Applications for Inertial Sensors

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Dr. Tech. Jussi Collin
Pervasive Computing
jussi.collin_at_tut.fi
Outline

- Research Group
- Research Projects
  - Indoor Navigation
  - Context Recognition using Smartphone
- Lab Equipment
- Recent Publications
Our Group

- Prof. Takala, Dr. Collin, Dr. Kirkko-Jaakkola, 5 PhD students
- Sensor-based navigation research started in 1999
- Deep understanding of performance of micro-electro-mechanical-system (MEMS) sensor in various applications
- The group has invented novel ways to use the GPS and sensor data in context-aware applications
MEMS Motion Sensors

**Accelerometers**
- *specific force*, ’all forces except gravitation’

\[ m \ddot{x} = F_f + N + G = F_{SF} + G \]

**Gyrosopes**
- *device body – inertial frame*

\[ \omega^B \]

+ Barometers, magnetometers
Indoor Navigation: GPS

NLOS and low signal strength causes lots of problems in indoors and urban canyons.
Indoor Navigation: MEMS

- Take advantage of physiological model of walking: count steps with accelerometers.

\[
\begin{align*}
DR\_East_i &= DR\_East_{i-1} + p_i \cdot \cos(\alpha_i) \\
DR\_North_i &= DR\_North_{i-1} + p_i \cdot \sin(\alpha_i)
\end{align*}
\]

- \( p = \) steplength
- \( \alpha = \) heading
Indoor Navigation: MEMS

- Maps are needed to correct drift
3D Indoor Navigation

- 3D Map, 3D collision detection
- Vehicle: speed + Smartphone: angular rates
- Combine the information using BT+OBD

Indoor 3D Navigation and Positioning of Vehicles in Multi-Storey Parking Garages, ICASSP 2013
Context: Motion Mode Detection with Accelerometers

[Diagram showing the process of context-aware motion detection using accelerometers.]
Sensor Placement Options

- Steering Wheel & Pedals
- Shoe
- Wheel

Energy Consumption Analysis for Green Routing - Data Collection from Electric Vehicles, *39th Annual Conference of the IEEE Industrial Electronics Society*

Lab Equipment

- Novatel DGPS, 1-10 cm reference position with 20 Hz
- Miniature wireless synchronized XSENS IMUs
- Customized programmable IMUs with BT and GNSS rx
- Ovenized IMU, barometers, measurement cart, etc..

http://www.xsens.com/
Recent Publications


Indoor 3D Navigation and Positioning of Vehicles in Multi-Storey Parking Garages, ICASSP 2013


Using a MEMS gyroscope to measure the Earth's rotation for gyrocompassing applications, Measurement Science and Technology, 23 025005 (8 pp), Institute of Physics Publishing

+ 6 patent applications 2011-2012

Video Channel:  http://www.youtube.com/user/insnavgroup