Colorado State University | 2020

A Proposed Solution to the Indy Autonomous Challenge by Team Pegasus

A Collaboration Led by Colorado State University and Western Michigan University

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Abstract

The Indy Autonomous Challenge (IAC) is a competition hosted by Energy Systems Network in collaboration with the Indianapolis Motor Speedway with the challenge for participants to send an Indy style vehicle around a race track at 120 MPH autonomously. We have assembled a team that represents a collaboration between industry and multiple prestigious academic institutes to research a solution to this challenge. This white paper goes over the experience and background of the team members and academic institutions, the anticipated technical approach, and an overview of how the project will be led and managed.

Team Pegasus

Team Pegasus is a collaborative effort between autonomous vehicle industry members, Colorado State University, Western Michigan University, and additional universities that have reached out to join our team.

Team Leads

Anthony Navarro is the acting team lead for Team Pegasus. With a Master's of Science in Computer Engineering from Colorado State University, Anthony began working with autonomous vehicles while at Lockheed Martin in 2016. Since then he has continued to work in the autonomous vehicle and mobility space. He was the Product Lead of the popular Udacity Self-Driving Cars course and worked with teleoperations and autonomous vehicle control solutions following that. Not only has he worked in the space for the last few years, he has also spent quite a bit of his free time working on projects related to autonomous vehicles. He was the Amazon re:MARS DeepRacer champion in 2019 and had the second fastest time in the world. He has been a part of two autonomous vehicle projects funded by the state of Michigan in partnership with Western Michigan University. He also participated in the Self-Racing Cars event at

Thunderhill raceway for the last 3 years where he met the other lead and advisor of this team, Rana Khalil.

Soulless Team at Self-Racing Cars 2016

Rana Khalil is acting as a lead and technical advisor on this project. She is an Autonomous Vehicle Software Engineer focused on building robust autonomous embedded systems while working on cutting edge decision making algorithms for a safe and autonomy enabled robotic systems. She has worked previously on Amazon Scout and currently working at an autonomous vehicle startup.

Team Members

The approximately 15 team members for this project are a diverse mix of graduate and undergraduate students who span multiple disciplines, universities, and backgrounds. They have participated in government funded autonomous vehicle research, extracurricular courses based around autonomous vehicles, hands-on autonomous vehicle courses at their respective universities, and completed internships at automotive companies pursuing autonomy. Autonomous vehicles are quite simply a robotics platform and robotics require multidisciplinary engineering skills to come together to create a successful system. Our team members, while each specialized in their own area of engineering, are seeking out opportunities like IAC to gain cross-disciplined skills and become more proficient and technically trained engineers.

Our team is ambitious, has a history of autonomy experience, and is excited and ready to push forward with technically proficient solutions for IAC.

Colorado State University

Dr. Thomas Bradley, Colorado State University

Colorado State University has a record of energy efficiency and autonomy research with Dr. Thomas Bradley playing a pivotal role in many of these projects. They are sponsored and work with many large partners including Toyota, Honda, General Motors, US DOT, US DOE, and many more. The areas they currently focus on are perception, advanced control, and real-world realization.

Western Michigan University

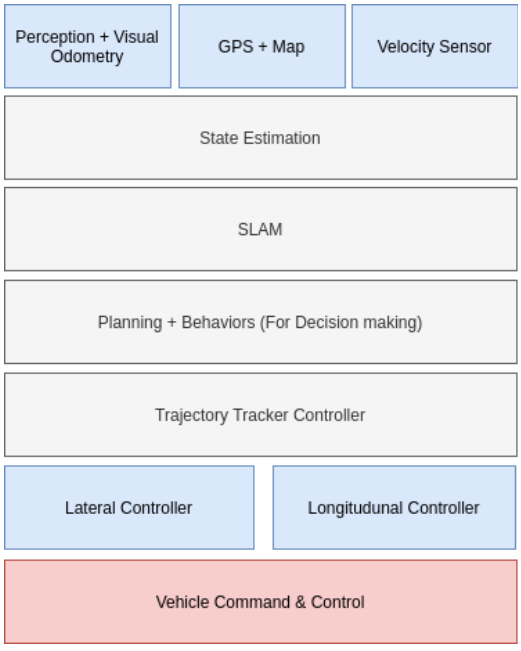
Dr. Zachary Asher, Western Michigan University

Dr. Zachary Asher has lit a spark at Western Michigan University in the short time that he has been there. While WMU had no active research in autonomous vehicles before Dr. Asher's arrival, WMU has participated in two Michigan Mobility Challenges in just over a year and started to attract the attention of the lieutenant governor and local engineering companies. They also launched a hands-on autonomous vehicle course open to undergraduate and graduate students that filled up in under 48 hours after it was offered.

Additional Partners

We are open to collaboration with other ambitious and skilled universities! We have partnered with a group from MIT and Boston University already to add their amazing skills and experience to our team.

Technical Approach



Diagram

Our team's autonomy stack will include a perception system that utilizes visual odometry and visual localization information to fuse with other sensory data such as

GPS, IMU, velocity sensors, cameras, and LIDAR. These will give us a holistic view of the race track while navigating. Throughout development, one of the main constraints our team will ensure is that filtering and fusing all the sensory information doesn't come at the cost of our vehicle's refresh rate in order to maintain the high speeds required by this type of race. After the sensory information has been provided, a state estimation filter such as an Extended Kalman Filter (EKF) or Unscented Kalman Filter (UKF) will be used to get a better understanding of our vehicle's state on the track. This information will aid us in performing Simultaneous Localization & Mapping (SLAM) in real-time.

After gaining certainty of the track and the vehicles position, a planning layer will be utilized to generate a high level trajectory for the trajectory controller layer which uses latitudinal and longitudinal controllers to achieve the desired interpolated trajectory to output the required steering, brake, and throttle actuation needed to achieve optimal performance on the track.

The vehicle command and control layer will send steering , brake and throttle data directly to the drive-by-wire layer of the car to enable us to build a safety stop system independent of our decision making and trajectory controller stack to ensure redundancy in our system.

Project Management

Anthony will be leading the team and ensuring milestones and logistics are taken care of. The student leads will be responsible for the project management of the day-to-day tasks. There have been three students selected to lead the group and they will be sharing the tasks required. These students were selected for their technical ability, leadership experience, and expected continuity through the project lifecycle. The advisors will be available on a as-needed basis to guide the team, help with technical hurdles, and provide any advice to help the team be successful.