Wearable Wireless Inertial Measurement for Sports Applications

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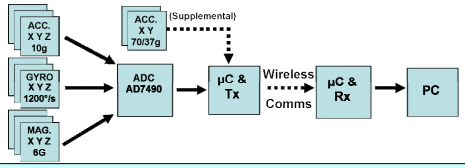
Introduction

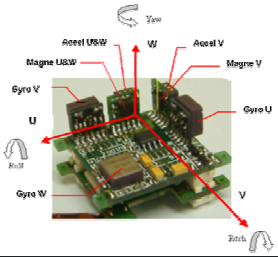
The advent of MEMS inertial sensors has reduced the size, cost & power requirements of 6 Degrees-of-Freedom inertial measurement systems to a level where their use can be considered for wearable wireless monitoring devices. Many applications for such Wearable Wireless Inertial Measurement Units exist in the area of sports and sports science. Such a system would be critical in providing data for the analysis of the kinematic motion data of an athlete - to characterise a player's technique or track progress and provide accurate, quantitative feedback to player and coach in near real time. A small, lightweight & low power device with the ability to sense the full range of human motion at a high sampling rate is required for such applications. It must also be robust, well sealed and comfortable to wear. Further development and miniaturisation of such devices coupled with progress in energy scavenging may lead to their use in other areas and their near ubiquity, with the potential to be embedded within clothes, buildings, materials, objects and people for health monitoring, location tracking and other purposes

Wearable Wireless Inertial Measurement Unit

Inertial measurement unit

- Accelerometer, Gyroscope and Magnetometer sensor triplets
- Onboard processing and wireless connectivity
- Attached to subject to record kinematic motion data





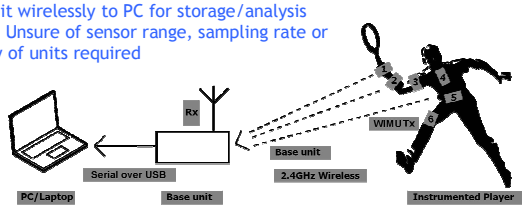
Wearable

Small Size	✓
Light Weight	✓
Ruggedness	✓
Good battery life	✓
Long wireless range	✓
Ergonomic packaging	✓

Current Application - TennisSense

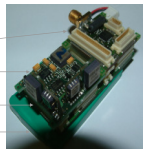
Initial Brief

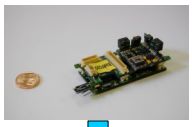
- Wearable WIMU system to monitor tennis player
- Transmit wirelessly to PC for storage/analysis
- Issues - Unsure of sensor range, sampling rate or quantity of units required



Original Prototype

- Tyndall mote modular nature and wide range of existing layers allowed a rapid development of initial prototypes
- Nordic 433MHz Transmit-Receive pair
- Standard IMU Rev 1.7 sensors - ±2g Acc. & ± 150°/s Gyro.
- Issues - Insufficient sensor range for application, lack of robust device packaging, low sampling rate





Requested Spec

- Upgraded IMU sensors - ±4g Acc. & ± 2000-3400°/s Gyro.
- Up to 10x WIMUs connected to 1 or 2 base stations
- Robust device packaging
- Sampling rate comparable to motion capture cameras (100's of FPS)

	IMU Sensor Specifications			
Sensor Type	Initial Prototype	Modified Prototype	Requested Spec	TennisSense WIMU
Accelerometer	+/-2g	+/-2g	+/-4g	+/-10*g
Gyroscope	+/-150°/s	+/-600°/s	+/-2000-3400°/s	+/-1200°/s
Magnetometer	+/-6G	+/-6G	N/A	+/-6G

*Note Current TennisSense WIMU also implements supplemental 37/70g accelerometer chip

TennisSense Spec System

- 6x WIMUs & 1x base station
- High spec. IMU sensors - ±10g (supplemental 37/70g) Acc. & ±1200°/s Gyro. ± 6G Magnetometers
- More robust device packaging
- Moved to Nordic 2.4Ghz transceiver for higher throughput
- 100's samples/second at distances found on tennis court
- Custom Labview Software with GUI
- Issues - Increased size and weight

Potential Wearable WIMU Applications

Sports

- Kinematic analysis of individual player
- Quantitative data as coaching aid
- Location monitoring of team members
- Physiotherapy compliance monitoring

Assisted Living

- Personal motion monitoring (fall sensor)
- Post-arthroplasty rehabilitation
- GPS independent location tracking

Other

- Building health monitoring in earthquake regions
- High value asset & livestock tracking in transit
- Equipment wear and tampering monitoring
- Motion capture for film & games
- Machine tool positioning

Future Work

Reduce
Size, Weight, Cost, Power req.

Increase
Sensor range, Wireless range, Sampling rate

- Calibration and alignment of sensors
- Improved transceivers and antenna
- Incorporate energy scavenging for self-powered, deploy and forget systems

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