Smoking D.A.R.T.S

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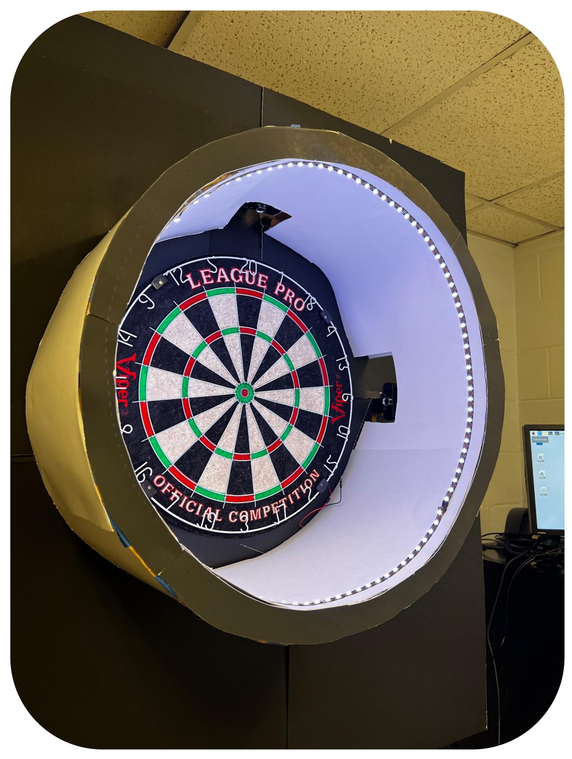
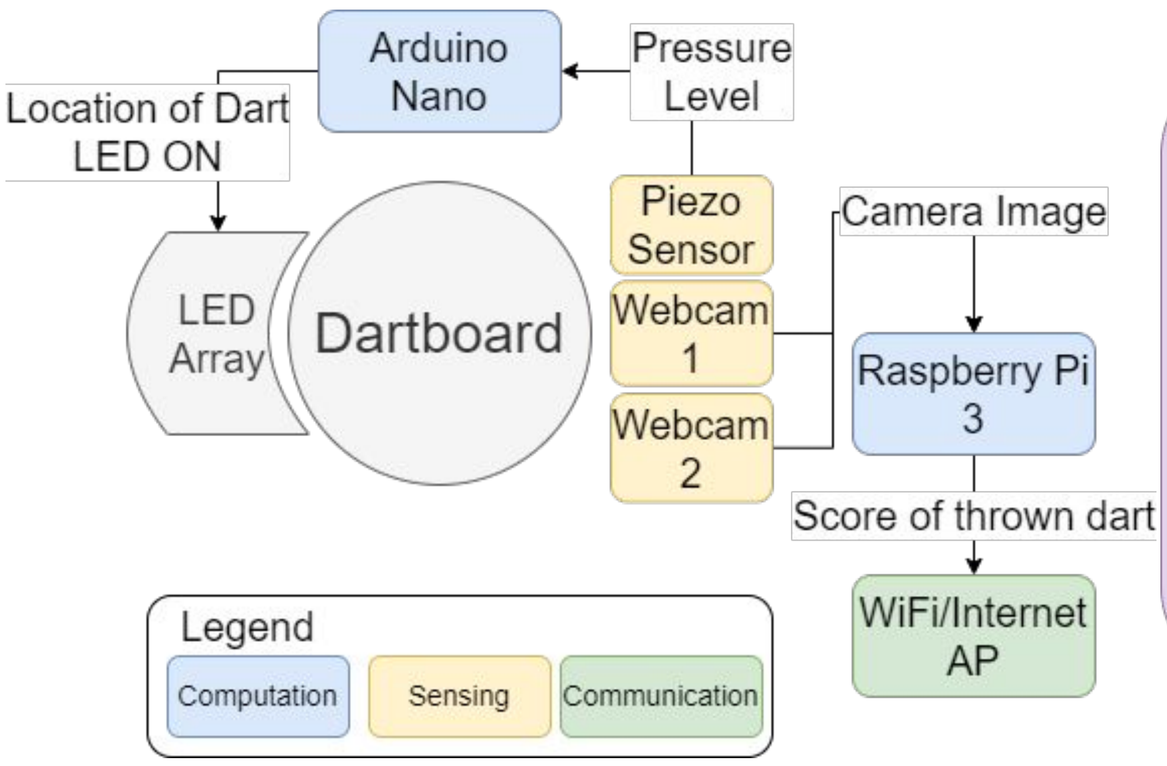
Abstract

Traditional darts consists of two players throwing darts at a dartboard and manually calculating their score over multiple throws. Smoking D.A.R.T.S. automates this scoring process and brings players together with an affordable system that enables users to play against one another without using the same board. Using a couple discreet cameras and a pressure sensor, Smoking D.A.R.T.S. achieves 96% accuracy in calculating a user's throw. A user's score is automatically updated and displayed in the mobile app.

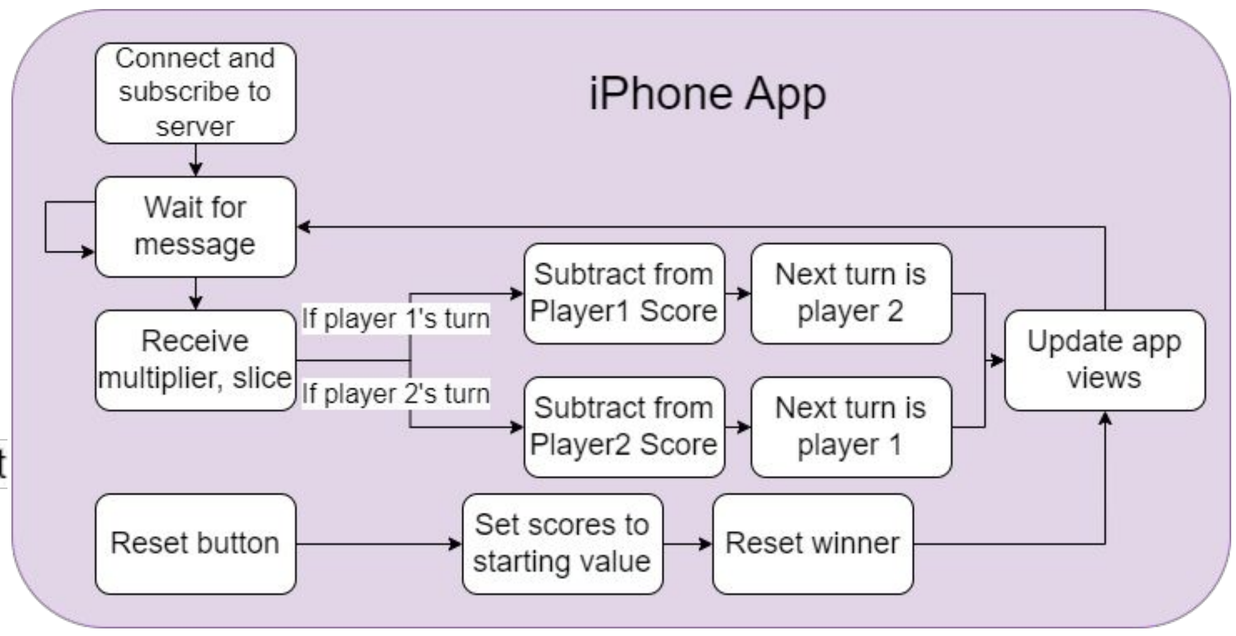
System Overview



Hardware Diagram



Software Diagram



- **Sensors: One piezo sensor behind the dartboard and two cameras placed on the sides facing the center**
- **Arduino Nano: Communicate data from the piezo sensor to the raspberry pi and coordinate the LED light array with the score calculated by the pi**
- **Raspberry Pi: Processes data from Arduino Uno and cameras, calculates the score of the dart, and sends score to app**
- **Communication: The score is sent to the phone from the raspberry pi**
- **Display: The app shows an image of the dartboard with the section of the board with the dart highlighted.**
- **Score: The score is updated by subtracting the dart score from the corresponding player**

Specifications

Specification	Goal	Actual
Accuracy	<2mm on 90% of throws	2.03mm on 96% of throws
Optimal Throws	Optimal throws suggested	Optimal throws suggested in app
Virtual Multiplayer	App registers score from two systems	App registers score from two systems
Responsiveness	User rating of 10	User rating of 7
App Information	Score displayed clearly to user	Displayed score and added corresponding virtual dartboard
Game quality	System does not alter integrity of game	System uses regulation dartboard and steel tip darts

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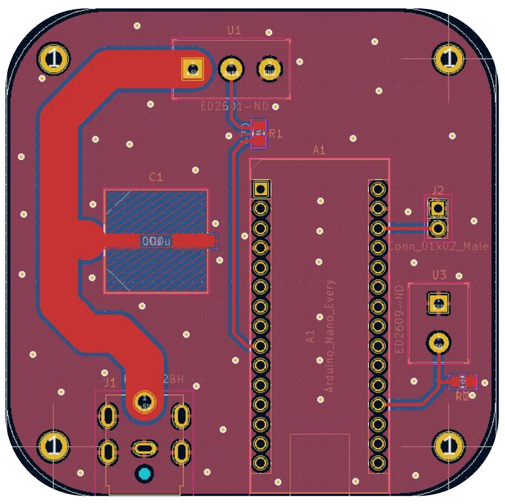
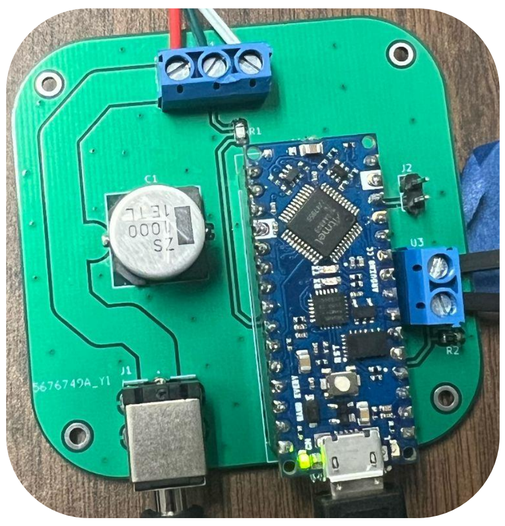
PCB/LED Array





- Components:
  - Arduino Nano - detects impact and communicates to pi via serial, pi responds with score
  - Piezoelectric element input for impact detection
  - 5V 10A DC power supply to power LED strip, at max brightness each LED draws 60mA
- 105 individually addressable WS1228B LEDs in ring orientation
- Custom animations for boot up/bull/bullseye/zone illumination

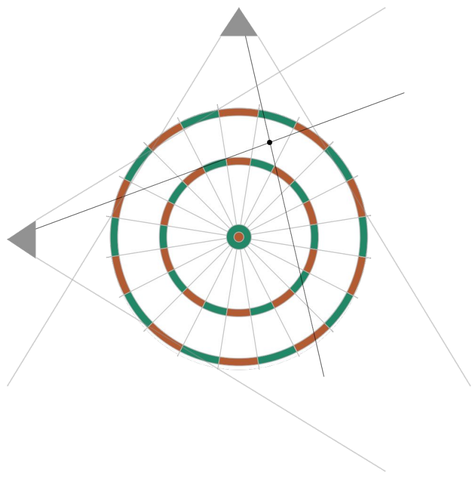
App

- Primary method of communication with the system
- Display:
  - Score
  - Dart Location
  - Checkout throws
- User inputs:
  - Begin a game
  - Indicate next turn
  - Override score (in case of system error)
- Uses MQTT to send and receive messages from system
- Coded in Swift for iPhone

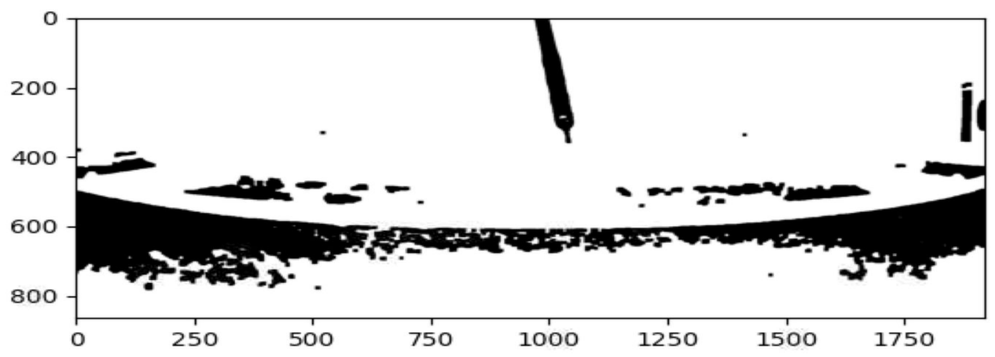
Cost

Part	Development	Production (1000)
Piezo Element	$ 1.60	$ 1.44
Arduino Nano Every	$ 13.70	$ 13.70
WS1228B LED Strip	$ 22.00	$ 7.70
HD 1080p Webcams	$ 54.00	$ 54.00
PCB	$ 10.00	$ 1.96
Resistors	$ 0.20	$ 0.02
Capacitor	$ 2.00	$ 0.79
Screw Terminals	$ 1.80	$ 0.76
DC Power Jack	$ 1.36	$ 0.78
DC Power Supply	$ 22.00	$ 22.00
Ring Enclosure Materials	$ 5.00	$ 2.00
Raspberry Pi 3B+	$ 35.00	$ 35.00
Total	$ 168.66	$ 140.15

From Image to Score

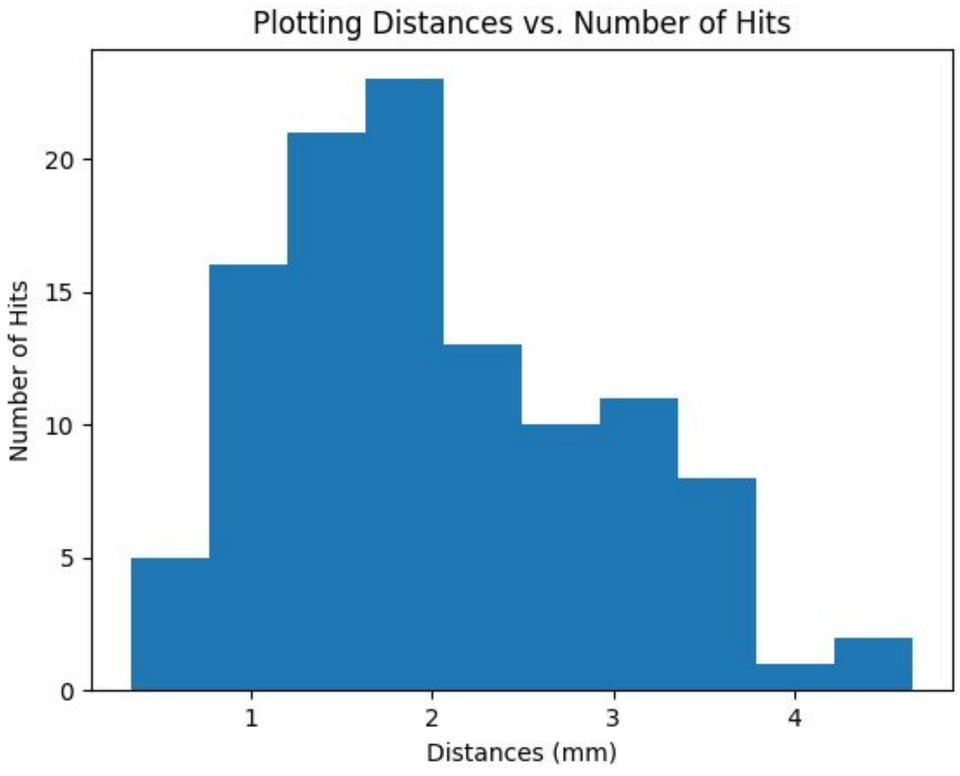


- Capture images
  - Calibrated so the center of the image is the center of the board
  - Cameras located at the sides of board and form a right angle with the bullseye
- Image processing
  - Isolate dart with structural similarity index measure (SSIM) and Otsu's threshold
  - Apply erosion and dilation to remove noise in image



- Acquire pixel coordinate of dart tip
  - Apply canny edge detection to image and select bottom most pixel of contour representing dart
- Calculate undistorted coordinates using non-linear mathematical model for radial distortion
- Convert pixel coordinate to location on board
  - Pixel coordinates tell us angle of dart to camera from center board
  - Use angles in slope-intercept formula to calculate polar coordinates
- Convert polar coordinates to score using region lookup table

Results



- Following results for 110 throws:
  - Average: 2.03 mm
  - Standard Deviation: 0.91 mm
  - Variance: 0.83 mm^2
  - Score Accuracy: 96%