Soccer Team Gameplay Metrics

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1 Introduction

1.1 Objective

In recent years, the use of data analytics is sports have become more and more widespread. To get an edge in games, players and coaches use data to make decisions in training and gameplay [1]. However, in the sport of soccer, there isn't an easy way of collecting data for player-ball interactions. Currently, if someone wanted ball possession data over the course of a game, they would have to record it by hand. It's a tedious task, and mistakes could be made during the data collection process, so it would be more effective to automate the entire process instead.

We aim to build a system that is able to measure and calculate metrics for individual players over the duration of a soccer game. For this project, we will be focusing on metrics between the player and the ball rather than more personal metrics. We will collect data using a sensor system integrated into a ball, and present it to the user on an application after analyzing it. The metrics that we aim to gather include: passes between player A and B, bad passes, longest string of dribbles, time of possession, shots on goal, and so on.

1.2 Background

Currently, there are companies that make smart soccer balls like the Adidas or DribbleUp, but their balls are primarily used for personal training. For example, the Adidas miCoach smart ball only records speed and spin of a shot from a stationary ball position [4]. You have to press a button to let the ball know that you are about to shoot it. This wouldn't work as we require touch recognition is a live game environment. The DribbleUp ball focuses on AR tracking of the ball [3]. This works with amount of touches and juggles for a player but making sure that nothing comes in between the camera and the ball and that the player is not in motion and focused in the middle of the camera frame. This again would not work in a live game environment. These smart balls lack the ability to be used in a multiple player drill session or in an actual soccer match. Thus we need to come up with a new solution that would fit this criteria.

1.3 High-level requirements list

- Each touch of the ball by an individual player must be registered by the RFID reader and captured by the microcontroller.
- The accelerometer, gyroscope and RFID reader must all work on battery power
- We must be able to process the data and display the metrics in the introduction.

2 Design

2.1 Block Diagram

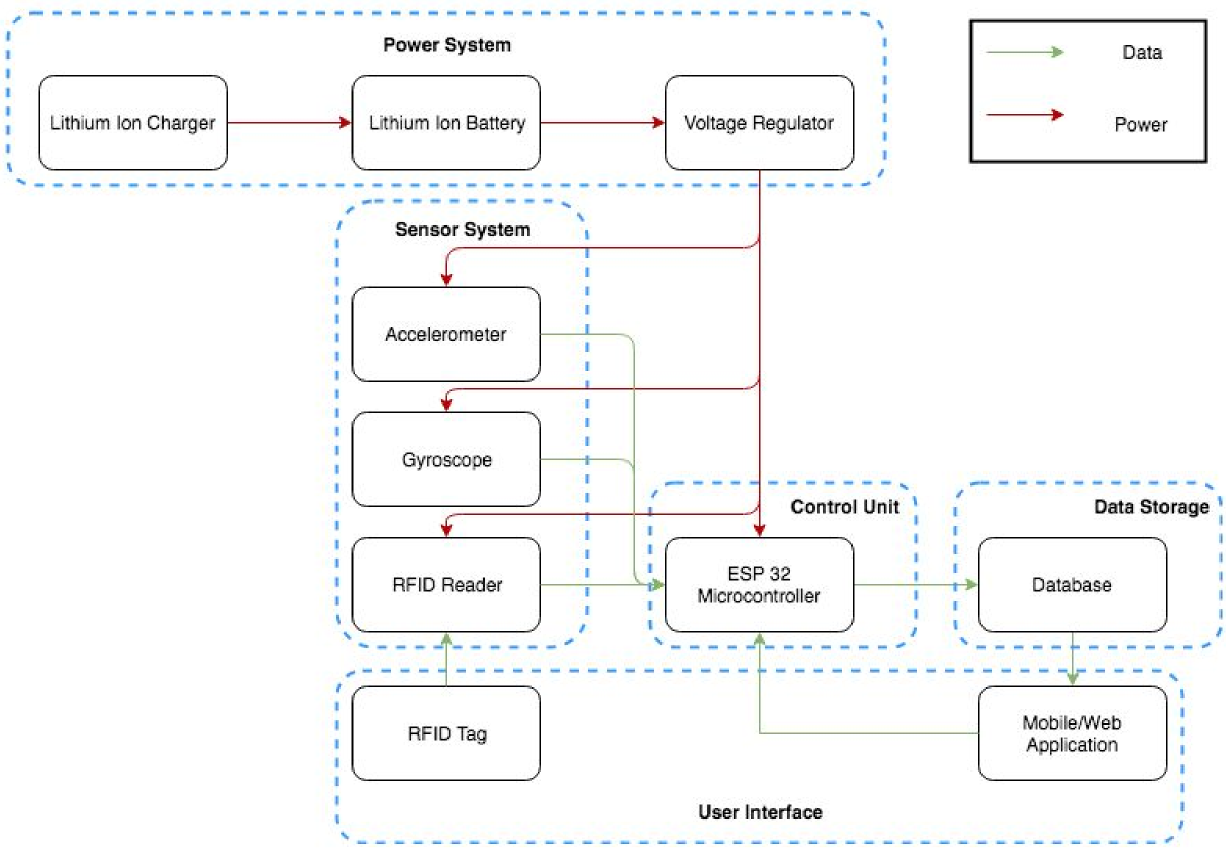

Figure 1. Block Diagram

2.2 Functional Overview & Requirements

2.2.1 Power System

- **Lithium Ion Battery**
  A soccer ball cannot be plugged in during a game, so we will have to use a portable power source to power the electronics inside the ball. Since none of the components we plan to use require high voltage or current, we will use a lithium ion battery as the power source. (3.7V to 4.2V output)

Requirement: The battery must be able to sustain a up to 250 milliamps of current draw at 3.3 volts for a quarter of a soccer match length (~22.5 minutes)

- **Lithium Ion Charger**
  The charger will regulate voltage and current going into the battery during the charging process.

  Requirement: It must be able to charge the battery to 4.2 volts with a continuous current of >100 mA from a 5V USB power source.

- **Voltage Regulator**
  The voltage of a lithium ion battery varies depending on how much charge is left. Some sensors require

  Requirement: Able to step down battery voltage to 3.3V ± 1% while maintaining a 250 mA peak current.

2.2.2 Sensor System

- **Accelerometer**
  The accelerometer provides data on the current speed of the ball. This will enable additional metrics to be computed, and will also help determine when the ball goes out of play.

  Requirement: Measure a minimum of ±4g of acceleration, and at least has 3 degrees of freedom.

- **Gyroscope**
  The gyroscope will provide data on the current spin and orientation of the ball. This will enable us to determine the spin on a shot or pass as well as provide data to help us determine other factors, like if the ball is stationary or not.

  Requirement: The gyroscope must be able to measure 2000 to 4000 degrees per second in 3-axis.

- **RFID Reader**
  The RFID reader provides the primary method of detecting the person that is in contact with the ball. It will read the RFID tag of the player in possession and send that information to the microcontroller.

  Requirement 1: Must at least have a detection distance of the radius of a soccer ball (~11 cm).

Requirement 2: Read time should be faster than the smallest contact time of a typical kick (~8 ms)[2]

2.2.3 User Interface

- **RFID Tag**
  Each player will have an unique RFID tag attached to their cleats to be identified with.

  Requirement 1: The RFID tags should be about as thin as possible (same thickness as a piece of paper).
  Requirement 2: It must be embedded in a sticker so that it is easily attached inside or on the cleat.

- **Web/Mobile Application**
  The application is the processing and visualization of the data that shows player's stat and analysis.

  Requirements: It must be able to compute display stats in a table/list and have interactive features that allow the users to select the items to display.

2.2.3 Control Unit

- **Microcontroller**
  A microcontroller unit is needed to pull data from the sensor systems and push it to an external data storage system.

  Requirements: The microcontroller must have enough pins to support the sensor system and run off a 3.7V to 4.2V lithium ion battery. Ideally, it will also have wifi+bluetooth capabilities to utilize cloud storage

- **Data Storage**
  Data will be continuously logged throughout the duration of the game. The data needs to be stored somewhere so that it can be pulled out and analyzed for the metrics we want.

  Requirement: The storage system must have enough capacity enough to store sensor data recorded every 0.5 seconds over the length of a soccer match (90 minutes).

2.3 Risk Analysis

The sensor system poses the greatest risk to our project. Our whole system and project is based around the success of receiving the data from the sensors, especially the RFID reader. The RFID reader poses the greatest challenge. It should be able to read the tags really quickly when the players touch the ball. It needs to be able to read the tag faster than the contact time of the soccer ball to a players cleat, which can be really fast, sometimes under 10ms. If the reader fails to read the tags then our project will not achieve the proposed goal. Our biggest focus will be in ensuring minimal read times and as accurate as possible reads.

3 Ethics and Safety

3.1 Ethical Issues

- **Honesty and Integrity**
  The testing and demo of our project involves data collection and processing. IEEE code of ethics, #3 [5] and ACM code of ethics 1.3 [6] address the issues of honesty, and mention that fabricating or falsifying data is strictly prohibited. We promise we will never manipulate data and forge results to make our product look like it works when it doesn't in our development and testing.
- **Equality**
  The working environment consists of people from different backgrounds with different roles such as our TA, teammates, and instructors. According to IEEE code of ethics #7 and #8 [5], ACM code of ethics 1.4 [6], we should treat everyone equally. We will respect and accept others' criticism and advice, and treat all individuals involved in this project equally and professionally and not engage in act of discrimination.
- **Copyright**
  In the software development part in this project, we will possibly use libraries and frameworks published by other people or organizations. According to ACM code of ethics 1.5 [6], we should respect and follow the permission of usage and license agreements of any outsourced software involved. We will give proper credit to authors of open source code that we use.
- **Damage prevention**
  IEEE code of ethics #9 [5] states that we should avoid injuring others, their property. To ensure this, we will evaluate the system stability and potential risk during the development and before testing. Actions will be taken immediately and accordingly when incident occur to prevent or minimize the damage to individuals and surroundings.

3.2 Safety Issues

The main safety risk in our project lies with our usage of a lithium ion battery.

The ball we plan on prototyping with is made of foam, which is flammable. The battery and hardware generates heat during operation, which may lead to overheating and can cause battery failure and fire. To prevent this, we will examine the thermal condition of the system during our development and decide whether to add a cooling design to the project. In addition, we will monitor the temperature inside the foam ball using a temperature sensor during the testing.

The battery may explode or burn when overcharged. During the building process, we will test the charging circuitry and make sure the charging voltage is correct before attaching the battery to the charging circuit.

Since lithium ion batteries have a tendency to catch on fire when damaged or pierced [7], we will try to isolate the hardware as much as possible by 3D printing an enclosure for it. The soccer ball should also have the capability to operate outdoor and moisture could damage the hardware leading to short circuit. The enclosure will help for this problem as well.

References

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