CPS Education with CAT Vehicle Testbed

Impacts and potentials

Presenter: Rahul Kumar Bhadani, PhD Student, The University of Arizona

NSF Cyber-physical systems PI Meeting 2018, Alexandria, Virginia
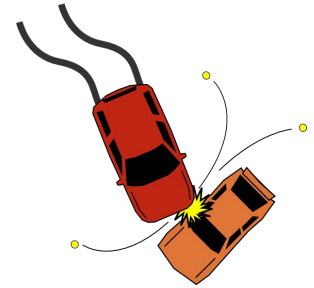November 15-16, 2018

Goal of student competitions

- Spreading awareness about cyber-physical system resources not only among students but also among educators who mentors students.

- Educating about importance of computer simulation for resource-critical operations e.g. verifying concepts/algorithms before going on the field to operate autonomous vehicles.

- Reinforcing research caliber by imparting collaborative attitude among students

How CAT Vehicle Testbed is important?

- Limitations of physical testing with Autonomous vehicles:
  - Accessibility of road scenarios
  - Safety issues
  - Logistics issues
  - Permission from risk management and law-enforcement agencies
 - Time constraints in preparing test setups
  - Weather

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Facilitating Model-based design

1 Requirements Analysis:
Understand the requirements, include various stakehoders involved and generate executable specifications.

2 Functional Analysis:
Functional modeling of system; breaks down the system in functional blocks with dedicated tasks.

3 Design Synthesis:
Environment modeling, computational modeling of physical components, algorithm development

4 Verification and Validation:
Correction implementation of model, uses corrected-by construction paradigm and domain specific modeling; Compliance to external requirementsl by running test cases with simulation.

5 Implementation and Integration:
Code-generation capability that facilitates platform indepdendent system design; modularity of the design process facilitates integration.

- CAT Vehicle testbed speeds up prototyping via model-based design.

- Use of WebGME, Simulink and Stateflow to develop to models independent of physical platform.

- Code generation techniques to generate code for specific platforms.

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Hardware-in-the-loop simulation
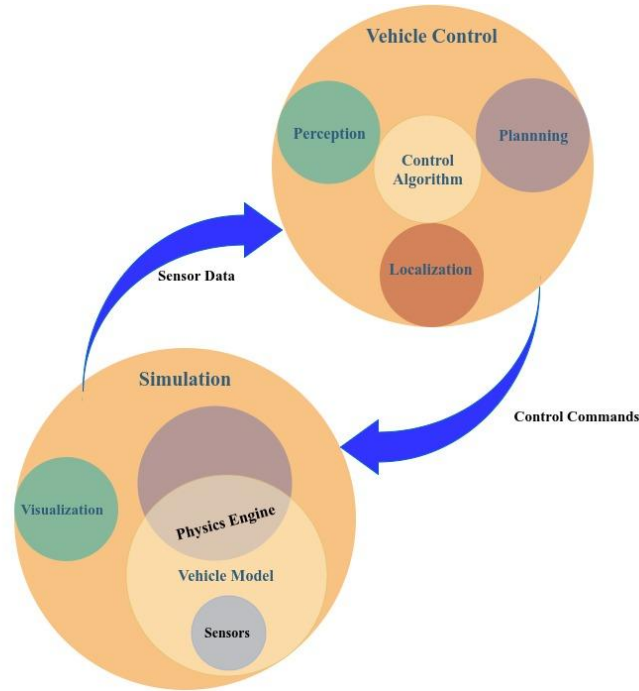
- Combining physical sensors with software components for safe-design.

CAT Vehicle Testbed on CPS-VO

Student Engagement with the testbed on VO

Spring 2017

**CAT Vehicle challenge**

- Aimed to broaden students' involvement in CPS-related projects.
- Goal: Identification of potential obstacles on the path of autonomous vehicle using least sensor possible
- Tasks divided into 4 stages.
- Physical platform unavailable until final round
- Facilitates collaborative work among students using testbed with Software-in-the-loop simulation
- A successful use-case of resource-critical application development using simulation and verification with physical platform within two days.

https://cps-vo.org/group/CATVehicleChallenge

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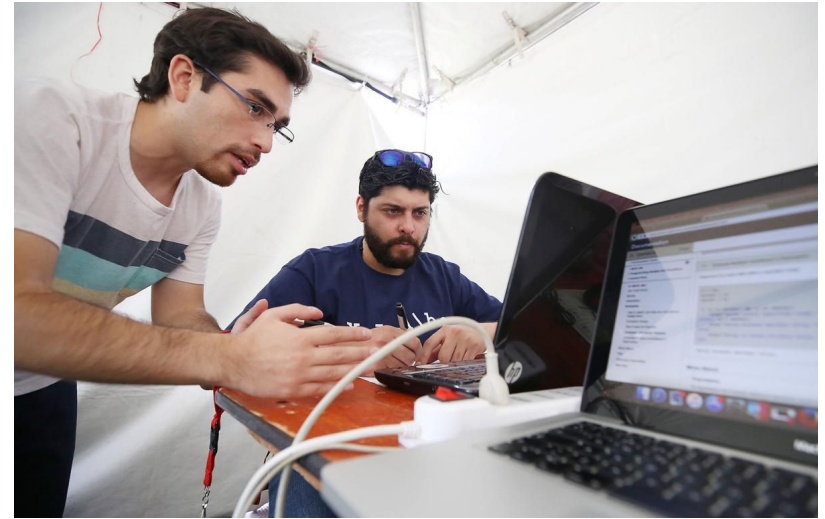
Promoting robotics education with the testbed

May 2016-May 2018

1. **Non-expert application Development**
2. **Robotics education among school students**

Enabled development of a domain specific modeling language for non expert to develop vehicle applications: use case in Canyon view and Sunrise elementary school, Tucson

Partnership with local school educators to facilitate robotics education starting from middle school level.

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Undergraduate research

REU 2015 – Continuing

10 Weeks summer research program for undergraduates

- Undergraduate students work on to develop various applications for self-driving cars and gain research experience under the supervision of professors and PhD students.
- Outcome published in number of conferences every year.

http://catvehicle.arizona.edu/

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Demonstration: visualizing vehicle's surrounding

- Terminal 1: `roslaunch catvehicle catvehicle_city.launch`
- Terminal 2: `roslaunch catvehicle catvehicle_spawn.launch`
- Terminal 3: `gzclient`
- Terminal 4: `rosrun rviz rviz`

https://youtu.be/voH15U-yKVo


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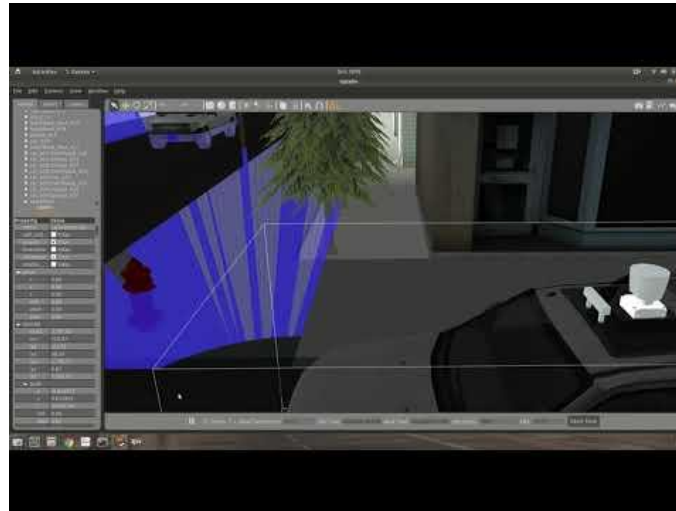
Demonstration: driving the vehicle

- Terminal 1: roslaunch catvehicle catvehicle_city.launch
- Terminal 2: roslaunch catvehicle catvehicle_spawn.launch
- Terminal 3: gzclient
- Terminal 4: rosrun rviz rviz
- Terminal 5: roslaunch catvehicle drive.launch

https://youtu.be/qyOeig9m-ns

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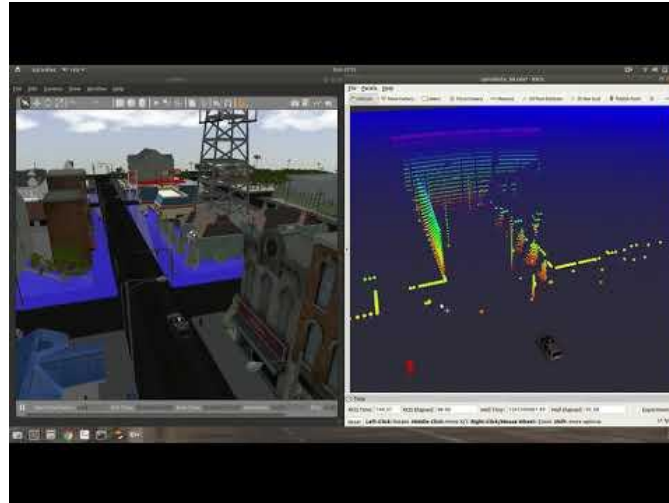
Releases at a glance

- Provided simple feature with single autonomous vehicle simulation with SICK LMS and Velodyne LiDAR simulation support

May 2016
Version 1.0

Version 2.0
Feb 2017

- Major changes including name changes to match ROS implementation in real Ford Escape Hybrid available.

- Multi-vehicle simulation

- Side camera simulation

- Support for ROS Melodic, Gazebo 9.0 and Ubuntu 18.04.

- Traffic and city simulation

- Front camera simulation

- Support for sensor fusion

March 2019
(Tentatively)
Version 3.0

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Where to find it?

CPS VO Website:
https://cps-vo.org/group/CATVehicleTestbed

Github: https://github.com/sprinkjm/catvehicle

Labpage: http://csl.arizona.edu/

Contact: rahulbhadani@email.arizona.edu

Compositional
∞Systems Lab

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