Running Pace Assistant

Group 5
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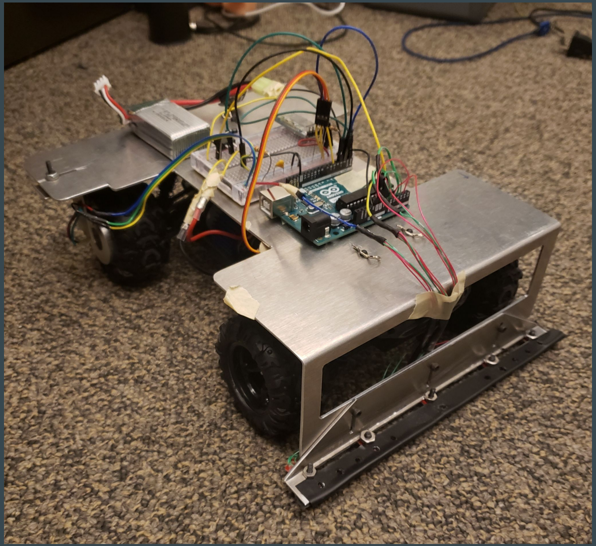
Intro

- Maintaining a constant speed during a distance race leads to the fastest times
- Help runners develop muscle memory for their desired pace
- Provide instantaneous feedback that other devices don’t

Overview

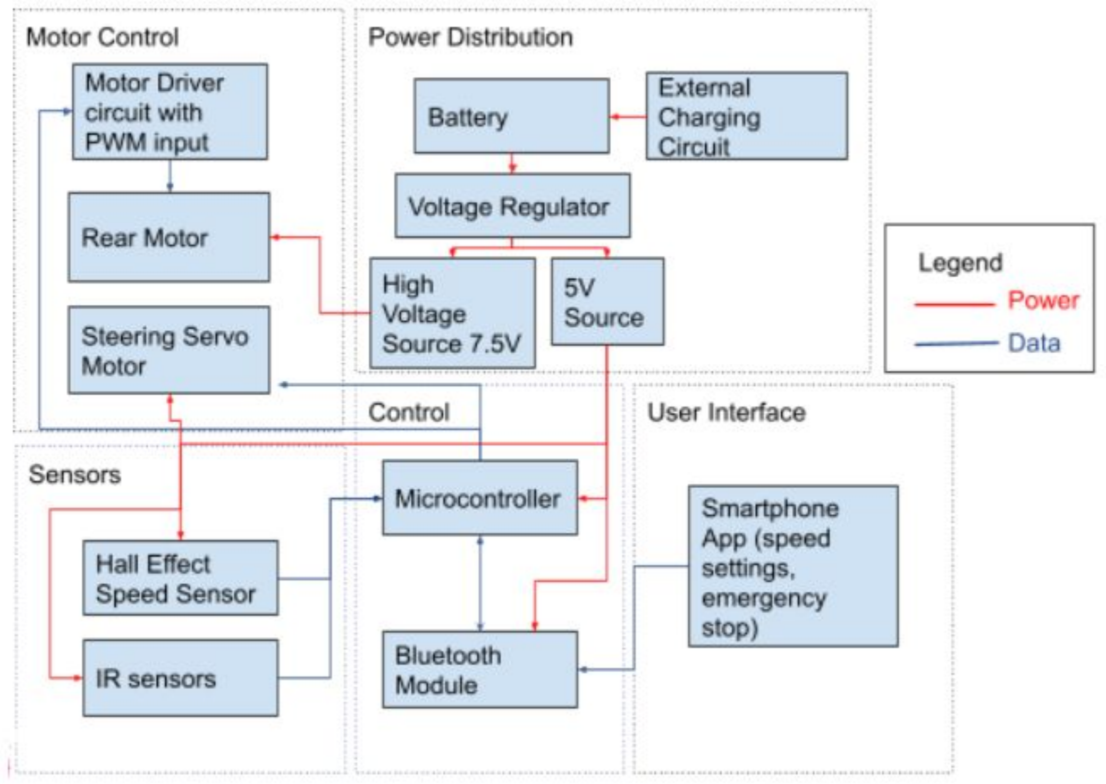
- Pace assistant runs at a constant speed on a standard running track
- Follows lane line around track using IR sensors
- Paired with a smartphone app for easy remote operation.

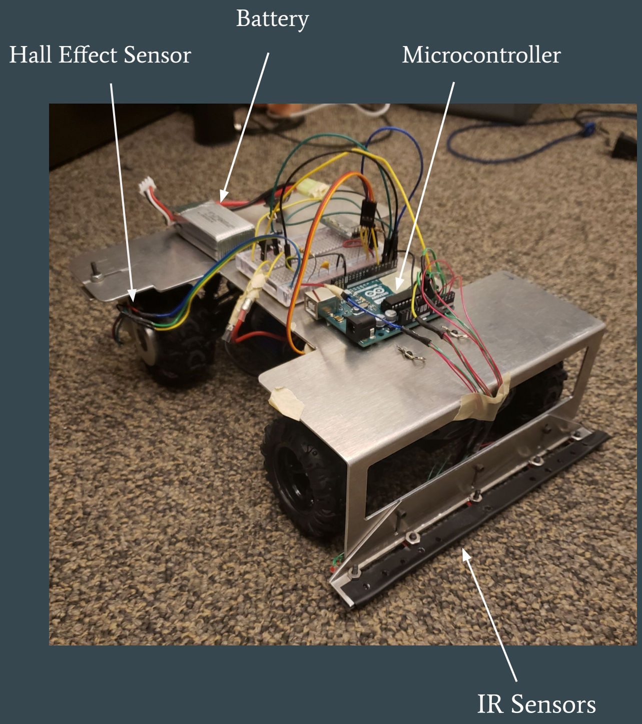


High Level Requirements

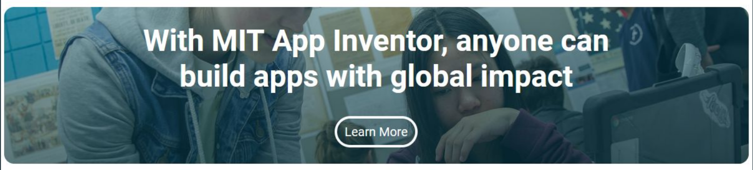
- The robot must have adjustable speed ranging from 5 to 10 mph, and be able to operate for at least 30 minutes at 6mph.
- The robot must follow all typical Olympic track lane markers at all times using IR sensors.
- The smartphone app must have a display showing set speed, distance travelled, and time elapsed. Distance, pace, and time must each be correctly displayed with an allowable error of 5%.

System Overview

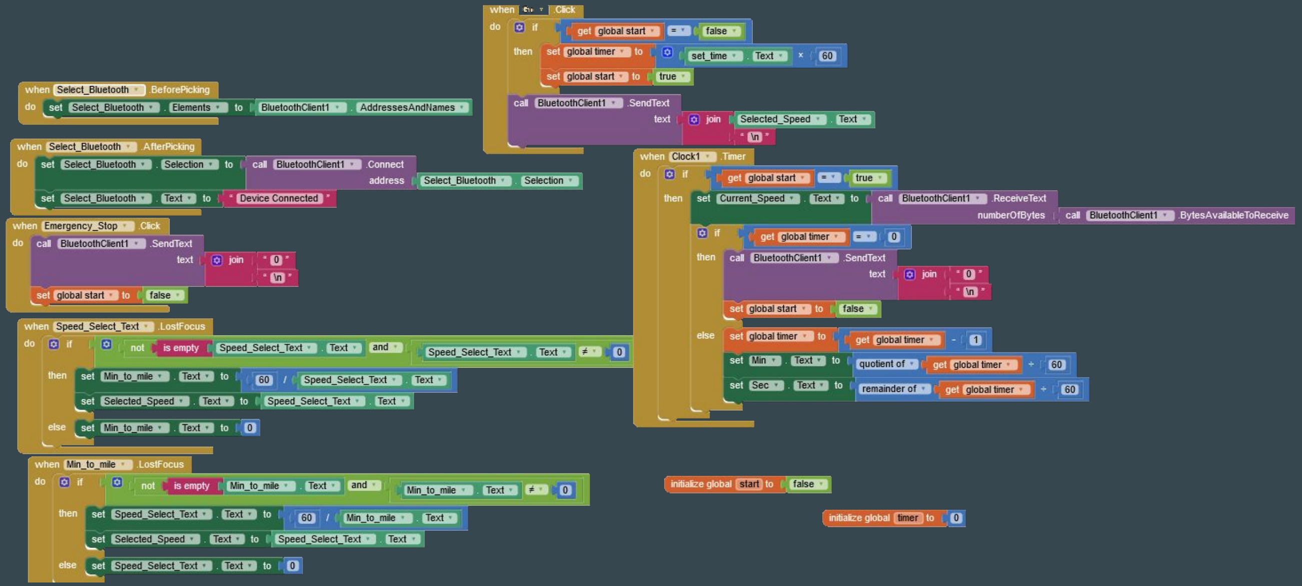




MIT App Creator



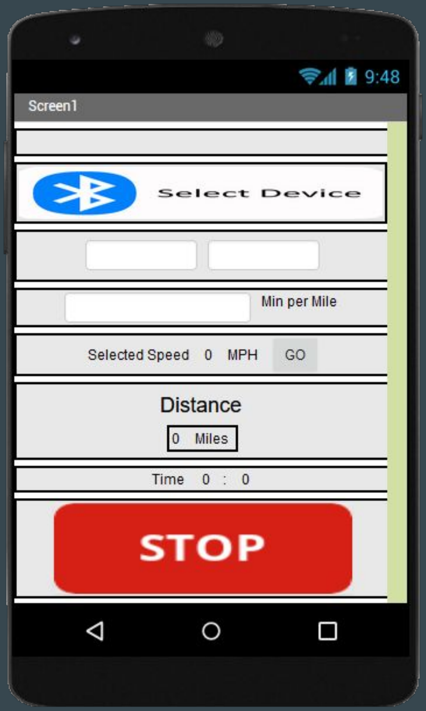
- Similar to scratch, allows for modular programming of individual components
- https://appinventor.mit.edu/
- Block based tools

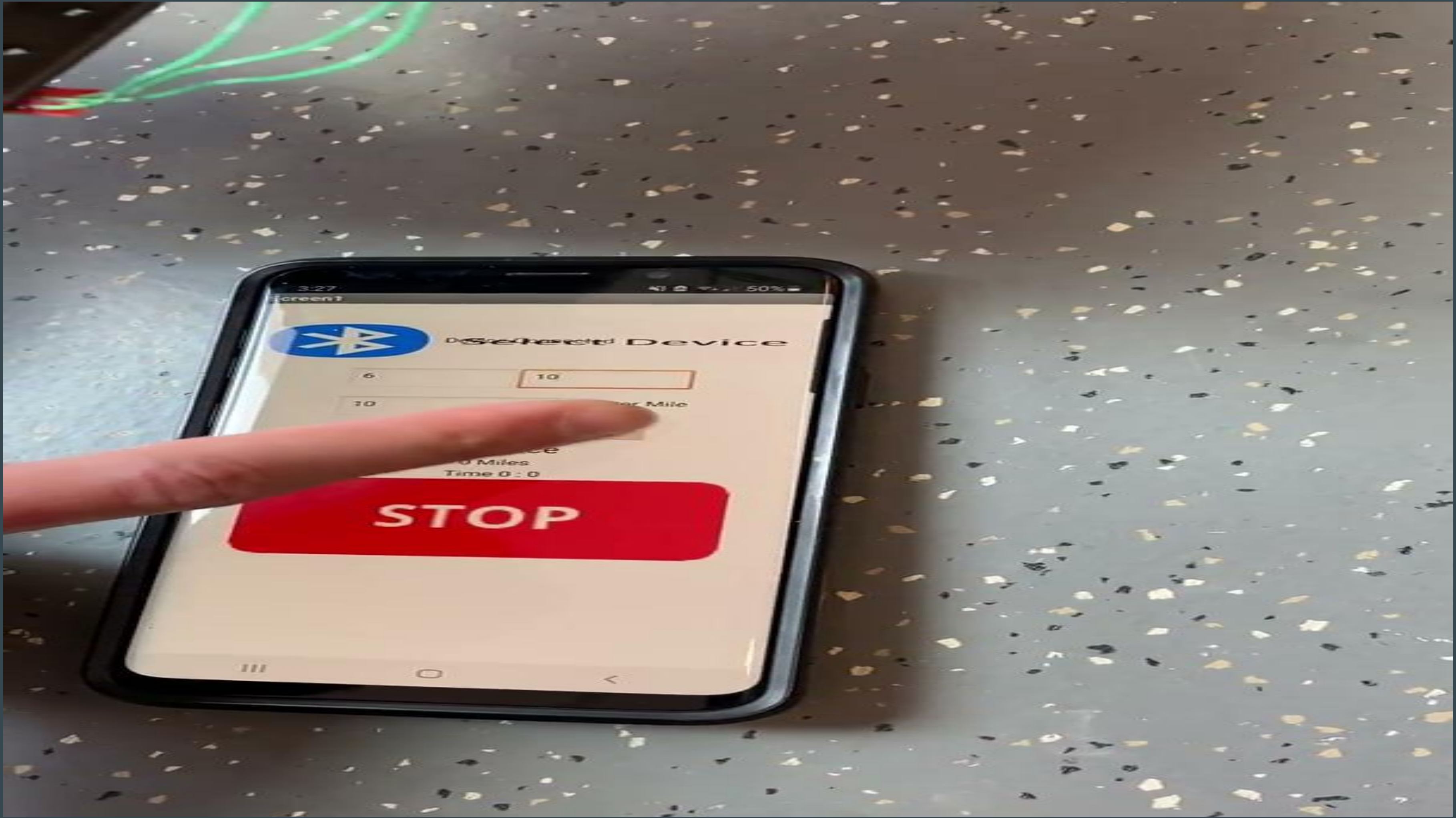


User Interface

- Allows the user to either input speed or pace
- Converts it both ways
- Allows user to set a time
- Go starts the RC car, and automatically stops
- Shows the total distance calculated by the RC car

Requirement	Verification
1. Sends a stop signal to the car when the button is pressed. 2. Accurately sends the required speed value. 3. Accurately displays time elapsed.	A. Measure time elapsed against a stopwatch. B. Read value that is sent on the microcontroller end




Select Device
6
10
10
Time 0 : 0
STOP

Speed Control

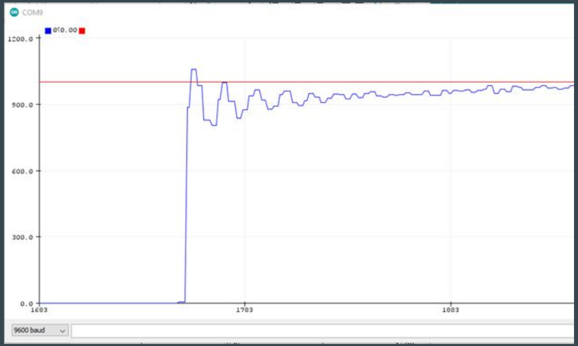
- Hall Effect Sensor
- PID Controller
- Requirement: Car drives at speed within 5% of target value
- Verification: Time with stopwatch how long it takes to travel 100m

$$Circumerence = 210mm$$

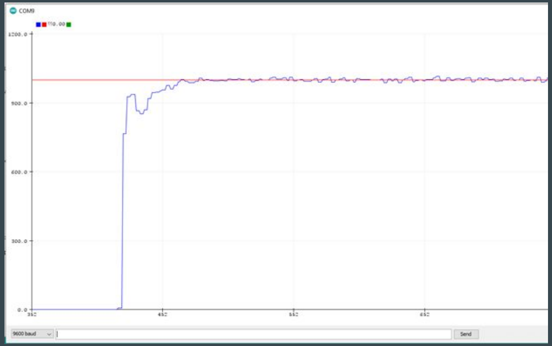
$$RPM = \frac{X\,mi}{hr} * \frac{1\,hr}{60\text{ min}} * \frac{1.609E6\,mm}{mile} * \frac{1\,rotation}{210mm}$$

*Calculation of Desired RPM from mph

```
float kp = 0.75;
float ki = 0.01;
float kd = 0.00001;
```




```
float kp = 0.5;
float ki = 0.1;
float kd = 0;
```



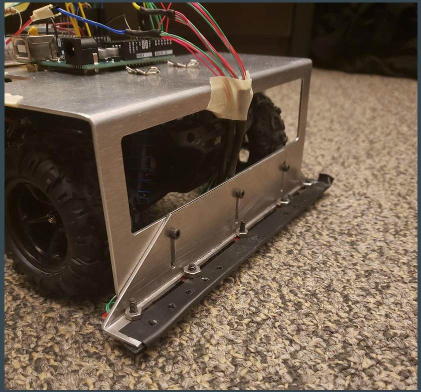
Speed	Calculated Time	Actual Time	Percent Error
3.5 mph	22.37 sec	23.05 sec	3.0%
4 mph	19.57 sec	20.06 sec	2.5%

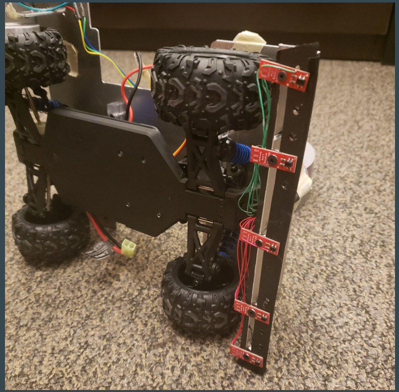
*Tests conducted on 35m line

Steering Control

- 5 IR sensors
- Lookup table for servo motor position
- Requirement: The robot must follow all typical Olympic track lane markers at all times
- Verification: Tape test in ECEB

IR SENSOR VALUES	10000	11000	01000	EVERYTHING ELSE	00010	00011	00001
SERVO POSITION	132	133	134	136	138	139	140





Microcontroller

IR sensors and Steering Code

```
Left2 = analogRead(2);            //reads IR sensor values
Left1 = analogRead(1);
Center = analogRead(4);
Right1 = analogRead(3);
Right2 = analogRead(0);


if (Left1 < Line && Left2 > Line && Right1 > Line && Right2 > Line){        //Turns wheels
position = 139;
}
else if (Left1 < Line && Left2 < Line && Right1 > Line && Right2 > Line && Center > Line){
position = 140;
}
else if (Left1 > Line && Left2 < Line && Right1 > Line && Right2 > Line && Center > Line){
position = 141;
}

else if (Left1 > Line && Left2 > Line && Right1 < Line && Right2 > Line){        //Turns w
position = 134;
}
else if (Left1 > Line && Left2 > Line && Right1 < Line && Right2 < Line && Center > Line){
position = 133;
}
else if (Left1 > Line && Left2 > Line && Right1 > Line && Right2 < Line && Center > Line){
position = 132;
}

else{
  position = 136;
}


servo.write(position);
```

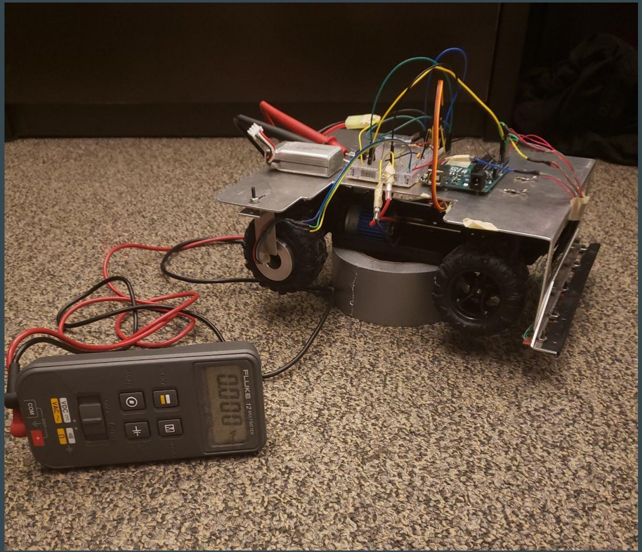
Speed Control Code

```
RPM = 60000000 / DeltaT;                //calculates RPM from DeltaT

if(micros() - t_prev > 500000){         //sets RPM to 0 if we get no pulses in 0.5 seconds
  RPM = 0;
}

error = RPM_desired - RPM;                //calculates error
integ_err = integ_prev + (0.0000001*DeltaT * ((error + error_prev) / 2));      //trapezoid

if(RPM_desired == 0){        //enforces that integral is 0 when desired rpm is 0 so that t
  integ_err = 0;
}

DutyCycle = kp*error + ki*integ_err + (kd * (error - error_prev) / (DeltaT*0.0000001)) ;

if (DutyCycle > 255){            //Anti-wind up. Caps duty cycle at 255 and maintains err
  DutyCycle = 255;
  integ_err = integ_prev;
}

if (DutyCycle < 0){              //prevents negative duty cycles
  DutyCycle = 0;
}
```

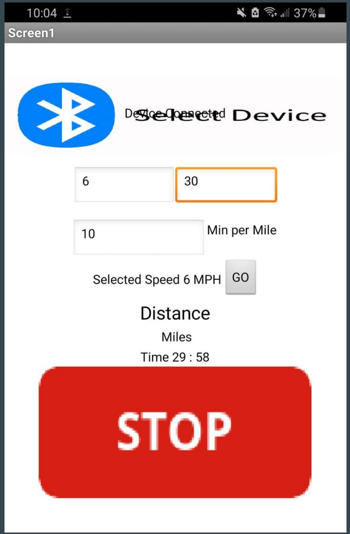
Battery Test

Requirement: Car must be able to drive 3 miles on a single battery charge

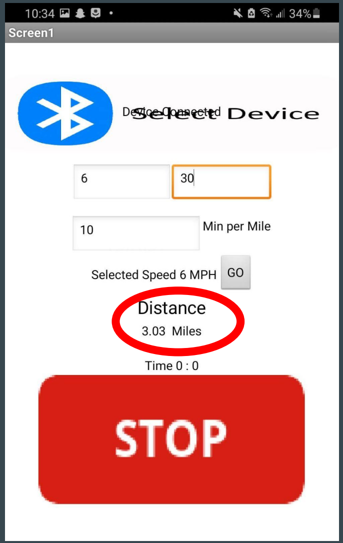
Verification: Endurance test on stand



Start

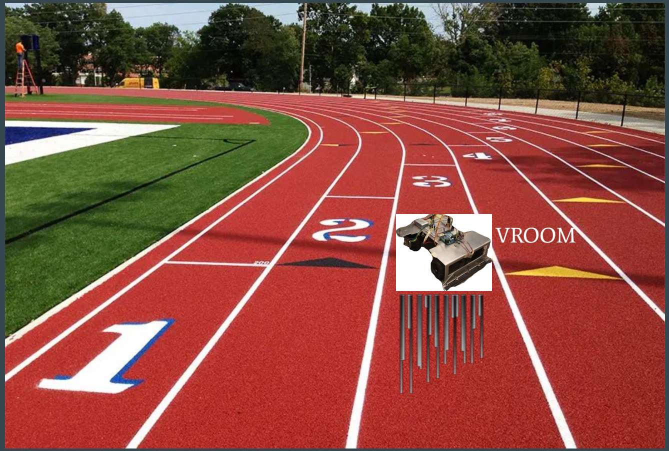


Stop



Successes

- The car worked perfectly in the ECEB with breadboards



Challenges

- No track access
- PCB issues
- Steering algorithm is very basic and required a lot of tuning

Conclusion and Future Work

- Problems
  - Fix PCB
  - Add more IR sensors
  - Implement a calibration feature for different colors of track and line markings
  - Fix the overlapping text after selecting a bluetooth device on the app

We hope that with these improvements, we can create a
a great tool for new and experienced runners alike.

Thank you