應用運算與多媒體實驗室
Applied Computing and Multimedia Lab

ACM LAB528
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Indoor Localization

- Home care
  - Wi-Fi based
- Museum guidance
  - Multi-sensors based
  - Navigation

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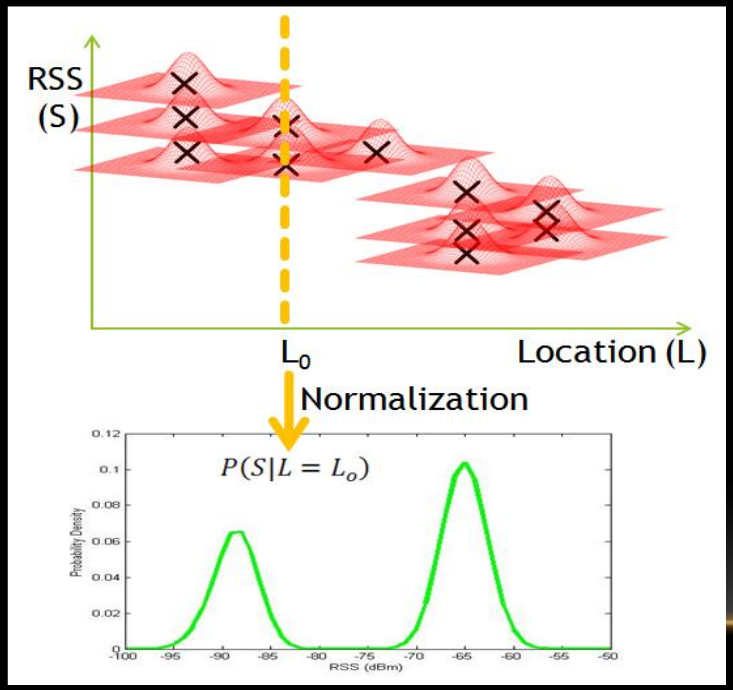
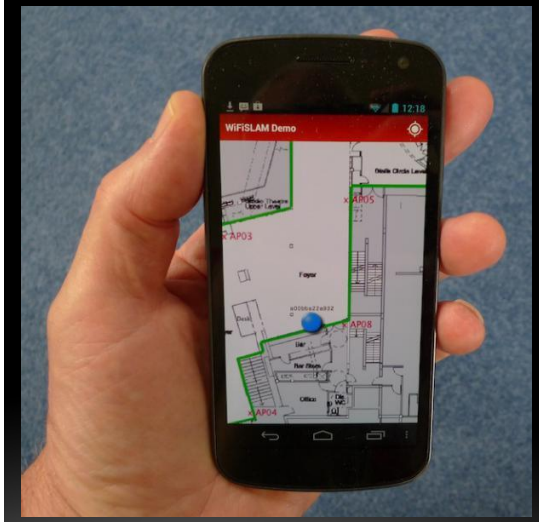
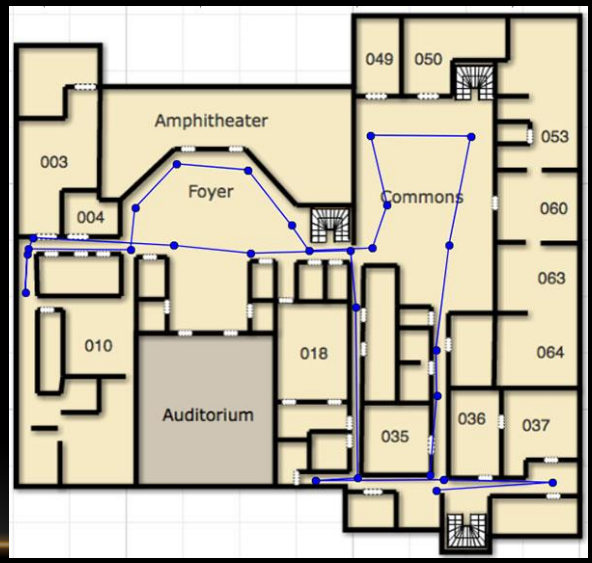
HOME CARE
INFORMATION FROM WI-FI SENSOR(1/2)

- Wi-Fi indoor positioning system
  - Based on Wi-Fi fingerprint
  - Multi-dimension kernel density estimation

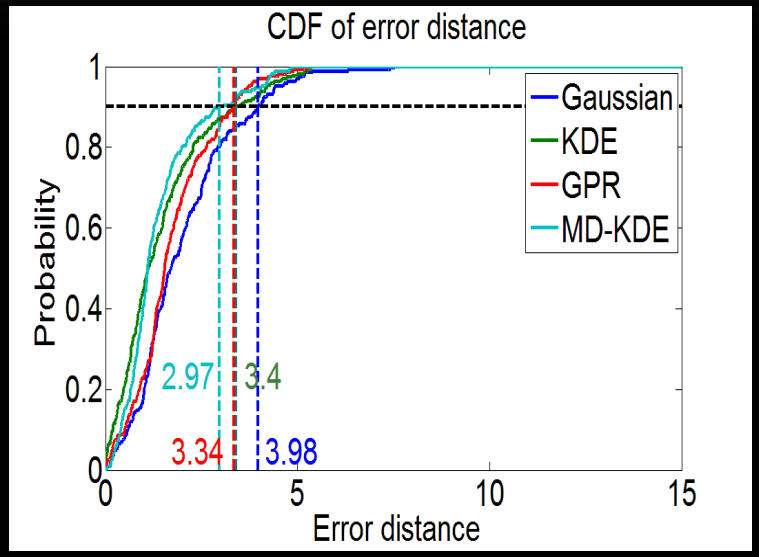




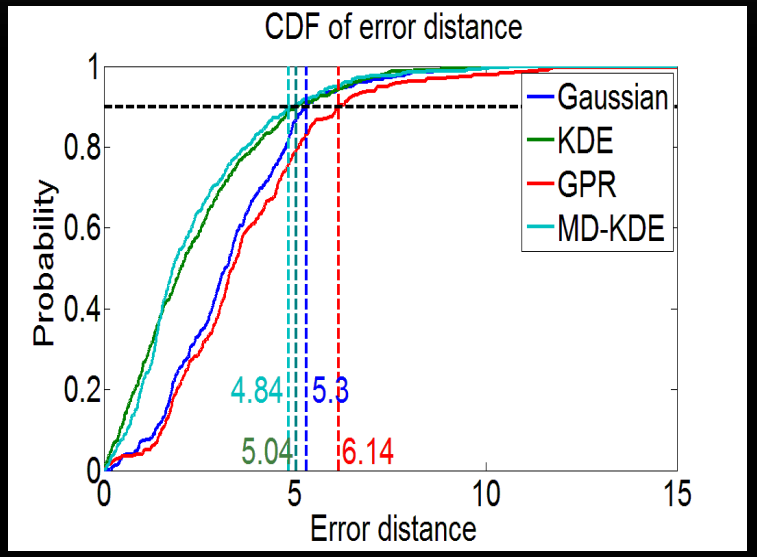


EXPERIMENTAL RESULTS

Data without multi-modal



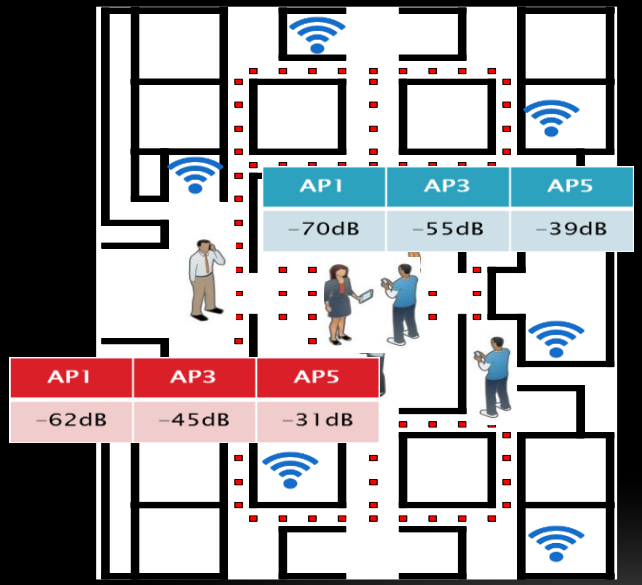
Data with multi-modal

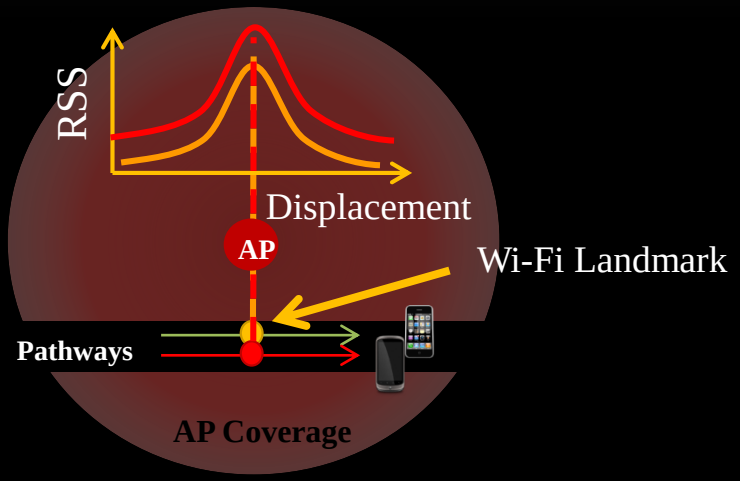


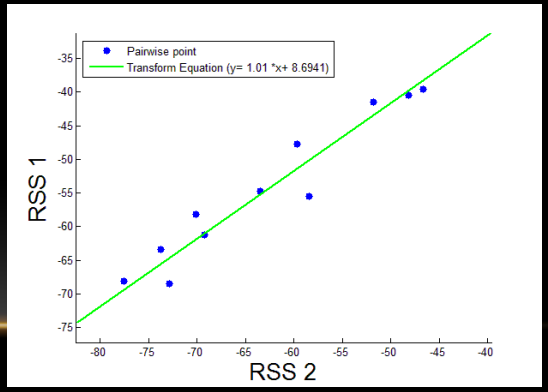
	Data without multi-modal		Data with multi-modal	
	Mean error	Max error	Mean error	Max error
Gaussian	2.029 m	7.518 m	3.348 m	18.861 m
KDE	1.483 m	5.373 m	2.494 m	11.744 m
GPR	1.746 m	5.328 m	3.721 m	16.157 m
MD-KDE	1.418 m	4.885 m	2.324 m	10.773 m

HOME CARE
INFORMATION FROM WI-FI SENSOR(2/2)

- Device diversity
  - Automatically training linear transform
  - Based on Wi-Fi Landmarks







EXPERIMENTAL RESULTS

Mean distance error	Raw data w/o region	Relative Feature w/o Calibration	Relative Feature with Calibration	Relative Feature with region+ Calibration
HTC	7.5	5.5	5.6	4.4
Infocus	16.3	8.3	8.2	6.1

Mean distance error	No Selection	K-strong AP	PCA
	5.09	6.43	4.78

Indoor Localization

- Home care
  - Wi-Fi based
- Museum guidance
  - Multi-sensors based
  - Navigation

MUSEUM GUIDANCE

- PROBLEMS

Problem of visitors:

- **Where are we?**
- **Where should we go?**

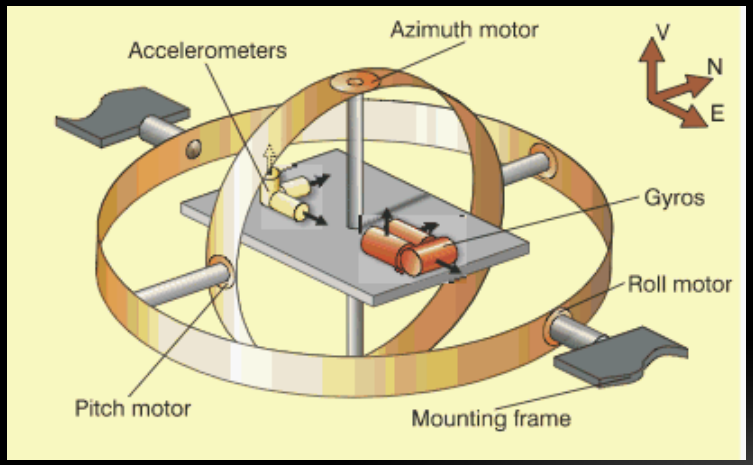
Problem of museums:

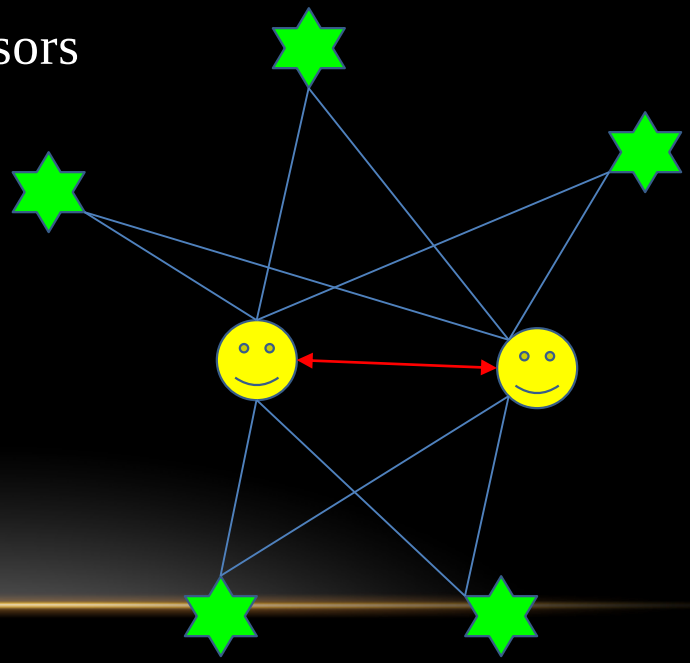
- **What is the behavior and preference of visitors?**
- **How can we improve the efficiency of museum services?**

- SOLUTIONS: Indoor positioning systems (IPS)
  - Build the smart guidance system for visitors
  - Acquire user behavior, habits and information
  - Improve the efficiency and the quality of the museum services

MUSEUM GUIDANCE

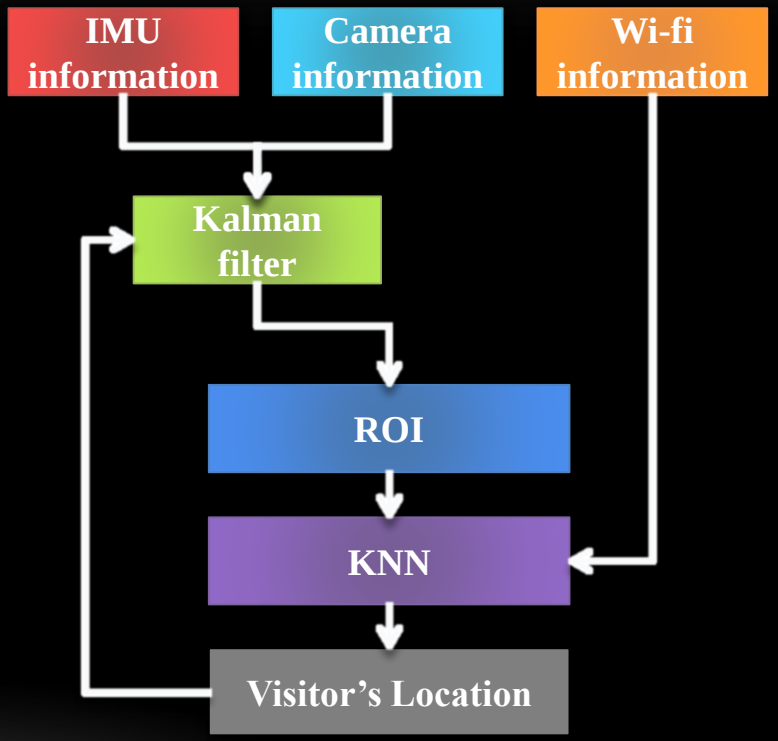
- Problem: How can we localize the visitor's position?
- Two main approaches:
  - Using relative positioning sensors
  - Using absolute positioning sensors





PROPOSED METHOD

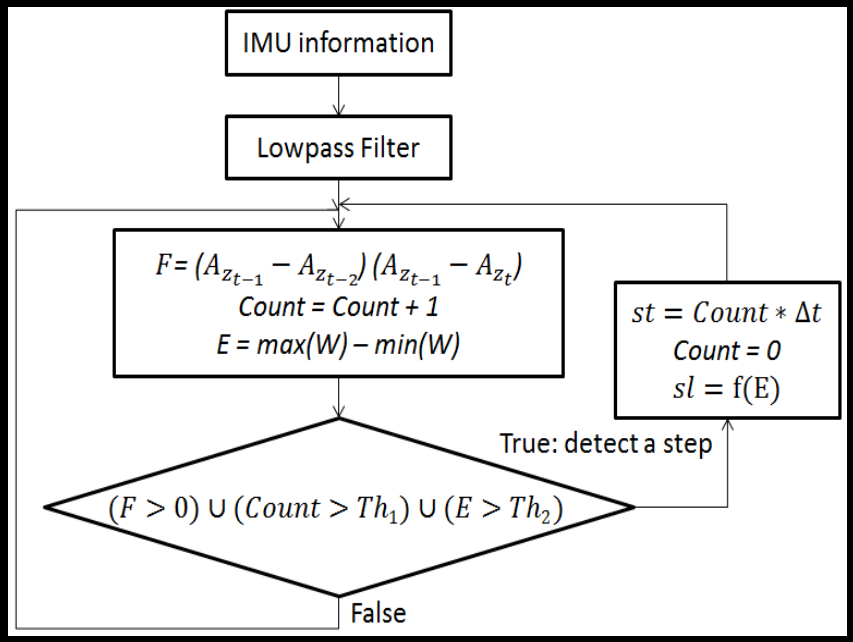
1. Form a predict model from IMU information
2. Retrieve location information from QR code and build an observation model
3. Apply KF to derive the coarse position of visitor
4. Form ROI from the obtained coarse position
5. Apply Wi-Fi fingerprinting in ROI
6. Use KNN to infer the visitor's final location



System flow of the proposed method

PROPOSED METHOD
INFORMATION FROM IMU SENSOR

- Where:
  - A_z: acceleration signal on z-axis
  - W: sliding time window
  - sl: Step length of a visitor's stride
  - Δt: time period for IMU signal acquisition
  - E: strength of a step
  - st: time step



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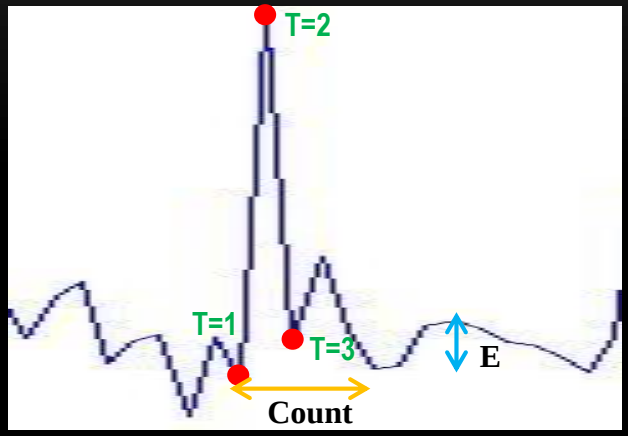
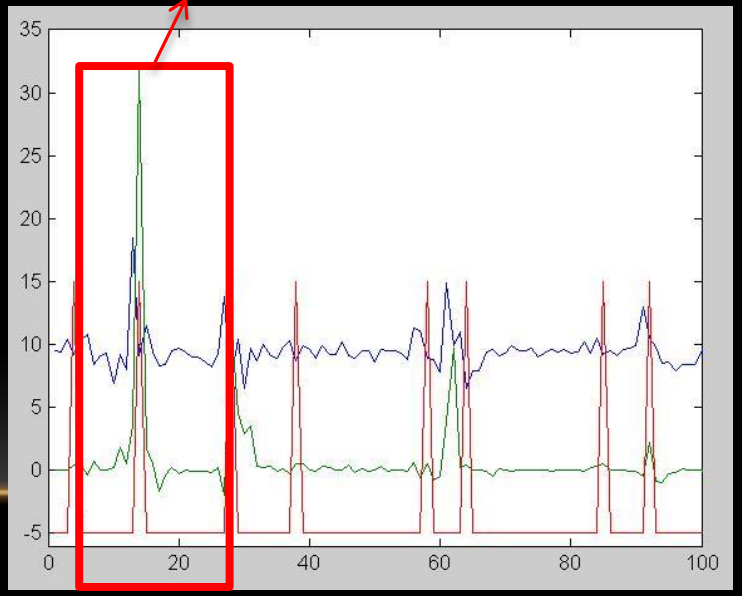




Detect a peak which could be treated as a reference point for step detection:
$F=(T_2-T_1)*(T_2-T_3)$

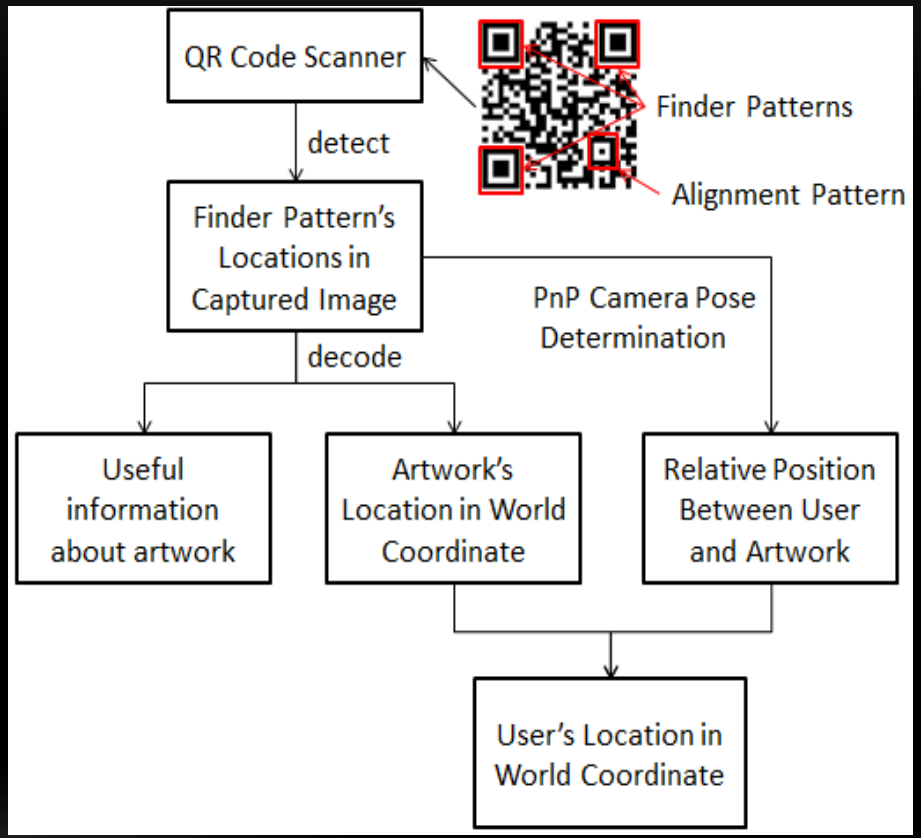
Merge the local peaks

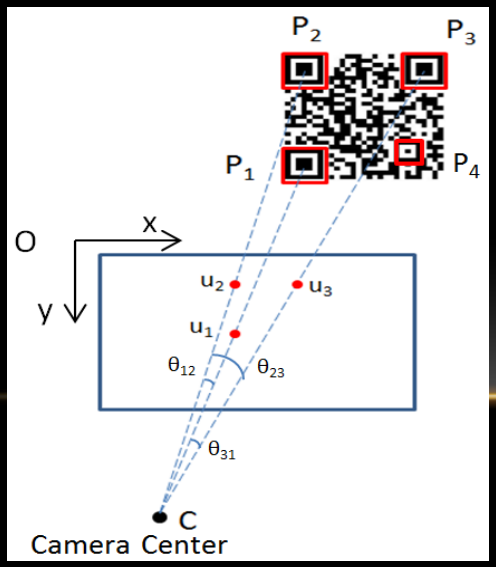
Avoid small irregular motion effects

$$sl = a * E + b$$

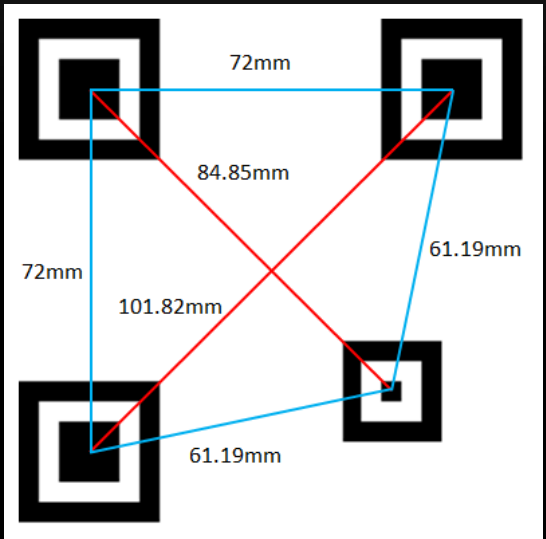
PROPOSED METHOD
INFORMATION FROM CAMERA

- Extract the embedded Artwork's location in world coordinate from QR code
- Using the finder pattern's locations in the captured image to find the relative position between User and the Artwork

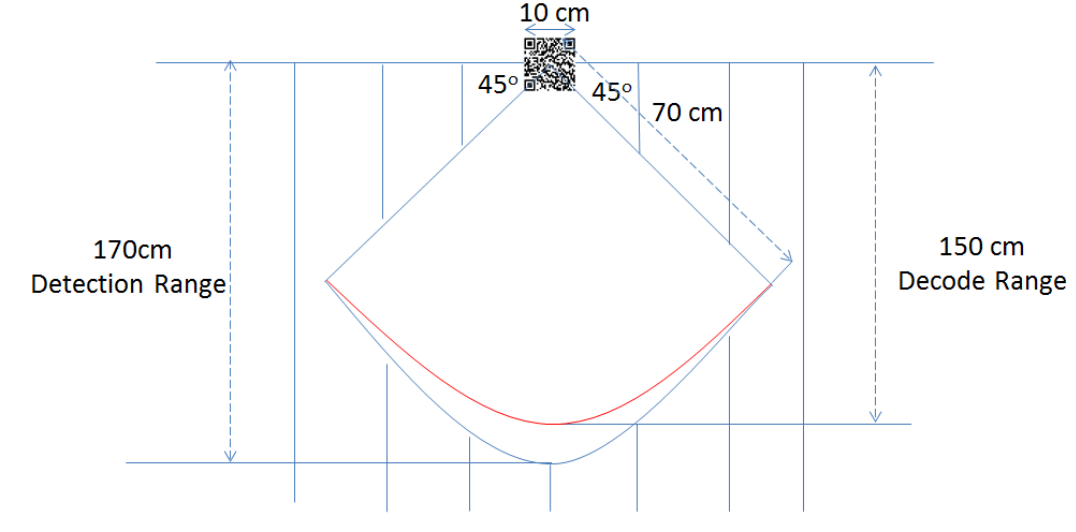




PROPOSED METHOD
INFORMATION FROM CAMERA



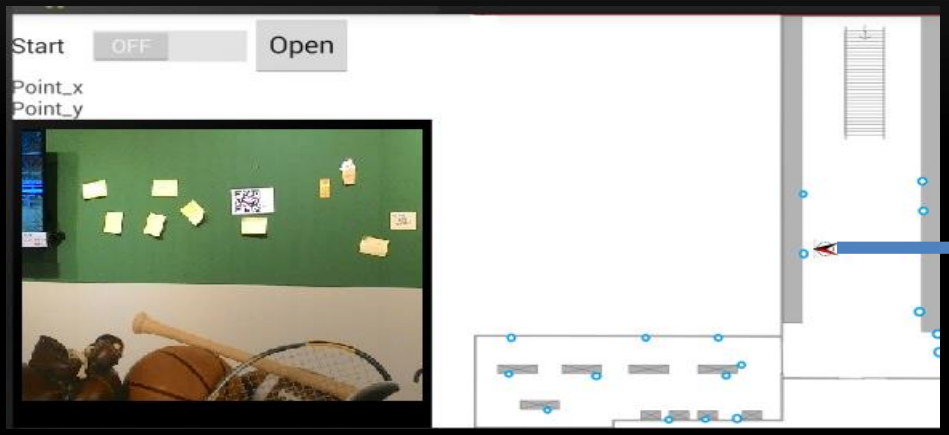
Distance between Patterns in QR Code



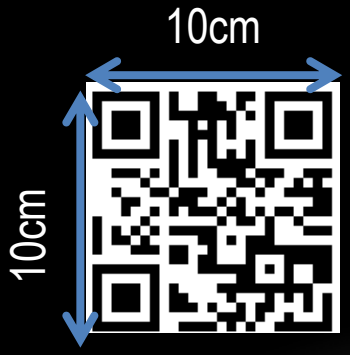
The effective ranges for QR code detection and decode

Accuracy of the Camera-Based Localization			
Position Error (meter)	Mean	Max	Variance
Camera-based localization	0.086	0.134	0.001

CAMERA INFORMATION



Estimated user location :
(-277.1954,954.4295)
Real user location :
(-276,955)

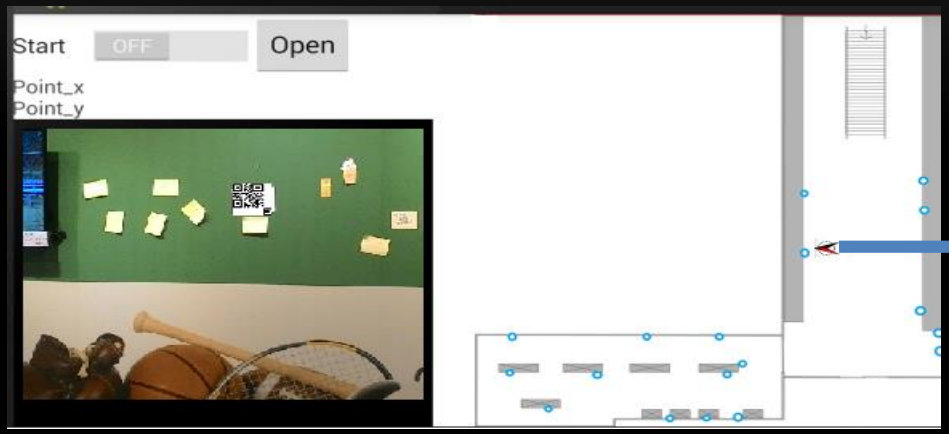


Old pattern

Detection range and distance

old	Distance(cm)
0 °	170
30 °	140
45 °	100

CAMERA INFORMATION



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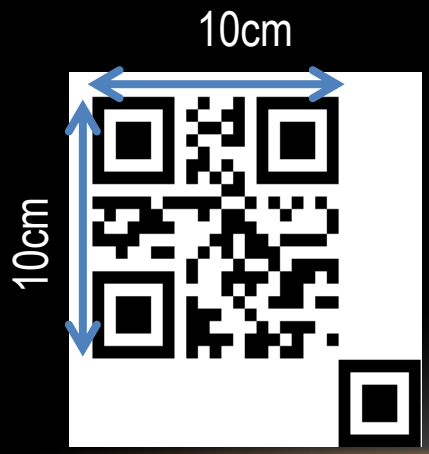


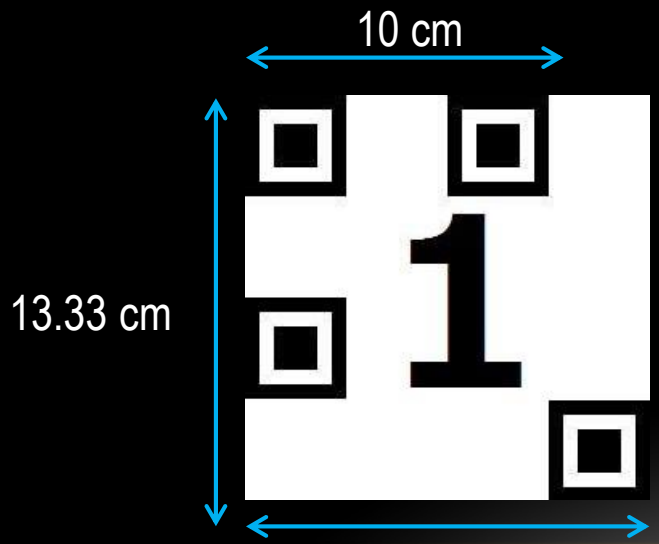
New pattern

Detection range and distance

new	Distance(cm)
0 °	280
30 °	250
40 °	230

CAMERA INFORMATION

- PROBLEMS : Distance is too far to decode the traditional pattern.
- SOLUTIONS : Using number to replace the code.



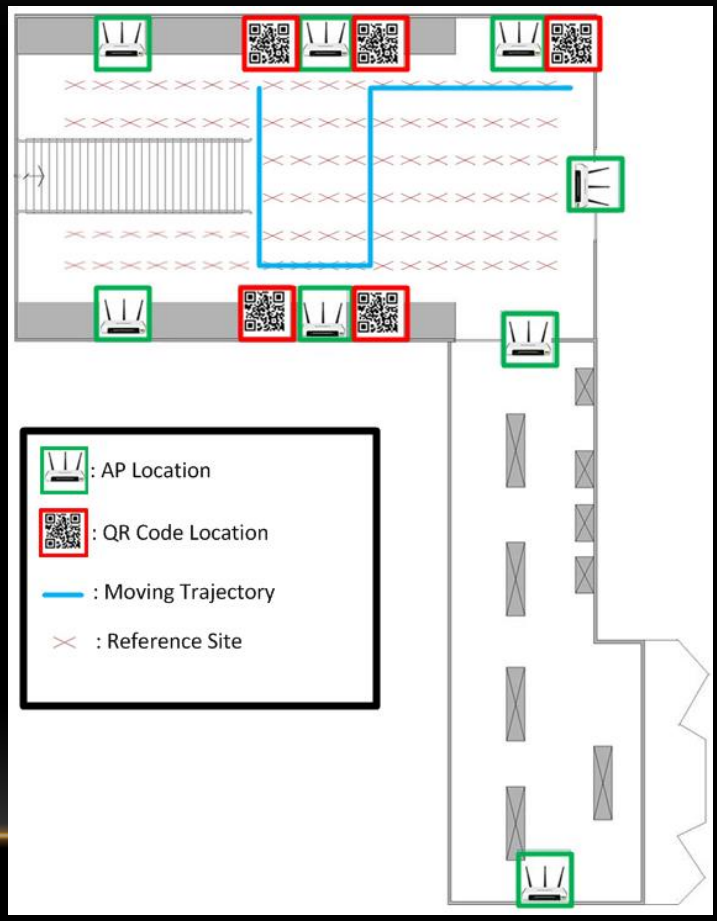
Number pattern

Detection range and distance

new	Distance(cm)
0 °	280
30 °	250
40 °	230

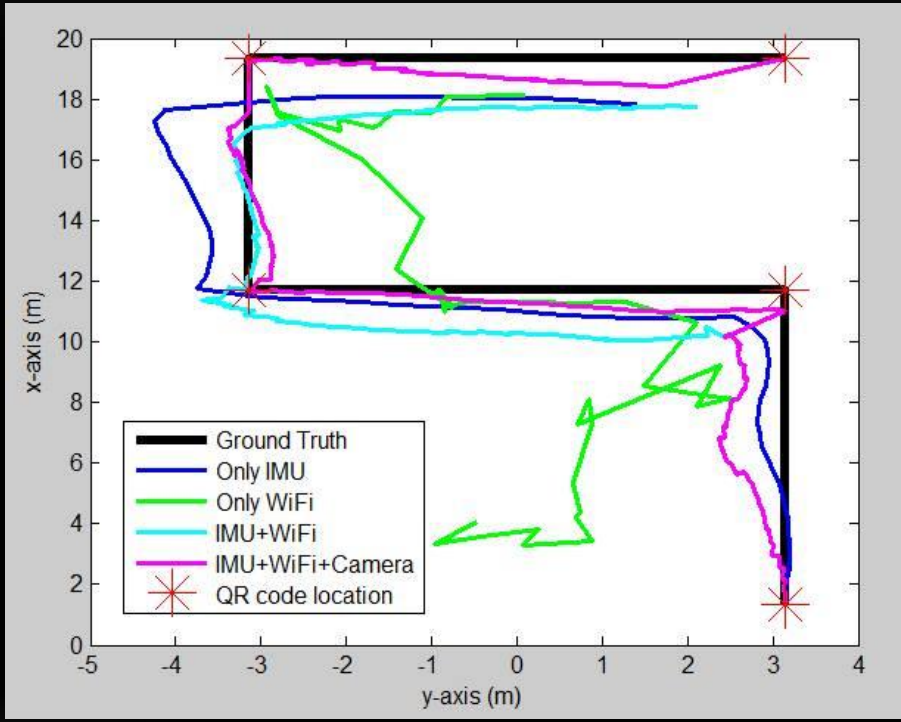
EXPERIMENT RESULTS

- SiME smart glasses for indoor localization
  - MEMS 9-axis IMU sensor
  - WLAN receiver
  - 5 megapixel camera
- 8 APs, TOTOLINK AC5



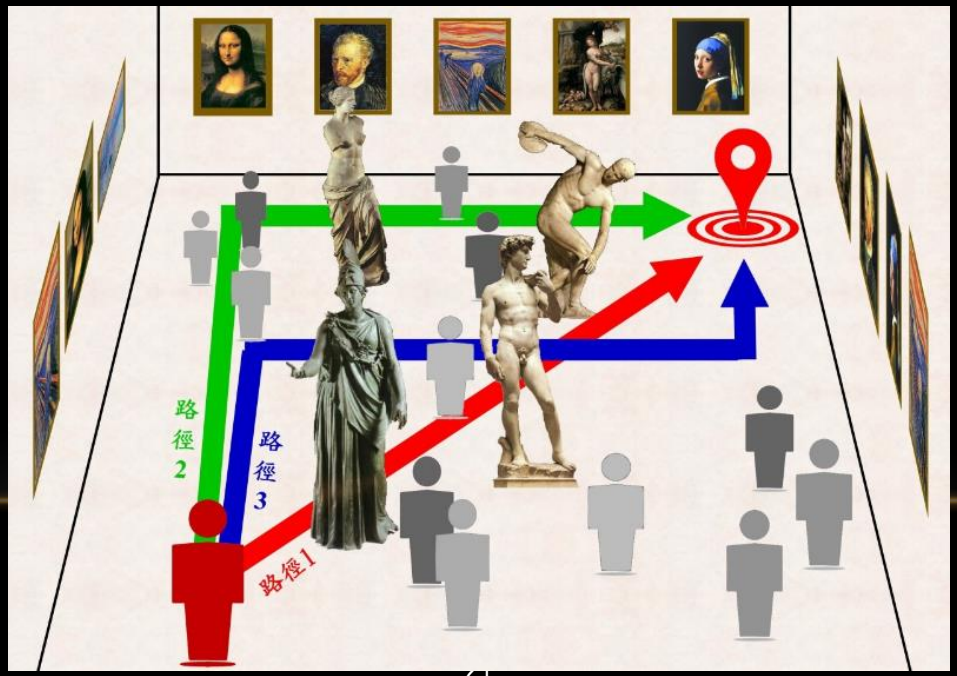
EXPERIMENT RESULTS

Table II. Performance Evaluation and Comparison			
Position Error (meter)	Mean	Variance	Max
Only IMU	0.9867	0.3913	2.4576
Only Wi-Fi	2.7544	0.7113	5.1036
IMU+Wi-Fi	1.2425	0.3797	2.3977
IMU+Wi-Fi+ Camera	0.7506	0.1595	1.8820



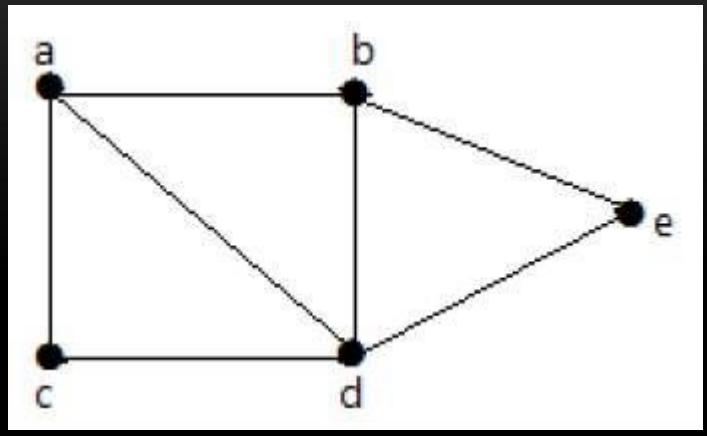
NAVIGATION

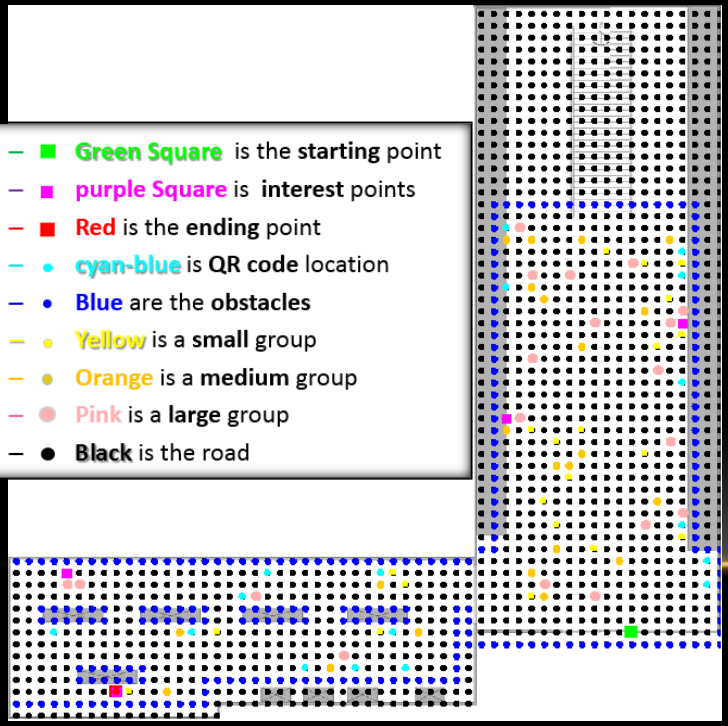
- Problem : how to recommend a suitable path for users?
- SOLUTIONS :
  - Using context-awareness technology

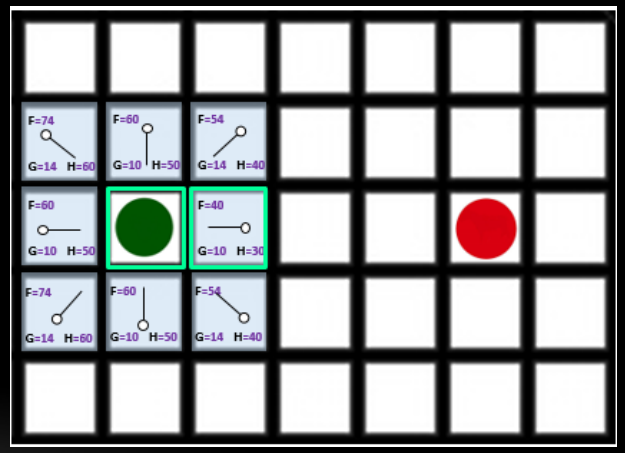


PROPOSED METHOD

- Graphic theory
- Cost rule
- A* Algorithm

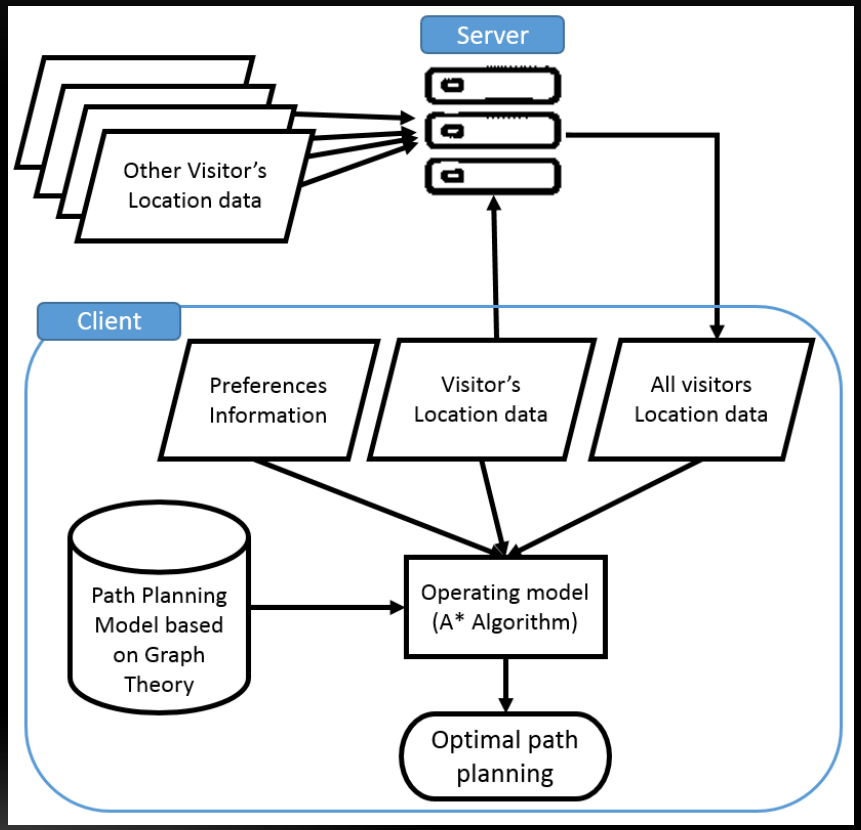






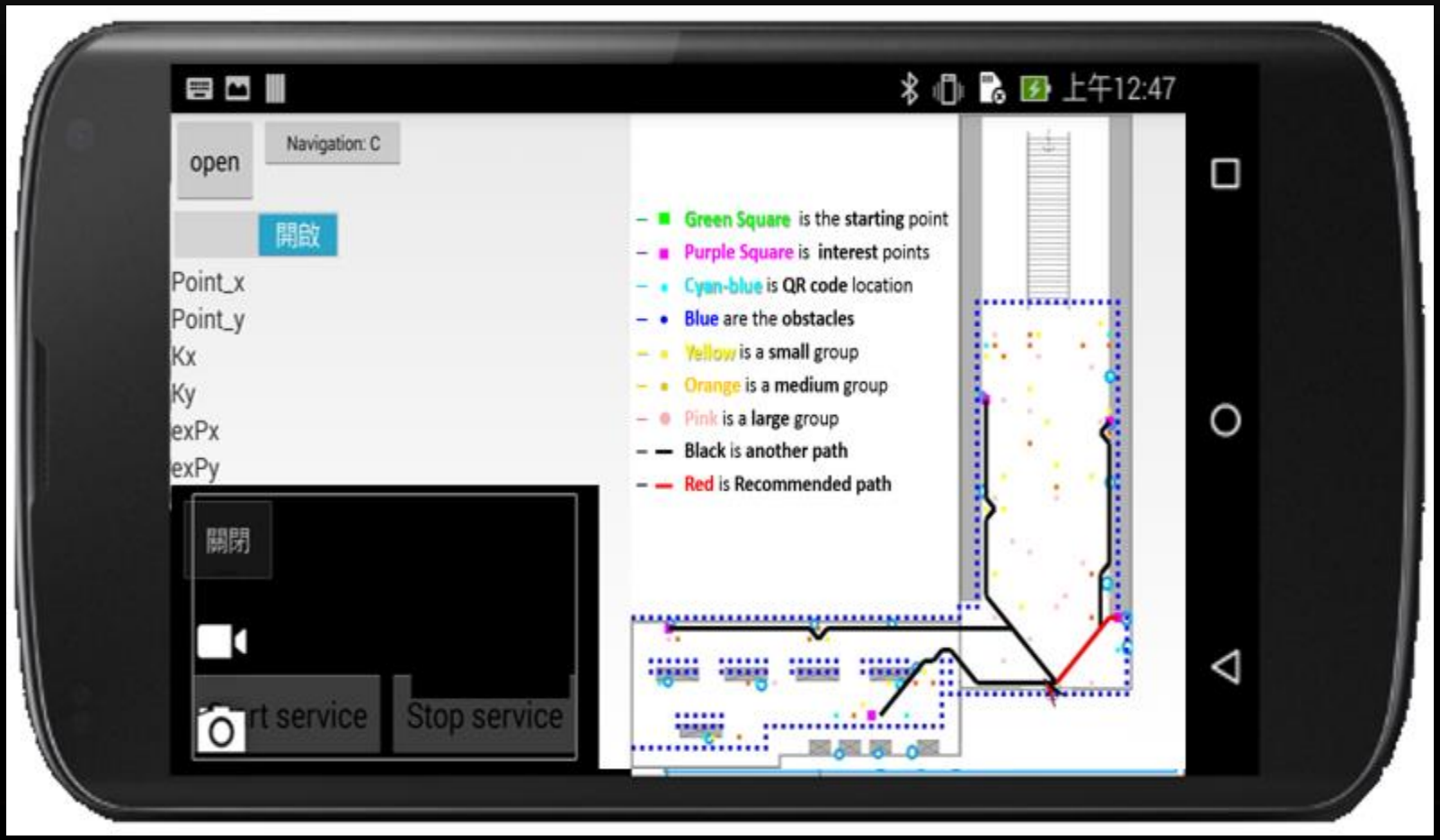
SYSTEM ARCHITECTURE

- Use Wi-Fi transmission
- Server
  - Collect all user locations
  - Return locations to all clients
- Client
  - Use three information to calculate a optimal path planning
    - User preferences
    - User location
    - all users locations



✓ Context-Aware Path Planning

EXPERIMENT RESULTS



Thanks for your listening!