

# Motion Capture for Runners

Design Team 8 - Spring 2013

Members:

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# Outline

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- Proposed Solution
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  - System Design
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# Introduction

- The efficiency of a runner's technique is directly proportional to the quality of their posture.
- Different running conditions significantly changes the form of the runner (running uphill, jogging, sprinting).
- Similar studies focused on measurement and analysis of running form using three dimensional acceleration and gyroscopic sensors.

# Objectives

- Capture running motion by choosing proper sensors
- Develop recording system that receives data from sensors and sends data wirelessly to processor
  - body-worn controller
  - real-time processing on external PC
- Analyze motion data and provide real-time feedback to improve runner efficiency
- Analogous to understanding flexible structures on aircrafts and spacecrafts

# System Benefits



- Direct benefit of maintaining proper running form
  - Improves overall performance, less chance of injury
- Real-time feedback with indicator for the runner
  - Allows for immediate changes of form
- Software to compare runner's form to an elite runner
  - Provides a baseline model
- This motion analysis and feedback is applicable to other systems

# Proposed Solution

- Body-worn Sensors
  - Inertial Measurement Units (IMUs)
    - Accelerometer
    - Gyroscope
  - Sensors wired to the body-worn Controller
  - Sensors and controller sewn into bodysuit
  - Used for treadmill purposes
- Body-worn Controller
  - Preliminary data processing, time-stamping
- Wireless Communication
  - Communication between body worn controller and PC
  - Xbee, Wireless
- Real-time Processing
  - Process data on PC
  - Comparison software to compare with elite runner data
- Real-time Feedback
  - Body-worn indicator: LED indication of proper or improper form

# Design Specifications

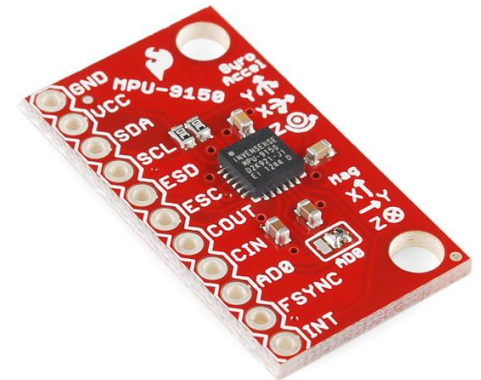
- Battery
  - Size
  - Life
- Sensors
  - Number of axes
  - Power consumption
  - Sampling Rate
  - Size
- Wireless
  - Bandwidth
  - Range
- Cost



# Project Components

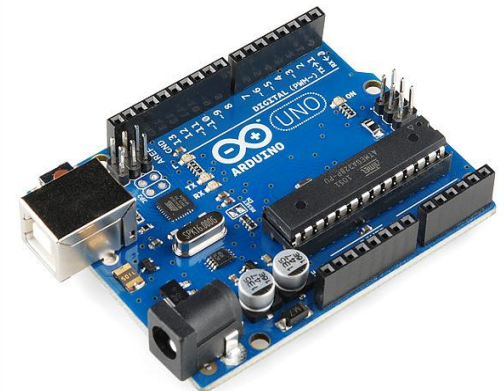
## IMU (Inertial Measurement Unit)

- Device that measures velocity, orientation and gravity
- Consists of an accelerometer, gyroscope and a compass
- 9-axis measurements



## Arduino Microcontroller

- Acquires data from the IMU sensors
- Synchronizes connected sensors
- Arduino UNO, and Arduino Due



# Project Components

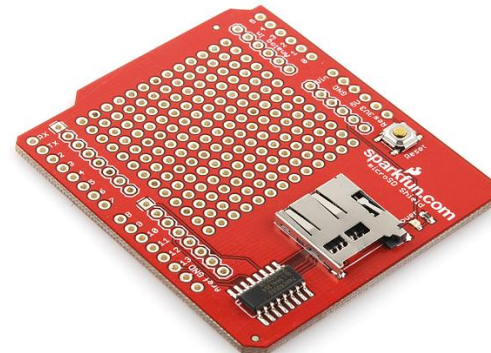
## ZigBee (XBee) Communication

- Connects Arduino and PC wirelessly
- Connects the PC to body-worn feedback controller



## Arduino Micro SD Shield

- Requires micro SD card
- Connects to Arduino microcontroller
- Provides additional memory for sensor data



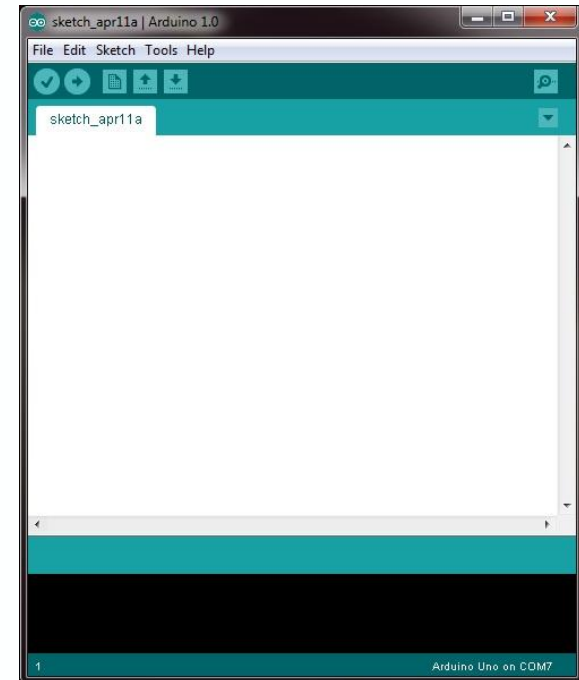
# Project Components

## Arduino Software

- Requires setup of I2C bus
- Timestamps acquired data
- Transmits data through Xbee communication to PC

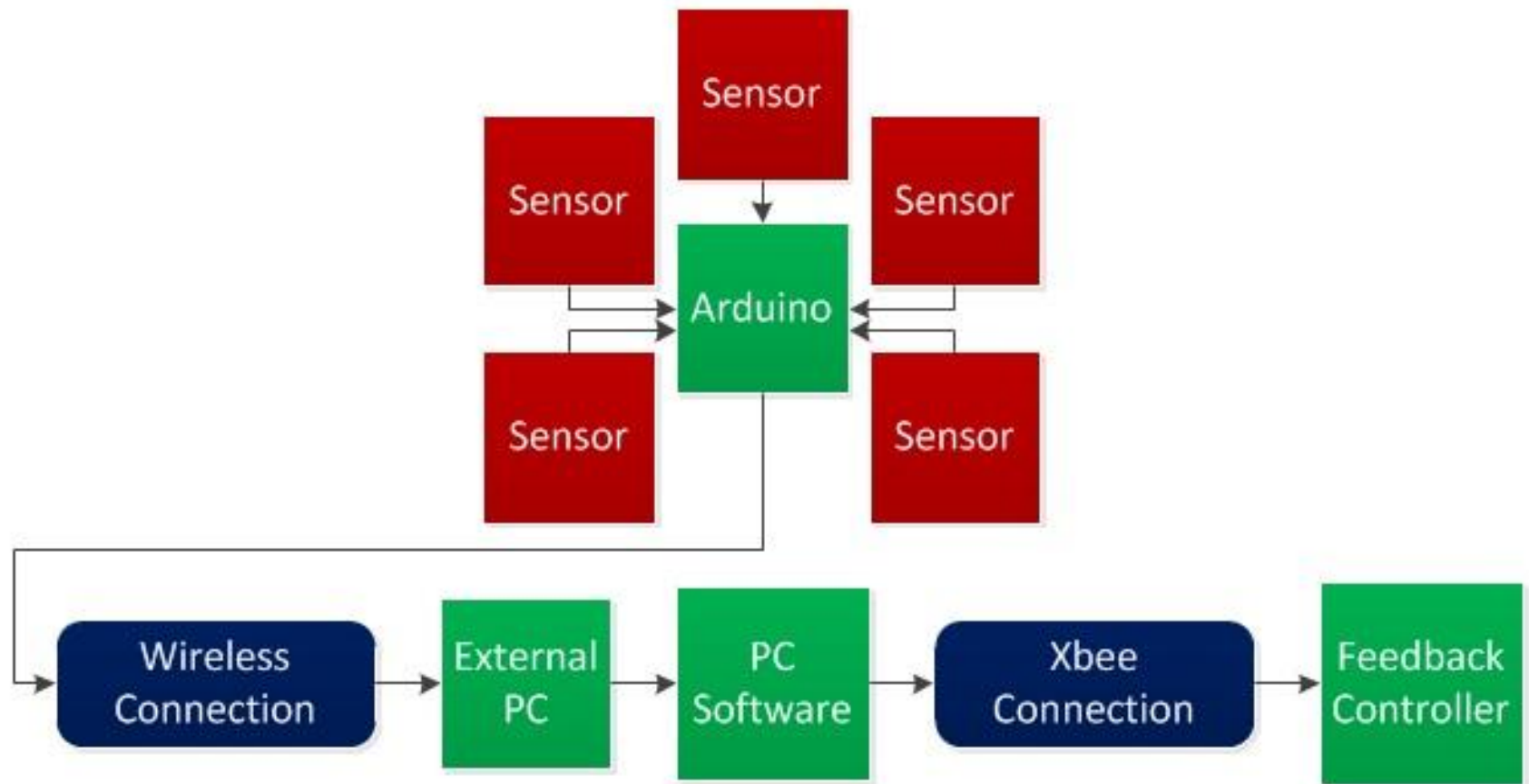
## PC Software

- Acquires data from arduino
- Calculates position of sensors using algorithm
- Matlab, LabView, or Processing



Processing

# System Design



# Testing

- Sensors
  - Each sensor capturing data
  - Sending directly to the Arduino board
- Arduino
  - Time-stamping data properly
  - Consistent data acquisition
- Communication
  - Fast, noiseless wireless communication (Arduino to PC)
  - Wire communication between IMUs and Arduino
  - Easily understood and accurate feedback
- Software Testing
  - Arduino
  - PC acquisition data
  - Comparison software consistent

# Risk Analysis

- **Sensors**
  - Power consumption
  - Sampling rate of sensors
- **Arduino**
  - Timestamping of acquired data
- **Communication**
  - Bandwidth of communication devices
  - Continuity of data acquisition (memory limitation)
  - Transmission of data
  - Synchronization
  - Range
- **Feedback**
  - Ease of interpreting form assessment

# Project Roles

| <b>Team Members</b> | <b>Non-Technical Roles</b> | <b>Technical Roles</b>                        |
|---------------------|----------------------------|-----------------------------------------------|
| Blake Frantz        | Presentation Prep          | Suit Fabrication and Demonstration Expert     |
| Zhichao Lu          | Documentation Prep         | Testing and Data Analysis                     |
| Alex Mazzoni        | Webmaster                  | Comparison Software Developer                 |
| Nori Wilkins        | Manager                    | Comparison Data Collection & Arduino Software |
| Chenli Yuan         | Presentation Prep          | Wireless Communication                        |
| Dan Zilinskas       | Lab Coordinator            | Interfacing Technician                        |

# Budget

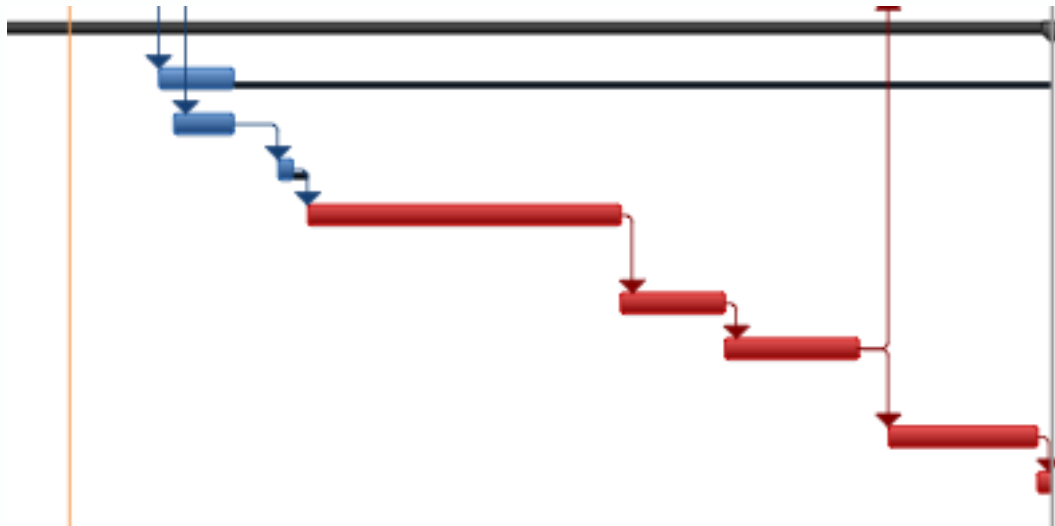
| Item                                                   | Serial Number      | Price   | Amount | Totals   | Supplier   |
|--------------------------------------------------------|--------------------|---------|--------|----------|------------|
| Conductive Ribbon Connector                            | 11681              | \$1.50  | 16     | \$24.00  | Sparkfun   |
| IMU MPU-9150                                           | SDN-11486          | \$49.99 | 5      | \$249.95 | Sparkfun   |
| Arduino Due                                            | ID:1076            | \$49.95 | 1      | \$49.95  | Adafruit   |
| Arduino UNO R3 (ID: 50)                                | ID: 50 (Atmega328) | \$29.95 | 1      | \$29.95  | Adafruit   |
| Arduino Headers R3                                     | PRT-11417          | \$1.50  | 1      | \$1.50   | Sparkfun   |
| Arduino Headers                                        | PRT-10007          | \$1.50  | 1      | \$1.50   | Sparkfun   |
| Arduino UNO USB A-B Connector                          | CAB-00512          | \$3.95  | 1      | \$3.95   | Sparkfun   |
| Arduino Due USBB Cable                                 | RTL-10767          | \$5.95  | 1      | \$5.95   | Sparkfun   |
| Conductive Ribbon Wires (Price per yard)               | 11680              | \$5.25  | 8      | \$42.00  | Sparkfun   |
| Micro SD Shield (Only needed if wireless doesn't work) | DEV-09802          | \$14.95 | 1      | \$14.95  | Sparkfun   |
| Class 10 SD Card (8Gb max)                             | SDSDX-008G-AFFP    | \$13.00 | 2      | \$26.00  | Amazon     |
| Arduino Wireless Shield                                | MKSP18             | \$84.00 | 1      | \$84.00  | Maker Shed |
| 1 Xbee expolorer dongle (Port Connection)              | WRL-09819          | \$24.95 | 1      | \$24.95  | Sparkfun   |
| 1 Xbee explorer USB (Cable Connection)                 | WRL-08687          | \$24.95 | 1      | \$24.95  | Sparkfun   |
| 1 Xbee Shield for Arduino                              | WRL-10854          | \$24.95 | 1      | \$24.95  | Sparkfun   |
| 4 Xbee Communication Devices (ZB Series 2)             | XB24-Z7WIT-004     | \$22.95 | 4      | \$91.80  | Adafruit   |
|                                                        |                    |         |        |          |            |
| <b>Totals</b>                                          |                    |         |        | \$700.35 |            |

# Schedule

|  |                                  |                        |                    |                       |
|--|----------------------------------|------------------------|--------------------|-----------------------|
|  | <b>Product Development</b>       | <b>0 edays 68 days</b> | <b>Tue 1/22/13</b> | <b>Thu 4/25/13</b>    |
|  | Test IMU's                       | 0 edays 5 days         | Mon 2/25/13        | Fri 3/1/13            |
|  | Test Processing Software         | 0 edays 4 days         | Tue 2/26/13        | Fri 3/1/13 13FS+1 day |
|  | Acquire Running Data             | 0 edays 1 day          | Tue 3/5/13         | Tue 3/5/13 14         |
|  | Write Code for Runner Comparison | 0 edays 15 days        | Thu 3/7/13         | Wed 3/27/13 15        |
|  | Real Time User Indicator         | 0 edays 5 days         | Thu 3/28/13        | Wed 4/3/13 16         |
|  | Interface Comparison Software    | 0 edays 7 days         | Thu 4/4/13         | Fri 4/12/13 17,9      |
|  | Initial Test of design           | 0 edays 8 days         | Mon 4/15/13        | Wed 4/24/13 18        |
|  | Final Testing                    | 0 edays 1 day          | Thu 4/25/13        | Thu 4/25/13           |

## Scheduling Breakdown

- Fabrication
- Software
- Interfacing
- Testing



# Summary

- Motion Capture
  - IMUs placed on body detect motion
  - Arduino receives data and transmits to PC
- Analysis
  - PC has elite runner reference motion
  - Comparison Software
- Feedback
  - Immediate real-time feedback to the runner for improper or proper running form

# Thank You and Questions

