Performance Verification of Satellite based Positioning Service

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INTRODUCTION

These days, satellite based positioning service is being extended into areas where hitherto it simply was not available. For years, it has served society remarkably well for surveying and a host of other applications like GIS (Geographical Information System) and ITS (Intelligent Transportation Systems) where the users have a clear view of the sky and can receive all satellite in view with little difficulty. However, there are still situations where satellite based positioning service will not provide users with desired precision such as in areas between buildings, tunnels, and underground shopping malls because the number and geometric distribution of tracked satellites may not be sufficient for accurate and reliable positioning. Since many navigation applications nowadays require seamless and accurate positioning, it is very crucial to evaluate the present positioning service level in urban environment and then examine the possibility of combining other positioning technologies, which can complement the existing Global Positioning System (GPS) based positioning.

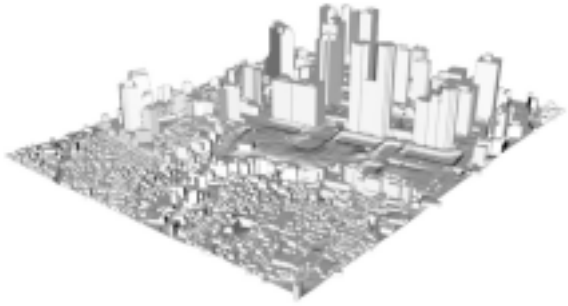

Fig.1. Simplified three-dimensional digital map which used in this simulation

DESCRIPTION OF SIMULATION SYSTEM

The developed simulation system consists of a simplified three-dimensional digital map (Fig.1) and the model of Keplerian and GPS satellite orbits. Each GPS satellite and map data are all implemented as individual classes in JAVA. The study area, Shinjuku area of Tokyo in Japan, is divided into the grid cells of regular tetragons with widths of two meters. This simulation system estimate whether the line of sight from the center of each grid cells to each GPS satellites intersects any object or not. Then the numbers of visible GPS satellites are computed for each grid cells. Consequently, it is possible to calculate the number of simultaneously visible satellites and available area for navigation, and, furthermore, this system can also calculate the Dilution of Precision (DOP) and the error distribution, which is a measure of satellite geometry with respect to the observing site. Especially, this simulation system can estimate the degradation of positioning accuracy under the influence of multipath, which will occur if the received signal is composed of the direct line-of-sight signal and one or more indirect signals reflected by the surroundings of the receiving antenna.

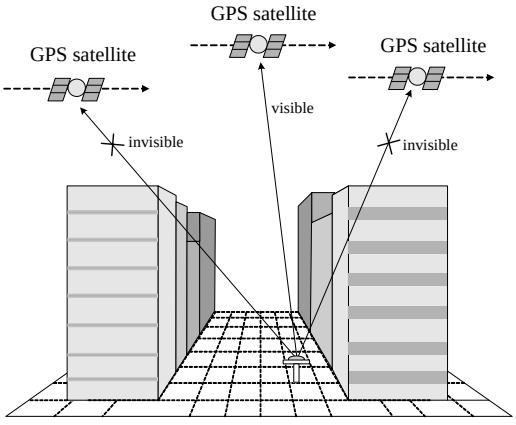

Fig.2 Concept of simulation system

SIMULATED MEASUREMENT SCENARIOS

As for the measurement scenarios, research activities started with investigation of the available area using a simulation system in order to find out the number and geometric distribution of tracked satellites when GPS satellites are utilized, and subsequently, the calculation of the number of visible satellites and DOP was also performed on the same time and day under

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identical environmental conditions on the same field on which the simulation was carried out. The measurement process was estimated every ten minutes from 0 o'clock on 15 November 2002 to 0 o'clock, 16 November 2002, that is, 145 steps in total and the 24 GPS satellite orbits were estimated using the actual satellite orbital elements on 14 November 2002..

SIMULATION RESULTS

In this paper, only the representative results of the simulations are presented. The graphical output is shown in Fig.4, which estimates the available area of positioning using only GPS satellites through simulation. This result is defined as the set of the grid cells where four or more GPS are visible based on the concept shown in Fig.2. As shown in Fig.4, there are still situations where GPS cannot provide users with positioning services such as in areas between buildings. Fig.5 shows the number of visible GPS on each grid cell. Moreover, Fig.6 and Fig.7 show the results of Horizontal Dilution of Precision (HDOP) and Vertical Dilution of Precision (VDOP). It can seen from these results that satellite based positioning service may not be sufficient to reliably carry out such as in urban environment.

Fig.3 3D digital view of Test area

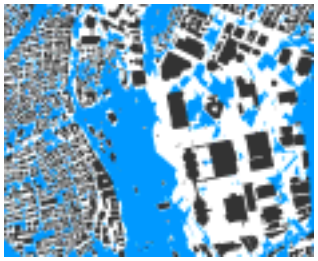

Fig.4 Available area

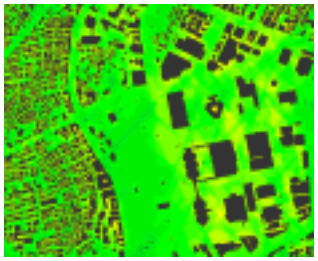

Fig.5 Number of visible GPS

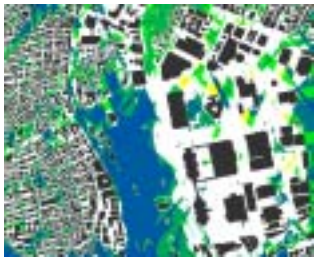

Fig.6 HDOP

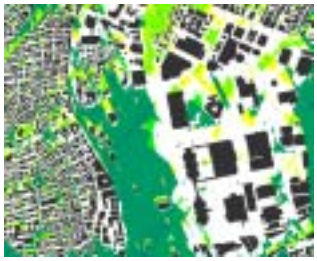

Fig. 7 VDOP

APPROACH FOR APPLICATION

The simulation system may be applicable when installing new positioning satellites system like ground-based systems (e.g. Pseudolites) and Quasi-zenith satellite system as a complement positioning technique, which has been proposed as the next-generation satellite navigation system in Japan as a mean to resolve poor satellite visibility and low positioning accuracy. Fig.8 is one of the samples of such an application. Fig.8 shows the result when 12 pseudolites are installed in the study area. In fact, the percentage of available area of the positioning in the case of only-GPS (Fig.3) is 38.5%, while the percentage improved significantly to 70.2% by installing the Pseudolites.

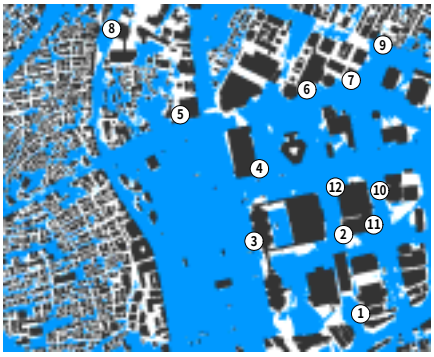

Fig.8 Case of pseudolites installation

CONCLUSION

Using this developed simulation system, it is possible to estimate how the availability and accuracy of positioning will be changed by the number and geometric distribution of tracked GPS. Under the challenging conditions of urban environments, the availability of the positioning service will be increased. Consequently, the evaluation of satellite based positioning service level will be even more crucial. Additionally, it turned out that this developed simulation system may also be applicable when planning to install new positioning satellites system like Pseudolite and Quasi-zenith satellite system.