Autonomous Vehicles: an Open Platform for Learning and Teaching

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Rational

Autonomous cars hold tremendous promise for making transportation safer, faster and cleaner than the manually driven vehicles we use today.

At UC Berkeley we have developed an open source platform called the Berkeley Autonomous Race Car (BARC) to teach students how to program autonomous vehicles. The platform consists of a 1/10 scale RC car, an embedded Linux micro-controller, and a suite of sensors. Our software stack also integrates features from ROS (Robotic Operating Systems) with cloud functionality through Amazon Web Services, so that cloud-based telemetry and simulations can be used to speed up estimation and control design. The BARC project is fully open-source and welcomes other research intuitions to use the platform. More information is available at barc-project.com.

This one-day workshop aims to introduce students, practitioners and teachers to designing model-based vehicle dynamics controllers through hands-on experience with the BARC platform. The participants will design a wide range of vehicle dynamics and Advanced Driver Assistance controllers, from simple lane changes with obstacle avoidance to autonomous drifting. The participants will be provided with a set of structured labs which can be used to learn and teach the topics discussed.

We will first present the basic control architecture and vehicle dynamics models used throughout the workshop. Then, the instruction will focus heavily on how to program algorithms in Python and Julia within the ROS framework. Participants are expected to bring their own laptops and download the workshop material before attending the class. The material will prepare the participants for in-class instruction and demonstration of the exercises. Participants will form small groups and program their algorithms on our robotic platform. The workshop will cover the following topics:

1. Vehicle dynamics: kinematic models, kinetic models, tire models
2. Open source robotic programming: Linux, ROS, Python, Julia
3. BARC system hardware: IMU, encoders, camera, DGPS, LiDAR, microcontroller, motor, servo
4. Parameter estimation and vehicle localization using subsets of camera, lidar and DGPS.
5. Stability control design: ABS, traction control, lateral stability control, drifting
6. Advanced Driver Assistance (ADA) control: cruise control, lane following, lane changes, navigation and parking
7. Cloud integration : Amazon Web Service and Dator

Prerequisites skills - Familiarity with basics of Linux and Python is encouraged but not necessary.

About the presenters

Jon M. Gonzales is a senior graduate student at UC Berkeley in the Model Predictive Control lab under the direction of Professor Borrelli. He received a B.S. in Engineering Sciences from Harvard University, an M.S. in Mechanical Engineering from UC Berkeley. He is a recipient of the Chancellor's fellowship and the GEM fellowship. His research focuses on dynamics and control for automotive systems at the limits of handling.

Charlott Vallon is a first-year PhD student at UC Berkeley in Professor Borrelli's Model Predictive Control lab. She received her B.S. in Mechanical Engineering from UC Berkeley, and an M.S. in Mechanical Engineering from ETH-Zurich. Her research is focused on driver modeling and statistical learning for autonomous vehicle control.

Francesco Borrelli received the 'Laurea' degree in computer science engineering in 1998 from the University of Naples 'Federico II', Italy. In 2002 he received the PhD from the Automatic Control Laboratory at ETH-Zurich, Switzerland. He is currently a Professor at the Department of Mechanical Engineering of the University of California at Berkeley, USA. He is author of the book Predictive Control published by Cambridge University Press, the winner of the 2009 NSF CAREER Award and the winner of the 2012 IEEE Control System Technology Award. In 2016 he was elected IEEE fellow. In 2017 he was awarded the Industrial Achievement Award by the International Federation of Automatic Control (IFAC) Council.

Since 2004 he has served as a consultant for major international corporations. He was the founder and CTO of BrightBox Technologies Inc, a company focused on cloud-computing optimization for autonomous systems. He is the co-director of the Hyundai Center of Excellence in Integrated Vehicle Safety Systems and Control at UC Berkeley.

His research interest are in the area of model predictive control and its application to automated driving and energy systems.