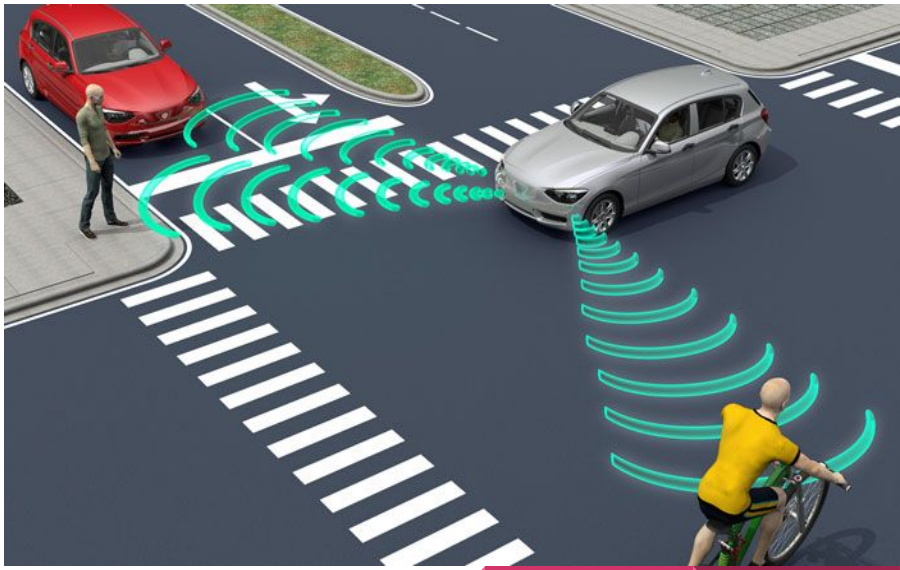
Path Planning of Autonomous Vehicles Using Radar

Team 10

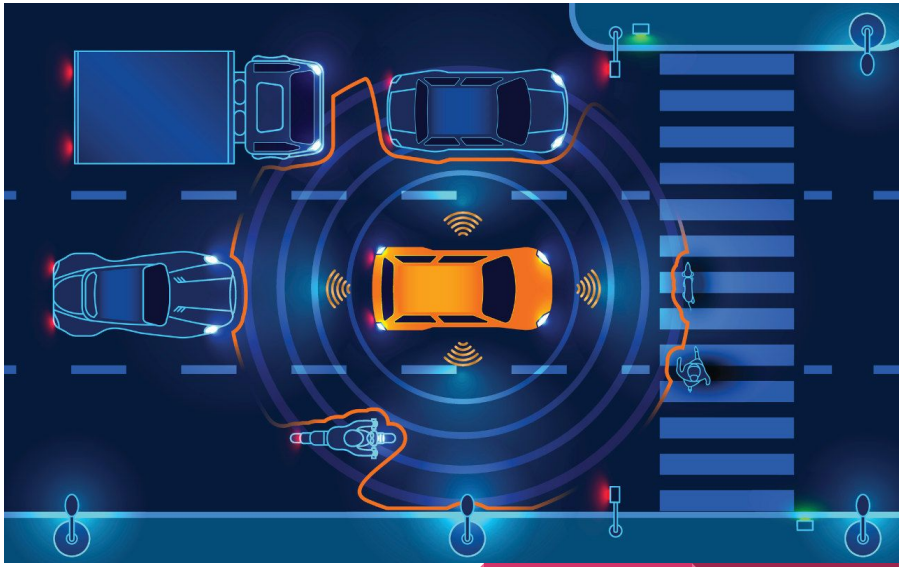
Introduction/Motivation

- Enhanced safety and efficiency
- Convenience
- Path planning
- Network of vehicles
- Adapting to dynamic environments



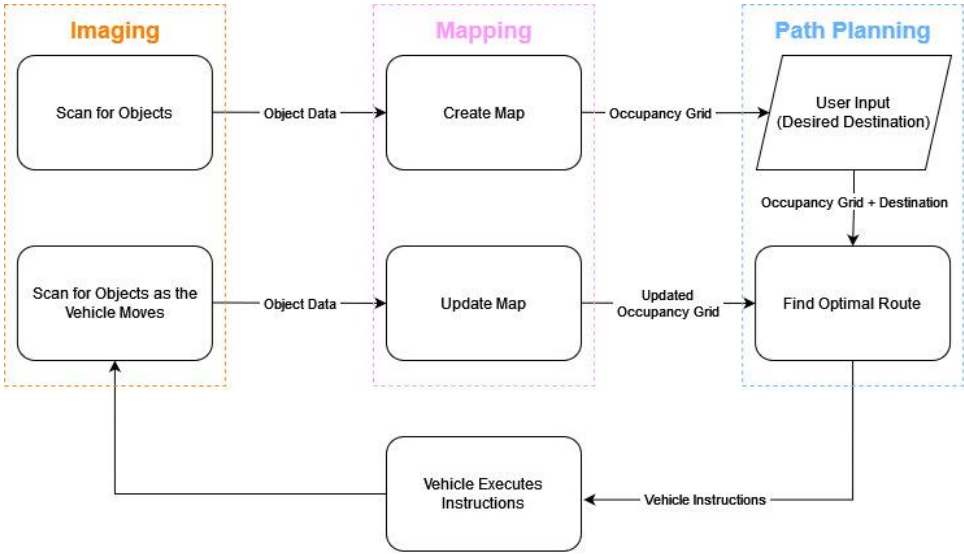
Problem Statement/Project Objectives

- 360 - Degree Object Detection
- Imaging System Capabilities
- Adherence to Environmental Conditions
- Cost - Effective and Reliable Design
- Mapping and Path Planning



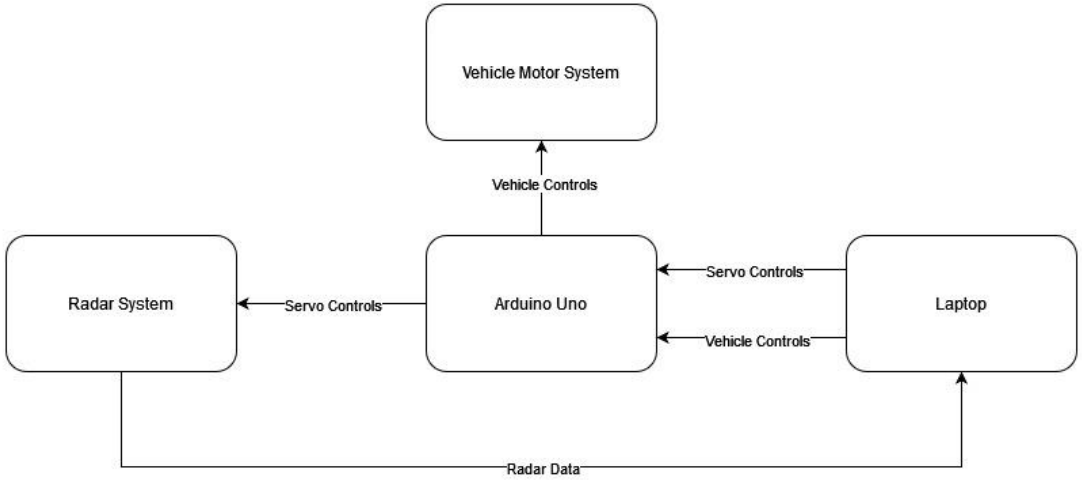
Current Solutions

- Three-part system: Imaging, Mapping, Path Planning
- Imaging scans surroundings for data
- Mapping system uses that data to create map
- Path Planning system uses map to find route
- Output from one part becomes the input for the next part



Proposed Solutions

- Three hardware units communicating together
- Radar gathers info at different points along
- Laptop is responsible for both mapping and path planning
- Arduino sends commands to the vehicle motor as well as the radar servo



Design Refinements

What worked well?

- Path Planning Algorithm
- Basic GUI functions
- Conversion of Polar Data to Occupancy Grid
- Precise Servo Rotation (Radar System)

What needed refinement?

- Radar Signal Processing System
- Vehicle Controls/INS
- Occupancy Grid Post-Processing Features
- Wireless Compatibility

Design Process

Concept

Identity project scope and cost estimation with stakeholders

Inception

Start the design process and mock up a vehicle prototype

Iteration

Develop the vehicle including both the hardware and software components

Testing

Test the prototype for any defects or problems

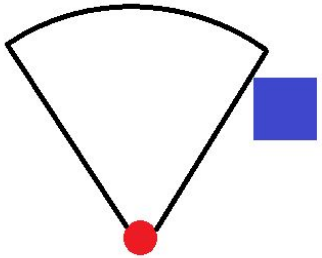
Production

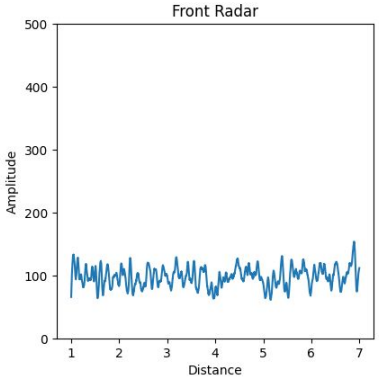
Release the design to the public and receive feedback

Maintenance

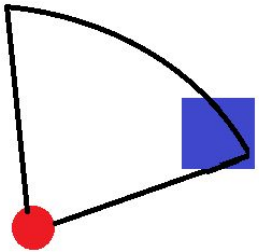
Improve upon the design with the feedback provided by the stakeholders and public

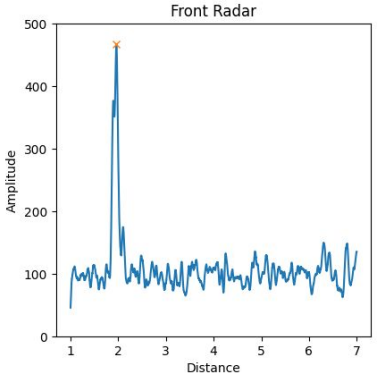
Architecture of Our Solution





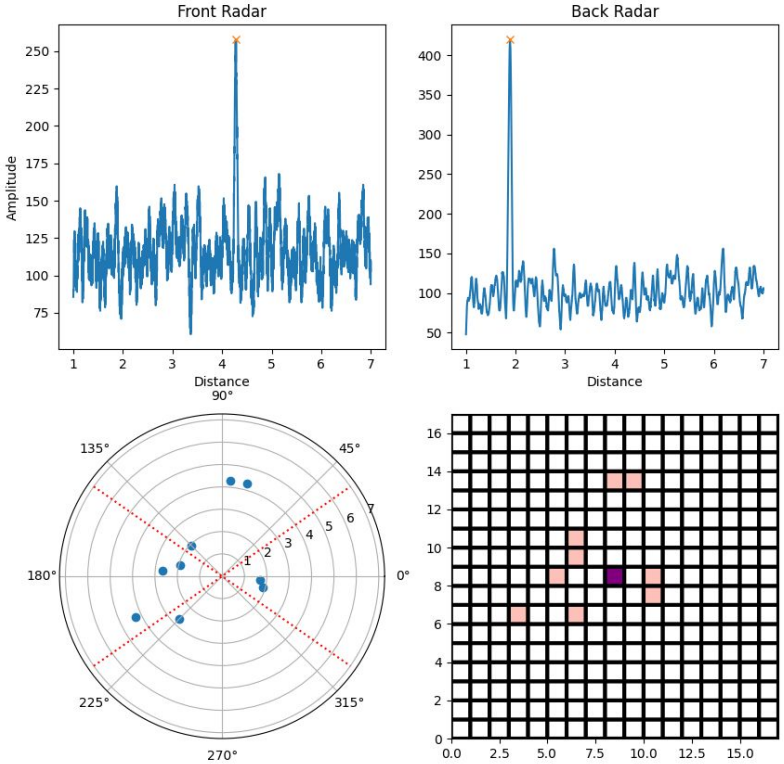
First frame of radar data: no object is in FOV so no peaks are recorded.





Second frame of radar data: An object appears in FOV after rotating. A peak is recorded.

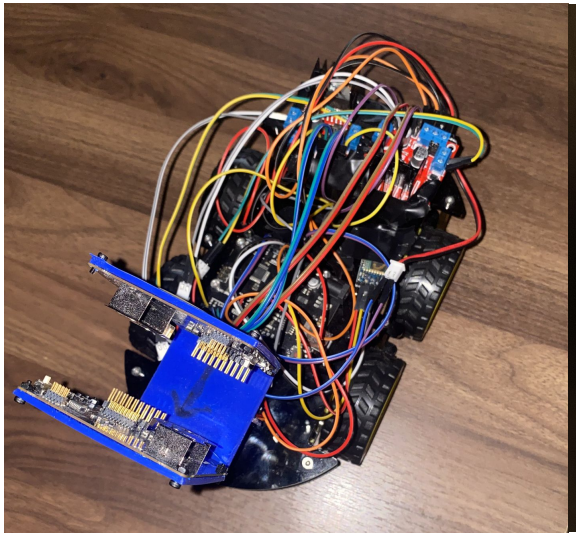
Architecture of Our Solution

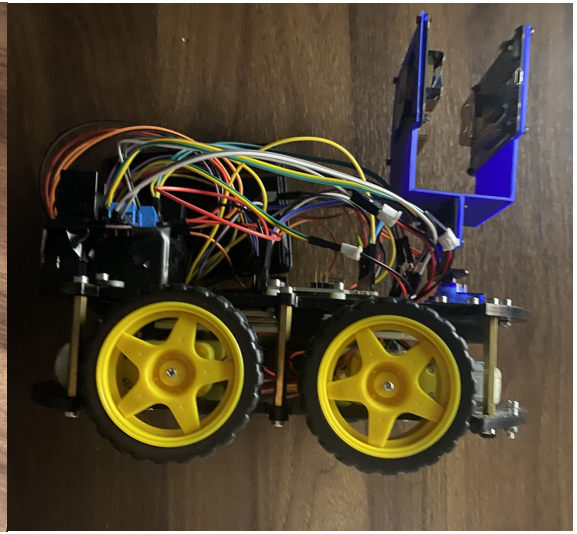


- Laptop script takes in radar hits, outputs radar graphs and vehicle grid map
- Results are displayed in a GUI, which can be interacted with to plot a destination
- Sends destination instructions to the vehicle

Final Product

- Same hardware design used in fall semester, with the addition of an accelerometer/gyroscope acting as our INS
- Radar bluetooth communication is not functional
- Further improvements are underway to manage wiring and loose hardware





Project Budget

Product	Description	Quantity	Cost per unit	Total cost
XM122	Radar Distance Sensing Module	2	$52.64	$105.28
XB122	Breakout Board for XM122	2	$134.90	$269.80
HC05	Wireless Serial Port	3	$11.99	$35.97
Radar Mount	3-D Printed Mount, Screwed Onto Servo	1	$6.40	$6.40
L298N	2-Pack Motor Drivers	1	$33.88	$33.88
FS90R	Micro Servo for Radar System	1	$16.94	$16.94
ELEGOO UNO R3 Project Smart Robot Car Kit	Robotic car kit, included all baserobot components and arduino	1	$100.37	$100.37

Total Project Cost: **$568.64**

Evaluation Results and Analysis

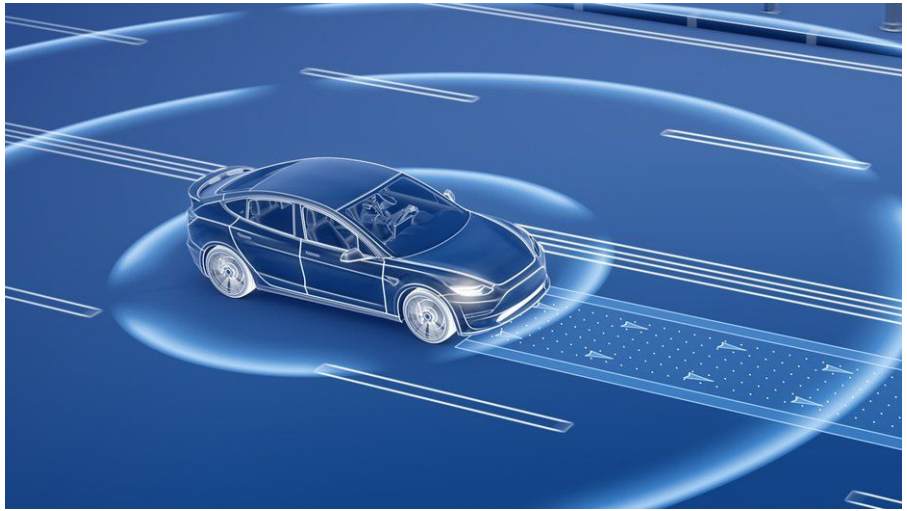
- Test requirements primarily focused on performance aspects such as mapping accuracy, scanning speed, vehicle positional accuracy, and the system's critical error rate.
- Test results showed that most of the software components of our system (grid mapping, path planning, GUI) function as expected, and that the biggest points of error in our system our related to the hardware (radar and vehicle control)
- The radar system is the most defective element of our design. Despite our updated processing method, our model of the radar data is still oversimplified as it does not account for all 3 dimensions of the radar's FOV

Challenges and Solutions

- Challenges include hardware limitations, budget constraints, testing and integration of components
- Some radar and bluetooth components were not working, and were too low-end to return accurate positional data
- Solutions include adjusting mapping and path planning algorithms to account for poor quality data, using approximations when interpreting data

Conclusion and Next Steps

- Aimed to advance autonomous car technology with radar-based navigation and mapping
- Achieved a system for precise obstacle detection and safe navigation, highlighting the potential for safer, more reliable autonomous vehicles.
- Valuable insights into autonomous vehicle techn, enhancing skills in engineering design, teamwork, and problem-solving.
- Future efforts on refining machine learning algorithms and multi-sensor integration.



Q&A