White Paper: GoHeels Racing Participation in Indy Autonomous Challenge

GoHeels Racing is a group of undergraduate students, graduate students, and faculty interested at University of North Carolina Chapel Hill in autonomous vehicles racing competitions. We have expertise in various aspects of autonomous vehicles, such as, perception, mapping, localization, planning, and control. Additionally, our expertise also includes developing mathematical models of the autonomous vehicles and rigorously proving safety specifications of planning and control algorithms deployed in autonomous vehicles.

Our Team

Our team includes one faculty member, two graduate students, and one undergraduate student.

Faculty: Parasara Sridhar Duggirala

Dr. Duggirala is an Assistant Professor in the Computer Science Department at University of North Carolina at Chapel Hill (UNC). Before joining UNC, he was a faculty at University of Connecticut. He has obtained his PhD in Computer Science from University of Illinois at Urbana Champaign and Bachelor of Technology in Computer Science and Engineering from Indian Institute of Technology Guwahati. He has extensive expertise in the domain of Formal Verification and Control Theory. He has been awarded best paper award at International Conference on Embedded Software (EMSOFT) 2013, ARCH@CPS Week 2015, and ARCH@CPS Week 2017.

Graduate Students: Abel Karimi and Manish Goyal

Abel Karimi is a third year PhD student at UNC Chapel Hill. He has a Masters degree in Mathematics from University of Connecticut and Western Illinois University, Masters degree in Computer Science from Yazd University, and Bachelors degree in Computer Science from University of Tehran. He has expertise in various aspects of formal reasoning techniques such as Model Checking, Logic Programming, Reverse

Mathematics. He also has experience working with autonomous vehicle simulation environments like CARLA and Unreal graphics engine. He currently works on rigorous certification of high level safety specification for autonomous vehicles.

Manish Goyal is a third year PhD student at UNC Chapel Hill. He has a Masters of Technology Degree in Computer Science from University of Connecticut and Indian Institute of Technology Guwahati. He has worked as a Senior Software Engineer at Synopsys, India; Lead Software Engineer at Atentra, India; Research engineer at Verimag, France; and Associate Software Engineer at IBM Software Labs, India. He has extensive industry experience in developing software tools for verification and EDA. He also has experience in using various tools for performing rigorous reasoning such as Satisfiability Modulo Theory Solvers and Model Checkers. He currently works on generating test case inputs for autonomous control systems.

Undergraduate Students: Charlotte Dorn

Charlotte Dorn is an undergraduate student in the Computer Science Department at UNC Chapel Hill. She is a hardware enthusiast and works in developing hardware (not just processors and sensors, but also hardware such as chassis, motors, and design) for autonomous vehicles. She is a volunteer at BEAM (**BE A M**aker) space where she provides training and help for operating 3D printers, laser cutters, welders, etc. She has not only built an F1Tenth autonomous vehicle but also developed a MuSHR vehicle (from University of Washington). She is currently working on improving path planning algorithms for autonomous racing.

Our Expertise

Our team has expertise in developing various planning and control algorithms for autonomous vehicles. Our group has been a strong contender at F1Tenth autonomous vehicle racing competition for the past 2 years. Our team has reached 2nd position in CPS Week 2018 and was the winner of F1Tenth competition at CPS Week 2019. We intend to compete in the upcoming competition at Berlin in July 2020.

As a part of the F1Tenth competition, we have developed several algorithms for performing planning and control. Our winning algorithm in CPS Week 2019 has been made public and interested readers can see it at:
https://www.nathanotterness.com/2019/04/the-disparity-extender-algorithm-and.html

As academics, and more importantly, as members of a public university, we intend to make all of our experiences public. In that spirit, you can find updates on our algorithms and approaches in the public blog posts of our team members. Stay tuned to https://medium.com/@chardorn for periodic updates. Some of our approaches for performing localization, planning, and some tutorials for building F1Tenth can be found at https://medium.com/@chardorn

One of the advanced skills of the team is in proving safety specifications of autonomous vehicles. Abel Karimi has been working on certification techniques for autonomous vehicles as a part of this research. Manish Goyal has been working on developing algorithmic techniques for proving safety specification for semi-autonomous features such as adaptive cruise control. Most recently, our group has conducted research in formally specifying high level properties that are provided as traffic rules, finding counterexamples in controllers, and proving safety properties of planning and control algorithms.

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