CSCI 4302/5302: Advanced Robotics
Semester Project: Autonomous Vehicle Competition

Learning objective: As part of a multidisciplinary team, design and implement a $\frac{1}{10}^{\text{th}}$-scale vehicle that has the ability to operate itself in an unknown closed course, while optimizing over multiple objectives.

Autonomous vehicles are becoming more widespread, and the tools of robotics are being applied liberally to the ongoing challenging of robustifying those vehicles. Electrical and mechanical engineers, computer scientists and technicians make up teams within countless startups, joined by behemoths at Uber, Google and Toyota to race to winning the self-driving car footrace.

Equipment. In teams of five, use the techniques introduced in this class to design and build an autonomous vehicle platform using the following equipment:

- ODROID XU-4
- oCam 1MGN-U USB3.0 Global Shutter Camera 0228
- 1/10 AMP MT 2WD Monster Truck RTR ECX03028T2
- Mini Maestro 18-Channel USB Servo Controller
- Adafruit IR Distance Sensor GP2Y0A710K0F (qty: 2)
- PhidgetSpatial 3/3/3 Basic 1042_0
- 64GB eMMC 5.0 Module XU3/XU4

Challenges.

A Portion of path is over rock salt or water.

A Taking and landing a jump.*

A Visual-inertial SLAM.

A Avoiding a ball rolling toward the vehicle.*

A Parallel parking between two obstacles.

B Power slide around turns.

B Stop at a stop sign.

B Developing an accurate sparse map.

B Real-time estimates of coefficient of friction.

C Report on human-robot interaction with autonomous vehicles.

C Report on how deep learning could be used to improve performance.

C Implement two control approaches and compare them.

* : this challenge may be completed separately from the racing portion.

Graduate student teams must choose at least one A-type, two B-type, and two C-type challenges. One of the BC-type challenge pairs may be replaced with an A-type challenge.

Undergraduate student teams must choose at least *either* one A-type challenge, *or* two B-type and two C-type challenges.

Race day procedure. All teams must have a fully autonomous vehicle by race day, with the exception of an "on/off" signal which will transmit to the vehicle over WiFi to start and terminate operation. Vehicles must use only the chassis, battery, compute, and sensing equipment provided; wires and other connecting equipment may be provided by teams but note that all vehicles will be retained by the course staff at the conclusion of the race.

Each vehicle will compete in four heats; the best overall performance will be used to judge the team for time and performance on challenges. Vehicles may be operating in waves, but the course will be closed (only one direction). The course will be indoors and feature adequate lighting, will be no wider than 4m and no

narrower than 2m, and be clear of most (but not all) obstacles. **Entrants will be traversing the course clockwise.**

At the conclusion of your vehicle's three trials, you will surrender the full vehicle to course staff as well as a **technical report** explaining your methods and rationale.

Technical Report.

Graduate students are responsible for an 8-page report in ICRA format which includes an abstract, introduction, related work, methodology, results, discussion, conclusion and bibliography. C-type challenges are an added 2-page appendix.

Undergraduates are responsible for an 8-page report in Springer format which includes an introduction, methodology, results, discussion, conclusion and bibliography. C-type challenges are an added 2-page appendix.

Scoring. This semester project is meant to underscore some of the challenges that arise in developing self-driving vehicles, but also autonomous as robots a whole. Two factors reign supreme in this field: capability and reliability. The scoring of the project will attempt to measure these factors.

Reliability will be based on all of your team's times falling within 25% of the average of your times, dropping the worst outlier. Time performance will be judged based on your fastest time being within some fraction of the overall fastest time.

- 20% time performance.
- 10% reliability.
- 40% report.
- 10% performance on challenges.
- 20% peer review.

Peer Evaluation Form for Group Work

Your name _____

Write the name of each of your group members in a separate column. For each person, indicate the extent to which you agree with the statement on the left, using a scale of 1-4 (1=strongly disagree; 2=disagree; 3=agree; 4=strongly agree). Total the numbers in each column.

Evaluation Criteria	Group member:	Group member:	Group member:	Group member:
Attends group meetings regularly and arrives on time.				
Contributes meaningfully to group discussions.				
Completes group assignments on time.				
Prepares work in a quality manner.				
Demonstrates a cooperative and supportive attitude.				
Contributes significantly to the success of the project.				
TOTALS				

Feedback on team dynamics:

1. How effectively did your group work?

2. Were the behaviors of any of your team members particularly valuable or detrimental to the team? Explain.

3. What did you learn about working in a group from this project that you will carry into your next group experience?

Adapted from a peer evaluation form developed at Johns Hopkins University (October, 2006)