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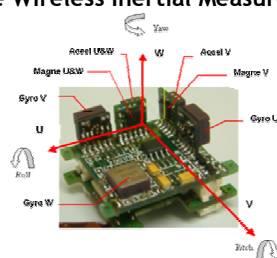
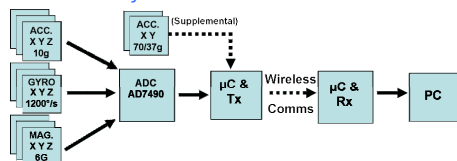
## Introduction

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

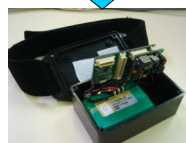
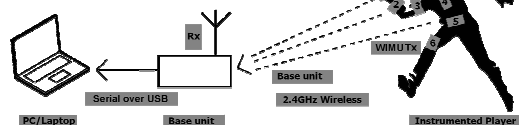
- Small Size ✓
- Light Weight ✓
- Ruggedness ✓
- Good battery life ✓
- Long wireless range ✓
- Ergonomic packaging ✓



## 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



### Requested Spec

- Upgraded IMU sensors -  $\pm 4g$  Acc. &  $\pm 2000-3400^\circ/s$  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)

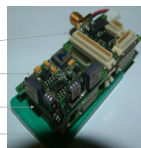
| Sensor Type   | IMU Sensor Specifications |                    |                         |                    |
|---------------|---------------------------|--------------------|-------------------------|--------------------|
|               | Initial Prototype         | Modified Prototype | Requested Spec          | TennisSense WIMU   |
| Accelerometer | $\pm 2g$                  | $\pm 2g$           | $\pm 4g$                | $\pm 10^\circ g$   |
| Gyroscope     | $\pm 150^\circ/s$         | $\pm 600^\circ/s$  | $\pm 2000-3400^\circ/s$ | $\pm 1200^\circ/s$ |
| Magnetometer  | $\pm 4G$                  | $\pm 6G$           | N/A                     | $\pm 6G$           |

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

### 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 -  $\pm 2g$  Acc. &  $\pm 150^\circ/s$  Gyro.
- Issues - Insufficient sensor range for application, lack of robust device packaging, low sampling rate

433MHz Radio & Microcontroller  
Inertial Measurement  
Interconnect, Power, High g accel.  
740 mAh Lithium Battery



### TennisSense Spec System

- 6x WIMUs & 1x base station
- High spec. IMU sensors -  $\pm 10g$  (supplemental 37/70g) Acc. &  $\pm 1200^\circ/s$  Gyro.  $\pm 6G$  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

### Sports

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

## Potential Wearable WIMU Applications

### 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

## Acknowledgements

The authors would like to acknowledge the support of Science Foundation Ireland (SFI) and the funding provided to the National Access Program (NAP) at the Tyndall National Institute, and Enterprise Ireland who have contributed to this work. Tyndall is part of SFI's CLARITY Centre for Sensor Web Technologies.