University of Hawaii – Maui

Introduction and Approach to Autonomous Vehicle Technology

Introduction: University of Hawaii – Maui (UH-MC) is a recent entrant to the world of Autonomous Vehicle technology education and research. A small but highly motivated school.

This semester the first dedicated and formal course on Autonomous Vehicle Technology has been added to the school's program. The course is UH-MC ETRO293v – Autonomous Vehicle Technologies and is a hybrid hands-on and technology learning class. The focus of the course is to build up the students' knowledge of the many elements of autonomous vehicle design and operation as well as give the students additional practical experience using their knowledge from other UH-MC classes. Very importantly it lets the students get hands-on experience working on integrating those technologies into an operational autonomous vehicle and then to enter that vehicle into a national competition to establish and validate their work. Here is a link to the national competition the class looks to enter. https://evgrandprix.org/autonomous/

Sponsored by Purdue the evGrandPrix competition has been running some pretty advanced "open class" electric motor powered eKarts at the college level for over 10 years. During that time, they added a High School level class and in the last 2 years Purdue has added in a College level "master" autonomous class. https://evgrandprix.org/about/ . The evGrandPrix program is a significant part of the Indiana STEM initiative and is incorporated into several Indiana high school as well as several Indiana university / college level programs.

Autonomous studies at UH-MC: It was the evGrandPrix autonomous class and associated competition that has driven UH-MC's focus and effort to prepare itself for participating in autonomous endeavors. With the creation of the Indy Autonomous Challenge we are even more excited to expand participation and research in this area. We see this initiative leading to many job opportunities and professional career options for the students.

The autonomous studies and this year's class being developed at UH-MC is related to, but generally agnostic, to the evGrandPrix and the students are tasked with developing more generalized modules for assembling their autonomous vehicle.

The class is led by Mr Passon, an experienced and successful software and business development executive. A few years ago, Mr Passon retired from the high-tech industry and moved to Maui. As part of his "give back" program to expand STEM related programs on Maui UH-MC has asked him to be the lead instructor for the course. Along with 2 TA's Mr Passon is responsible for developing the course content as well as lecturing and mentoring the students in putting together their vehicle.

It is the expectation that next year this class, as well as a higher-level class to be implemented next fall, will be evolved to take the autonomous theoretical knowledge as well as practical knowledge developed this year by the AV team to the next level. An outreach program to other University of Hawaii campuses is underway and an inter-University collaboration is being discussed. If accepted to the Indy Autonomous Challenge the UH-MC team will be reaching out to other universities to investigate collaboration opportunities.

Autonomous Team Leader: Mr Passon has over 35 years' experience in developing business and large software systems. This includes developing large distributed software systems, distributed communication and loosely coupled processing systems as well as managing diverse multi-location teams. Mr Passon holds a patent in software. He retired from his last company from the position of President/COO/CTO.

Mr Passon brings an uncommon and very specific background in racing to the challenge. Mr Passon has a background in racing as a young man in Indiana and before and during his attending Purdue studying Mechanical Engineering and doing some graduate course work in Computer Science.

In high school he had a short career in local go-karts racing, and then moved on to competing in SCCA Formula Ford racing for several years including going to the national championships. Graduating from that level Mr Passon became a semi-professional racecar driver racing SCCA SuperVee and Atlantic cars as well competing for 3 seasons in USAC/Champ sanctioned Mini-Indy cars (forerunners of the Indy Lights).

After retiring from active racecar driving Mr Passon did racecar engineering, team management, and at-track consulting for a few years, including as a mechanic / engineer for an Indianapolis car for a season.

These years of hands-on racing, both in and out of the racecar, gives Mr Passon a deep understanding of the challenges of applying more traditional racing technologies and knowledge to the challenges of autonomous racing vehicles.

Most recently as the course developer and instructor for the UH-MC Autonomous Vehicle Technology class Mr Passon is bringing a balance of reviewing and evolving the current technologies supporting autonomous vehicles with the real-life hands-on tasks of building up an autonomous vehicle.

Other AVT members: At this time the AVT Class is supported by 2 "TA's". One is a degreed Mechanical Engineer and the other a recent graduate with relevant computer and programming experience. The class is currently being taken by 5 undergrads with electrical engineering tech and some programming experience. Some of those students will hopefully move onto the next class in this series.

Course Skills enhancement to date: This semester the students have built and begun modifying (5) Jet Racers based on the Nvidia Nano technology. The students have been working in Linux and writing code in Python and C++. They are getting familiar with ROS and OpenCV. They also have access to (3) 1/10 scale Redcat F1-Tenth cars based on Nvidia Nanos as well as a larger 1/5 scale car based on a Nvidia Jetson AGX to develop larger systems. In addition, the students have gotten hands-on experience working with USB cameras, small Lidars, Ardupilot, and GPS/RTK systems. As a class project they are implementing data loggers and real-time telemetry transmission systems for Vehicle to Pit communications.

Approach to the IAC competition: UH-MC has a multi-axis approach to the Indy Autonomous Challenge.

A) First recognize the IAC is a "racing competition" and prepare as fully as possible recognizing unknowns.
B) Develop detailed timelines, pert charts, system and module specs of the elements needed to be successful and then track performance against the plan. Recognize time is precious.
C) Be diligent in researching what has gone before and try not to reinvent the wheel but enhance it. Recognize others are trying to do the same thing.
D) Get help… Find and attract others to collaborate in the team success. Get others in and out of the UH O'hana engaged and involved. Get industry people involved and support their engagement.
E) Keep it fun! Success will take a lot of effort. People will get tired and mistakes will be made but most importantly everyone must feel what is being done is worthy and that they can have a bit of fun along the way.
F) Start small and grow… Start with JetRacer sized vehicles, grow to F1tenth, and then to 1/5 scale outdoor vehicles and finally to human carrying sized vehicles. Adding complexity and speed as we go. In process….
G) Learn a lot… prepare our students to take on industry opportunities with confidence and sound knowledge. Provide more and deeper experience in Linux, Python, C++, ROS, autonomous hardware, system design, teamwork and may other valuable tools for their career.

Fundraising & People Raising:

A) Build local community support (Maui Economic Board, Maui Research and Tech Park as well as identify local businesses. Get their support based on supporting the students and growing Maui Tech base)
B) Build industry support (autonomous product and software providers based on providing feedback and qualification, as well as association with a competitive team).
C) Go for Grants (based on growing Maui Tech base as well as increasing the STEM programs at UH-MC

D) Find “patrons” … based on finding people that find what the team is doing as inspiring and want to be associated with its efforts.

Approach to Autonomous Racing Vehicles:

A) Identify the General Autonomous Vehicle Problem
   a. Computer Vision - How well can we see
   b. Deep Learning - How well can we detect and identify things
   c. Sensor Fusion - How do we bring different technologies together to collaborate and enhance.
   d. Localization and Mapping - Where the heck are we?
   e. Planning - Ok we are here... How are we going to get to “there”?
   f. Control / Locomotion - Gotta move this thing to get "there" - safely
   g. System Integration - Bring it all together and handle "failures"....

B) Recognize there is some very specific areas where the Autonomous Racing Challenge is more challenging and sometimes less challenging than typical AVT levels.
   a. Speed of vehicles. Sensor and compute performance
   b. Need for greater preciseness in localization
   c. Soft sensor degradation does not significantly affect lap times. Robustness
   d. Weight
   e. etc

C) Organize a Software Stack / Architecture to distribute the responsibilities.
   a. Break down the problem into levels of abstraction
   b. Typical elements in the autonomous vehicle abstraction layers would be:
      i. Specific sensors (hardware and software)
      ii. Integrated / fused sensors / stored data
      iii. Data reduction / data isolation
      iv. Item Detection
      v. Item identification
      vi. Scene Creation
      vii. Mapping & Localization
      viii. Goal / Path Objective
      ix. Route optimization (Racing specific)
      x. Control
   c. Recognize the opportunities to create loosely couple modules and parallel processes for speed and efficiency
   d. Develop and document in state-of-the art languages and on state-of-the art tools.
   e. Reuse and build on others work where possible.

D) Specific Areas of "deep diving" … areas to develop UH-MC expertise
   a. Enhanced Computer vision and depth information from camera data
   b. Fast path assessment and accurate micro path control adjustments (high Hz)
   c. Integrated SLAM consisting of highly fused sensor data streams

E) Develop robust Testing and Qualification Methodology
   a. Determine "mean line" though the software stack and robustly test it
   b. Determine most likely software, hardware and human failure modes and replicate as best as possible.
   c. Determine the mostly likely "degraded modes" and replicate as best as possible.
   d. Do as much SWIL, HWIL and Human-in-the-loop testing as possible
   e. Do as much testing of headroom as possible (electrical load, processor/memory/communication bandwidth, response time, etc)
   f. Don't break expensive things!
   g. Safety in testing… Protect people at all costs.
   h. Track testing is expensive. Track testing is cheap… Both true!

Approach to Autonomous Race Operations:

A) Race Control (RC) is a TBD… No one has really run an autonomous race.
   a. Safety and People are CRITICAL to protect
   b. RC must provide clear rules of operation that assure "a".
   c. RC should be able to control all the major operations as seen in F1 from arrival at the track, beginning of practice, to race competition, to last transporter leaving the track.
   d. RC must assure teams adhere to the rules.
   e. Any RC communication system not only must be robust but should have redundant methods for critical communications to the car, teams, track personal, etc (For example "ALL STOP now" …)
   f. Need Forms of two-way V2RC & V2TM
   g. May want to add two-way V2V in the future
   h. Seems like the concept of Virtual Safety car would work in some manner.
   i. Vehicles are going to need a lot of test time on race weekends, particularly in the beginning
   j. Racing is dangerous.

B) Team Safety Driver
   a. Place the Safety driver in the loop with ability to "take control".
   b. Provide real-time First-Person Video
   c. Provide real-time Telemetry
   d. Make controls as close to the real car as reasonable possible

e. Since the safety driver must be able to take control provide for testing and training

C) Real-time Team Data Operations
   a. Recognize this is essentially only partially tested software
   b. Provide "high levels" of communication bandwidth with minimal lag between the vehicle and the team (local and base operations)
   c. Provide for emergency controls from the team to the vehicle
   d. Provide for operational adjustments to be made to the software while on the track (maybe not during the qualification or race?)

D) How to get Fans and Sponsors involved? TBD…

University of Hawaii – Maui believes our team could provide a lot of value to the competition. We think we could successfully compete and are willing to collaborate with others, if appropriate. We are a small school but big on O'hana. We are certain our students would get a lot out of this and our community would support this endeavor.

Thank you for your consideration.

Gary Passon