Motion Capture for Runners

Design Team 8 - Spring 2013

Members:
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Sponsor:
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Dr. Eric T. Vinande

Facilitator:
Dr. Selin Aviyente
Outline

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  - Objective and Benefits
- Proposed Solution
- Design Specification
  - Project Components
  - System Design
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- Testing
- Risk Analysis
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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
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

<table>
<thead>
<tr>
<th>Team Members</th>
<th>Non-Technical Roles</th>
<th>Technical Roles</th>
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<tbody>
<tr>
<td>Blake Frantz</td>
<td>Presentation Prep</td>
<td>Suit Fabrication and Demonstration Expert</td>
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<tr>
<td>Zhichao Lu</td>
<td>Documentation Prep</td>
<td>Testing and Data Analysis</td>
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<tr>
<td>Alex Mazzoni</td>
<td>Webmaster</td>
<td>Comparison Software Developer</td>
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<tr>
<td>Nori Wilkins</td>
<td>Manager</td>
<td>Comparison Data Collection &amp; Arduino Software</td>
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<tr>
<td>Chenli Yuan</td>
<td>Presentation Prep</td>
<td>Wireless Communication</td>
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<tr>
<td>Dan Zilinskas</td>
<td>Lab Coordinator</td>
<td>Interfacing Technician</td>
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## Budget

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<thead>
<tr>
<th>Item</th>
<th>Serial Number</th>
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Schedule

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<th>Product Development</th>
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<td>Test Processing Software</td>
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<tr>
<td>Acquire Running Data</td>
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<td>Tue 3/5/13</td>
<td>Tue 3/5/13</td>
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<tr>
<td>Write Code for Runner Comparison</td>
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<td>Real Time User Indicator</td>
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<td>Interface Comparison Software</td>
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<td>Thu 4/25/13</td>
<td>Thu 4/25/13</td>
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**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