FIG WORKING WEEK 2017
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Developing of GNSS technique for improving positioning accuracy under urban environments

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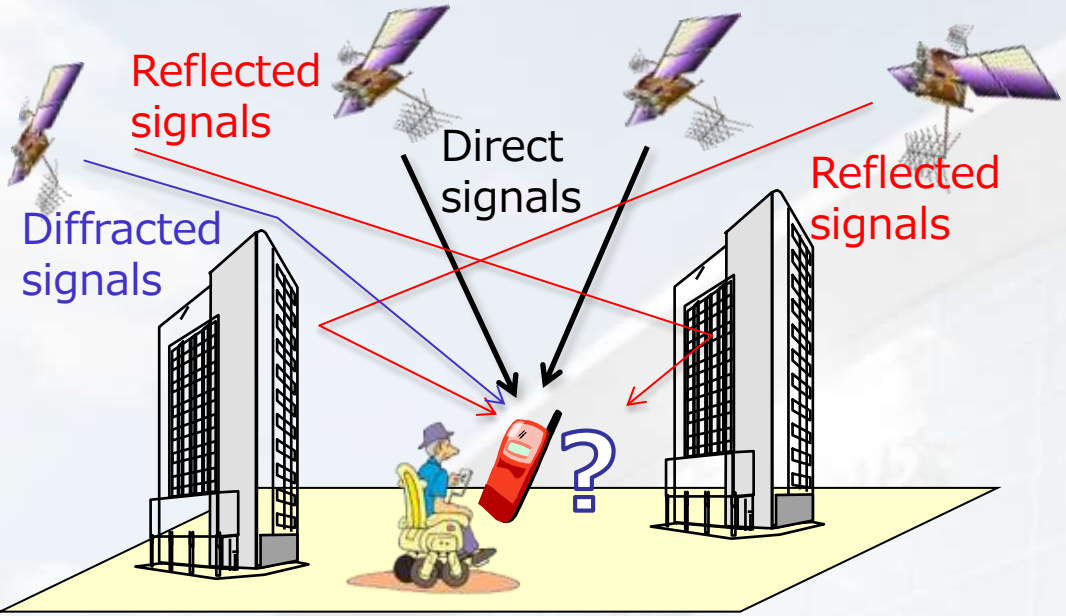
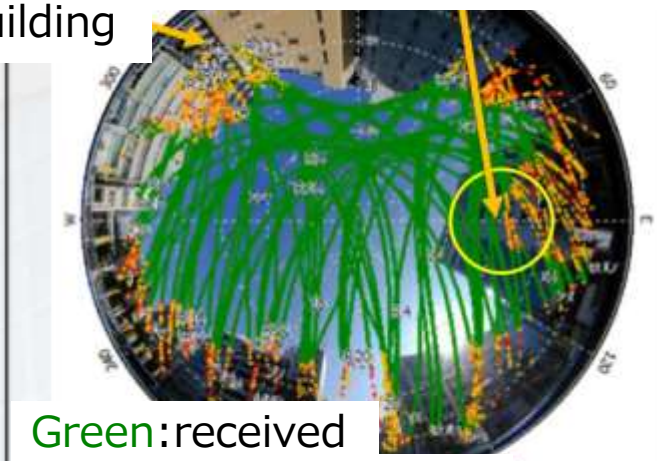
Observation condition in urban area



Receiving signals located behind buildings



Green:received
Orange:unreceivable
Sky view and signal reception

Mulipath caused by obstacles reduces positioning accuracy

Purpose

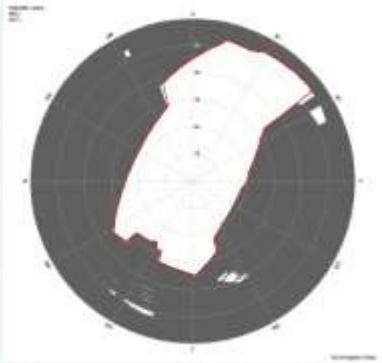
Mulipath mitigating method is necessary for precise positioning

Geospatial Information Authority of Japan (GSI) is developing new software-based techniques mitigating multipath effects in order to expand availability of GNSS precise positioning in urban environment

Multipath mitigating methods

Method 1

Selecting line-of-sight satellites with cutoff masks generated from fish-eye lens photos taken at observation stations. (T.Suzuki(2011))



```
% Elevation Mask
% AZ(deg) EL(deg)
    0.0   22.4
    1.0   21.6
    2.0   20.9
     .      .
     .      .
```

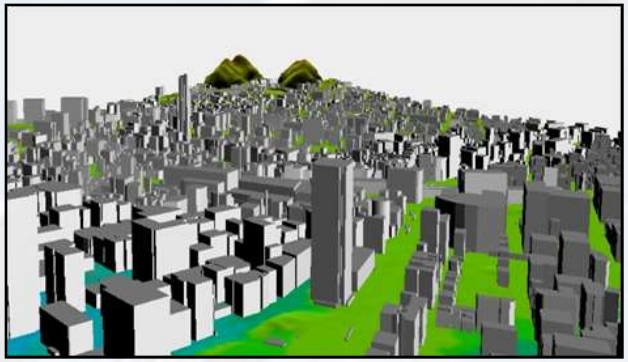
Method 2

Quality check of observation data based on phase differences of Doppler observables. (T.Ikeda(2013))

Multipath mitigating methods

Method 3

Selecting line-of-sight satellites with cutoff masks generated from 3D maps. (S.Miura(2014))



```
% Elevation Mask
% AZ(deg) EL(deg)
    0.0   22.4
    1.0   21.6
    2.0   20.9
     .      .
     .      .
```

Method 4

Improvement of precision based on velocities from Doppler observables. (N.kubo(2009))

Verification observation

We conducted 2 kind of observation

Fixed point observation
12 hours observation under severe condition for verification on various satellite constellations.

Multipoint observation
Short time observation under severe condition for verification on various obstacle conditions

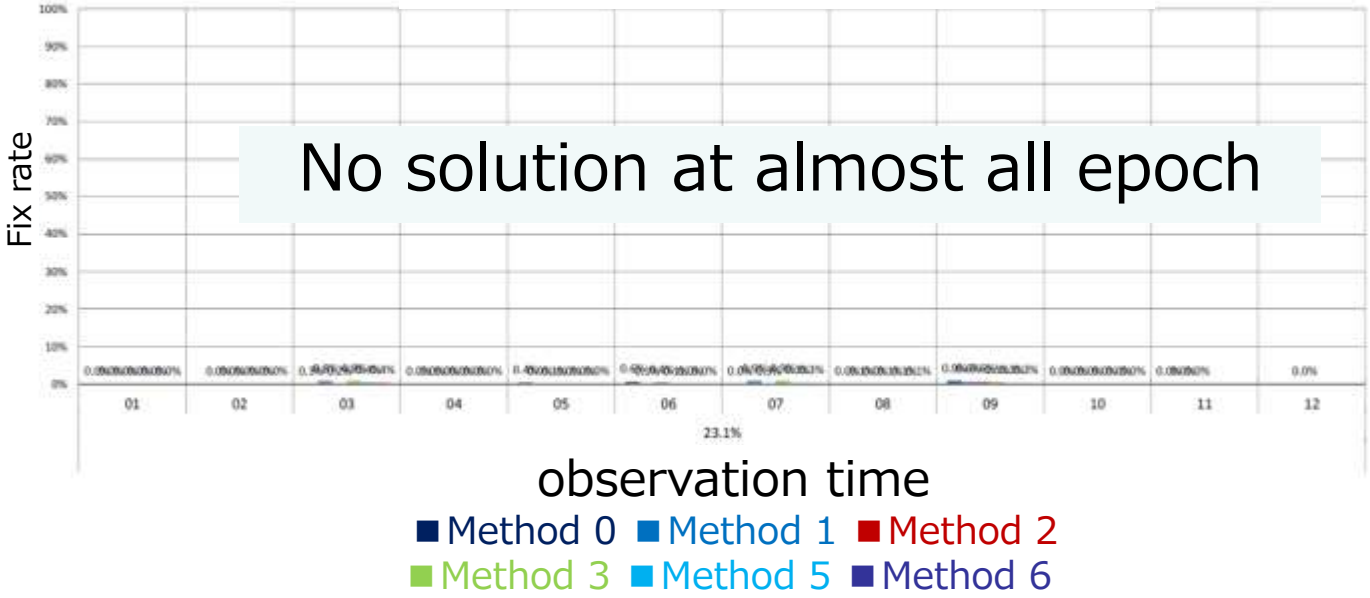
Result

Method 0 : Observed data are used for comparison
Method 5 : Method 1 + 2 Method 6 : Method 2 + 3

Site 1

Sky % : 23.1%

Fix rate on each observation time



- Any method didn't make improvement at Site 1 because of extremely bad condition.

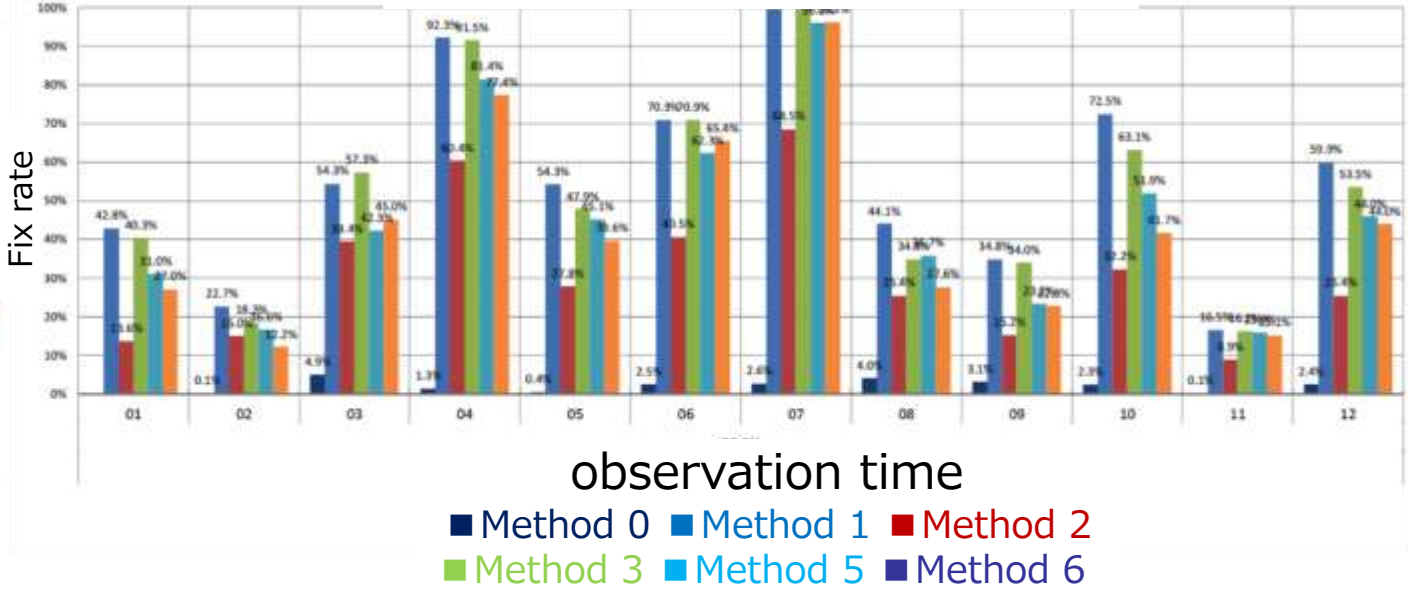
Result

Method 0 : Observed data are used for comparison
Method 5 : Method 1 + 2 Method 6 : Method 2 + 3

Site 2

Sky % : 50.8%

Fix rate on each observation time



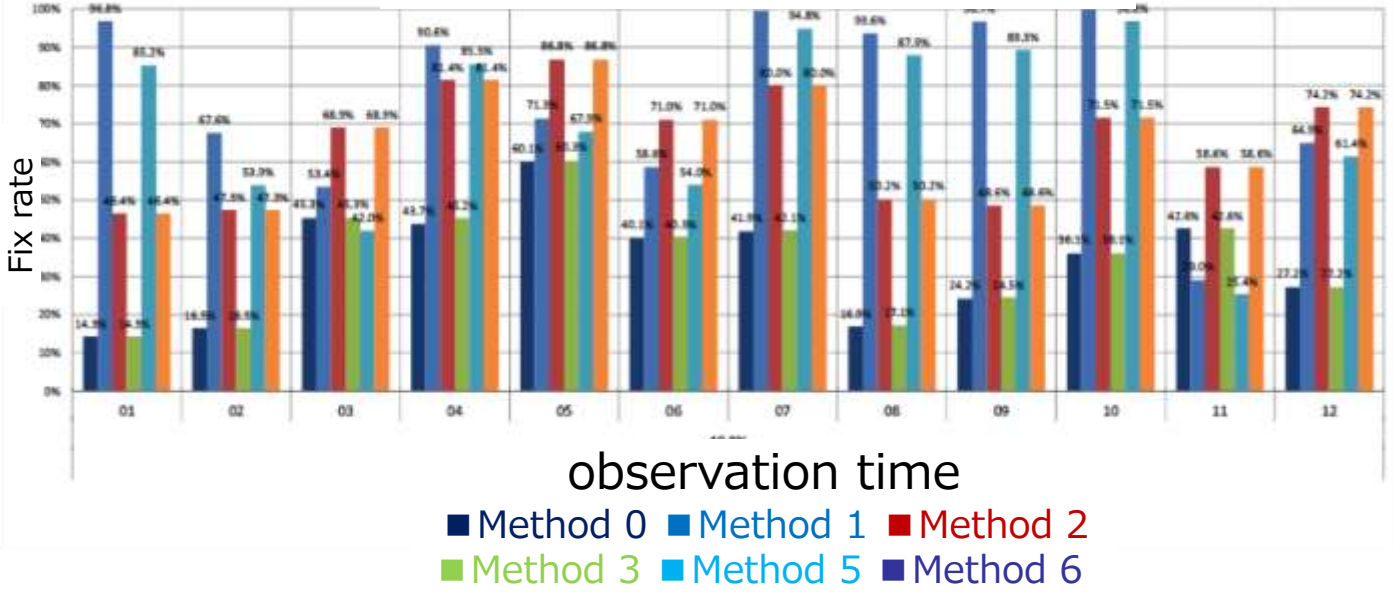
- Fix rate was improved by all methods. Method 1 was most effective.
- Degree of improvement depended on time.

Result

Method 0 : Observed data are used for comparison
Method 5 : Method 1 + 2 Method 6 : Method 2 + 3

Site 3 Sky % : 49.8%

Fix rate on each observation time



- Fix rate was improved by all methods. Method 1 was most effective.
- Degree of improvement depended on time.
- Effect of Method 3 wasn't seen because there is no tree data in 3D maps.

Summary

- GSI developed 4 multipath mitigating methods.
- Verification observation was conducted under severe conditions.
- Except for extremely severe condition, fix rate was improved by all method.
- Method 1 was most effective.

Future Plan

- Conducting the improvements of multipath mitigation methods.
- Indexing the effective range of each method
- Developing program for publication.

Thank you for your attention!