Vertically Integrated Project (VIP) Course

Autonomous Racing and Self-Driving

Course Information

- **Course Title:** Autonomous Racing and Self-Driving
- **Semester:** Spring 2027
- **Credit Hours:** Variable (0–3)
- **Meeting Time:** Bi-weekly on Fridays, 1:00–2:00pm. Additional weekly team meetings will be arranged, as necessary, with the supervising graduate students.
- **Location:** Montgomery Knight 325 (bi-weekly meeting) and 425 (Lab); the bi-weekly update meeting may also be held via zoom when necessary. An email will be sent to the VIP team prior to that.
- **Meeting Format:** Alternating weekly between:
  - Progress update meetings with student presentations.
  - TA-led instruction sessions with bug-fixing workshops or mini-lectures on technical topics.
- **Faculty Advisor:** Prof. Panagiotis Tsiotras (Email: tsiotras@gatech.edu)
- **Graduate Teaching Assistants:**
  - Felix Sanchez fsanchez33@gatech.edu
- **Slack Channel:** ae-vip.slack.com

Course Description

This course is part of Georgia Tech's VIP program, which emphasizes project-based, vertically integrated teamwork across academic levels and disciplines. This Vertically Integrated Project (VIP) course offers students the opportunity to engage in hands-on, multidisciplinary research at the intersection of robotics, artificial intelligence, and control systems. Students will design, implement, and test algorithms for autonomous driving using 1/10th scale race cars equipped with Hokuyo 2D LiDAR, Nvidia Jetson platforms, and stereo cameras. Over the course of the semester, the student teams will progress through a series of technical milestones, culminating in an end-of-semester competition where their cars will race against each other. Along the way, the students will learn modern methods in autonomous systems design and implementation, including mapping, localization, planning, and control, supported by targeted mini-lectures from the TAs.

NOTE: Since this is a VIP course that requires students to stay for multiple semesters, the objectives, projects, and criteria are continuously updated to keep the course engaging and challenging. The goals, timelines, and deliverables are meant only as a general reference and are subject to change. If you have questions about details, feel free to email the TAs or ask in the team Slack channel for clarifications.

Learning Objectives / Outcomes

By the end of the course, the VIP students will:

- Gain practical experience with Linux, Python, and ROS2
- Learn to interface with sensors such as LiDAR and cameras
- Understand the fundamentals of SLAM, planning, and control for autonomous vehicles
- Develop teamwork, communication, and project management skills

Prerequisites / Recommended Skills

- Strong Python programming skills
- Familiarity with Linux
- Familiarity with Git/Github, the version management system
- Working knowledge of linear algebra and multivariable calculus
- Access to a personal computer capable of running Linux/ROS2 (Ubuntu 22.04 or higher)

Course Structure

- This is a project-based, team-oriented course. The participating students will be organized into teams of four and assigned a dedicated 1/10th scale autonomous Racecar/F1Tenth platform. The teams will be responsible for managing their projects, coordinating tasks, and ensuring steady progress throughout the semester.
- Graduate students and returning VIP students are expected to take leadership roles, mentoring newer members, and providing technical guidance to the more junior/incoming students
- Long-term participation in the VIP team is encouraged to gain familiarity with the underlying theories of autonomy, build continuity, and allow teams to tackle increasingly ambitious goals

Tentative Weekly Schedule

- Week 1–3: Basics
  - **New Students:** Learn ROS2 (topics, messages, publish/subscribe, interact with car)
  - **Returning Students:** Car detection and following
    - Vehicles to have a square cardboard in the back
  - **Individual Demo:**
    - Reading from sensors, sending actuator commands
    - Any task where the car responds to sensors
  - At least one student: car detection/following
  - **Presentation:** Each student must present their own work
- Week 4–6: Mapping
  - Use RVIZ and F1Tenth simulation to visualize sensor data
  - Choose between SLAM approaches:
    - Gmapping
    - Hector SLAM
    - Slam-Toolbox (recommended)
  - **Team Demo:** Map a track live
- Week 7–9: Localization
  - Within SLAM package or using particle filter localization
  - **Team Demo:** Car drives around track slowly, show localization in RViz
- Week 10–11: Planning and Control
  - Trajectory optimization on occupancy grid, minimum curvature
  - Control algorithms: Pure Pursuit, Stanley
  - TAs will provide sample code
  - Students tune boundary conditions, cost functions, etc.
- Week 12-15: Competition
  - Final tuning and race competition

Resources

- **Hardware:** 1/10th F1Tenth scale race cars, Hokuyo 2D LiDAR, stereo cameras, Nvidia Jetson boards
- **Software:** ROS2, Python, C++, MATLAB
- **Lab Access:** Dedicated workspace and testing facilities
- **References:** Research papers, tutorials, and competition resources (F1Tenth, DARPA, Indy Autonomous Challenge)

Policies

- **Attendance:** Active participation in meetings is required
- **Deadlines:** Project milestones must be completed on time unless prior arrangements are made
- **Safety:** Students must adhere to lab safety guidelines when working with hardware

Assessment & Deliverables

- Midterm progress check-in and presentation
- End-of-semester report documenting design, results, and lessons learned
- Final demo and competition

Grading Criteria

Grades will follow the attached "Grading Specifications" document.

Code of Conduct

Students are expected to maintain the highest standards of academic integrity, professionalism, and teamwork. Constructive collaboration, respectful communication, and equitable contribution are essential. Georgia Tech's policies on academic honesty apply to all aspects of this course.

Academic Honesty

The main principle in VIP academic honesty is that you will not present someone else's work as your own. Tests and specific assignments (homework, lab assignments, etc.) must be your

own work. You are encouraged to consult whatever sources are helpful in learning and understanding the issues associated with the course material, but you should always provide appropriate references and citations where such material is included in your VIP notebook, programming code, presentations, etc. Failure to adhere to these principles will result in a violation of Georgia Tech's Academic Honor Code and will result in disciplinary actions according to the Student Code of Conduct.

Welcome aboard! Let's push the limits of autonomous racing together.

Grading Specifications

Grade will follow the scheme below based on whether the student meets or does not meet specified expectations

A = meets expectations on 12/12 standards and meets all * expectations
B = meets expectations on 8/12 standards
C = meets expectations on 6/12 standards
D = meets expectations less than 5/12 standards
F = meets expectations less than 3/12 standards

Standard Met	Area	Details
	Documentation (1/3 of grade)	
	Individual Documentation	
___	Consistent to-do lists	Leaves each team meeting with tasks/work to be done; checks items off list as tasks/work are completed; progress and work completed can be tracked over time.
___*	Explanation of what was done	Sufficient explanation of work, progress, and next steps. Someone knowledgeable/skilled in the field would be able to understand decisions made, repeat what was done, and obtain the same result.
___*	Reflects on what did/did not go well	Discusses what did and did not go well. **Instructors can add detail on how frequently or infrequently this should occur – is it in weekly reflections, an organic part of documentation, etc.? If you have too many items in the documentation group, this could be collapsed into "explanation of what was done" above.**
	Team-level documentation	
___	Item	Expectations for team-level documentation
___	Item	Expectations for team-level documentation
	Contributions (1/3 of grade)	
___	Proactive	Identifies or asks for tasks to do; does not leave weekly meetings without work to do, suggests next steps; does not stop working and searches for solutions when obstacles arise – checks team documentation, searches online, reaches out to teammates, etc.
___	Quality of contributions	Work is timely, thorough, and accurate; comes to meetings prepared.
___ *	Appropriate level of contribution	**Considering the course level and number of credit hours**, contributions to the project were appropriate. Contributions may include obtaining skills needed to do the work.
	Teamwork (1/3 of grade)	
___*	Attitude and participation	Demonstrates interest in the project; treats teammates with respect; pays attention to the people speaking during meetings; avoids distractions during meetings; participates in discussions around others' work; asks thoughtful, relevant questions; acknowledges the value of others' contributions.
___*	Engages with teammates' work	Knows what others on the team/subteam are doing; checks in/stays abreast of their progress; gives teammates constructive feedback and suggestions; helps or provides guidance to teammates; helps keep the team/subteam moving forward.
___	Communicates well	Communicates clearly and in a timely manner; exchanges relevant information with teammates; facilitates communication within the team.
___	Receptive to feedback, suggestions and help	Solicits and listens to suggestions and feedback; willing to accept help; uses suggestions and feedback to improve.

* **Must meet expectation in order to earn an A**

Temporary page!

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