AUTONOMOUS ISOTROPY-BASED INTEGRITY USING GPS AND GLONASS

SEPTEMBER 21-24, 2010 - PORTLAND, OREGON

SESSION E4: INTEGRITY MONITORING FOR NEXT GENERATION APPLICATIONS
OUTLINE

- IBPL: Isotropy-Based Protection Levels
- PPP: Precise Point Positioning
- Products for PPP
- Static IBPL results
- Kinematic IBPL results
- Long-term IBPL results
- Conclusions
IBPS stands for Isotropy-Based Protection Level

Applicable to standalone single-freq pseudorange-based user positioning

RAIM only, no FDE applied

Protection Level (PL) bounds the position error to a certain probability or confidence level $1 - \alpha$

$\alpha$ is the integrity risk

Vector of least squares estimation residuals is used for characterization of the position error

$HPL = k \cdot r \cdot HDOP$, $k$ is a function of $\alpha$

It is assumed that the measurement error vector has an isotropic distribution in the measurement space

Isotropy implies that the pointing direction of the error vector defines a uniform distribution in the measurement space

No gaussianity assumed on individual errors
In order to validate the IBPL concept it is necessary to know the \textit{true} receiver antenna position.

By true position we mean coordinates that are known to have an error several orders of magnitude smaller than the standard pseudorange-based position used in IBPL.

High-accuracy positioning at the cm-level can only be achieved combining pseudorange and carrier-phase measurements.

Two main techniques are in used nowadays, the well-established RTK (Real Time Kinematics) and the relatively new PPP (Precise Point Positioning).

PPP processes measurements from a single user receiver, using detailed physical models and corrections, and precise GNSS orbit and clock products.

PPP differs from other precise-positioning approaches like RTK in that no reference or base stations are needed in the vicinity of the user.

The PPP algorithm uses as input pseudorange and carrier phase observations from a dual-frequency receiver (iono-free).
PRODUCTS FOR PPP

- Input *products* for PPP (sat orbits and clocks) are calculated beforehand by an offline process called ODTS (Orbit Determination & Synchronization)
- ODTS works in near-real time (30-min latency)
- IGS tracking network is used (NTRIP streams)
- GPS and GLONASS products generated
- Static and kinematic PPP supported, cm-to-dm level accuracy
STATIC IBPL

- Topcon Hyper dual-frequency GPS+GLONASS receiver
- Can be mounted on a tripod or on a magnetic base for a car roof
- 7-day data recording on GMV’s roof near Madrid (open-sky)
- July 20-26, 2010 (20 GLONASS flying)
Protection Levels and error vs time for $\alpha = 10^{-4}$ (probability of integrity failure = 0.01%).

- PL is nearly always larger than the position error
- PL effectively overbounds the user error, within the given integrity risk
Stanford diagrams for $\alpha = 10^{-4}$

- Horizontal results show that integrity fails around 0.02% of the time, as compared to an a-priori failure probability of 0.01%.
- No integrity failure is observed in the vertical component.
STATIC IBPL RESULTS (3)

- Accumulated PL histograms for $\alpha = 10^{-1}$ to $\alpha = 10^{-7}$

- Size of the PL increases as the integrity risk decreases
STATIC IBPL RESULTS (4)

- **GPS+GLONASS**

- **GPS-only**

- PL size decreases a lot when adding GLONASS
KINEMATIC IBPL

- 30-min open-sky tour, countryside near GMV offices
- Around 2.5 km
- July 23, 2010
Protection Levels and error vs time for $\alpha = 10^{-4}$ (probability of integrity failure of 0.01%).

- PL is always larger than the position error
- No integrity failure is observed in the horizontal or vertical components
- PL effectively overbounds the user error, within the given integrity risk
Accumulated PL histograms for $\alpha = 10^{-1}$ to $\alpha = 10^{-7}$

Pattern and PL sizes similar to static IBPL
LONG-TERM IBPL RESULTS (STATIC)

- Processing 200 days of WTZR data @ 30 sec (500000+ samples)

- $\alpha = 10^{-5}$

- $\alpha = 10^{-6}$
**magicGNSS**

- **magicGNSS** is a web application for GNSS data processing featuring high-precision and integrity
- Register for a 1-month free trial account
- Upload and process your own dual-frequency station data (RINEX observation files)
- Try IBPL/PPP online!
- [magicgnss.gmv.com](http://magicgnss.gmv.com)
CONCLUSIONS AND FUTURE WORK

- IBPL provides autonomous integrity for stand-alone pseudorange-based positioning
- GPS+GLONASS real data processing shows much reduced PL sizes vs GPS-only
- PPP is an effective and convenient way of validating IBPL performance (true position)
- Open-sky GPS+GLONASS results show promising performances
- IBPL/PPP can be applied to static and kinematic scenarios
- IBPL/PPP can be tested online at magicgnss.gmv.com
- Tests in urban and other difficult environments still to be done
- IBPL might be applicable to carrier-phase cm-level positioning (RTK, PPP) for precise-positioning integrity; to be studied in the future
Thank you!

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