Annual Plan, 2022-2023

Nova at UT Dallas

Revised Oct. 24

1: Members during our annual kickoff meeting this year.

1 Contents

2 About Nova

Nova is UT Dallas's premier autonomous driving group, run by undergrads as part of the Applied Systems Lab (Dr. Justin Ruths). Nova started as a one-student project in 2019 and has

since grown to sixteen members as of October 2022, hailing from four academic departments and representing all four undergraduate years. Our membership applications reached a high of fifty during our recruitment period last month.

3 Mission

Since its foundation three years ago, Nova has worked toward a three-part mission:

1. Develop an open-source autonomous driving software platform as an important resource to the research community
2. Connect our community with autonomous driving technology
3. Establish UT Dallas as an important contributor to self-driving research

4 Where we stand

4.1 Progress

Nova has made huge progress over three years. We've developed a working open-source software platform called Navigator that manages every part of the self-driving system: firmware, localization, control, path planning, 3D mapping, and more. This software was deployed successfully not only in our simulator, but also in limited campus tests.

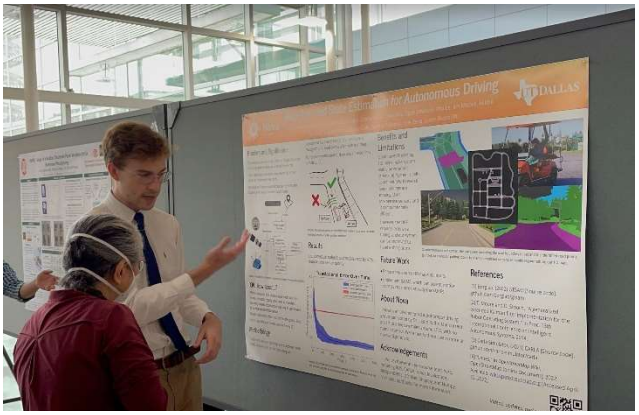
We've added a complex electrical system to our experimental vehicle, nicknamed Hail-Bopp. This system includes multiple communication buses, actuators, voltage lines at four different levels, a real-time safety controller and embedded computer, and more.

2: Jai and Meyli, two of our vehicle technicians, inspect the rear battery banks.

Both Navigator and Hail-Bopp have been designed, developed, and maintained by undergraduate students at UTD. Our work has culminated in autonomous driving in a real-world parking lot, terabytes of real-world data captures on campus, and miles of successful simulation tests.

4.2 Limitations

We've managed all this despite limited funding, though **additional funds would allow us to embrace the state of the art**. For example, a lack of high-quality LiDAR means that we cannot use LiDAR-based object detection, which is far more accurate than purely camera-based methods. The limited power of our onboard computer means that we cannot run mapping in real-time. We rely on small car batteries that prevent us from conducting the long-term testing that we need.



3: Will presents our state estimation research to a member of the public.

5 Tasks for this year

5.1 Submit our system to a global leaderboard

To bring recognition to UT Dallas and to Nova, we seek to submit our agent (software) to the CARLA Leaderboard (leaderboard.carla.org), a global list of the best self-driving systems in the world. We realize that our limited time and expertise may make it difficult to achieve a top spot (nearly all submissions come from university faculty and PhD candidates).

However, even *placing on the leaderboard at all is a significant accomplishment*, since meeting the requirements of submission alone is a challenging task.

By working toward this task, we will meet parts one and three of our mission. Leaderboards provide a consistent and recognized metric of a system's capabilities, and placing on the leaderboard would be an undeniable achievement.

5.2 Complete a 2-mile loop of campus autonomously

After completing the previous task, Nova will have necessarily developed a highly capable autonomous driving system. In this task, we will deploy this system on campus using our experimental vehicle.

Our campus presents a difficult driving environment, even for experienced human drivers. Skateboarders blow through intersections. Heavy traffic forms during rush hour. Cars stop frequently in the roadway to drop off passengers. Emergency vehicles must be yielded to.

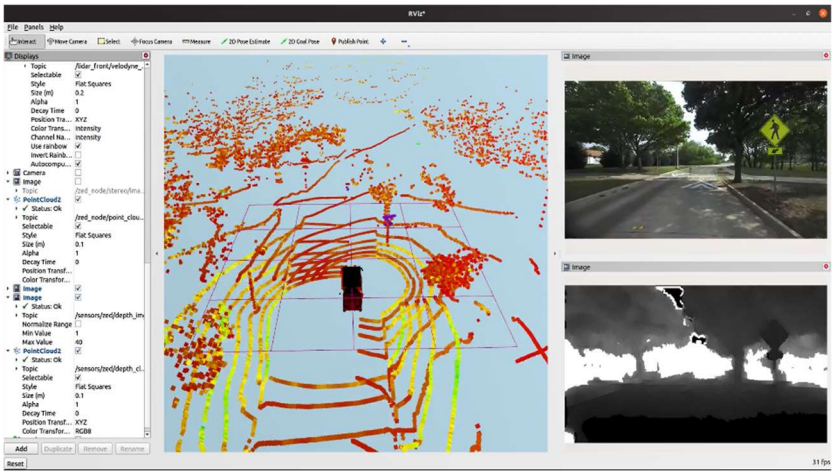


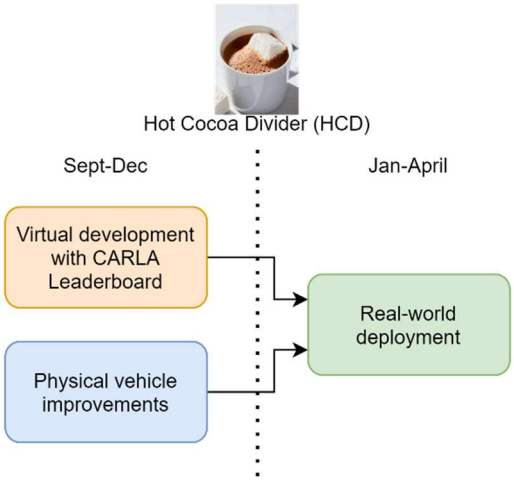
Figure 4: Example of our software running on campus

Luckily, our simulated scenarios and the CARLA Leaderboard allow us to test our software in challenges far more complex than what campus provides.

5.3 Success metrics

1. Navigator, our software, appears on the CARLA Autonomous Leaderboard.
2. Hail-Bopp, our physical vehicle, can drive in a 2-mile loop of UT Dallas's campus without human intervention and while obeying all traffic rules.
    - Many algorithms across the whole spectrum of robotics must be designed, implemented, and refined to accomplish this: path planners, state estimators, motion predictors, object classifiers, 3D mappers, behavioral state machines…
3. Nova has presented its mission and technology at multiple campus and community outreach events.

5.4 Annual timeline



5: **This year is split by a "Hot Cocoa Divider."**

From September-December 2022, our core development team will add new features to our software system, Navigator. At the same time, our vehicle technicians will prepare our car for real-world deployment.

At the end of December we will submit Navigator to the CARLA Leaderboard. Overhaul to the physical testbed will be mostly complete, so long as funding is available.

In January we will have adapt Navigator to work on campus data.

In February Navigator will self-steer on campus.

In March Navigator will drive fully autonomously for at least part of the 2-mile test loop.

By the end of April, Navigator will have steered autonomously for two miles on campus, and our software will be released for free to the community as Navigator v2.0.

This project year is divided by the so-called "Hot Cocoa Divider." The idea is that by the time our members are sipping hot cocoa (around New Year's), both our software and hardware will be prepared for real-world deployment.

5.4.1 Fall semester timeline

Phase and milestone	Due	HFE	Perception	Prediction	Planning
Phase 1: Our current system is refined and refactored. Most obstacle-free routes can be completed in sim.	Monday, Oct. 31	• Sensors remounted • Initial schematic and re-wire complete • Onboard computer prepared, sensor data visualized	• 3D bounding boxes generated and tracked • Occupancy grid published (for static obstacles)	• Physics-based prediction ready • Dynamic occupancy grid published	On-rails motion planner working in CARLA (only var. is speed)
Phase 2: Our first submission to the Leaderboard is made	To be determined	• EPAS (steering) fixed, power system stress-tested • Pedal actuators mounted	• Stop lights detected • Map masks for stop lines, crosswalks, and other road features prepared	• ML-based occupancy grid ready	RRT planner working in CARLA [?]
Phase 3: Final Leaderboard submission is made. System ready for campus tests.	To be determined	• Firmware code complete • All sensor data is stable • All hardware control is stable • System boot and setup is as close to automatic as possible • Vehicle teleoperated across two mile loop. Tuning performed.	• Models tuned for acccuracy and performance • Models tested on the vehicle	• ML-based occupancy grid refined (e.g. with map priors used) • Occupancy tested in the car	RL-based planner trained and working