Combination of Inertial Survey Systems and GNSS for Surveying

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Overview

Introduction
• Imego in general
• Imego’s inertial sensors, systems and applications

GNSS + INS
• Comparison GNSS / Inertial Navigation Systems (INS)
• GPS Shadow Explorer (2004)
• Performance now and in the future
Imego: a research institute focusing on microsensors, sensor systems and prototype development
Imego’s applications in motion tracking

- Surveying
- Drill hole measurement
- Fireman localization
- Rocket navigation
- Sport
- Crash tests
- Other applications
Imego’s IMU-history

IMU = Inertial Measurement Unit

IMT 6000

GyroSmart

IMT30

IMT40
Imego’s inertial sensors with MEMS-technology

Gyrosopes
– measure angular velocity

Accelerometers
- measure linear acceleration
Gyro technologies
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GNSS compared to INS

**Satellite navigation**
- Absolute position data
- Limited resolution
- Slow
- Worse at orientation
- Easily disturbed
- Best at X&Y

**Inertial navigation**
- Drift in integrated terms
- High resolution (rel.)
- Fast (kHz)
- Best at orientation
- Disturbance-free (no external ref)
- Best at Z

- complement each other well!
GPS Shadow Explorer (2004)

- Demonstrator
- With Lantmäteriet (National Land Survey) and other governmental inst.
- Inertial navigation used during GNSS/RTK shadow intervals
- Light and (relatively) inexpensive
GPS Shadow Explorer (2004)

○ = GPS-data
✓ = INS-data

Known start- and end-point

IMU

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GPS Shadow Explorer (2004)

- Two reference courses with a number of measured points 5/10 m apart

- Measuring rod is held at the known-point markers
- Pauses appr. 2 s
- 5/10 s between points
- Known start- and end-points, inbetween GPS-shadow
GPS Shadow Explorer
Navigation software

- Kalman filter
- Pauses identified
- ZUPT - zero velocity update
  - recalibration of offset-values of gyros and accelerometers
  - at pauses when measuring rod is held fixed on the ground
- Navigation performed between pauses
- Coordinates of start- and end-points known (GPS)
Results 2004

Short course (appr. 50s, 35 m):

9 cm horizontal accuracy

1 cm vertical accuracy
Results 2004

Long course (appr. 120 s, 100 m):

51 cm horizontal accuracy

13 cm vertical accuracy
Then, Now, Tomorrow

- **GPS Shadow Explorer 2004**
  - Analog gyroelectronics and 30 deg/h bias-stability
  - 51 / 13 cm (h/v) error after 120 s with known start- and end-points

- **Present generation’s digital IMU (2009)**
  - IBG20/21 gyros with appr. 1-3 deg/h bias-stability
  - 5 / 2 cm (h/v) error after 100 s *without known end-point*

- **Next generation gyros (under development)**
  - Goal: appr. 10 times better performance

- **Tight integration between INS and GNSS**
  - INS used to support GNSS’s phase tracking
Personal navigation – fireman localization

- In buildings – only inertial navigation
- Inertial sensors on foot
  \[\Rightarrow\] Drift can be set to zero at every step
Due to zero-velocity updates, drift is minimized.