

# Wireless Motion Tracking

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# Overview

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- Goal
- Traditional Methods
- Motion Capture Speck – '*Orient2*'
  - Hardware
  - Orientation Estimation
  - Firmware
- Future Work
- Demonstration

# Motion Tracking Goal

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- Tracking the positions / orientations of articulated rigid bodies
- Many applications
  - Film / Animation
  - Human Computer Interaction

# Traditional Methods

- Vision
  - Suffers from occlusions
  - Often requires time consuming post-processing
  - Expensive
- Joint angle sensors
  - Hinders free movement



# Speck Alternative

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- Use small, wireless, devices to capture orientation information
- Proof of concept demonstrated Sept 2005
  - Based on ProSpeckz-IIK with add-on 3-axis accelerometer and magnetometers
  - Slow response time
  - Suffered from error during rapid movement

# Speck Advantages

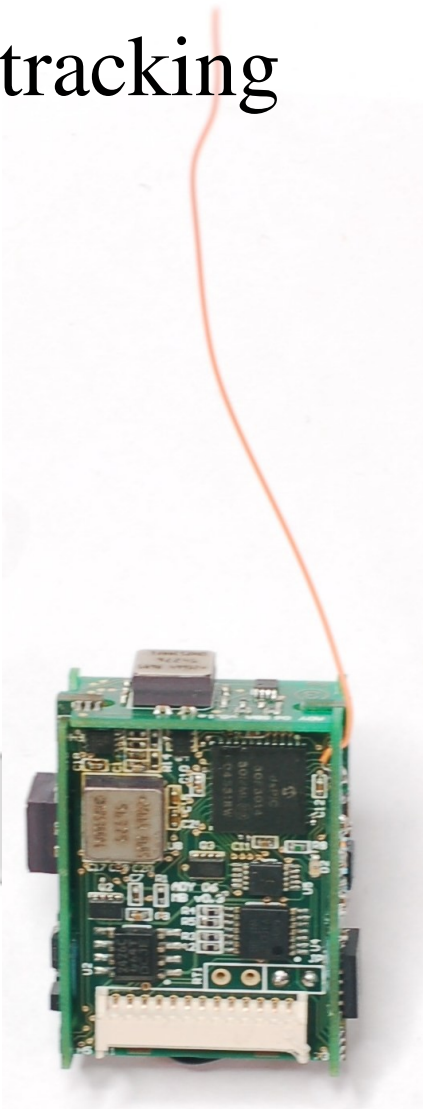
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- Works anywhere\*
- Real-time
  - Low latency
  - No post-processing
- Wireless
  - Little hinderance to user movement

\* Absolute orientation correction does not work in presence of continuous external acceleration on in the presence of magnetic field disturbances

# Orient2 Hardware Platform

- Custom designed wireless motion tracking platform
  - 16bit Microchip dsPIC processor
  - 500 kbps 868MHz Chipcon CC1100 radio
  - Freescale 3-axis accelerometer
  - 2 Honeywell 2-axis magnetometers
  - 3 Analog Devices MEMS rate gyroscopes
  - 32Mbit STMicro FLASH
  - 120mAh Li-Poly battery
- 36x28x11mm



# Orient2 Hardware Platform

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- All subsystems under processor control
  - Sensor sensitivity
  - Power control
- Expandable through Input/Output header
  - SPI bus – shared with radio & FLASH
  - UART Serial communications
  - 2 General Purpose Input/Output (GPIO) lines
    - Shared with In Circuit Debugger
  - 3.3V regulated power supply
  - External power supply input

# Orientation Estimation

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- Absolute estimate
  - Based on observing the Earth's gravitational and magnetic field vectors
    - Acceleration vector gives 1<sup>st</sup> basis vector defining the X-Y plane
    - Magnetic vector projected into X-Y plane to produce 2<sup>nd</sup> basis vector
    - Cross product yields 3<sup>rd</sup> basis vector
  - High frequency noise due to movement
- Inertial estimate
  - Based on integrating rate gyroscope data
  - Low frequency noise due to gyroscope null offset

# Orientation Estimation

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- Complementary filter
  - Fast response from inertial estimate
  - Drift correction from absolute estimate
  - Falls back to pure inertial tracking when measured acceleration out of bounds

# Current Firmware Features

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- Complementary quaternion orientation filter
  - Updated 256 times per second
- Carrier Sense Multiple Access (CSMA)  
Medium Access Control (MAC)
  - Inefficient for multiple devices streaming data in real-time
  - Lack of synchronisation wastes power
    - Radio always in Receive mode

# Current Firmware Features

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- 5 major modes
  - Idle, Calibrate, Run, FLASH log, FLASH replay, Basestation
- Serial PC link
  - Packet synchronisation, 8bit CRC
- Configurable output
  - Raw data, Calibrated data, Orientation Quaternion
  - Programmable sub-sample rate
- Over the Air command interface

# Future Firmware Goals

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- Time Division Multiple Access (TDMA)  
MAC
  - Reduce packet loss due to collision/congestion
  - Reduce power consumption
  - Possibly add Frequency Hopping Spread Spectrum
- Sensor power savings
  - Sensors to low power mode between samples
- Low power Wake on Radio mode
  - Supported by CC1100

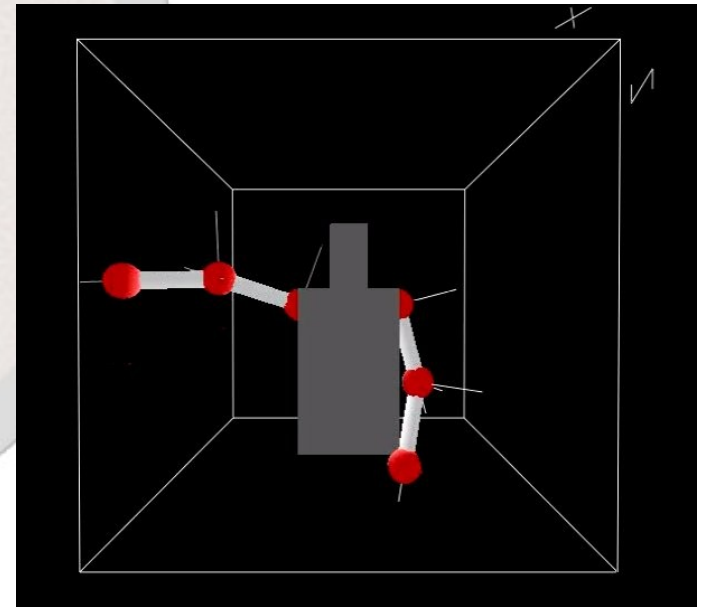
# Future Firmware Goals

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- Improved calibration routine
- Acceleration vector estimation
  - Allow for inertial tracking of translation
- Rigid Body position calculation
  - Distributed computation over network
  - Reduce load on Host machine

# Future Work

- Body model fitting
  - Limb segment connectivity
  - Speck / Limb segment alignment
  - Limb segment length
- How much can be determined automatically?



# Demonstration

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- Game controller
  - Joystick controlled by roll and pitch of sensor
- Tomorrow - Breakdancing!

