Robo-AR

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Anmol Parande, Ankit Agarwal, Jay Monga, Eashaan Katiyar

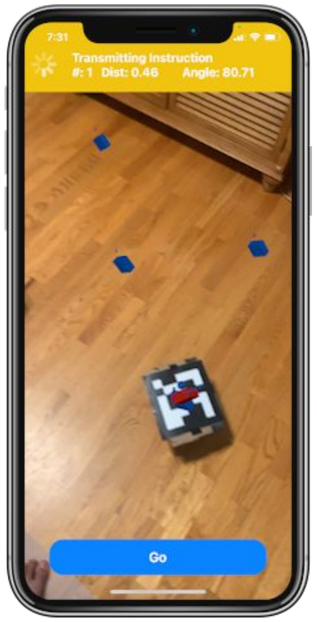
Project Purpose/Goals

Main Goal

Have Romi autonomously follow a user-defined AR trajectory on an IPhone via waypoint navigation and avoid obstacles.

Features

- BLE communication protocol between iPhone and Romi
- Closed-Loop P control on Romi for driving
- Automatic path correction using feedback from AR
- Robot localization with AR and robot sensor data
- Autonomous obstacle detection and avoidance
- In-scene and out of scene robot navigation.



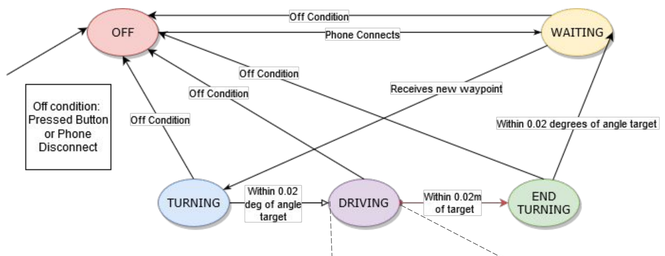
Design

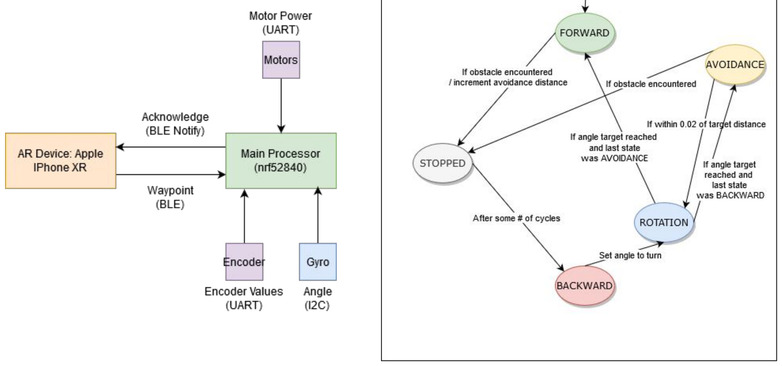
Hardware Architecture

- Iphone communicates with NRF Microcontroller over BLE
- NRF gathers information from Encoders and Gyro for motor control

State Machine

- Implemented a Hierarchical State machine for simplicity of design and clear division of tasks within the Robot.
- The robot at any given time only knows a single waypoint it has to travel to for simplicity.
- Autonomous obstacle avoidance is treated as a subprocess in relation to the driving state.
  - During obstacle avoidance the robot keeps track of its local coordinates as it travels.
  - Everytime it hits an obstacle from the FORWARD state, increments the avoidance distance.





Bluetooth Communication

Characteristics

1. Acknowledge (Read/Notify) - Boolean (1 or 0)
2. Waypoint (Read/Write) - 8 float byte array (distance, angle)

Message Computation

- Checkpoint saves last known position + orientation
- When robot off screen, assume reaches checkpoint
- Don't send next waypoint until < 10cm from current one

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Save initial robot position as checkpoint

When sending waypoint:
  tracked_obj = robot or last checkpoint
  angle = tracked_obj.angleTo(waypoint)
  distance = tracked_obj.distanceTo(waypoint)
  Instruction = {distance, angle}
  orientation = checkpoint.orientation + angle
  checkpoint = {waypoint, orientation}
  Send Instruction via BLE
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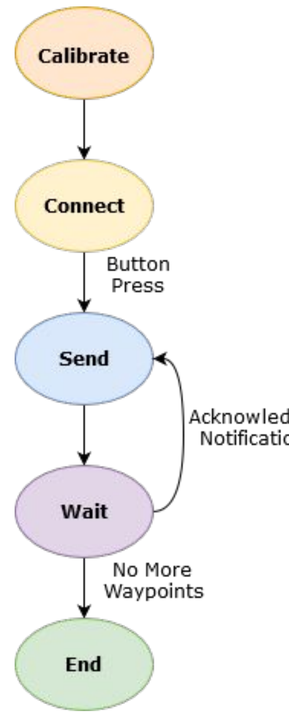
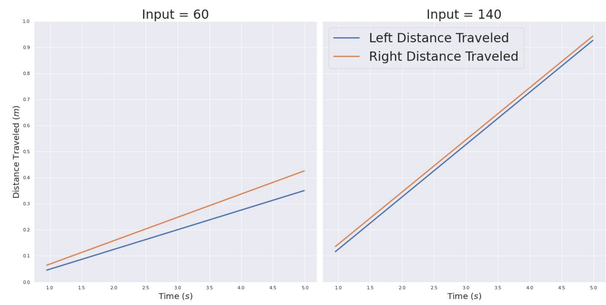


Sensors and Control

- Relative motor velocity converge at high inputs -> favor large magnitude inputs in control for straight driving
- No (observable) overshoot or steady-state error under P controller -> I, D terms unnecessary



Design Evaluation

While we provide an evaluation of the AR technology relative to actual measurements, it's important to consider that we set the perspective of the phone as the ground truth of the project as the phone's user is the true evaluator of functionality

True Distance - AR Distance	True Angle - AR Angle	AR Distance - Robot Distiance	AR Angle - Traveled Angle
-0.0175m	-1.12˚	-0.0725m	2.2˚