STATISTICAL DATA ANALYSIS IN SOCCER USING GPS TRACKING

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Presentation Overview

• Project Motivation - Why do the design?
• Design Goals
• Project Components
• Results
• Future Work
Motivation and Scope

- Difficult for managers to assess every player on the field equally due to players moving concurrently in specialized positions
- Motive: Coaches need more insight about their team at the competitive level
- Alternative to exp. tech or watching tape
- Active RFID tags
Solution

• Overall Goal: Provide coaches with a better overall picture of player’s training status including their positioning and fitness levels
• Position tracking via GPS
• Stats and visual location map
• Aggregate data
• Cost and flexibility
Design Requirements

- Ability to provide accurate data to coach, sensing performance within +-2m
- Need sufficient refresh rate for GPS module (5 Hz)
- Programmable Microcontroller (Arduino Uno)
- Adequate battery power
- Robust Encasing and attachment
- Intuitive User Interface for reading in data
- Feedback from Coaches
Feedback from Coaches at Union

- Primary Requirement – Distance Travelled
- Work Rates
- Positioning
- Speed
- Live Video Solution
Design Components

- 66 Channel GPS module
- Microcontroller with USB/Bluetooth connection
- Interface cable
- 9V Battery connection
- Read GPS data into Matlab
Uploading software for Logging GPS Data

• The Arduino software correctly reads data from the GPS and then logs the data into a text file on the SD card

• Refresh rate

• Takes roughly 30 seconds for GPS unit to achieve a ‘fix’ once outside

• Once fixed, the recorded data will provide precise coordinates and speed

```c
logfile = SD.open(filename, FILE_WRITE);
if(!logfile)
    Serial.print("Could not open ");
    Serial.println(filename);
    error(0);
}
Serial.print("Writing to ");
serial.println(filename);
// Connect to the GPS at the desired rate
GPS.begin(9600);

GPGGA,035803.000,4249.1781,N,07355.6219,W,1,07,1.19,81.0,M,-33.6,M,,*63
GPRMC,035803.000,A,4249.1781,N,07355.6219,W,5.74,18.14,210115,,,A*41
GPGGA,035804.000,4249.1793,N,07355.6209,W,1.06,1.23,83.0,M,-33.6,M,,*6C
GPRMC,035804.000,A,4249.1793,N,07355.6209,W,4.14,13.48,210115,,,A*41
GPGGA,035805.000,4249.1794,N,07355.6207,W,1.06,1.35,83.5,M,-33.6,M,,*66
GPRMC,035805.000,A,4249.1794,N,07355.6207,W,0.10,13.48,210115,,,A*47
GPGGA,035806.000,4249.1793,N,07355.6204,W,1.06,1.35,85.7,M,-33.6,M,,*6F
GPRMC,035806.000,A,4249.1793,N,07355.6204,W,0.20,13.48,210115,,,A*47
GPGGA,035807.000,4249.1805,N,07355.6202,W,1.06,1.23,87.7,M,-33.6,M,,*67
GPRMC,035807.000,A,4249.1805,N,07355.6202,W,0.21,13.48,210115,,,A*48
GPGGA,035808.000,4249.1814,N,07355.6200,W,1.06,1.23,90.1,M,-33.6,M,,*6A
GPRMC,035808.000,A,4249.1814,N,07355.6200,W,0.13,13.48,210115,,,A*47
GPGGA,035809.000,4249.1818,N,07355.6198,W,1.06,1.23,91.3,M,-33.6,M,,*66
GPRMC,035809.000,A,4249.1818,N,07355.6198,W,0.05,13.48,210115,,,A*4F
GPGGA,035810.000,4249.1820,N,07355.6197,W,1.06,1.23,91.7,M,-33.6,M,,*6E
GPRMC,035810.000,A,4249.1820,N,07355.6197,W,0.04,13.48,210115,,,A*42
```
NMEA Sentences

• Two types of sentences:
  - $GPRMC – Recommended Minimum Specific GPS Data
  - $GPGGA – Fix GPS Data

• $GPRMC,035803.000,A,4249.1781,N,07355.6219,W,5.74,18.14,210115,,,A*41
  - GMT
  - Active
  - NMEA Coordinates
  - Speed
  - Tracking Angle
  - Date

• $GPGGA,035803.000,4249.1781,N,07355.6219,W,1,07,1.19,81.0,M,-33.6,M,,*63
  - GMT
  - Coordinates
  - Fix
  - Altitude
  - Number of Satellites
  - Dilution of Position
Testing the GPS unit

- Mapping perimeter of the Field
- Passing and Jogging
- Sprints using stopwatch
  - 10m Walk
  - 10m Jog
  - 10m Run
  - 10 m Sprint
- Weather
- Data logged onto microSD
Parsing GPS Data and NMEA format

- Since the text file data is delimited by commas, the data needs to be taken into columns to separate successive lines for calculating useful statistics from the data.
 Parsing and Importing GPS Data

• The data can be imported into Excel and then filtered into two files to be read into Matlab
• Need to differentiate between $GPRMC$ and $GPGGA$ sentences due to different column lengths
• Field Perimeter Data
• Given assignment of variable names for each column in Matlab

```
%% Allocate imported array to column variable names
VarName2 = data(:,1);  % Time
VarName3 = data(:,2);  % Latitude
W2 = cellVectors(:,1);
VarName5 = data(:,3);  % Longitude
W2 = cellVectors(:,2);
VarName7 = data(:,4);  % Fix Indicator
VarName11 = data(:,5); % Number of Satellites
VarName12 = data(:,6); % Horizontal Dilution of Position
VarName13 = data(:,7); % Altitude in Meters
```
Converting NMEA to Decimal Form

- Import excel file of parsed GPS data into Matlab
- Filtered NMEA sentences provide good data, but are not intuitive to the user

<table>
<thead>
<tr>
<th>NMEA Coordinates</th>
<th>Decimal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude</td>
<td>42.8172</td>
</tr>
<tr>
<td>Longitude</td>
<td>73.9251</td>
</tr>
</tbody>
</table>

- Having decimal coordinates allow for:
  - Plotting in Matlab
  - Calculations
  - Statistics
Google Earth/Maps Capability

• A KML converter from the original NMEA text file on the SD card can be used to create a Google Maps friendly set of coordinates.

• Putting it all together, I took the system outside and walked around, and this is the received data track.

• Google Maps can display the actual time (GMT) and approximate speed.
Results

• The GPS unit successfully displays position and speed during a session
• Relative Accuracy is within 1m
Results (Cont’d)

• Statistics
  • Avg. Speed
  • Max. Speed
  • Total distance travelled
  • % of Time ≥ 6 mph
  • Altitude

>> GPSSprintData
Statistics
Average Speed = 7.016724 mph
Maximum Speed = 16.997006 mph
Total Distance Travelled = 0.037033 miles
Percentage of Time spent Sprinting = 0.969078
Tracking Angle = 83.188421°
Average Number of Satellites = 8.894737
Elevation = 291.804817 ft
Elapsed Time = 19.000000 seconds

>> GPSPassingData
Statistics
Average Speed = 3.264522 mph
Maximum Speed = 17.848582 mph
Total Distance Travelled = 0.359098 miles
Percentage of Time spent Sprinting = 0.148207
Tracking Angle = 159.714242°
Average Number of Satellites = 8.954198
Elevation = 288.804080 ft
Elapsed Time = 6.516667 minutes
Alternative Design Options

• Have a user wear multiple GPS units, average the data in Matlab for better accuracy
• Analyze data for players in different positions on field
• Bluetooth / Wireless Integration
• Minimize Device
• External Antenna
• Additional Applications
Future Work

• Limited to 32 Kb on Arduino Uno microcontroller
• The parsed GPS data had to be stored on an external microSD card, which defeats wireless capability
• Improved microcontroller with greater memory and wireless capability would allow for the user to simply upload the data to a computer for tracking a player’s movement rather than input an SD card
• Improved user interface
• Continue Testing
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