FOOTBALL TRACKING SYSTEM

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TEAM

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ABOUT

The Football Tracking System (FTS) is an effective solution to current issues in the game of American Football. The purpose of the FTS is to track the position of the football to help officials validate if the play resulted in a touchdown, first down, fumble, etc. This can reduce the time it takes for play reviews and removes uncertainty for questionable plays. The tracking system is programmed through Arduino using GPS and IMU technology. Similar to drone control and navigation, the FTS works by gathering GPS coordinates, acceleration, and orientation to solve for position. The team has gone through an iterative process to find solutions to track accurately and efficiently, yet not affect the physical properties of the football.

HOW IT WORKS

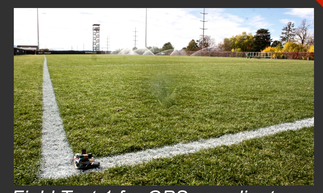
The football tracking system records GPS (Latitude and Longitude) and IMU data which is then processed through Arduino and in Matlab. The data is transferred through an XBEE and all three components are mounted on a custom printed circuit board. Running on a single 9V battery, these components are fitted onto a custom mounting piece inside the football. The system locks onto approximately eleven satellites before data is analyzed. The GPS data is processed through trilateral computation to solve for the distance based on the GPS reference points. The algorithm takes multiple coordinate systems based on the GPS references for improved location accuracy.

RECOMMENDED FUTURE IMPROVEMENTS

There are a great deal of potential improvements for the entire system. With more funding the FTS requires upgrading the GPS to a helix antenna which allows for flexibility in positioning and improvements to accuracy. An entire custom board with the aspects of each individual component in one piece can reduce the weight and improve efficiency. Powering with smaller batteries and using a lighter material for the mounting mechanism all contribute to a better tracking system.

TESTING OVERVIEW

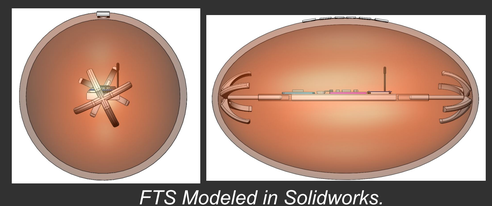
Tests were conducted at the Spencer Eccles Football Facility Outdoor Field. The first two tests provided information on the accuracy of the system. The third and fourth test tracked the positioning of the system when introduced to movement.



Field Test 1 for GPS coordinates.

MOUNTING

The biggest challenge in adding components inside the football was to leave the weight of the football unaffected and close to the center of mass so it would not affect the trajectory when being thrown. The mounting mechanism is spring loaded at the nose ends to retain stability and allow room for flexion. With the PCB and components mounted in the center, the entire system weighs approximately 50 grams equaling to 10% of the football's weight. The entire system fits inside the bladder of the football and is sealed back to its original state.



FTS Modeled in Solidworks.

TRILATERATION

The first step to track the football was to get the GPS coordinates for the four corners of the field. With the GPS location of the ball, the distance from each of the four corners could be found. Then using the known locations of three of the points the coordinate of the ball can be found using the equations:

$$x = \frac{r_1^2 - r_2^2 + d^2}{2d}.$$

$$y = \frac{r_1^2 - r_3^2 - x^2 + (x-i)^2 + j^2}{2j} = \frac{r_1^2 - r_3^2 + i^2 + j^2}{2j} - \frac{i}{j}x.$$

Trilateration with the three points being (0,0), (0,d),(i,j).

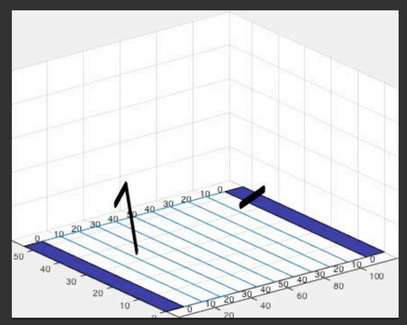
PERFORMANCE/TEST RESULTS

Test 1 involved plotting test points at every corner of the field, the end-zones, and every ten yards in between. The data from Test 1 became the reference points for plotting.

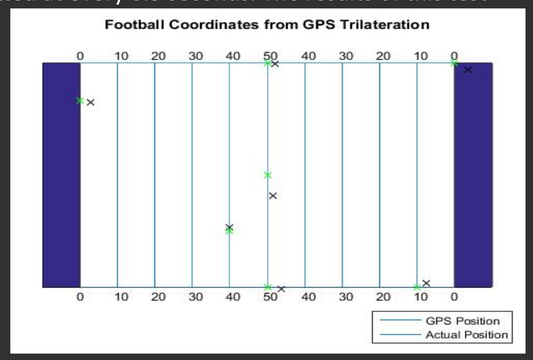
Test 2 re-tested the accuracy of Test 1 points. The field measurements were re-evaluated and averaged to improve accuracy for the following test.

Test 3 compared the accuracy of unknown points. The FTS was positioned at random locations and evaluated for accuracy at 12 satellite connections. This test showed that the most accurate points were those found near the center of the field (50yds) compared to the end-zones. The center field results were within 4 inches of accuracy with end-zones being 12 inches.

Test 4 tracked the movement of the football similar to game-play conditions. With movement at 15mph, the tracking collected and plotted at every 0.5 seconds. The results of this test averaged an accuracy of 2 ft.



Test 4 modeling movement in 3D space.



Test 3's positioning based on multiple trilaterial computations.

GPS

The FTS takes position data in the form of Longitude and Latitude up to nine decimal places. The data is then processed through our trilateration distance calculation to plot in the visual interface.

IMU

The Inertial Measurement Unit (IMU) collects the details of velocity, flight dynamics (roll, pitch, yaw), and altitude to track the movement of a football in action. The data collected is linked to reference points set up by the GPS to analyze the movement.

XBEE

The XBee provides wireless communication between the GPS, IMU, and the Arduino/ Matlab computational process. It is able to relay reliable data every 0.02 seconds from up to 70 yards.

CUSTOM PCB

The 2-layered custom printed circuit board connects the GPS, IMU, and XBEE components into a single compact board that is able to fit into the mounting mechanism.