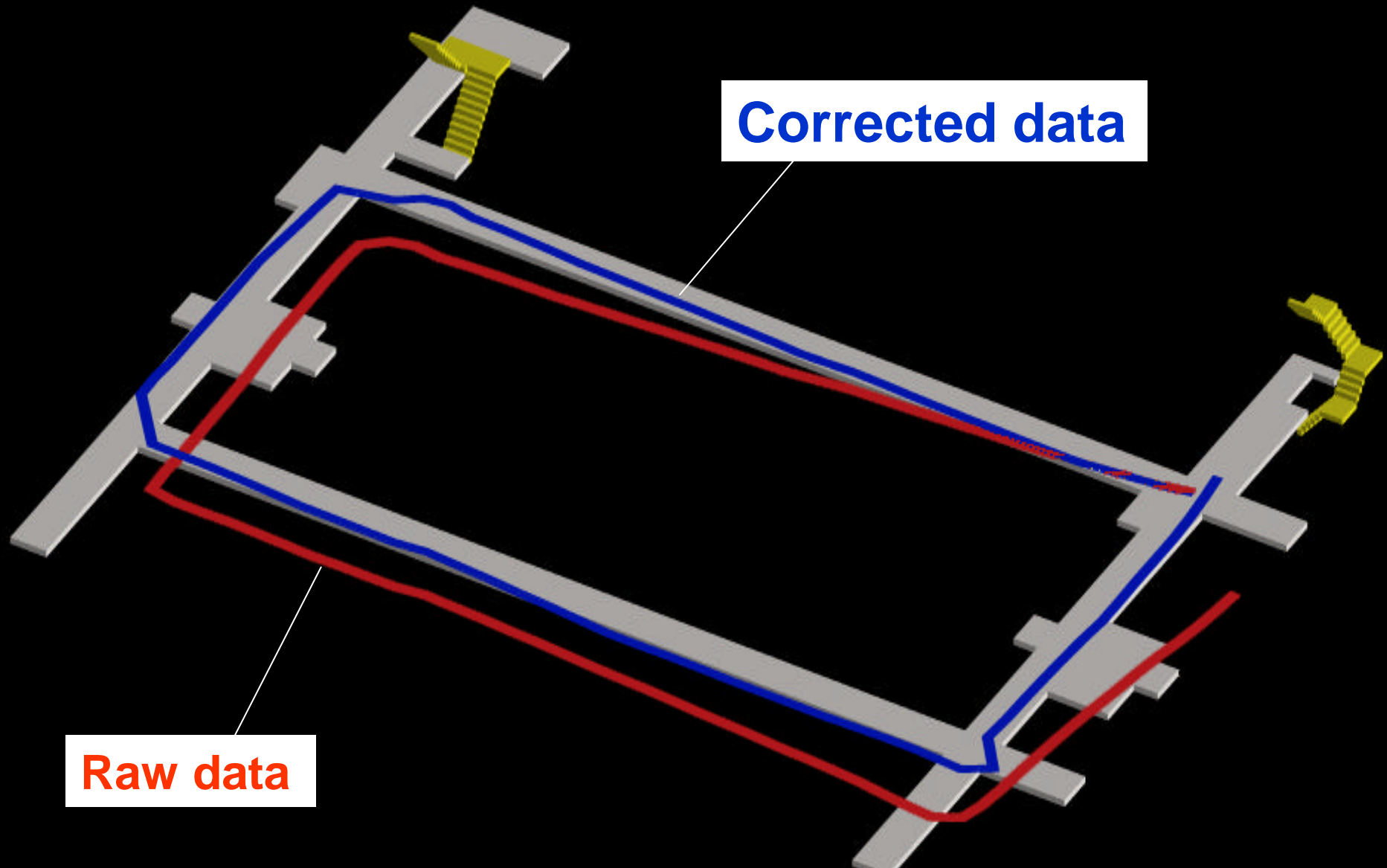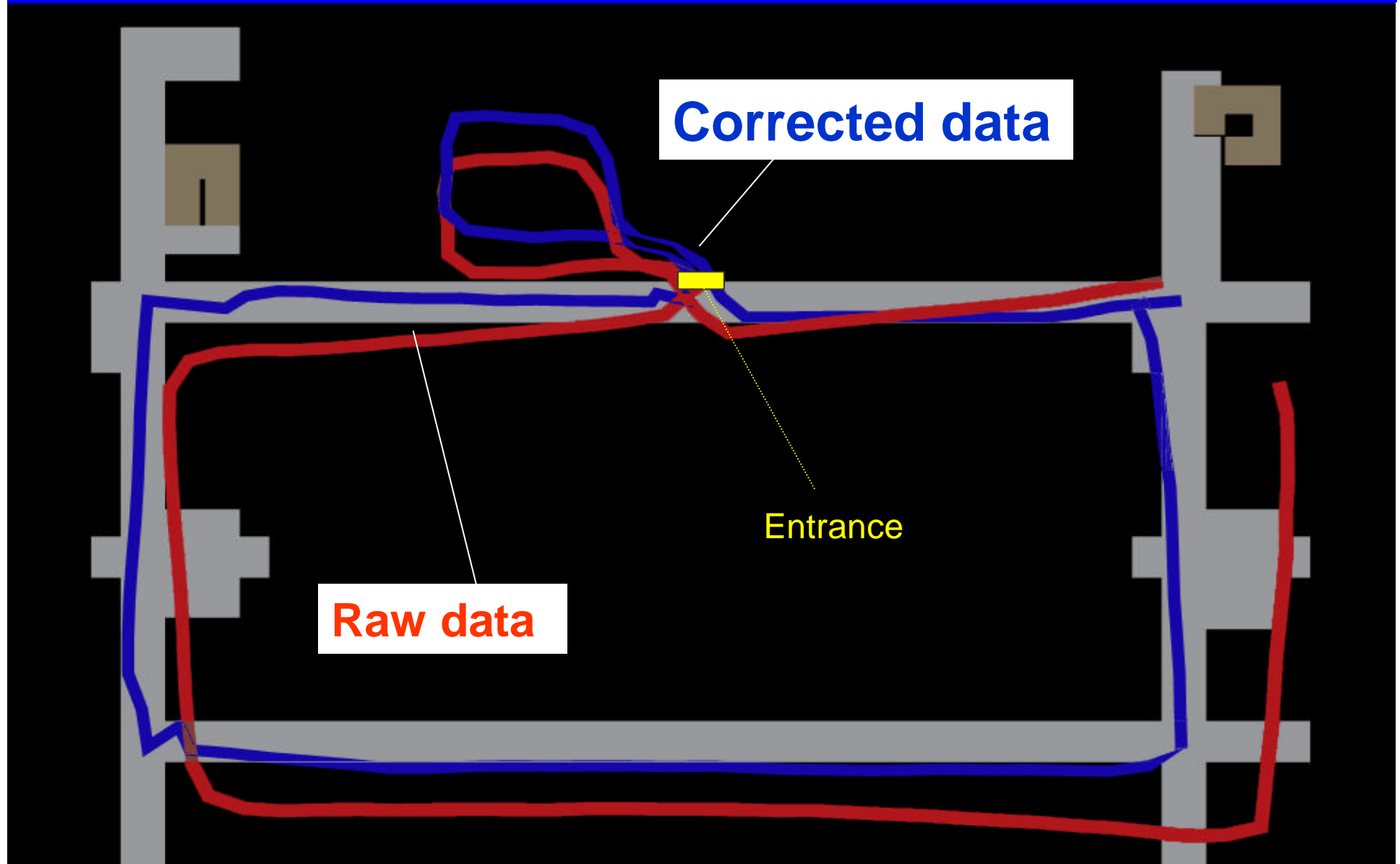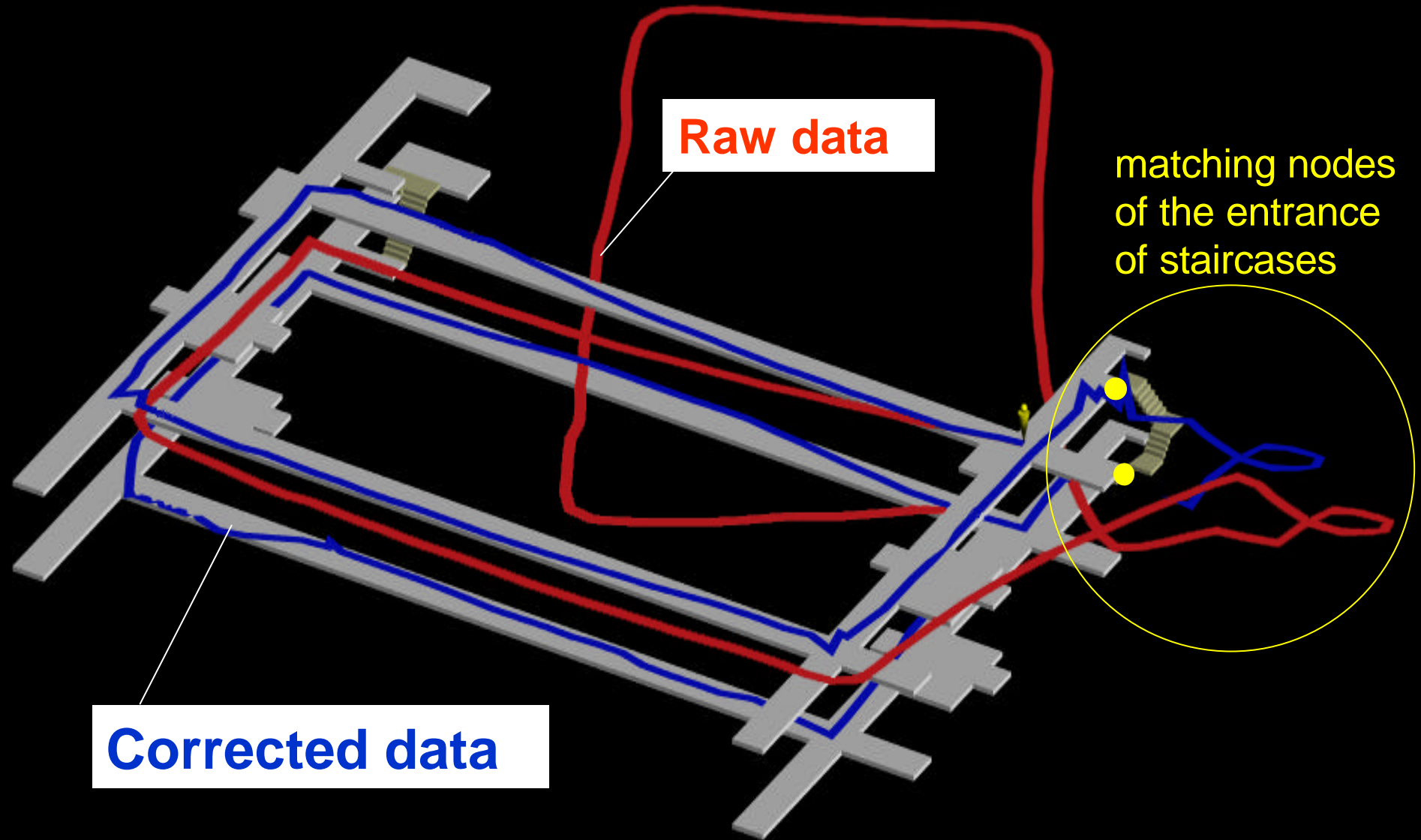
Conclusions

- The combined algorithm is effective

- "Natural and free" trajectory can be reconstructed with least geometric constrains (e.g only obstacle boundaries)

Future works

- Adjustment of the <u>parameter value</u>
(e.g threshold of sharp change in angle)

- Extend the matching algorithm for
movements in staircases

  <u>Discrimination of "action mode"</u>

  (e.g walking, pausing,going up/down stairs   etc.)

  <u>Always apply network in staircases</u>

Flow chart

Map Matching

Get coordinates of estimated position and time (x, y, z, t)

⬤ (x, y, z, t)

**Calculation of tracks (vector)
&
Modification of initial errors**

vector

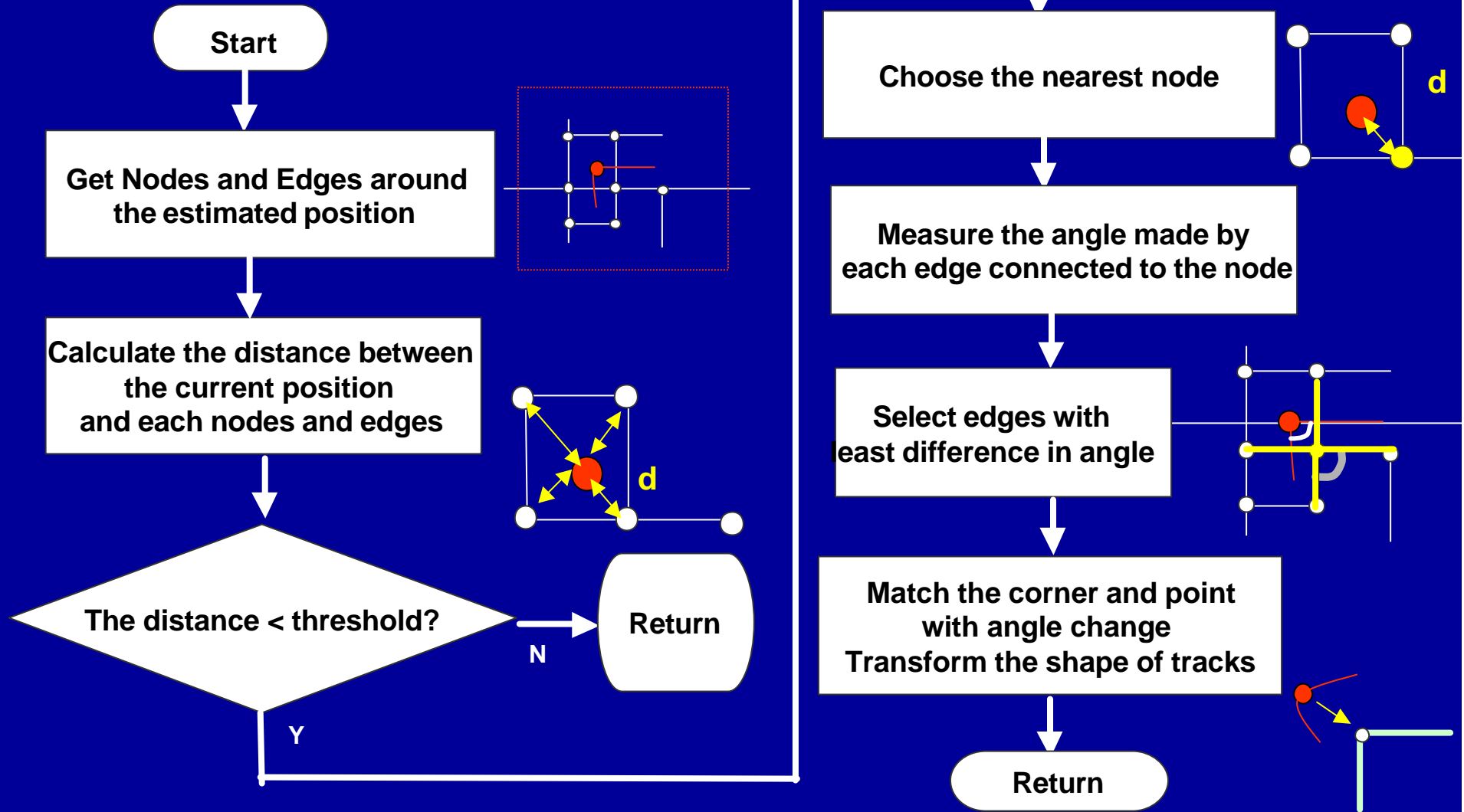angle error

Ratio of length

Recent value of local modification

Sharp angle change?

Y

N

Global matching

Data of the objects around the current point is obtained

The track crosses the outline of objects?

Y

N

Local matching

Return the data of estimated point intact

Add positional data to Database

End

Flow chart : 2

Global matching

Start

Get Nodes and Edges around the estimated position

Calculate the distance between the current position and each nodes and edges

d

The distance < threshold?

N → **Return**

Y

Choose the nearest node

d

Measure the angle made by each edge connected to the node

Select edges with least difference in angle

Match the corner and point with angle change Transform the shape of tracks

Return

Flow chart : 3

Local matching

Start

Intersect with entrance?

Entrance ?

Y → **Return the value intact** → **Return**

N

Get track of 5 more steps

Measure the angle made by tracks and outlines

Angle < 90° ?

Y

N

Angle < threshold?

Y → **Rotate tracks around the first point counter-clockwise for the cross angle** → **Return**

N

Distance between entrance < threshold ?

Y → **Relocate intersection to the entrance** → **Return**

Return modified points

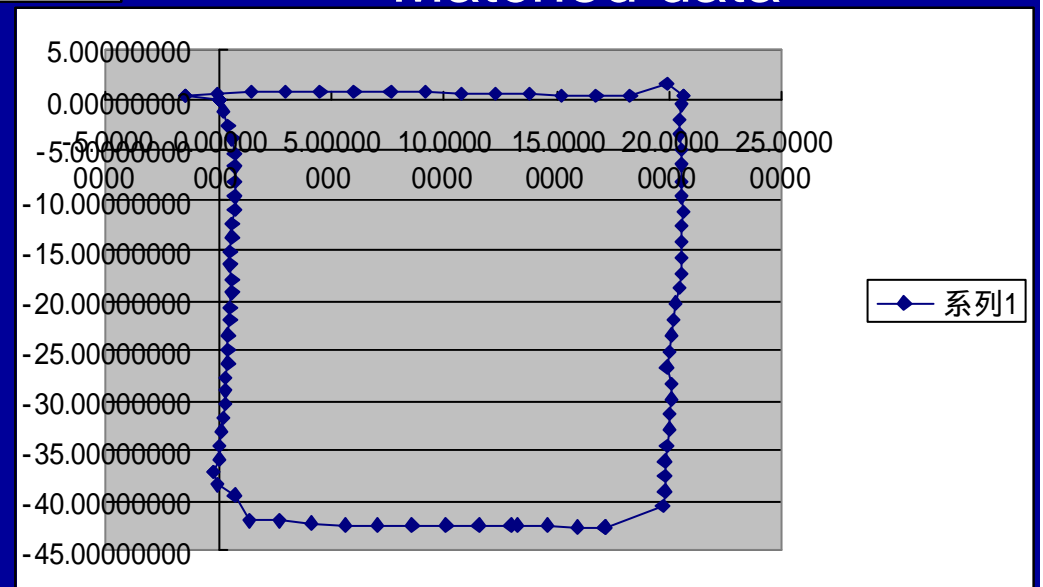**Record coefficients for correction of cross angle and length**

Initial errors

Return

Data 1

Estimated data

Matched data

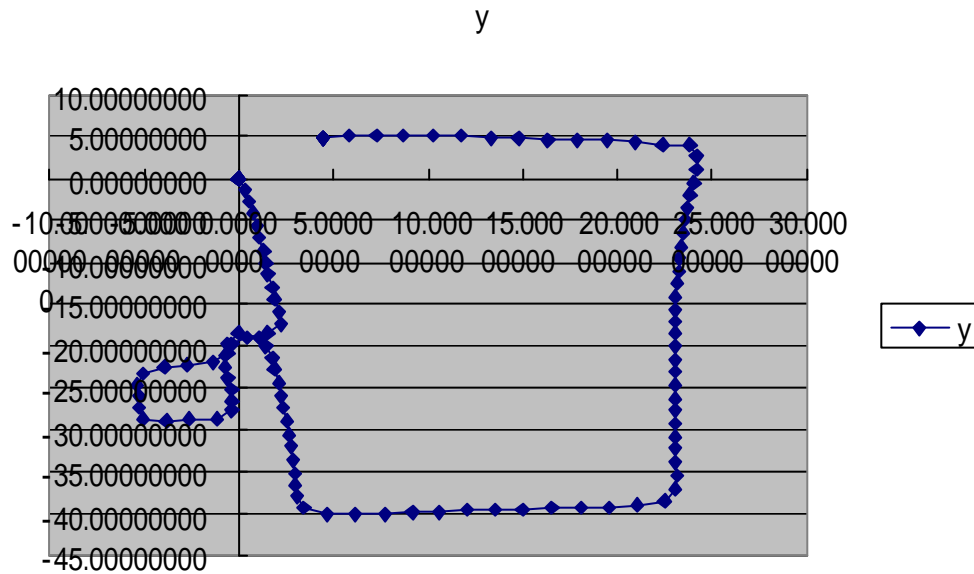# Data 2

y
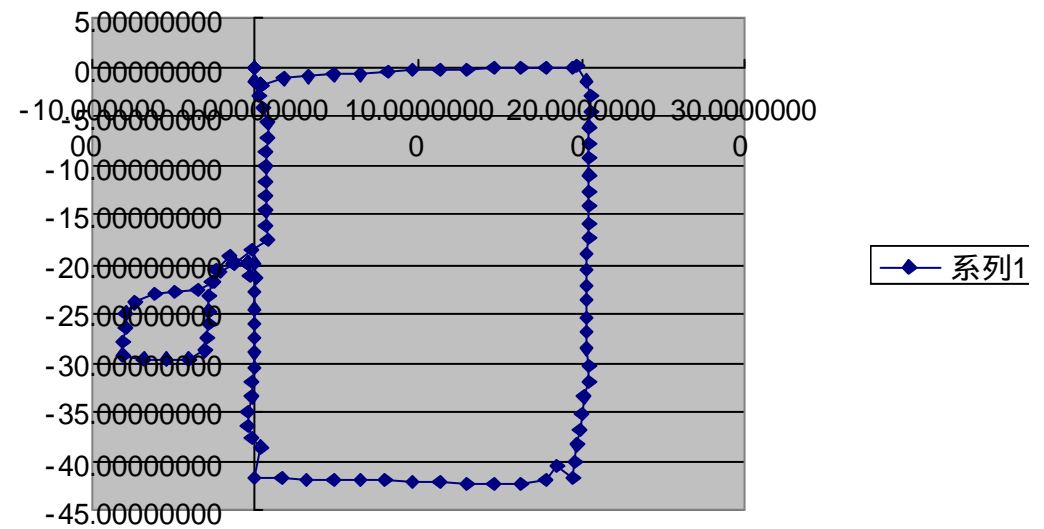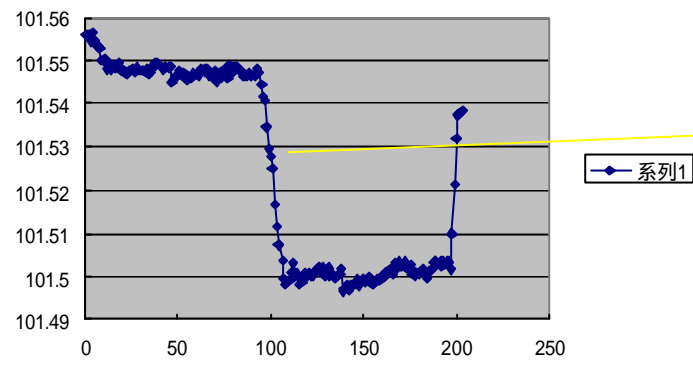

Matched data

Estimated data

Data 3

Fluctuation in air pressure

Estimated data