Summary of SIP-adus Project (FY2016)

Name of the project	Survey on utilization of satellite positioning information for realization of automated driving system
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Object of the Project

Toward realization of automated driving system, on the assumption of using high precision autonomous sensors and position determination systems by the feature recognition on the dynamic map, it is considered to utilize the satellite positioning information to complement them.
In this project, data about accuracy of satellite positioning information is collected by positioning experiments and its position accuracy is evaluated.
In addition to examining the reliability of satellite positioning information and its evaluation method, we examine the test method and detection method for security measures of satellite positioning information.
These investigation will enable us to contribute to international discussions on security of location information and satellite positioning information, as well as leading to consideration of how to utilize satellite positioning information.

Project Summary

1. Comprehensive satellite positioning error investigation
   - ➢ Investigation of satellite positioning accuracy and availability on inter-city expressway
     - In case of using a single frequency receiver equipped with a high-performance filter, there is a possibility of achieving lane recognition level positioning if the system is under open sky environment.
     - In case of performing a carrier phase positioning such as RTK, it is possible to measure positioning with precision within a few centimeters in both the traveling direction and the lateral direction by using the fixed solution. Meanwhile, owing to miss-fixed solutions etc., there are cases a large error occurs.
     - By using the augmentation information created by same way as QZSS L1S, the error in the lateral direction became 0.55 m (RMS), and it has become clear that it is effective for improving accuracy of single frequency positioning results even on moving vehicle.
     - By using the augmentation information of QZSS L6, the error in the lateral direction became 0.08 m (RMS) even in real-time operation. It has revealed that high accuracy positioning is possible even on moving vehicle.
   - ➢ Evaluation of time errors / errors in the traveling direction
     - Using external measuring equipment, as a result of evaluating the accuracy of time and positioning in the traveling direction at the timing when the positioning data was output, it was confirmed that carrier phase positioning receivers have a stable time error about 0.2 (sec). Meanwhile, using single frequency receivers, time errors at low speed increased due to the influence of the filter.
   - ➢ Examination of error factors
     - In case of using QZSS augmentation signals etc., it is clarified that the main cause of position errors is satellite position and the ground environment such as shielding etc.
     - For utilizing the satellite positioning on the dynamic map, because accuracy errors are generated in both maps and satellite positioning sides, it is suitable to use linear positioning information of continuous positioning results or surface model having error amount instead of using the positioning results for each point.
   - ➢ Consideration of the influence of crustal movement
     - It is confirmed that the deviation in the horizontal direction due to crustal deformation from the Japanese geodetic system JGD2011 is around 1 m in Tohoku region and remote islands.
     - By applying the coordinate transformation parameters generated from information of GEONET (GPS Earth Observation Network System), it was shown that these gaps can be reduced to several cm level.

2. Consideration of measurement method of data reliability
   - ➢ Consideration of reliability of satellite positioning results
     - The method of evaluating positioning reliability using the error variance of the satellite positioning solutions was indicated.
     - In case of carrying out carrier phase positioning, we confirmed that positioning reliability can be greatly improved by removing NLOS (Non-Line-of-Sight) signals and eliminating miss-fixed solutions. Also it was shown that INS (Inertial Navigation System) estimation are effective to remove them.
   - ➢ Security survey on satellite signals
     - Because attacks on the satellite signals has become easier, it was investigated what kind of influences are caused by the attack.
     - Existing detection methods against attacks were investigated, and resistance to attacks was evaluated.
     - Since positioning results at the timing of attacks are influenced by suppression technique and filtering setting of receivers etc., an evaluation system using a simulator is indispensable in order to evaluate the behavior of a specific receiver.

Future plan

・Evaluation of satellite positioning accuracy and study for utilization of satellite positioning on the dynamic map .
・Investigation and examination of consistency technology between geographical information created by JGD2011 and positioning information obtained by satellite positioning
・Evaluation of satellite positioning reliability measurement method using composite sensors such as INS
・Performing demonstration experiments and evaluation of security attack influence during automatic driving