A Study on Establishing the Radio MAP based on Wi-Fi AP utilizing Mobile Mapping System

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Abstract: Building up a quicker and more accurate positioning information that utilize location information of smartphones in emergency. This study has suggested the method to collect and build standard position based Wi-Fi AP data using MMS on the targeting areas of top five high criminal rate of 5 major crimes per 100,000 population, among districts of Seoul. As a result, we obtained the values of the whole districts' average; 25.46m, and its standard deviation; 27.76m.

Keywords: Wi-fi AP, MMS, SmartPhone

1. Introduction

As the number of smartphone users are soaring, location informations are being utilized in various services fields. Acquired location information could be very useful for public services and industrial utilization possibilities.

Therefore in this study, to promote people's safety and welfare by building up a quicker and more accurate positioning information by utilizing smartphone's location information on emergency, we suggest the method to collect and build exact position based Wi-Fi AP data using MMS(Mobile Mapping System) for targeting areas of top five high criminal rate of 5 major crimes(homicide, robbery, rape and sexual assault, theft, violence) per 100000 population, among districts(autonomous) of Seoul. Accuracy evaluation was performed on these Wi-Fi AP data.

2. Select Targeted Areas for Study and Establishment Procedure

In this study, we selected top five criminal rated districts in Seoul (5 major crime rate per 100,000 population, on the first half year of 2013), collected and built Wi-Fi AP positioning DB. We analyzed the collecting environment of each targeted areas and made collection plans and collected Wi-Fi AP raw data using MMS (Mobile Mapping System) equipment, and established the Wi-Fi AP DB by integrating the confirmed/corrected collected location and Wi-Fi AP result.

3. Wi-Fi AP DB Establishment Experiment and Complement

3.1 Collecting High Speed Wi-Fi AP Positioning DB using MMS

We made plans in advance for collection on the targeted areas of 5 districts. The risk of data loss and dual task from losing data were minimized by resetting the collection sensors for high speed collection MMS vehicles. We collected 377,337,484 of Wi-Fi AP information from 1,556 ㎞ from the location of the vehicle.

Table 1. Crime Status on experimental area

District	Gathered distance (Around trip included) (km)	AP collection status (overlapped collection)
A	176	33,626,108
B	220	35,437,996
C	367	97,634,896
D	537	158,817,534
E	256	51,820,950
Total	1,556	337,337,484

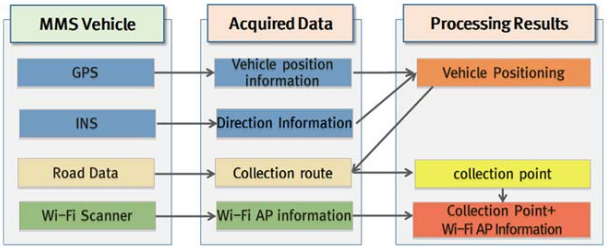

Figure 1. Wi-Fi AP information gathering procedure utilizing MMS

3.2 Positioning DB Establishment

(1) Correction of Collected Location Data

Correction has made in order to establish more accurate location data collected from MMS vehicle. GPS post-processing was carried out in kinematic baseline analysis as the primary treatment method, reference station data was processed by utilizing data from National Geographic Information Institute all time base station.(Fig 2).

Fig. 2. GPS data kinematic post process

(2) Positioning Error Correction for GPS

In order to correct the collected location data, we minimized errors of the Wi-Fi AP collection location by compensating defective GPS signals and disconnected signals caused by high-rise buildings, and by integrating calculation process of GPS, INS, and DMI.

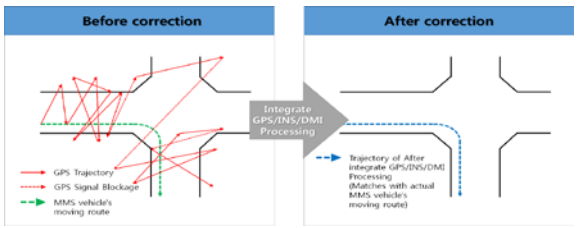

Fig. 3. Correction of MMS vehicle's location to integrate GPS/INS/DMI

(3) Integration of Collected Data

Integration of exact position of collected signal and Wi-Fi information was made through coupling process based on GPS time data that saved each collected informations via Wi-Fi signal collector and location information of the MMS collection vehicle.

The integrated data consists of GPS time (collection time) collecting location (x, y), Wi-Fi AP's MAC Address, radio wave strength, SSID, radio channel information as shown in Table 2.

Table 2. Data integration result

GPS Time	MAC Address	Collection of Point (X)	Collection of Point (Y)	RSSI	SSID
2014-10-19 PM 12:40:10	0025a6a55ecd	37.57038135	126.9922591	-85	FON
2014-10-19 PM 12:40:10	0025a6a57921	37.57038135	126.9922591	-85	FON
2014-10-19 PM 12:40:10	0025a6a5791f	37.57038135	126.9922591	-85	ollehWiFi
B 2014-10-19 PM 12:40:10	0025a6a57920	37.57038135	126.9922591	-83	ollehWiFi
2014-10-19 PM 12:40:10	00089f79efc8	37.57038135	126.9922591	-83	iptime2
2014-10-19 PM 12:40:10	0025a6a6fe1c	37.57038135	126.9922591	-81	Cafe_h2
2014-10-19 PM 12:40:10	00089f8ca036	37.57038135	126.9922591	-91	Iptime

(4) Refining Collected Wi-Fi AP information

To remove signal noise that lowers the positioning performance within integrated data, we removed unwanted AP and we refined collected Wi-Fi AP information by filtering the information of radio signal strength error and removing radio signal noise.

Refining procedures of the collected Wi-Fi AP information, as shown in Figure 4; removal of unwanted Wi-Fi signal noise; removal of portable Wi-Fi AP, removal of personal hotspot, signal pattern analysis, and removing Wi-Fi signal noise. The numbers of the refined Wi-Fi AP of five districts regions are shown in Table 3.

Table 3. Before/After refining AP collected number

District	Before refining AP collected number	After refining AP collected number
A	83,744	71,750
B	85,974	78,656
C	186,963	152,286
D	324,658	299,211
E	118,285	93,177

Total	799,624	695,080

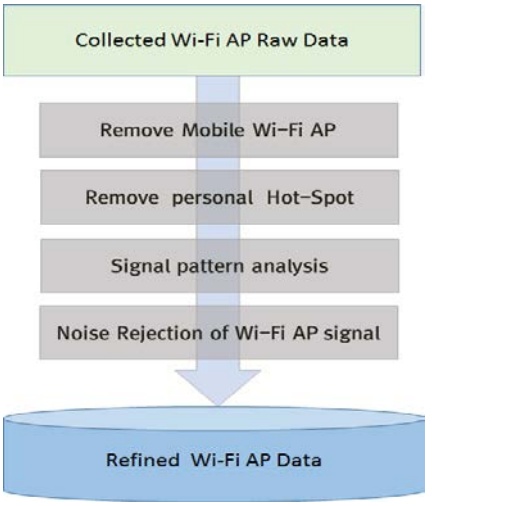

Fig. 4. Raw Wi-Fi AP information refining process procedure

4. Positioning Performance Evaluation Test

Positioning performance evaluation tests were proceeded on the 10 selected testing points from each targeted districts and positioning performance was verified through on-site inspections. The equipment that used for performance verification is L's G PAD 8.3 (CPU Qualcomm Krait 300, GPU, Qualcomm Adreno 320, adjunct Qualcomm Hexagon QDSP6V4, Wi-Fi IEEE 802.11 a / b / g / n / ac) using Android 4.4.2 Jelly Bean operating system which released in May 2014 . As for procedure, we selected 10 performance verification points on each distrcits in advance, and transmitted surrounding wifi scanned data to positioning server and requested the position and received the result (the position coordinates value).

Positioning verifications were performed more than 30 times on each test points by saving position coordinates, comparing and analyzing the true positioning value and the test positioning value. Performance verification result reflects the minimum and maximum positioning error, the average margin of error, and the standard deviation result.

By putting these positioning results together, and by calculating the mean and standard deviation for each point, the following were obtained the results shown in Table 4.

Table 4. Average and standard deviation of positioning result

District	Average(m)	standard deviation(m)
A	28.9	30.8
B	17.1	18.9
C	42.4	44.5
D	11.5	13.0
E	27.4	31.6
Total	25.46	27.76

District D scored the highest accuracy on positioning, whereas District C got the lowest, in positioning performance evaluation test. The reason of the differences in positioning accuracy is depending on GPS reception rate by geographical characteristics, and distribution and density of the Wi-Fi AP.

5. Conclusion

In this study, to utilize location information for emergency rescue purpose, we collected outdoor Wi-Fi AP information using MMS vehicles from five districts of highest ranked of five major crimes in Seoul. Through this collected result, we corrected the exact location of collection vehicle by correcting via GPS / INS / DMI and coupled them up based on Wi-Fi AP collector and GPS time, and built raw data by integrating Wi-Fi information and collection location, by removing the Wi-Fi AP signal noise that degrades the positioning performance and built Wi-Fi Radio Map.

For positioning performance evaluation of established positioning DB, we selected 10 test points from each district (autonomous) and calculated the estimated position and utilized the minimum and maximum of the distance margin of error with surveyed true position, the average margin of error, and standard deviation. As a result we obtained the values of average

of whole district; 25.46m and standard deviation; 27.76.m.

The result of this study, the positioning accuracy of less than 30m, shows the possibility to supplement or replace the carrier base station positioning(500m~2km) which is currently being used in emergency rescue and GPS positioning technique which is impractical in indoors.

However, the areas with insufficient Wi-Fi AP number (low density) are lacking the reference value of positioning DB, so it prevented from getting high positioning accuracy. Another problem found in traditional markets, there were diffused reflection of GPS signals caused by installations, such as tents, awnings, etc. Meanwhile, the areas with too much Wi-Fi AP number (high density), as the amount of information collected in the Wi-Fi collector increases which prolongs scanning time, and that elongates the travel distance of vehicle that result the estimation error and lower the accuracy of positioning.

Therefore, further studies are needed to ensure the position accuracy on the areas where Wi-Fi reception is poor, and to secure the position accuracy of received MMS collection vehicle according to the Wi-Fi AP scanning delay information.

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