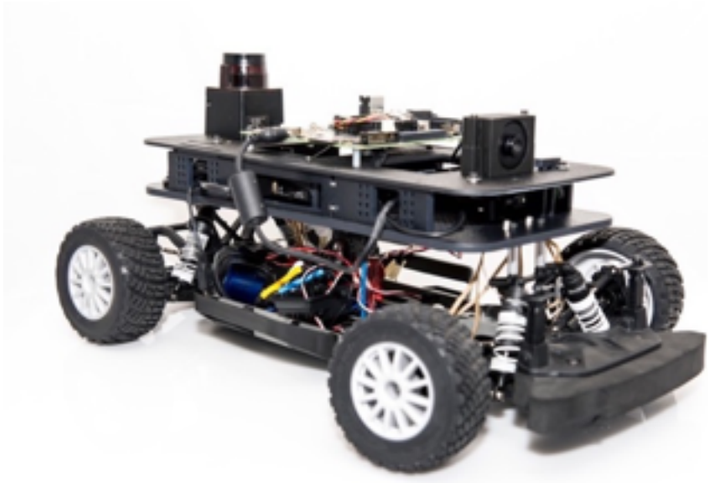
Autonomous Racing Kit, Course & Competition



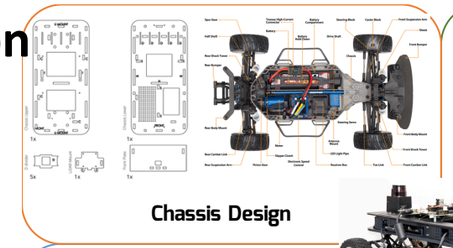
An open research and education platform to develop safe autonomous systems. F1/10 is 10^{th} the scale by 10x the fun in learning the foundations of Perception, Planning, Control and Coordination with real hardware, software and mechanical platforms.

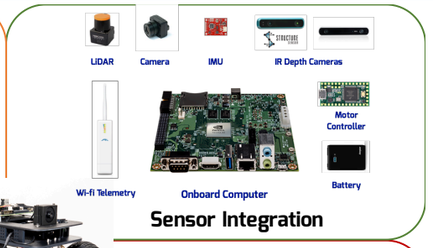
PI: Rahul Mangharam
University of Pennsylvania

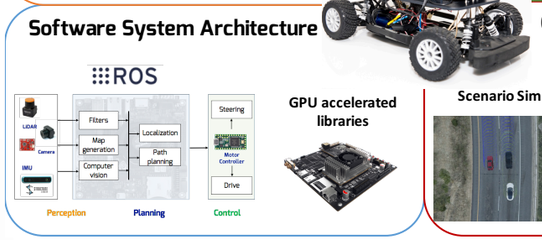
Autonomous Racing Kit, Course & Competition

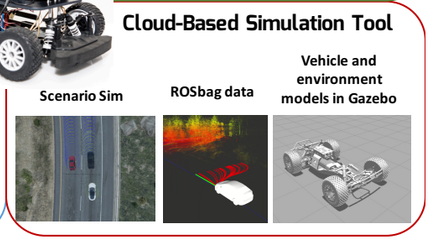
Build ● Drive ● *Race*

1/10th the scale. 10 times the fun!





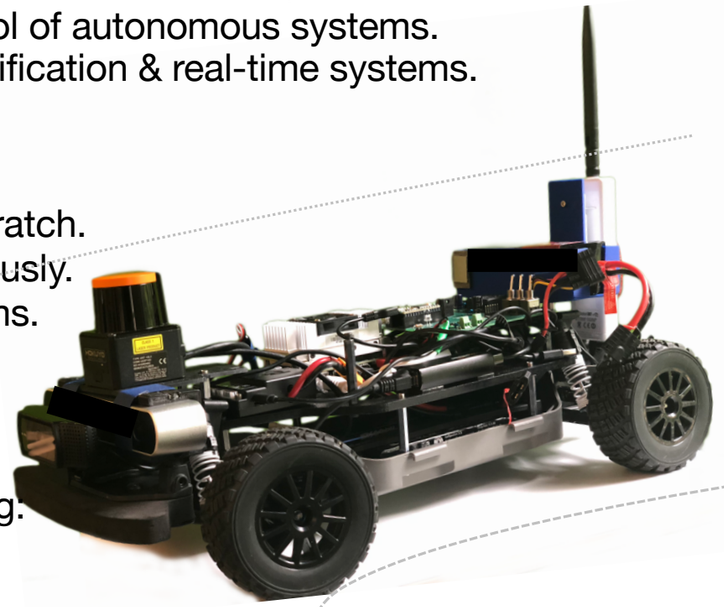


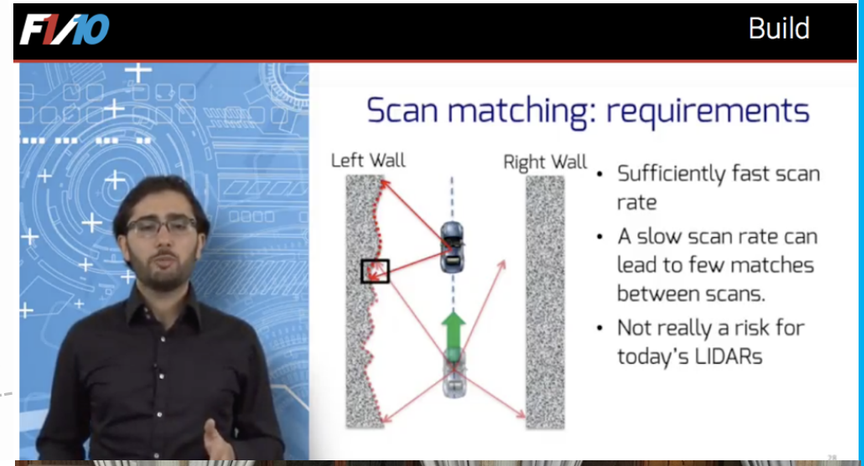


- F1/10 is a complete, ready-to-run platform for research, education and outreach.
- Community driven with reference hardware, software, courses and competitions.
- A great introduction to perception, planning and control of autonomous systems.
- Explore challenges across learning, control, formal verification & real-time systems.

THE F1/10 PLATFORM

- All the hardware needed to build an F1/10 car from scratch.
- All the software needed to have F1/10 drive autonomously.
- A simulator to test perception and navigation algorithms.
- Exhaustive documentation available online





THE F1/10 COURSE KIT

Material for a semester-long class on autonomous driving:

- Lecture slides and videos
- Code for weekly labs
- Month-long projects in Machine Learning, Computer Vision, IoT

THE F1/10 COMPETITION

- Every year, 2 races are organized at CPS Week and ES Week.
- These are battles of algorithms: same hardware platform, compete on machine intelligence
- Some focus on better perception; others on better path planning; others still on better control.

Do you have what it takes to be the best autonomous driver?

Autonomous Racing Kit, Course and Competition

Perception ● Planning ● Control

1/10th the scale. 10 times the fun!

RESEARCH ENABLED

Perception	Planning	Control
Computer Vision	Sampling-based planning	Trajectory trackers
Image Processing	Multi-agent systems	Distributed control
Sensor Fusion	Scenario generation	Learning and control

CROSS-CUTTING RESEARCH

- Formal verification and testing of autonomous systems
- Security of connected Autonomous Vehicles
- Learning for planning and control
- Runtime verification and online monitoring
- Real-Time robotic systems
- Energy-efficient hardware for perception workloads

F1/10 ROLES

- Research Advisor: Conduct research using the F1/10 platform.
- Team Director: Send a team to an F1/10 racing competition.
- Course Instructor: Offer a quarter-long or semester-long class
- Community Builder: Organize outreach and demonstrations to local community

Open-source AV Platform Development		Research Enabled		Impact
Instrument Design	**Modular Chassis Design** Plug-n-play system to fit multiple sensors, actuators, compute platforms and controllers **F1/10 AV Development Board** Plug-n-play unit for power management, multi-sensor interface and motor drivers **F1/10 AV Programmable Hardware Platform** Specialized for perception, planning and control	**Robustness-guided Verification** Combine robust testing with delta-decidability to scale up formal verification **On-board Verification** Real-time, periodic, on-board verification of plans **Formally-Constrained Machine Learning** Machine-learned controllers that are provably correct	Safe Autonomy	3 Annual AV Racing Events
AV System Software	**AV Software Libraries** Models, code and ROS APIs for Safe, Agile and Coordinate autonomy **GPU-Accelerated Algorithms** ML-based planning, aggressive maneuvers, overtaking strategies, collaborative mapping	**Aggressive Maneuvering and Control** High-speed path planning and overtaking **Attention, Anticipation & Task-driven Perception** Exploit information sparsity; Throttle perception and verification to suit control needs	Agile Autonomy	Online Ed and MOOCs
AV Toolchains	**Cloud-based AV Simulator** Vehicle and environment data to model capture, race strategy optimization, power optimization **Robustness-Guided Verification** Capture AV scenarios in a domain specific language, falsification and reachability analysis engine, counter-example visualization	**Cooperative Map Merging** Navigate with partial knowledge of environment **Cooperative Path Planning** Navigate with shared information across fleet **Coordination with Model Exchange Protocol** Networked active safety with models and intents	Coordinated Autonomy	Benchmark Datasets
	Single Vehicle Optimization • Behavioral Planning Libraries • Q-Learning for Speed Opt. • Scenario Safety Certification	**Fleet Optimization** • AV Fleet Coordination Libraries • Evasive and Tactical AI Drivers • Fleet Safety Certification	Migration to real AVs AutoWare	Community Platforms

RAHUL MANGHARAM
rahulm@seas.upenn.edu