

# FROM MOTORCYCLE TO CHEVY BOLT: A JOURNEY WITH MATLAB IN AUTONOMOUS VEHICLES AND ROBOTS RESEARCH



**Dezhen Song, Ph.D.**

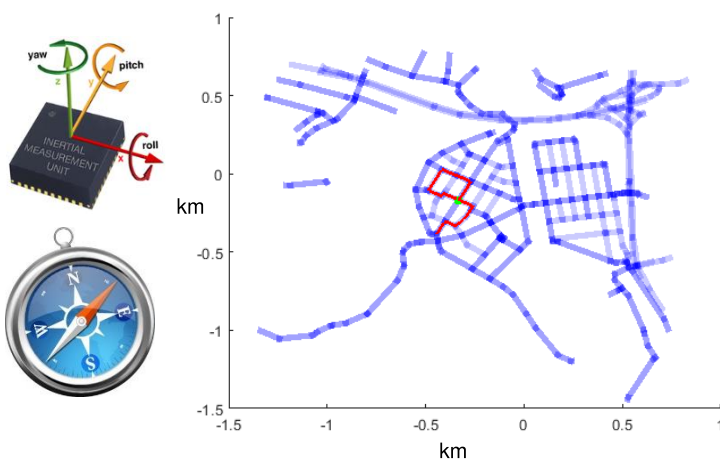
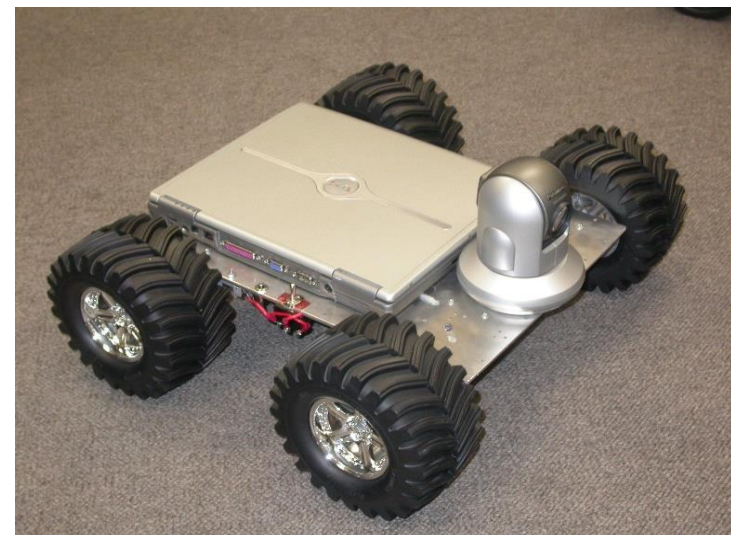
Professor and  
Associate Department Head,  
Dept. of Computer Science and Engineering  
*Texas A&M University*

# FIRST ENCOUNTER WITH MATLAB - 1993



VAX Terminal:  
MATLAB 3?

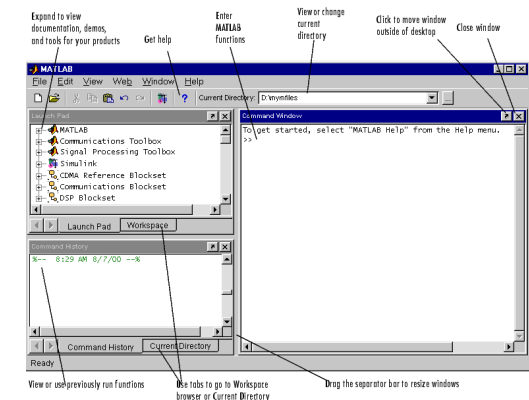
# OUTLINE

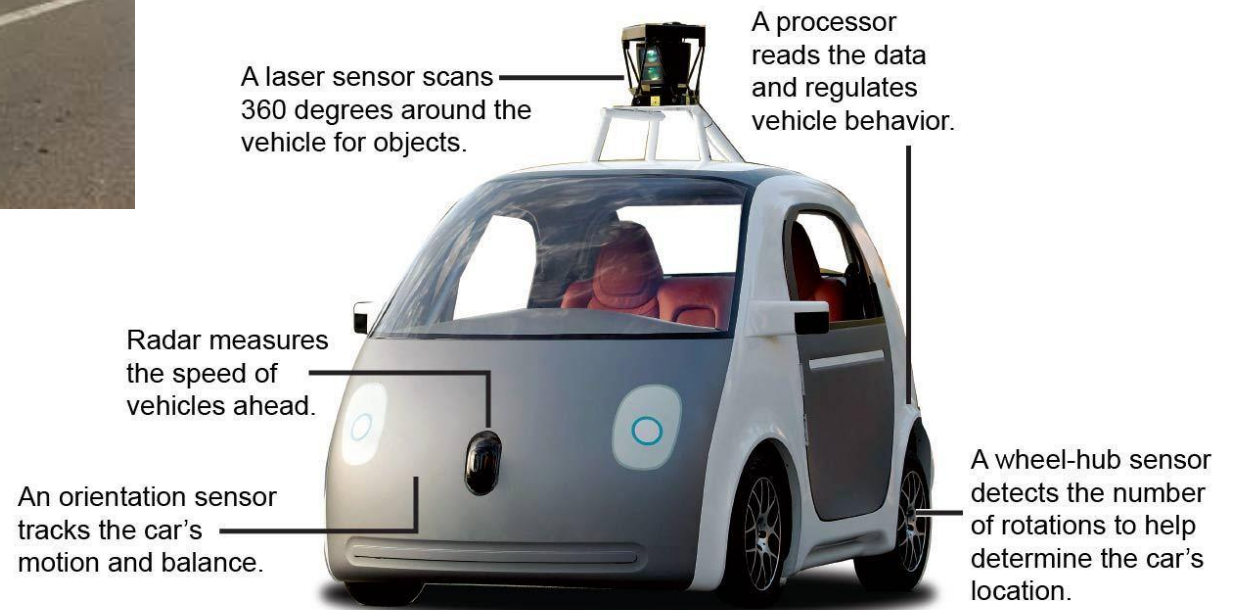


# DARPA GRAND CHALLENGE 2005



# AUTONOMOUS MOTORCYCLE & MATLAB VERSION 6.0

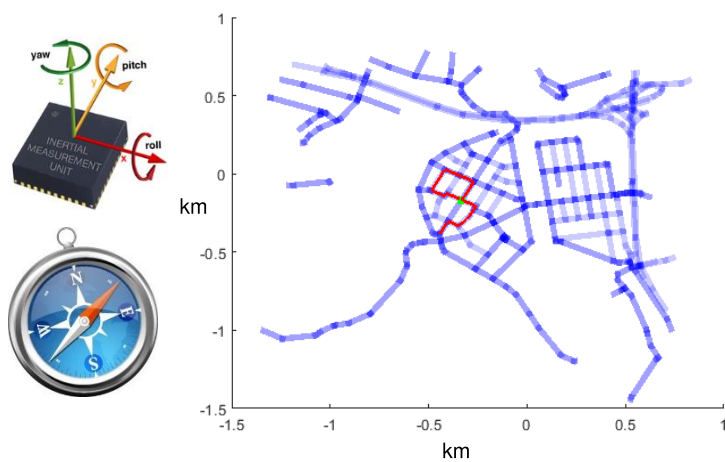
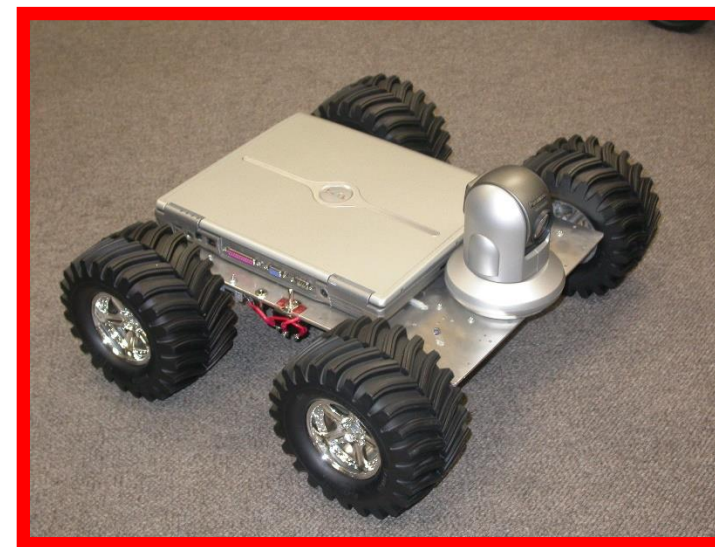




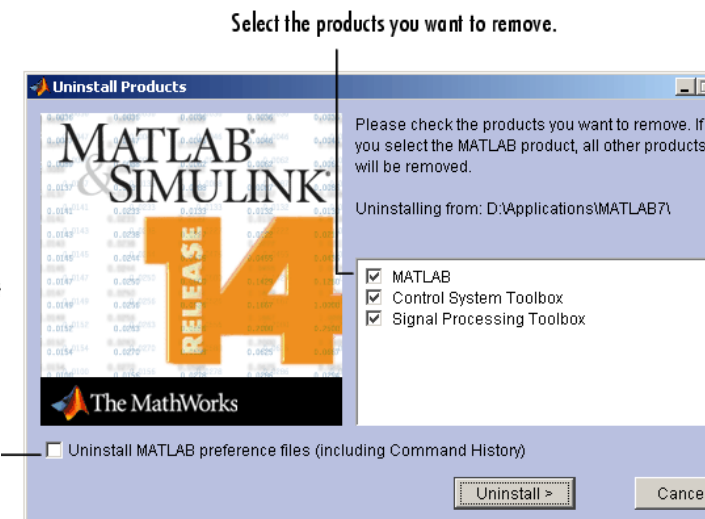
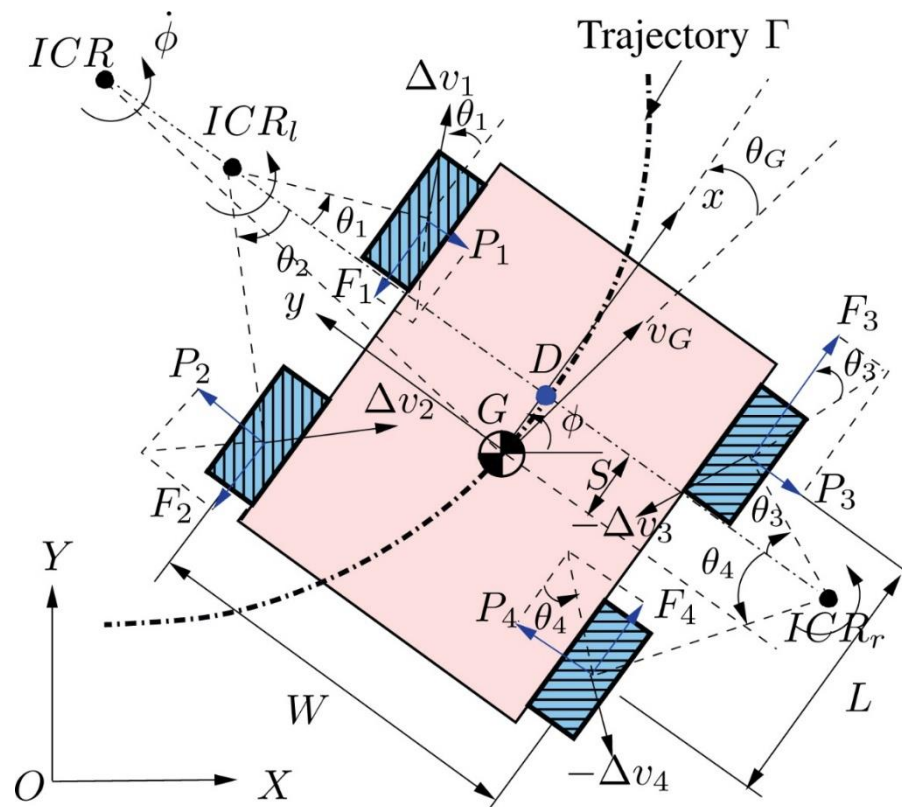
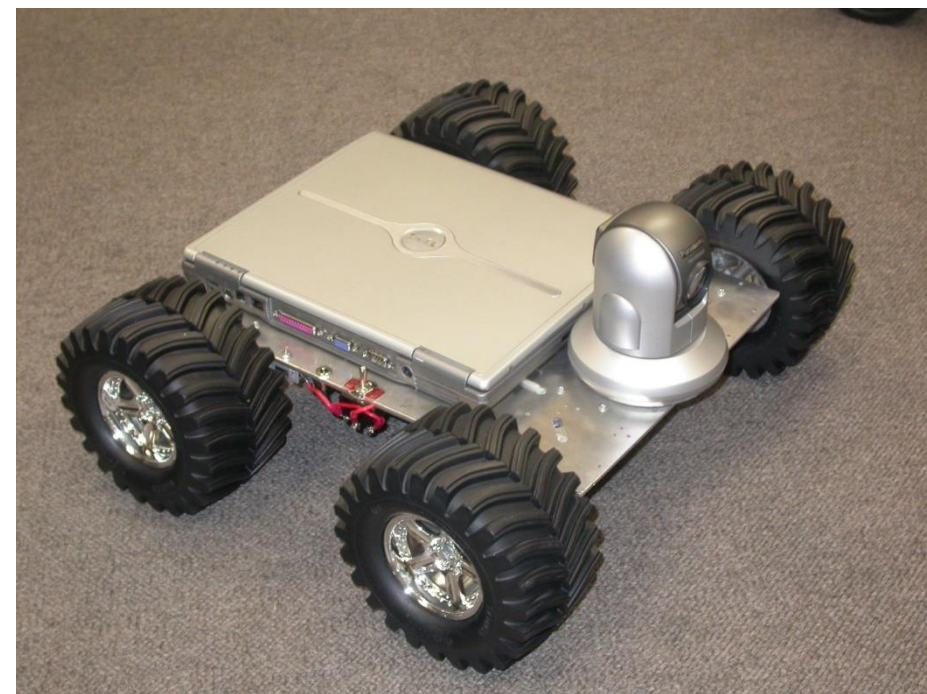
Source: Google

Raoul Rafoa / @latimesgraphics

# OUTLINE



# SKID-STEERED MOBILE ROBOTS

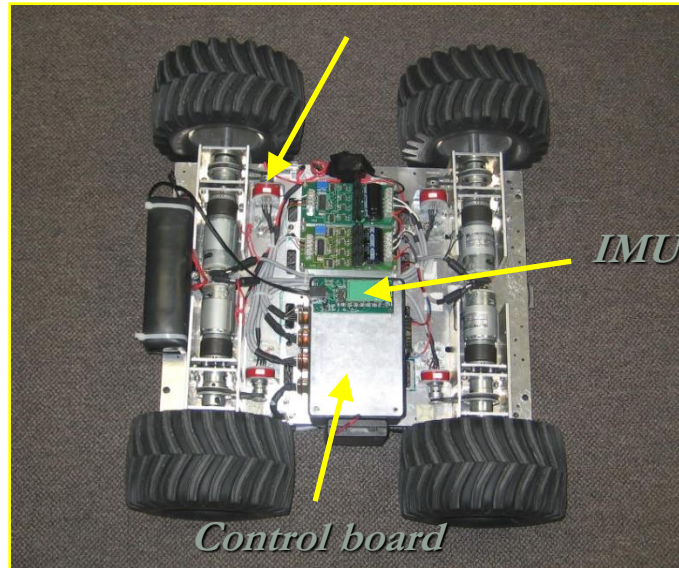




# EXPERIMENTAL SETUP

- On-board control systems and a sensor suite
- Vision-based computer localization as the global location reference

*Wheel encoders*

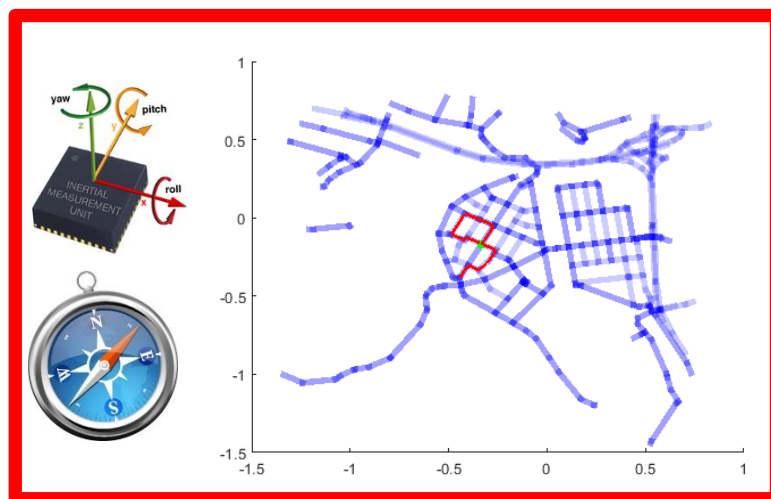
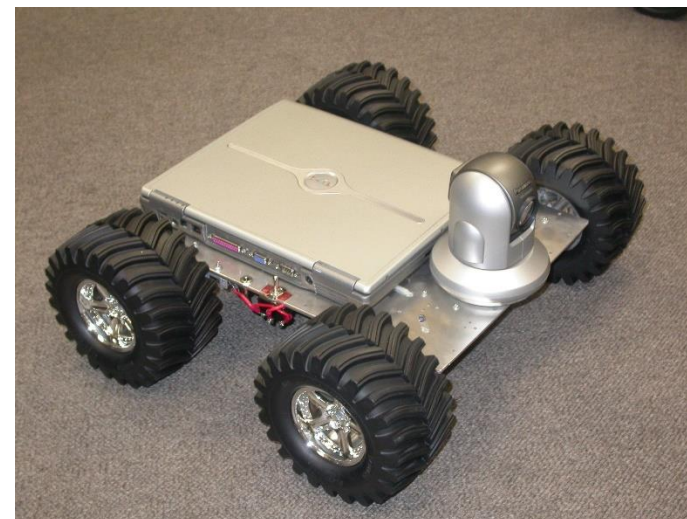


*(a) The experimental robot*

*(b) Various ground conditions*

*(c) Camera positioning systems*

# OUTLINE



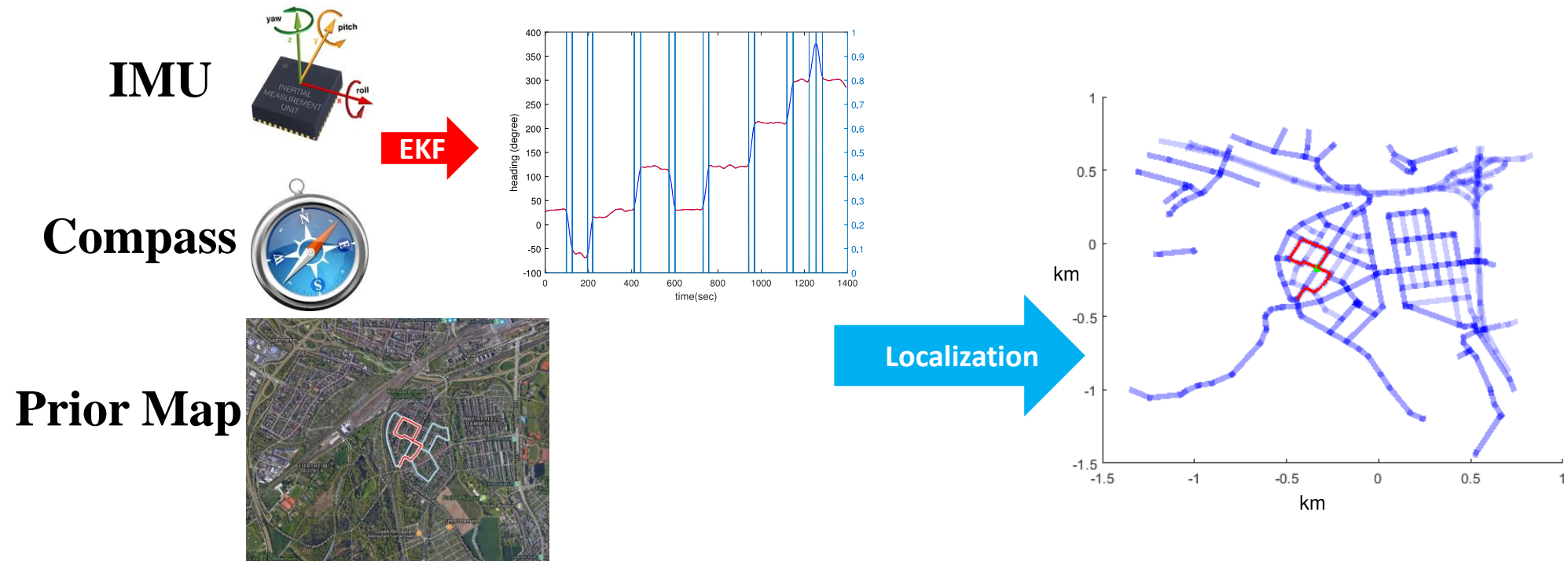
# INTRODUCTION

- Localization Scenario
  - Bad weather and poor illumination conditions
  - High-rise buildings block GPS signals

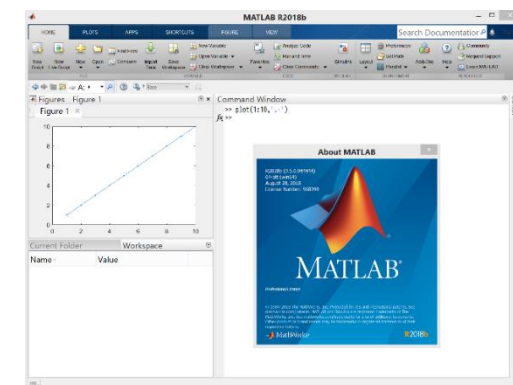
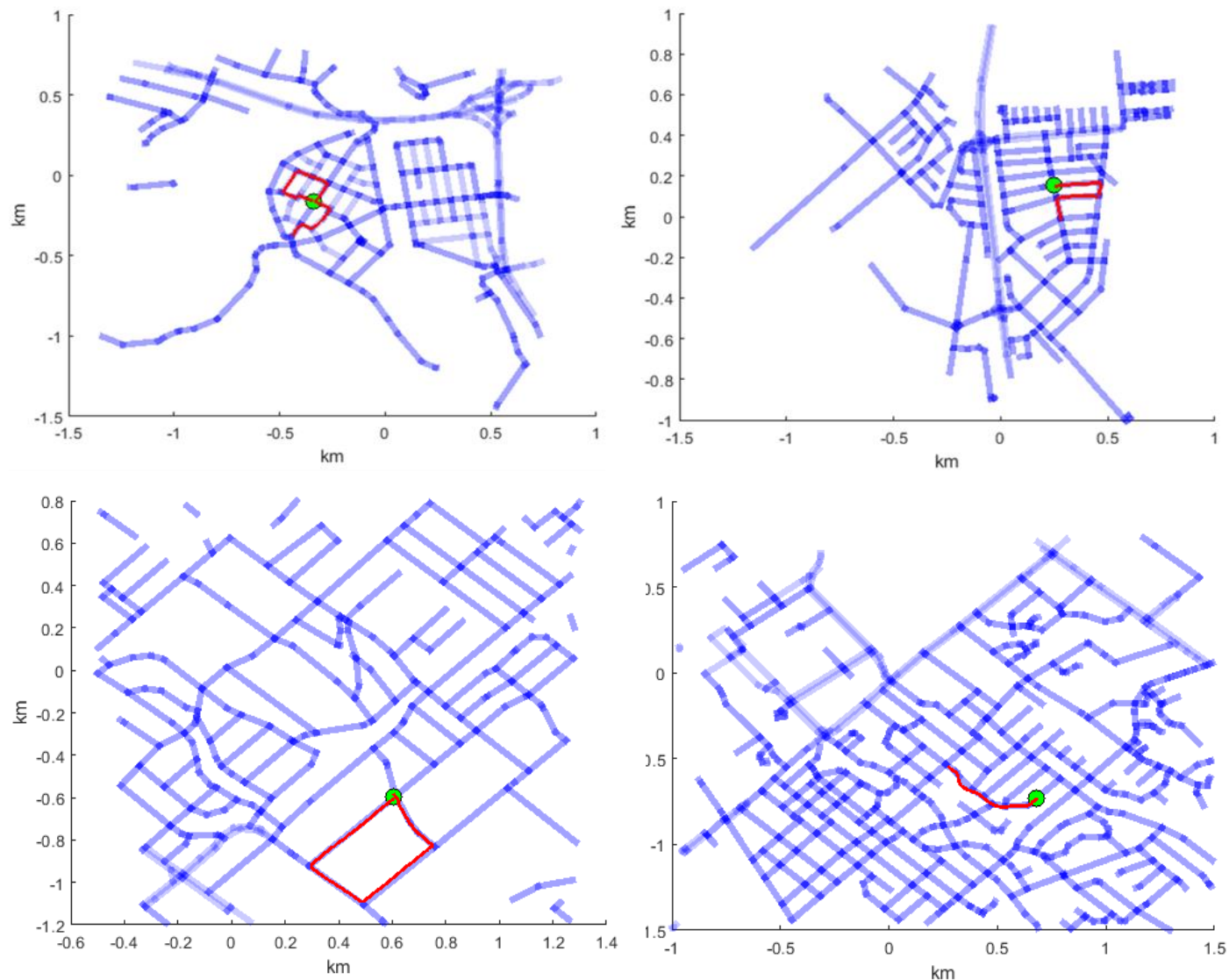


# PROBLEM DEFINITION

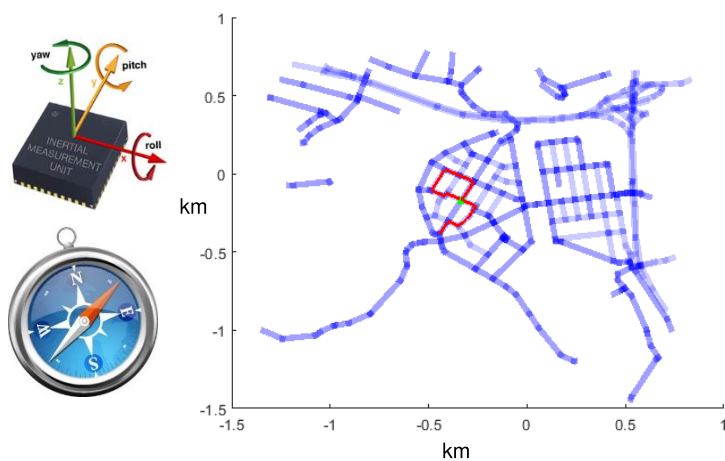
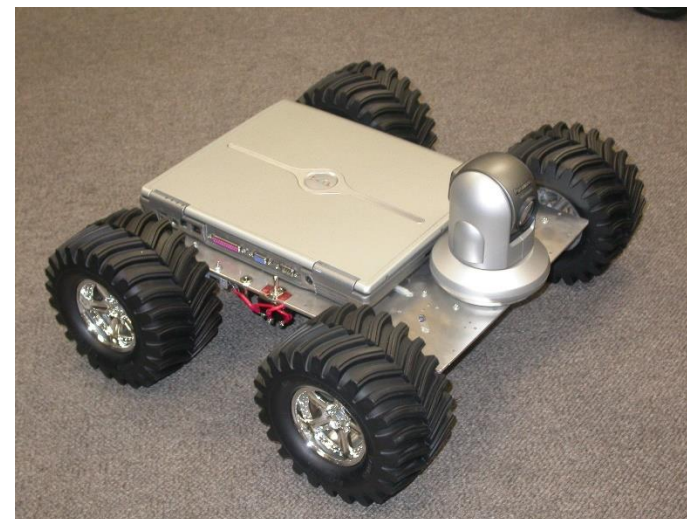
**Problem 1.** Given  $\mathcal{M}_p$ ,  $\mathcal{R}$ ,  $\omega_{0:t}$  and  $\phi_{0:t_\phi}$ , localize the robot after its heading changes.



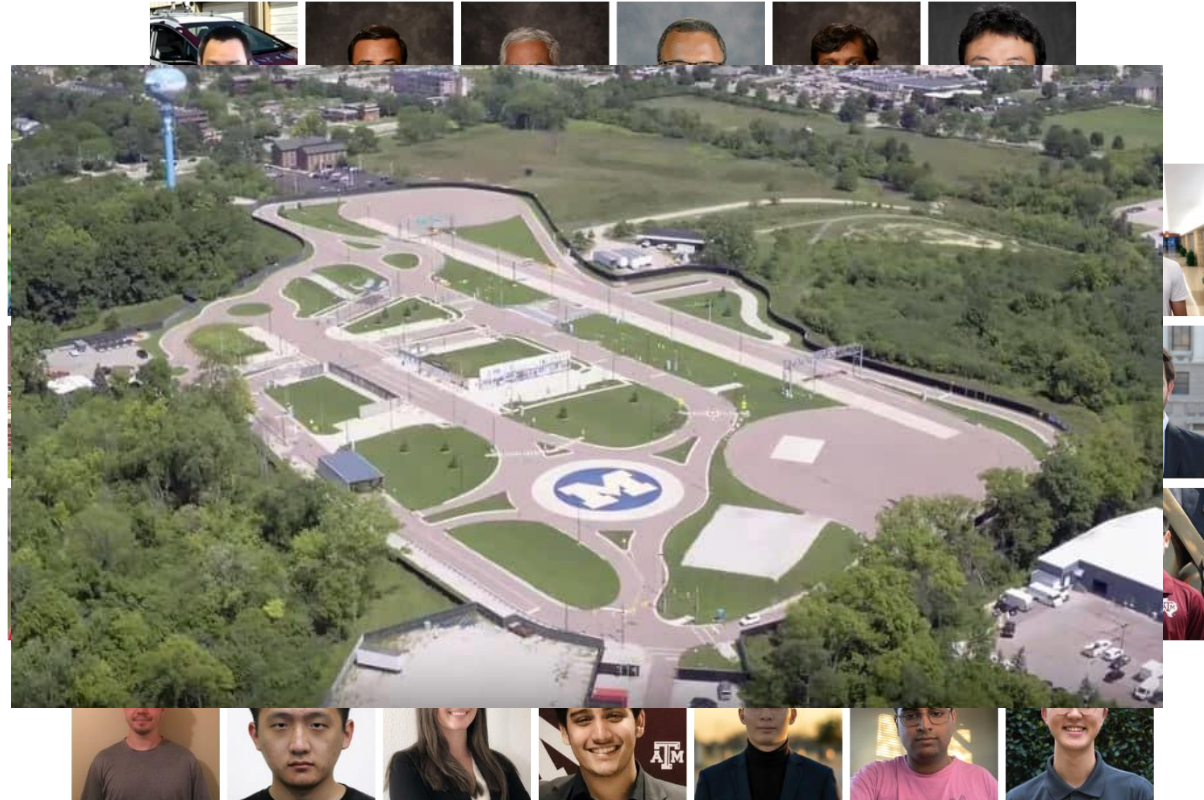
# EXPERIMENTAL RESULTS: SAMPLE



# OUTLINE



# GM/SAE AUTODRIVE CHALLENGE 2017-2021



**Year 4**

# HOW MATLAB HELPED OUR TEAM

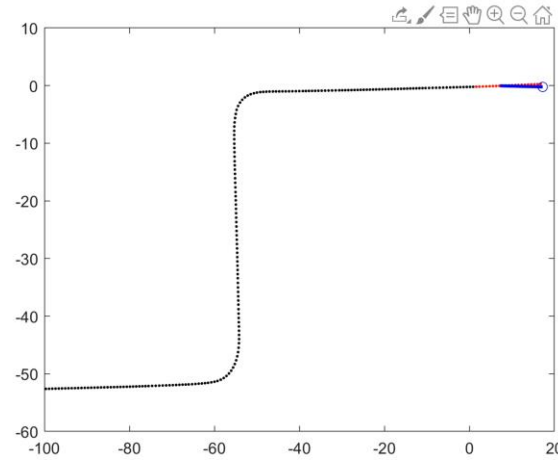
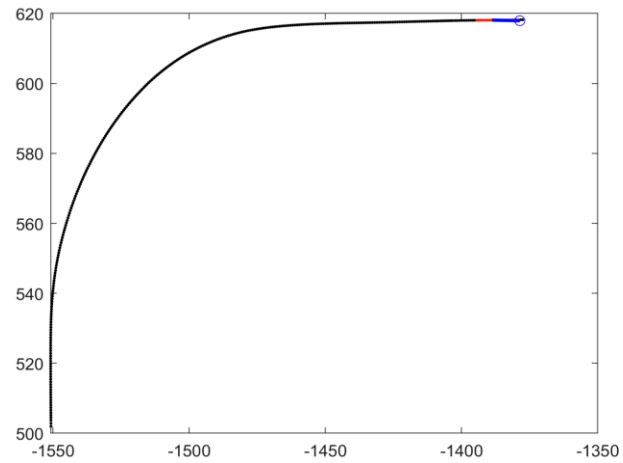


- Vehicle Control
- Sensor Calibration
- Perception Testing
- Planner Testing



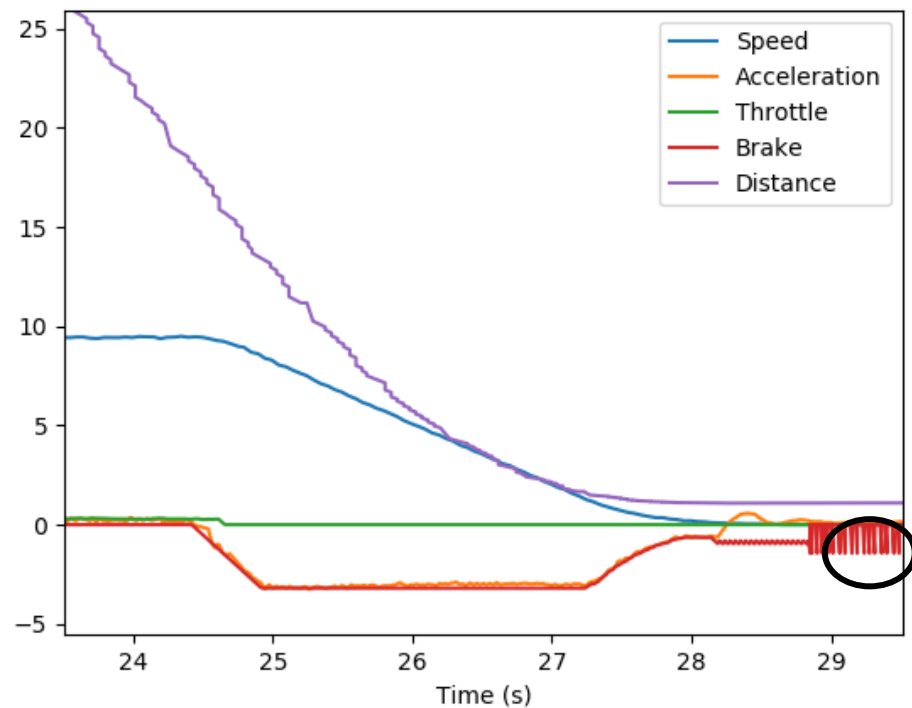
# LATERAL CONTROLLER ANALYSIS

X: detected waypoints at turning      : vehicle position      : vehicle trajectory

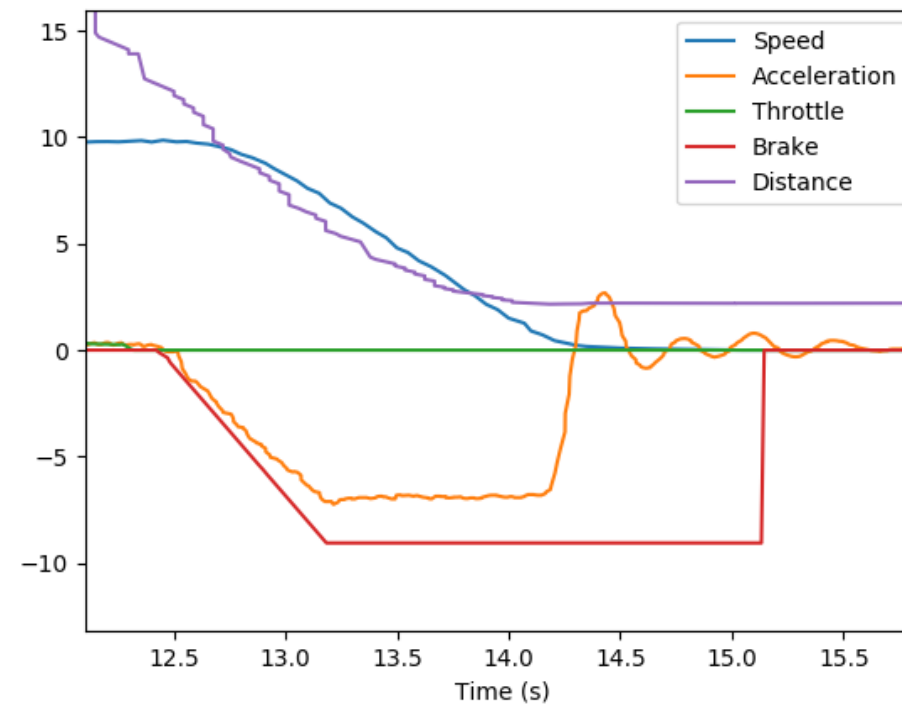


# LONGITUDINAL CONTROLLER ANALYSIS

- Mimic human driving in designing controller behaviors
- Visualize the CAN bus output



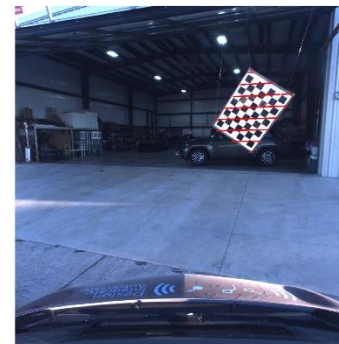
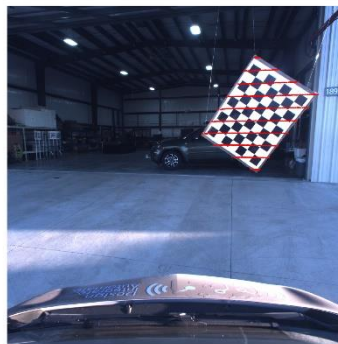
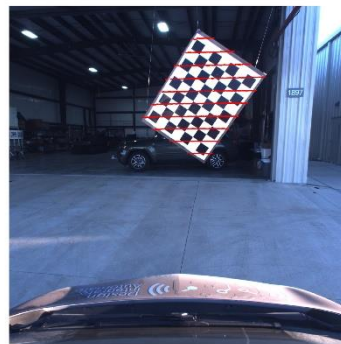
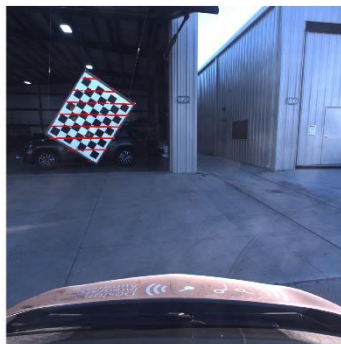
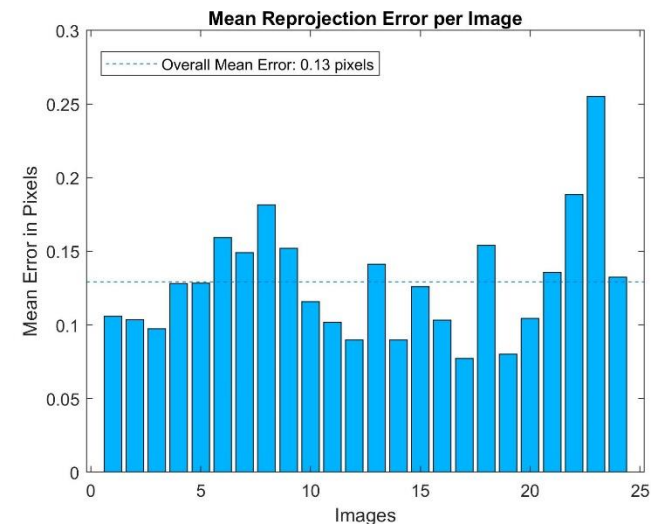
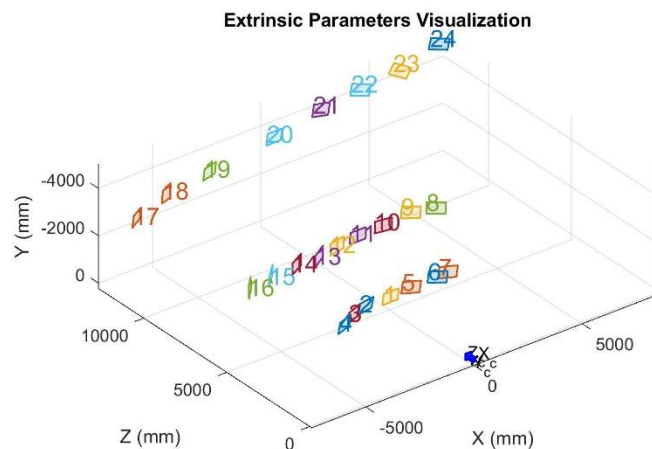
(a) Trembling brake (See black circle) happens since the numerical issues and solved after adding the filtering.



(b) Maximum deceleration analysis when emergency brake happens.

# SENSOR CALIBRATION

- Computer Vision Toolbox
- Verify the calibration accuracy using visualization

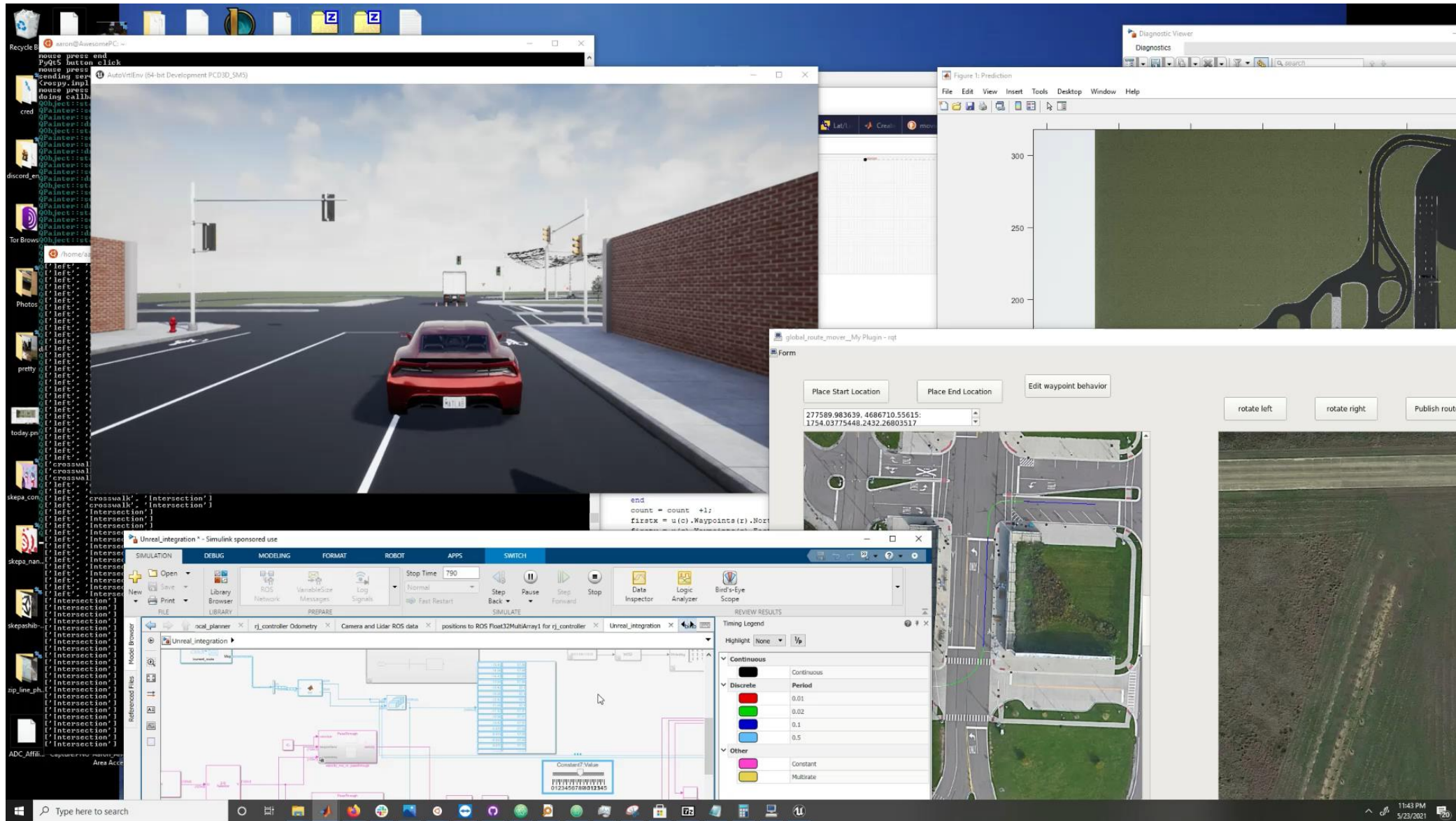


# PERCEPTION TESTING – TRAFFIC LIGHT

The screenshot displays a Simulink simulation environment for a traffic light perception test. The main window shows a 3D view of a red car on a road with a traffic light. An inset window shows a zoomed-in view of the traffic light. A 'Simulation Data Inspector' window is open, displaying a graph of signal states over time for 'TrafficSigns2-1' and 'TrafficSigns1-1'. The graph shows a red line for 'TrafficSigns2-1' and a green line for 'TrafficSigns1-1'. The red line starts at 110 and drops to 0 at approximately 25 seconds. The green line starts at 105 and drops to 0 at approximately 25 seconds. The 'Simulation Data Inspector' window also shows a list of signals and their properties.

Signal Name	Line Color
TrafficSigns2-1	Red
TrafficSigns1-1	Green
heading-1	Blue
vehicle_steering-1	Orange
rawsteering-1	Yellow
angular_velocity_deg-1	Purple
distance_to_obj-1	Cyan
Constant7-Value	Magenta

# PLANNER TESTING



# THANK YOU!

- This is a long journey with my
  - current grad students: **Shu-hao Yeh, Aaron Kingery, Aaron Angert, Di Wang, Shuangyu Xie, Fengzhi Guo, Yingtao Jiang, and Chengyuan Qian**
  - former grad students: **Drs. Jasmine Cheng, Binbin Li, Jay Chou, Yiliang Xu, Wen Li, Yan Lu, Joseph Lee, Chang Young Kim, Hyunnam Lee, Qin Ni, Ji Zhang, and Mr. Qiang Hu**
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**TELEROBOT.CS.TAMU.EDU**