University of Verona,

School of Exercise and Sport Science,

Laurea magistrale in Scienze motorie preventive ed adattate

Metodologia delle misure delle attività sportive

Monday 21/12/2015 h. 13:30÷15

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A class within a six classes module

Global Navigation Satellite System

Figure 1. Custom-built platform for mounting GNSS devices and cameras on the roof rack of the car.

measures

Supej et al, 2014

Global Navigation Satellite System

measures

1) Smart phone: HTC Sensation HD (HTC Co., Taoyuan City, Taiwan)
2) Wrist watch: Garmin Forerunner 305 (Garmin International Inc., Kansas City, KS, USA)
3) Handheld device: Locosys Genie GT-31 (LOCOSYS Technology Inc., Taipei, Taiwan)
4) Professional system for testing engines and vehicles: Racelogic VBOX 20 SX (Racelogic Ltd., Buckingham, UK) with an external antenna B3G02G (Inpaq Technology Co., Ltd, Taipei, Taiwan)
5) High-end geodetic Leica RTK GNSS system (Leica Geosystems, Heerbrugg, Switzerland) consisting of a rover and a reference station, which had equal hardware components: RTK GNSS receivers (Leica GX1230GG), Leica survey antennae (GLONASS/GPS AX1202 GG) and Leica Satelline 3AS radio modems. The reference station was set up at the appropriate Leica tripod.

Global Navigation Satellite System

measures

Table 1. Selected technical specifications of the GNSS devices. Legend: GNSS—Global Navigation Satellite System; GPS—Global Positioning System; GLONASS—Globalnaja Navigacionnaja Sputnikovaja System; A-GPS—Assisted GPS; SBAS—Satellite-Based Augmentation System; RTK—Real Time Kinematics.

Device	GNSS Satellites	Doppler Effect	Frequency	Processing Mode	Sampling Rate (Hz)	Receiver's Number of Channels	Latency (ms)	Antenna Type
HTC	GPS	No	L1	A-GPS	1	?	?	Internal
Garmin	GPS	No	L1	SBAS	1	12	?	Internal
Locosys	GPS	Yes	L1	SBAS	1	20	?	Internal
Racelogic	GPS	No	L1	SBAS	20	20	41.5	External
Leica	GPS + GLONASS	No	L1/L2	RTK	20	72	20	External

Figure 2. Laptop with the external analog-digital unit in the vehicle synchronously stored data from two GNSS systems and the vehicle speedometer.

measures

Figure 7. Bland Altman test of agreement between the Leica and other GNSS devices. On x axis is average speed of both compared devices; on y axis is difference in speed between both devices. The first row shows data for steady speed, the second for acceleration and the third deceleration. Full horizontal line represent the mean differences and the dash-dot line 1.96 SD (standard deviation) interval in each diagram. Note that the vertical scale change sometimes in order to improve the visibility of the diagrams.

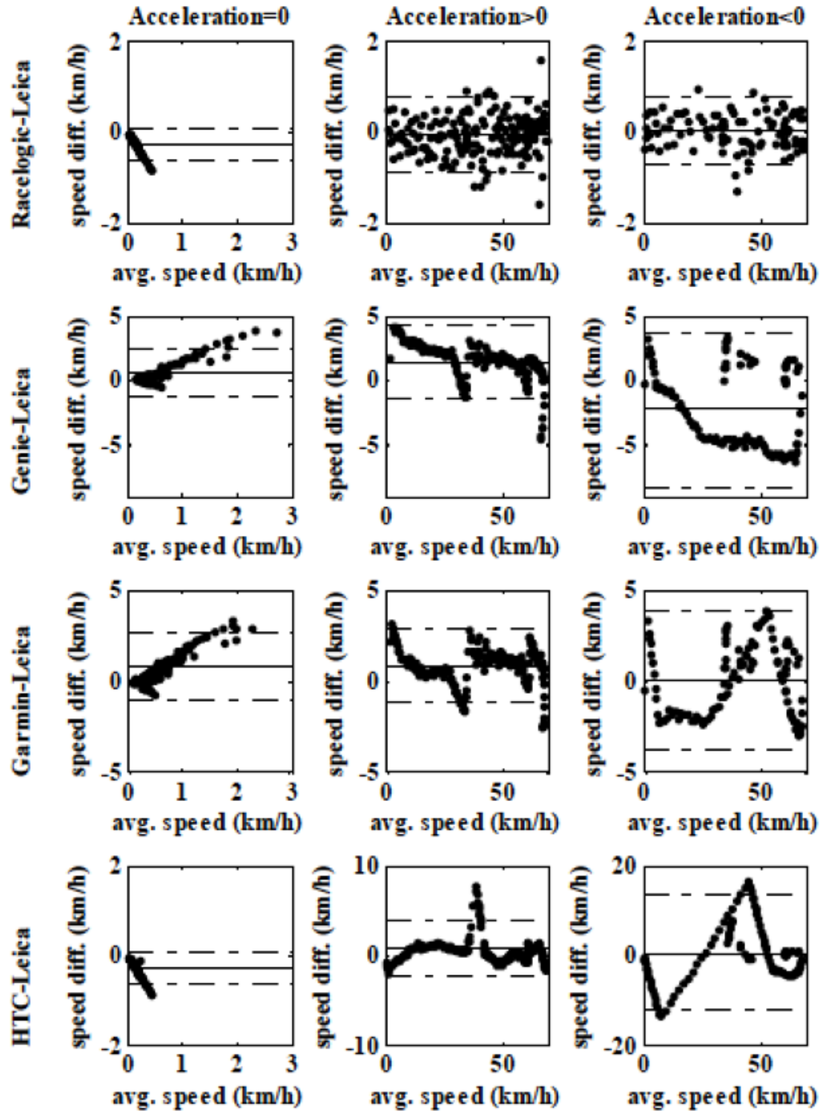
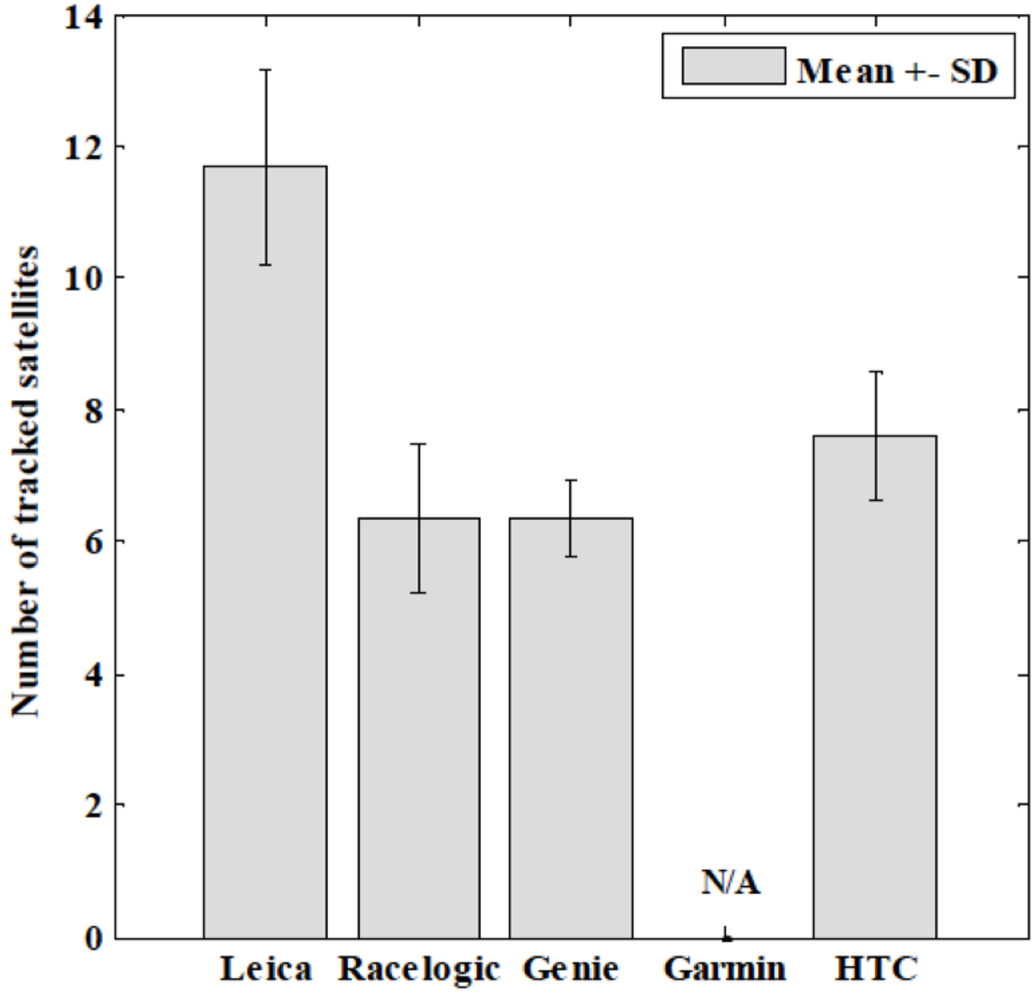


Figure 8. Mean number of tracked satellites (bars) for each GNSS device during the measurements and the corresponding standard deviations (SD) (error bars). Note that the number of tracked satellites for Garmin was not available (N/A).

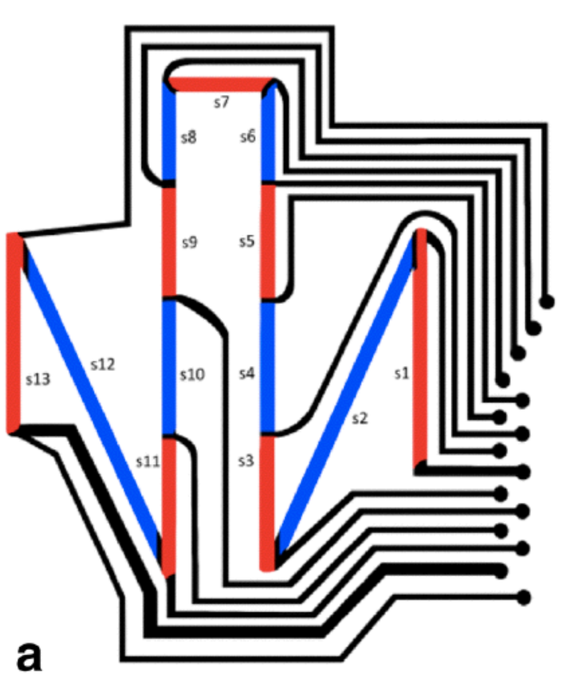


Other issues

- Specially patients are aware of being measured (effect of reactivity or interference) and therefore the use of portable instruments to measure PA might prevent them to perform some activities (e.g., a device could be used during a sport but not while having a shower, this may prevent the person from doing that sport);
- multi-sensor portable devices (e.g., Zephyr BioHarness, Hidalgo equivital)

Other issues

- multi-sensor garments;



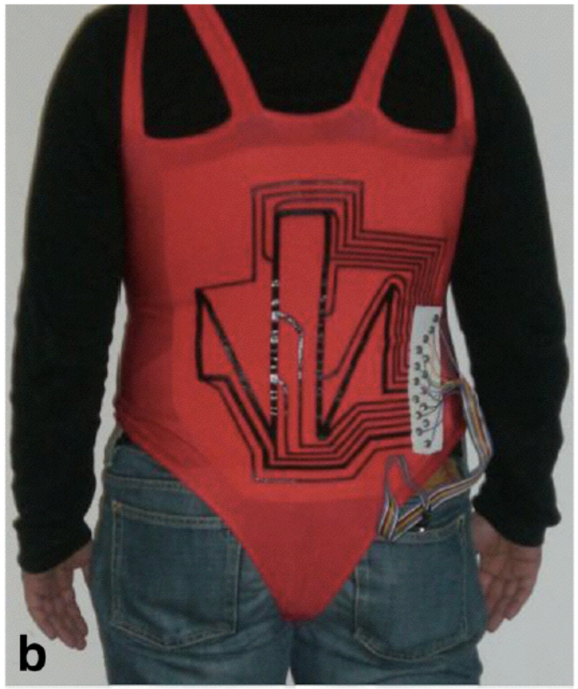


Figure 1 Garment Prototype. a) Layout of the placement of CE strain sensors on the garment prototype. Thick lines are sensors; thin lines are connection wires made of the same polymer. **b**) Picture of the garment from behind. The readout electronic device is placed in a pocket of the subject's pants.

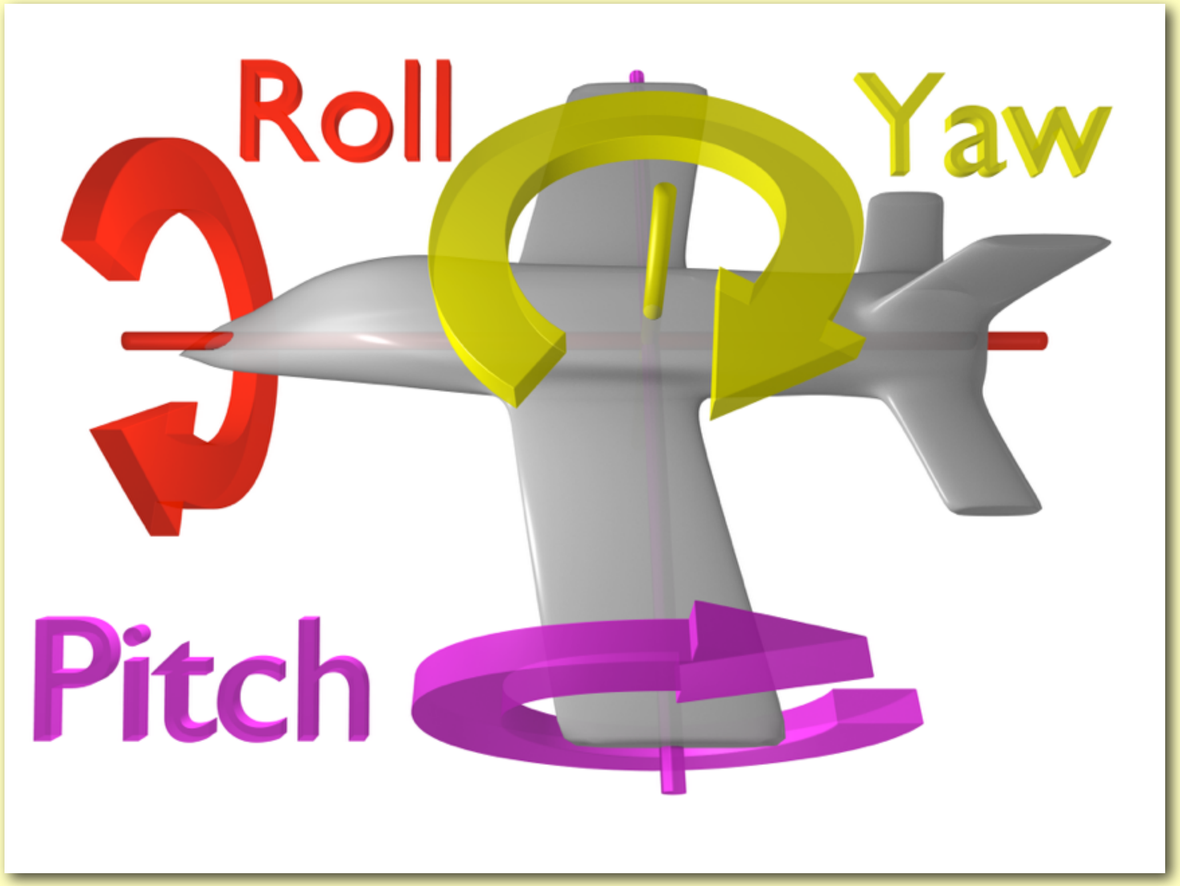
Tormene et al., 2012

Other issues

- Inertial Measurement Units-based systems;
- IMU is an electronic device that measures and reports on a craft's (aircrafts, drones, missiles, spacecrafts, satellites, landers..., humans) speed, orientation, and gravitational forces, using a combination of accelerometers and gyroscopes, sometimes also magnetometers. Recent developments allow for the production of IMU-enabled GPS devices. An IMU allows a GPS to work when GPS-signals are unavailable, such as in tunnels, inside buildings, or when electronic interference is present;
- data collected from the IMU's sensors allow a computer to track a craft's position, using a method known as dead reckoning;

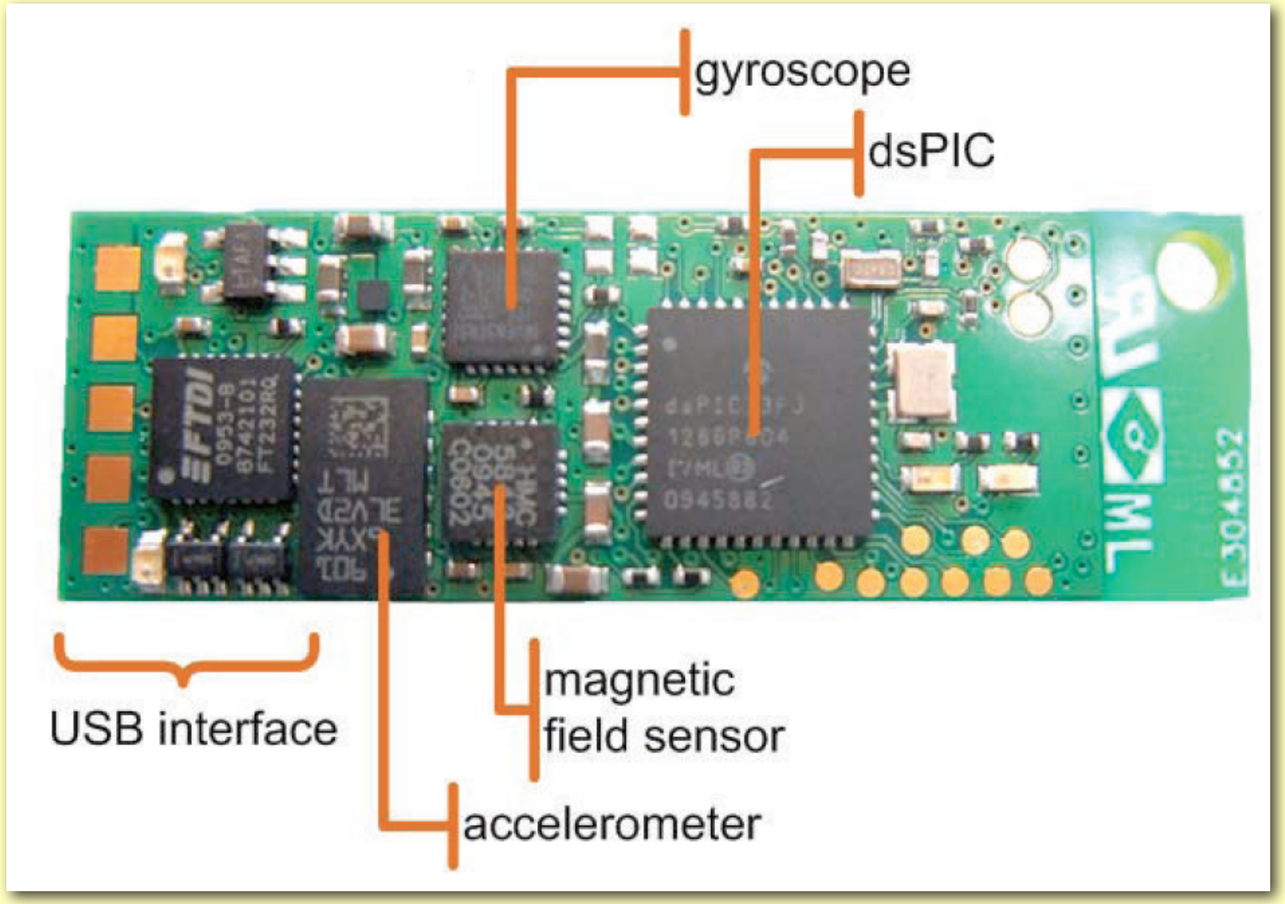
Other issues

- IMU works by detecting the current acceleration using one or more accelerometers, and detects changes in rotational attributes like pitch, roll and yaw using one or more gyroscopes. And some also include a magnetometer, mostly to assist calibrate against orientation drift;



Other issues

- inertial guidance systems are now usually combined with satellite navigation systems through a digital filtering system. The inertial system provides short term data, while the satellite system corrects accumulated errors of the inertial system (an integration over time -> s -> s integration over time -> position w/e);



measures

Other issues

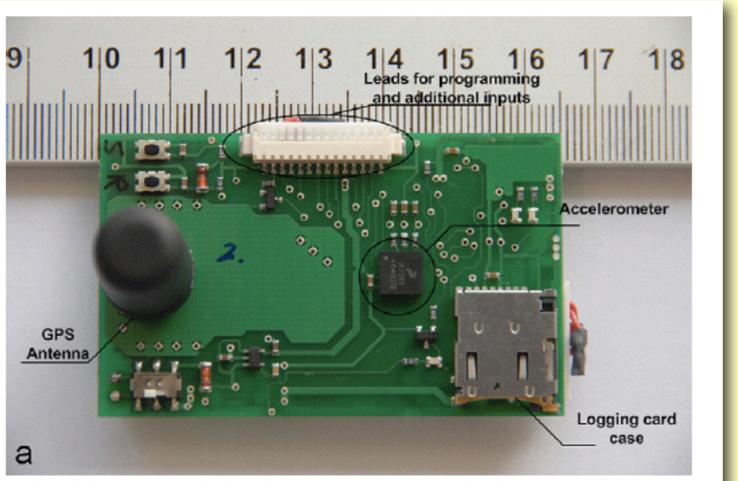


Fig. 1. Custom designed GPS/IMU system with a single frequency GPS receiver, a tri-axial accelerometer and ARM7 based logger: (a) front view and (b) back view.

Tan et al., 2008

Other issues

- IMU is often a box containing three accelerometers, three gyroscopes, optionally three magnetometers:

  . three accelerometers are placed such that their measuring axes are orthogonal to each other. They measure acceleration;

  . three gyroscopes are placed in a similar orthogonal pattern, measuring rotational position in reference to an arbitrarily chosen coordinate system;

  . three magnetometers in IMUs allow better performance for dynamic orientation calculation;

measures

Other issues

Fig. 5. Implementation of the sensor network: Three IMUs on the oars and the boat, indicated by red arrows.

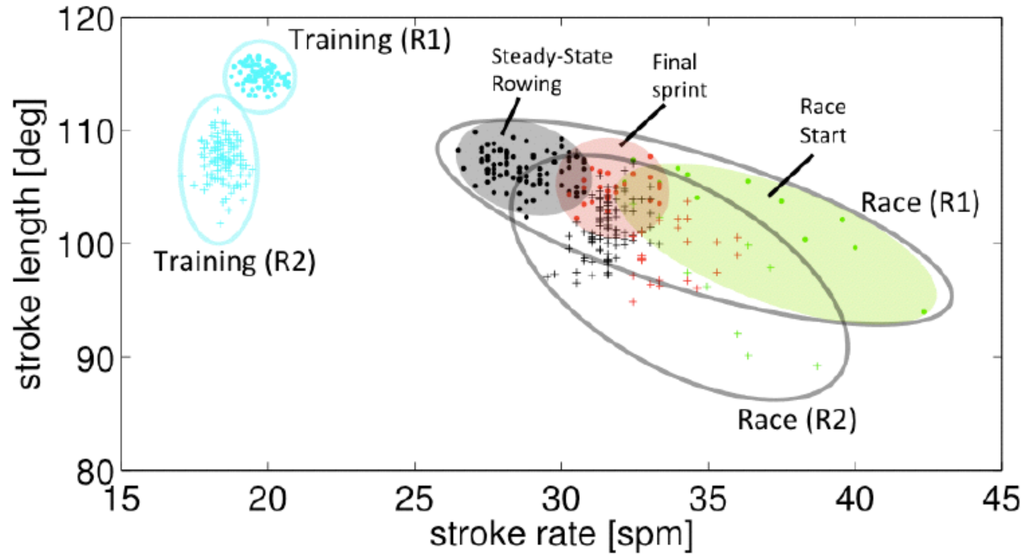


Fig. 7. Visualization of data of stroke length and stroke rate from two world-class rowers (R1 and R2) for training and racing sessions.

Other issues

measures

Other issues

Other issues

- dead reckoning:
  . (also ded (for deduced) reckoning or DR) is the process of calculating one's current position by using a previously determined position, or fix, and advancing that position based upon known or estimated speeds over elapsed time, and course;
  . GPS receiver supports DR machine;
  . GPS receiver (e.g., parking garages, tunnels, urban canyons, forest, multipath propagation) & DR machine support each other;

Other issues

- Xsens products

Other issues

- Equinosis products

Other issues

- Wiva products