Cooperative vs Non-Cooperative Autonomous Driving

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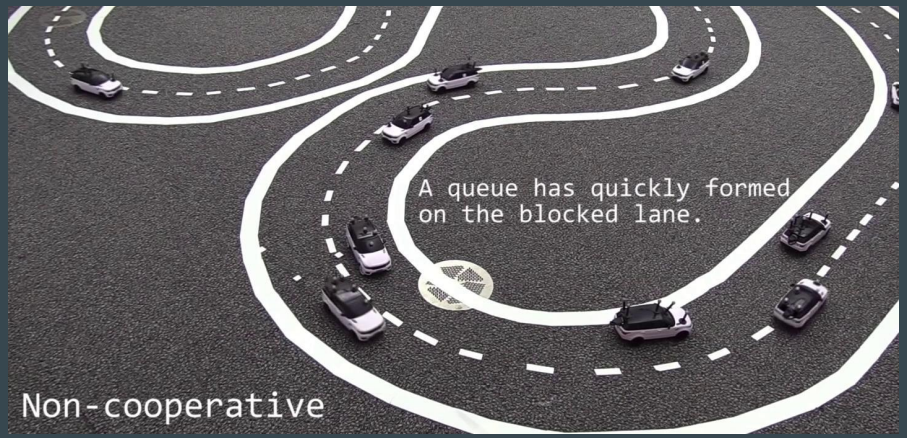
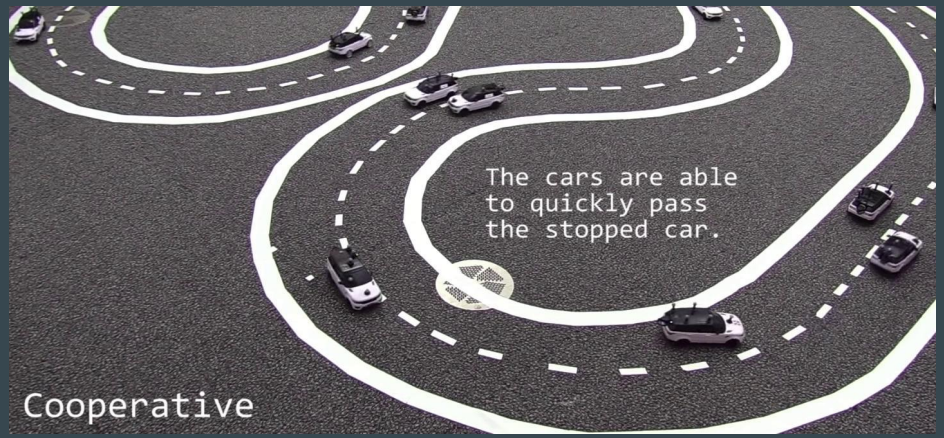
Use Cases

- Autonomy will likely be the future framework of transportation
- Currently in autonomous driving, vehicles optimize for their own ***individual*** goals, while trying to sense and ***react*** to obstacles in the environment
- Cooperative autonomous driving would allow vehicles to ***communicate*** and make collective decisions that are optimal for ***all*** vehicles in the system
- ECE Areas: Software, Hardware, Signals

Use Case Example





Improve road safety and overall traffic flow

Allow vehicles to make more informed decisions

Requirements

- Video processing computation in **400 ms**
- **97%** accuracy in identifying vehicles in object detection
- **5cm** precision in determining vehicle's position
- Path planning computation in **50 ms**
- Communication latency from laptop to vehicles in **100 ms**
- **0** collisions

30% increase in throughout in cooperative vs non-cooperative case

Solution Approach

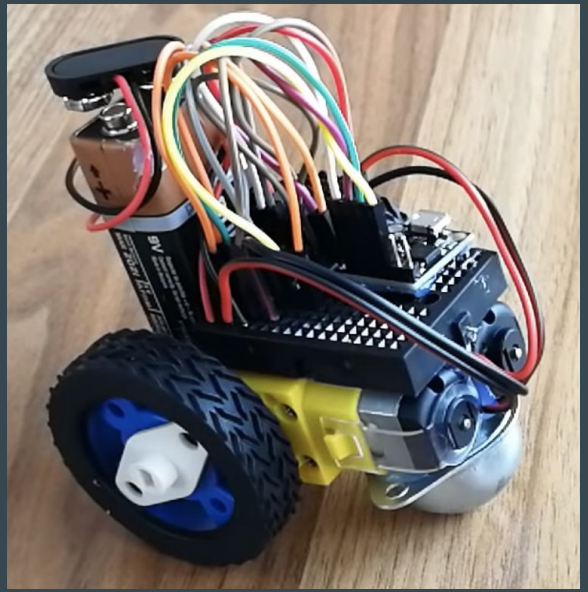
We will simulate ~6 robotic vehicles in a circular track with 2 lanes. They will all be controlled and monitored under the same centralized system. A global camera system will use object detection to distinguish and identify each vehicle's location and orientation.

The vehicles will make decisions based on the data that is given by the server. We will show the difference between vehicles taking action solely based on their individual sensory input and vehicles communicating with each other.

Solution Approach: Hardware

Each of the cars will need the following:

Item	Cost
NodeMCU	~$4
L293D IC (Motor Controller)	~$1
DC Gear Motor (x2)	$4
Wheels (x2) + Wheel Ball	~$6
Battery	$2
Mini Breadboard	$1
TOTAL (x8):	~$20 ($160)



Solution Approach: Hardware

Item	Cost
8 Vehicles	$160
Camera	$100
Track	$20
Misc (i.e. shipping, broken piece)	$50
TOTAL:	$330

Solution Approach: Software

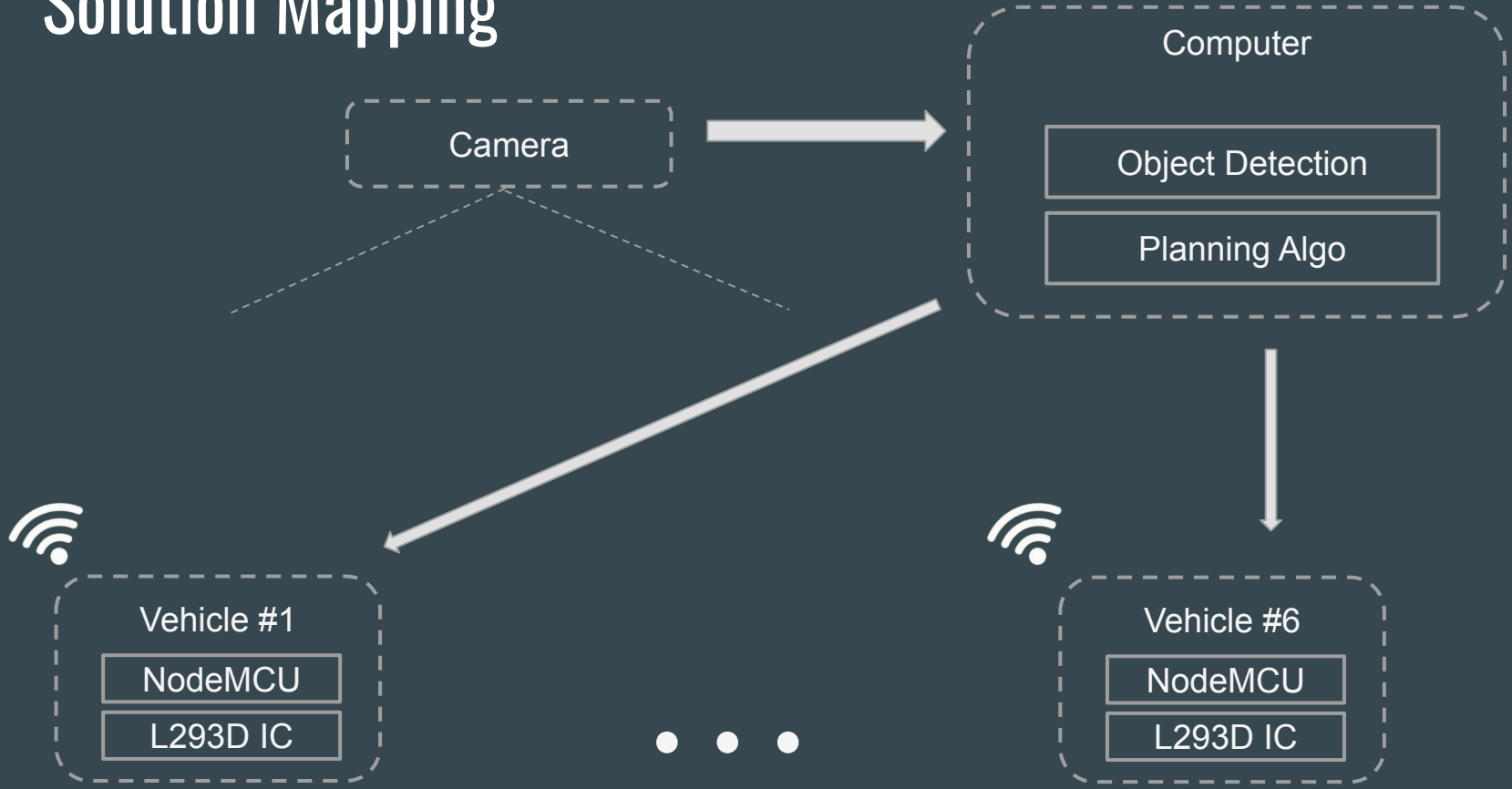
Object Detection

- **MicroPython:** transfer Arduino code to a Python interface
- **OpenCV:** identify each vehicle and its relative location/direction
- Object detection with **YOLOv3 or MobileNet SSD** trained on the COCO dataset
- Object detection alternative : Assign colors to each car and apply image thresholding

Path Planning

- **Intelligent Driver Model** to simulate urban traffic
- **MOBIL Lane Changing Model** for lateral control between lanes

Solution Mapping



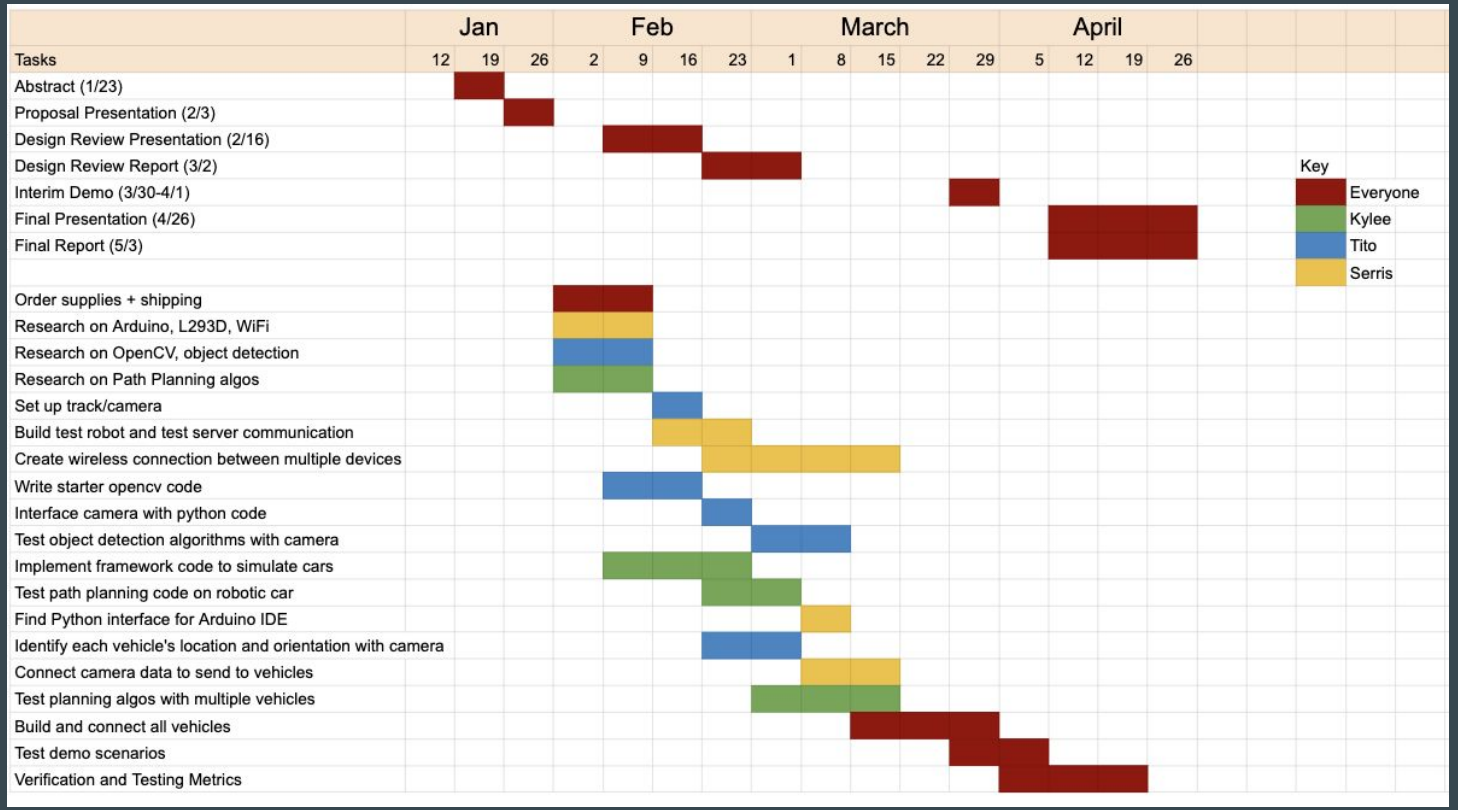
Testing, Verification & Metrics

- Individual latencies (video processing, path planning, communication) will be tested using timing libraries within our code
- Object detection performance will be manually tested on the track after training (test and validate with ~100 different frames)
- Precision testing will also be done on the track (measuring distances from ~20 configurations)
- Overall throughput will be measured in 5 minute periods
    - We will count the number of vehicles that pass a start line in the given period

Workload Breakdown

	Vehicles	Object Detection	Path Planning	Wireless Comm.	Testing
Kylee					
Serris					
Tito					

Gantt Chart


Jan
Feb
March
April
Tasks
12 19 26 2 9 16 23 1 8 15 22 29 5 12 19 26
Abstract (1/23)
Proposal Presentation (2/3)
Design Review Presentation (2/16)
Design Review Report (3/2)
Interim Demo (3/30-4/1)
Final Presentation (4/26)
Final Report (5/3)
Order supplies + shipping
Research on Arduino, L293D, WiFi
Research on OpenCV, object detection
Research on Path Planning algos
Set up track/camera
Build test robot and test server communication
Create wireless connection between multiple devices
Write starter opencv code
Interface camera with python code
Test object detection algorithms with camera
Implement framework code to simulate cars
Test path planning code on robotic car
Find Python interface for Arduino IDE
Identify each vehicle's location and orientation with camera
Connect camera data to send to vehicles
Test planning algos with multiple vehicles
Build and connect all vehicles
Test demo scenarios
Verification and Testing Metrics
Key
Everyone
Kylee
Tito
Serris