The goal of this challenge is to engage students in hardware-software development of a self-driving car for racing. The competition is directed to USC master students regardless of their program or year. Undergraduate students are also welcome; however, the difficulty of this competition may be more appropriate for masters students. Students are not expected to have prior experience with self-driving cars. Teams of 2 or 3 students compete to build the fastest car and have one semester to prepare for the final challenge, when all cars, turn by turn, race to record the fastest time. Cars are built on the same platform and race against each other on the same track configuration, thus innovation and creativity is what counts.

To help the teams get started and provide support along the way, a series of workshops on embedded hardware and software concepts will be organized, along with optional weekly sessions where teams can work on their projects and interact with other teams. In conjunction with these workshops, there will also be two progress-checking races, where teams demonstrate their car's functionality so far on the track. This is to ensure that teams are making progress toward the final product, meeting certain milestones, and allowing them an opportunity for intermediate feedback and suggestions for improvement. Though these workshops and practice races are meant to help the teams develop their car, outside work on the project will be necessary, since an exceptional car will require thoughtful optimization to excel. With these workshops as a starting place, teams are given the unique opportunity to apply their technical knowledge and creative abilities to a real-world situation.

Timeline

Week 1 – 2. Register team and order components.

Week 3. Three lab style workshops on:

- Hardware and software for embedded systems
- Image acquisition and processing technique
- Control loop and PID controller design

Week 6. Stay on track challenge.

Week 10. Infinity loop challenge

Week 13. Final race.

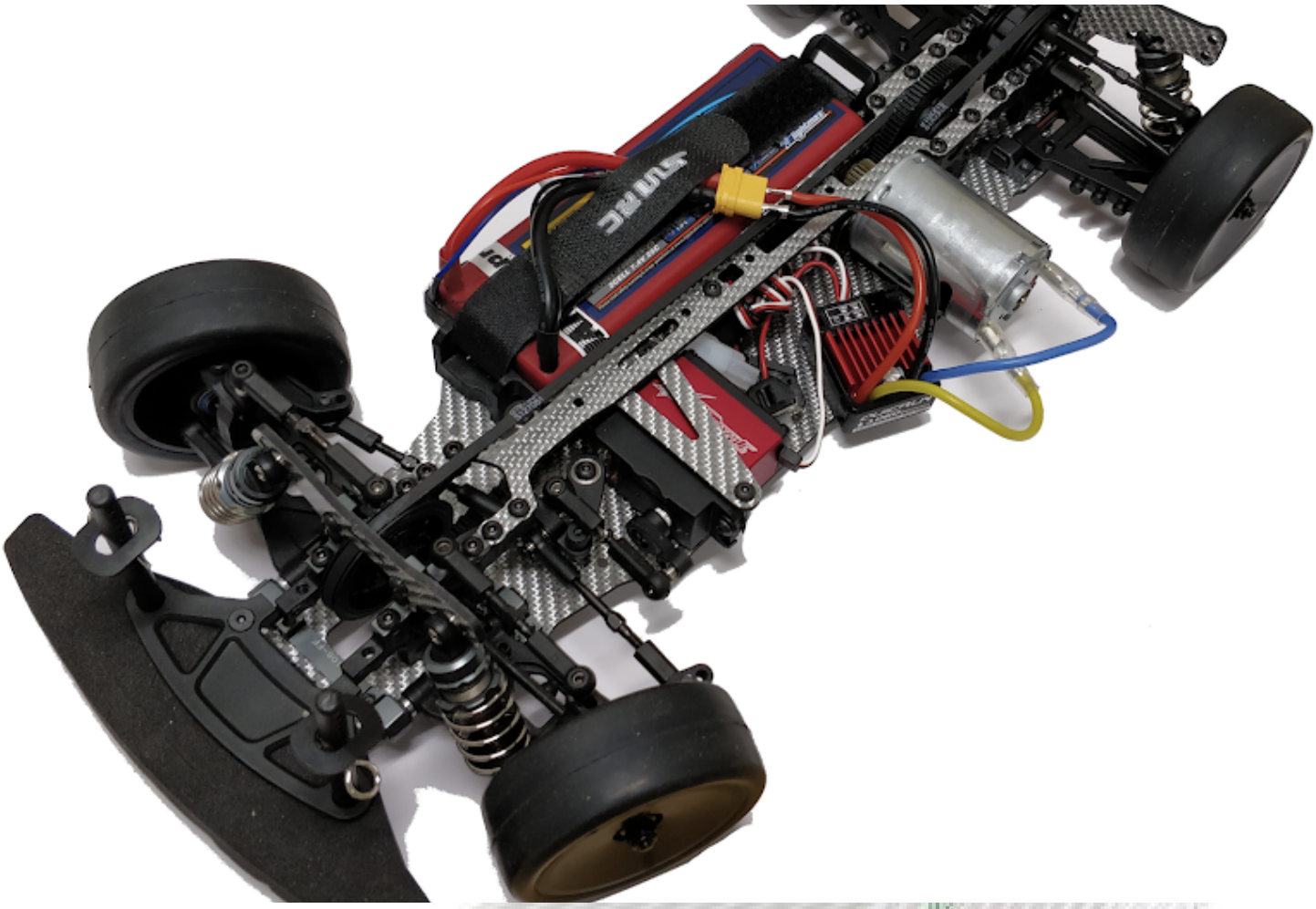
Car Kit

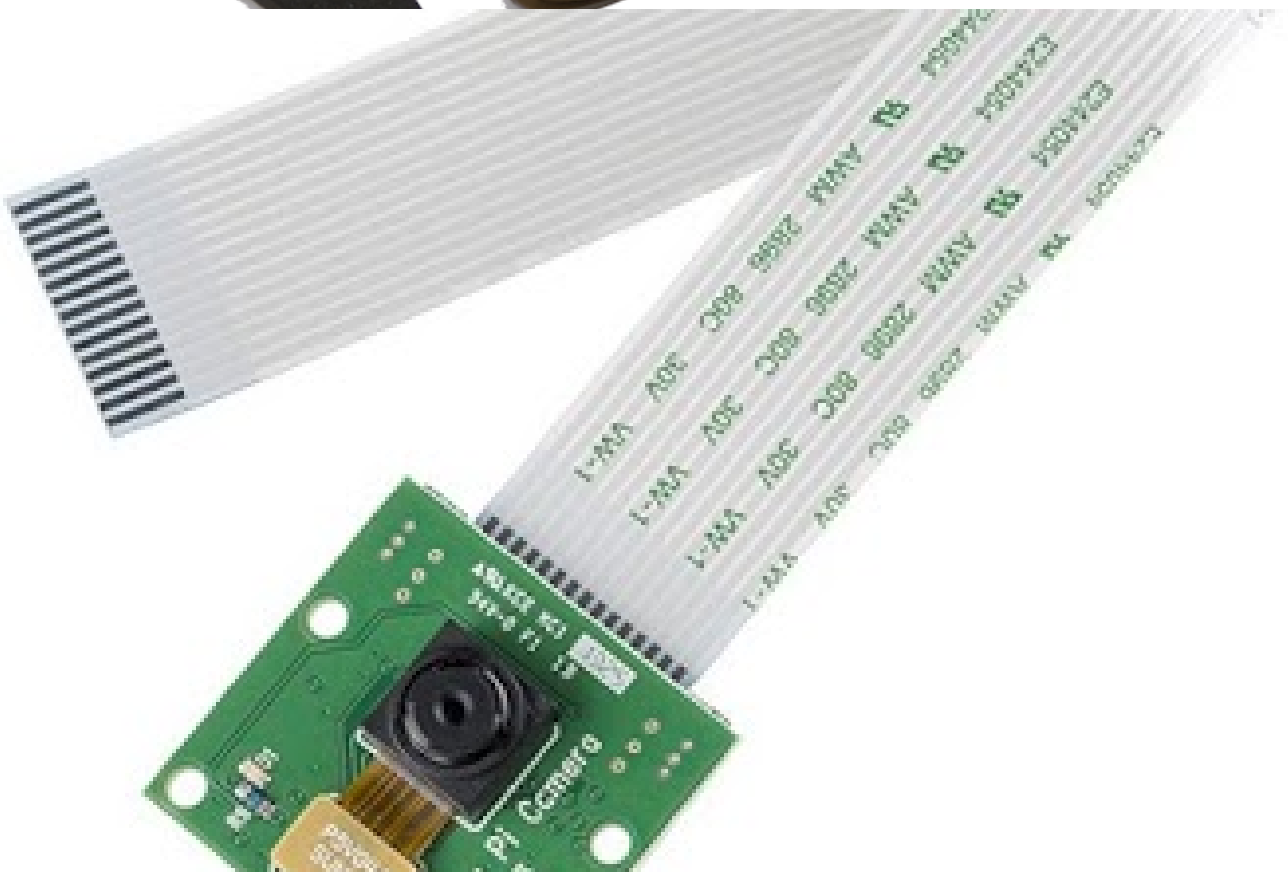
Upon registration, the student will receive their pre-built car, described below.

The car is built around a 1/10 scale RC touring chassis powered by a brushed motor and a 2–cell LiPo battery. The Raspberry Pi microprocessor through image processing will detect the track from the images supplied by a camera and adjust the steering angle and the motor speed to keep the car on the track. The images below show the assembled car, the camera and the Raspberry Pi board that when assemble form the car to be raced. The chassis, battery and the motor are regulated to ensure that no team gains an advantage through better components, and that creativity and superior programming differentiate the teams.

Modifications of the chassis are allowed as long as the weight is less than 7 pounds and the length or the width of the car do not exceed 20 inches. Moreover, more sensors can be added as long as the camera remains the main sensor used for steering the car. Cars are permitted to have a wireless connection with a computer for development and calibration, however, during the final race the car should operate autonomously and no external connection is permitted. All cars will be inspected before the final race and only the ones which comply with the above rules will be allowed to compete.

To receive the car, each team (not each individual member) will pay $60 to offset the cost of the car, which originally costs approximately $200-$260. The Raspberry Pi and the camera are included in this cost.




Pi Camera

Workshops

For a smoother start, a series of three seminars after the registration will introduce students to the basics of embedded hardware and software design for self-driving cars.

Workshop #1 : Car and Raspberry Pi setup

Workshop #2 : Image acquisition and processing on Raspberry Pi

Workshop #3 : Introduction to servo and motor control using a PID controller

1. **Stay on track challenge.** The cars should autonomously navigate on a 3 yard (108 inches) straight section of the track with no wheel crossing entirely outside the track limit and register an average speed of 2 inches per second. Teams that succeed within 3 attempts receive a one second deduction from their final race time. The purpose of this challenge is to require that teams finish the image processing and the control loop before the midterms start but also to serve as a progress verification.
2. **Infinity loop challenge.** This second challenge is similar to previous challenge except that the track has the shape of an 8 to test the car handling in tight turns. This requires more robust control algorithms as a simple proportional controller might have trouble staying on track. Teams that succeed within 3 attempts receive an additional one second deduction from their final race time.
3. **Final race.** The final race track is more complex compared to previous challenges as it will include multiple turns, straight lines and intersections. Teams have 2 minutes to prepare the car for the race, place it on the race track and press the start button. One of the straight lines is equipped with a electronic gate for recording the lap time. The cars are positioned at maximum 1 yard behind the start line. Moreover, after the lap is completed, the car must stop no more than 6 yards past the finish line. The team with the fastest total time within 3 attempts wins.

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