Deterministic indoor detection from dispersions of GPS satellites on the celestial sphere

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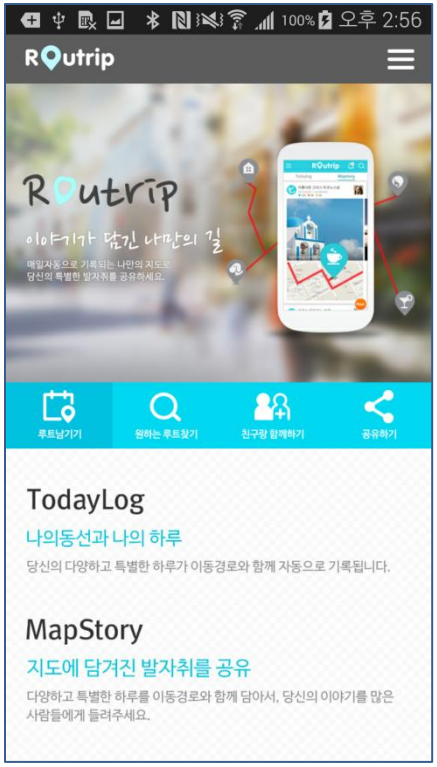
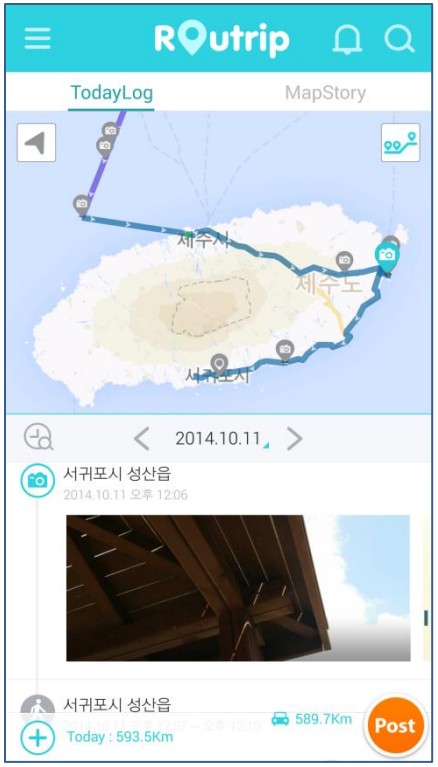
Background

- We are making a location-based service, called Routrip.
  - TodayLog : Record my whole day movements with my activities.
  - MapStroy : Compose the routes to a story and share with friends.





Background

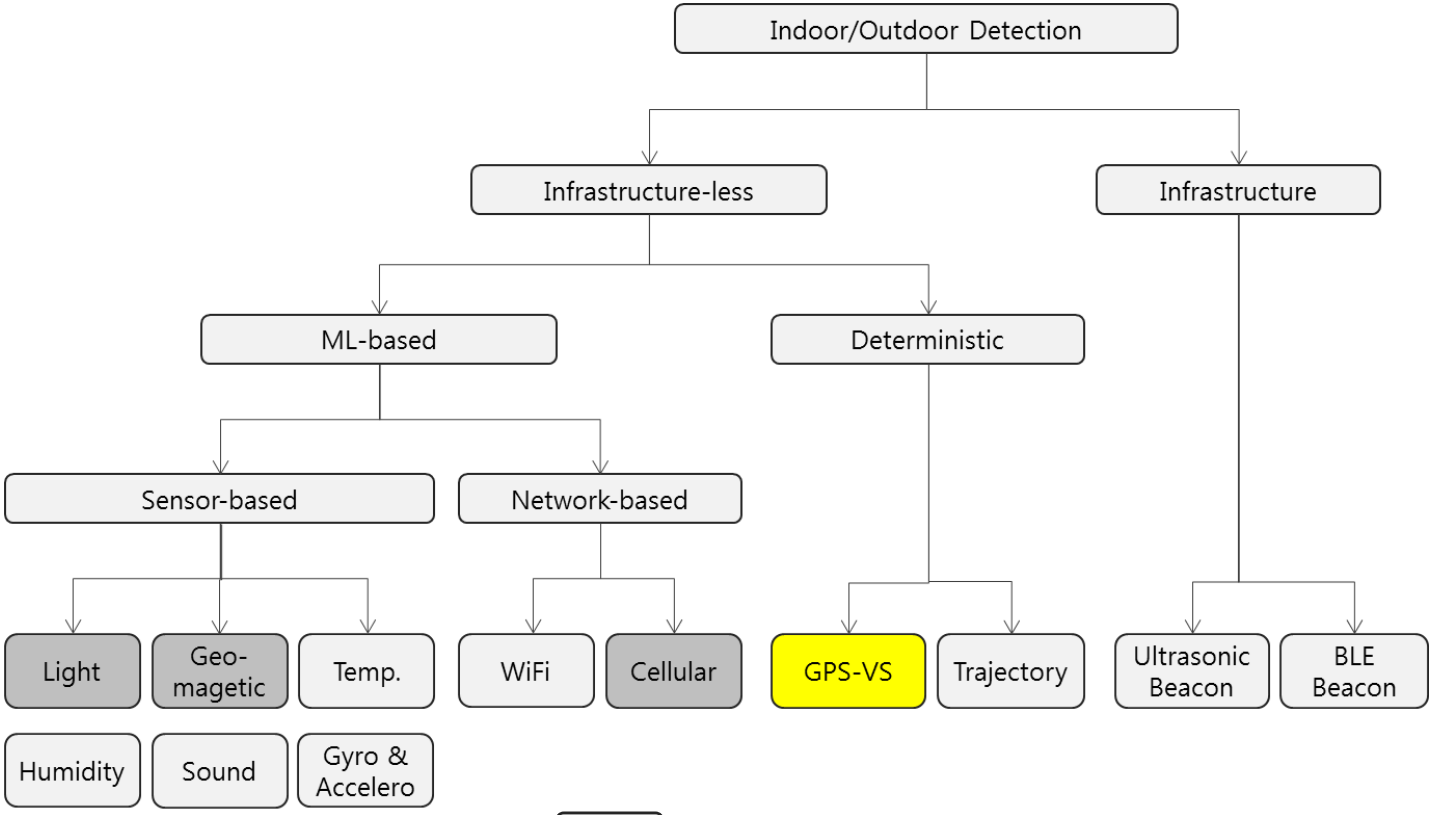
- One of the biggest hurdle is the power consumption while tracking the location of users continuously.
  - Coarse sampling → loss in movement points
  - Fine sampling → battery drain

- After many trial and errors, Routrip consumes
  - 1.6mA in the stationary state
  - 5.6mA in the walking/running state
  - 18.3mA in the vehicle/transport state

- As most users spend much time in the stationary state, we want to reduce the power consumption while stationary much less.

Indoor Detection

- If the mobile device could detect that it is inside buildings, the service can use longer intervals to check its location.



[SenSys2012] IODetector: A Generic Service for Indoor Outdoor Detection

ML-based vs. Deterministic

- In machine-learning based approaches,
  1. Collect the sample data (training set)
  2. Generate the classifier model using ML algorithms
  3. Decide the status from real-time test data

- As the classifier model is generated by training set data, we need sample data as many as possible for high accuracy, but even with many data, the model may be over-fitted to the specific environments.

- So, we want to make a method to detect indoor or outdoor without any prior knowledge on the environments.

GPS & NMEA

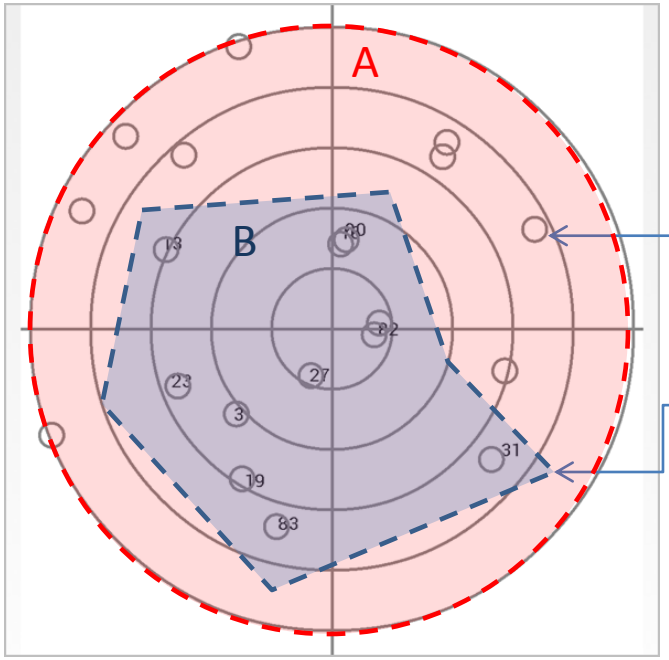
- The fixed location from GPS chipset is delivered to the host system using the format of NMEA0183 standard.
  - GPGGA: Global Positioning System Fix Data
  - GPGSV: GPS Satellites in View

$**GPGGA**,092750.000,5321.6802,N,00630.3372,W,1,8,1.03,61.7,M,55.2,M,,*76
$GPGSA,A,3,10,07,05,02,29,04,08,13,,,,,1.72,1.03,1.38*0A
$**GPGSV**,3,1,11,***10,63,137,17***,07,61,098,15,05,59,290,20,08,54,157,30*70
$**GPGSV**,3,2,11,02,39,223,19,13,28,070,17,26,23,252,,04,14,186,14*79
$**GPGSV**,3,3,11,29,09,301,24,16,09,020,,36,,,*76

- Usually, we concern only fix data for the current location.
- But, there are more information for all visible satellites including their azimuth and elevation.

Plotting on the Celestial Sphere

- First, we calculated the position of all visible GPS satellites using information from NORAD and NASA.
- And, plotted both calculated and received GPS satellites information on the celestial sphere.



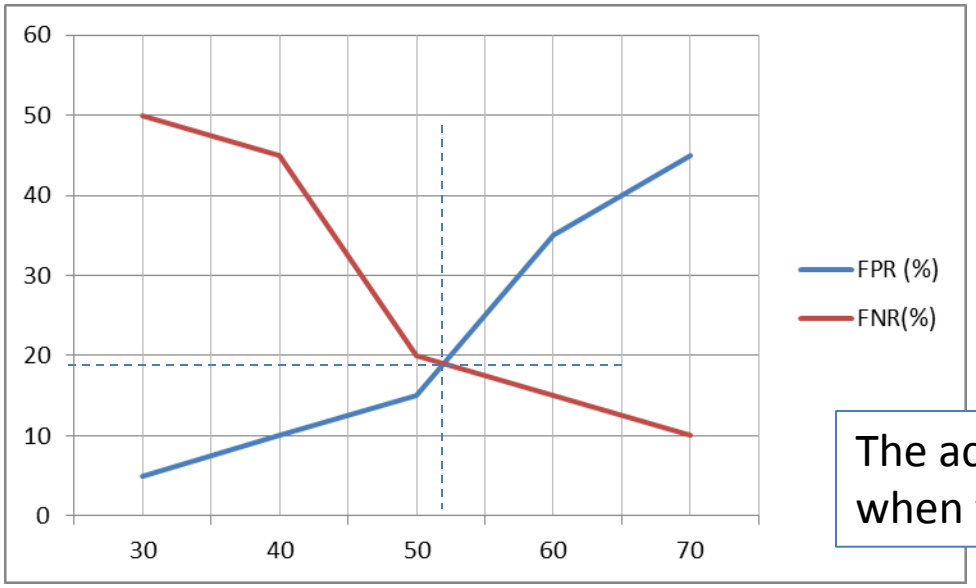
A GPS satellite should be there, but no or weak signal received.

DOOS (Degree-of-open-skies) =(Area of B)/(Area of A)

Determining DOOS threshold

- We measured false positive and false negative ratio according to the threshold value of the DOOS metric.

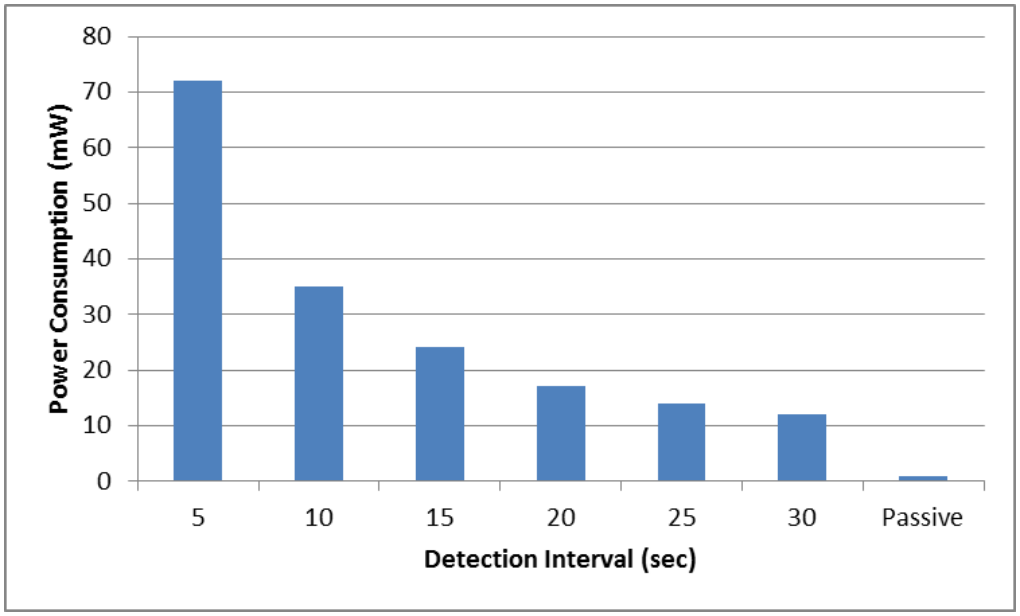
	Ground Truth	System Result
False positive	Outdoor	Indoor
False negative	Indoor	Outdoor



The accuracy shows optimal
when the DOOS threshold is about 53.

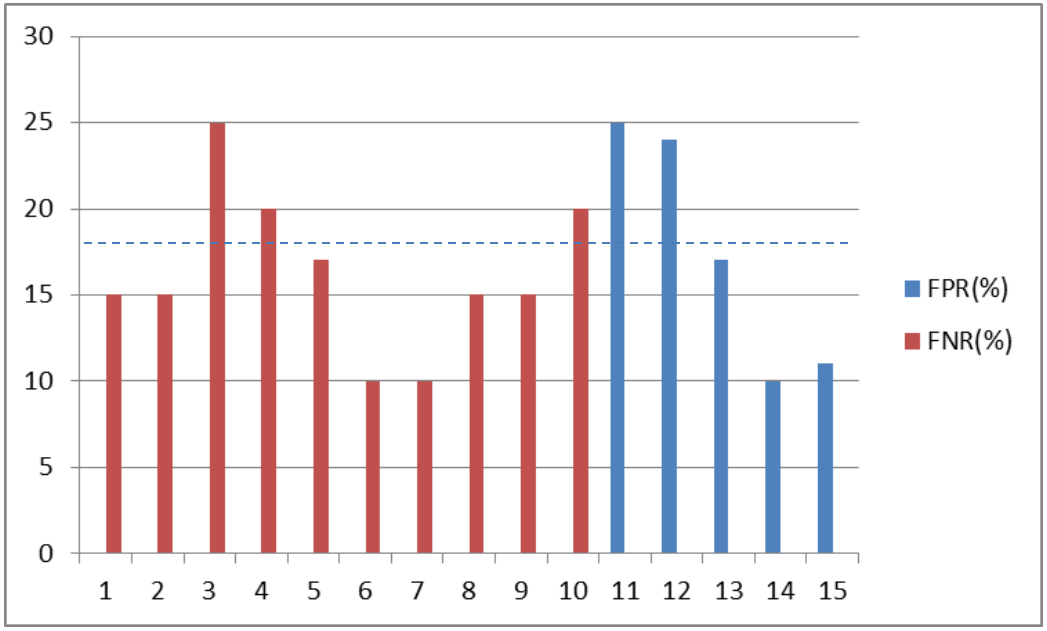
Power Consumption

- Periodic use of GPS might consume much power.
- But the detection mechanism can utilize the GPS location requests from other location-based services passively.



Availability

- To evaluate the availability, we selected 15 identical locations and performed the detection 10 times over two days.



The false ratio showed about 17%

Conclusion

- Detecting indoor/outdoor status of the smart phone is valuable context to most location-based services.

- We tried to find a solution with
  - Low-power consumption
  - High availability
  - High accuracy

- The accuracy cannot meet the QA requirement currently, but we will try to improve the method itself and to hybridize with sensor-based approaches.