DEPARTMENT OF
Electrical and Computer Engineering

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OBD-based Auto Dynamics System

Sponsored by

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1. Objective

Design an On-board Diagnostics (OBD) II based system to monitor dynamic parameters for rally racing vehicles. Include some form of machine learning that will aid in monitoring performance and vehicle health.

2. Motivation

A vehicle's OBD II [1] system is a rich source of operational information, but vehicle dynamics is not a part of it. Knowing the vehicle acceleration- and rotational-forces as measured from arbitrary locations on a vehicle would be a start, but it is likely that including/combining more information could be useful. For example, tire temperature, differential temperature, brake disc temperature, maybe air intake rates, engine RPM, and other measurements may be useful.

These days, using machine learning to handle some of the monitoring is almost a given, but as far as we know it's not been applied to this specific application. It's probably that some form of unsupervised machine learning is appropriate for this project, but that is up for debate with the sponsor.

3. Suitable Background for the Project

A knowledge of the OBD II system is good to have, but not necessary. Embedded processor development experience is very good to have, as is experience working with inertial motion units and other sensors.

4. Description

This project was inspired by the need for detailed knowledge of rally car operation during races. The cars are subject to extreme dynamics that are ever changing during a race.

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Naturally, the use of OBD information is essential during a race to understand the vehicle's performance, state, and to warn of any impending problems.

Since the sponsor is not an expert in rally car design and operation, the aim is to provide a representative example of how someone might build a monitoring system with a machine learning component. A minimum functional prototype is one that captures some standard OBD-II parameter identifiers (PIDs) [2], such as fuel system status, engine speed, vehicle speed, throttle position, etc., and captures accelerometer and gyroscope information.

The information would be displayed (numerically or graphical depending on the quantity) on a dedicated LCD, or could be wirelessly transfer to a tablet or smartphone. A system like Node-Red [3] might be useful.

In collaboration with the sponsor, it is up to the design team to determine what form of machine learning makes most sense.

The team is encouraged to look for online examples of OBD-II systems, such as the project by Pavel Vasilev [3].

To support development, an OBD-II simulator is needed. The ECE Department shall endeavor to procure one [4][5].

5. Functional and Performance Requirements / Objectives

The system design requirements and objectives are as follows:

1. It must be demonstrated to work with an actual automobile,
    a. This can only be done with the vehicle not in motion as University safety guidelines make it very difficult to do a road test.
2. It must be demonstrated to work with a provided OBD-II simulator.
3. It should be not more than 1500 cm^3 in volume
4. It may be line or battery powered,
    a. If battery-powered, the battery must be a commercially available closed unit, such as a Li-Ion power bank
5. It should not weigh more than 2 kg
6. It should support wireless connectivity to smart devices
    a. If it does not, then it must support USB 2 or later connectivity
    b. If it does, then it may support USB 2 or later connectivity.
7. The following OBD-II SAE J1979 PIDs [2] must be acquired and used in some way and preferably displayed:
    a. Calculated engine load

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   b. Engine speed
   c. Vehicle speed
   d. Throttle position
   e. Distance traveled with malfunction indicator lamp (MIL) on
   f. Any, at least one oxygen sensor reading
   g. Optionally, any others that are convenient or interesting.
8. At a minimum, data from at least one inertial motion unit/sensor must be acquired and used in some way and preferably displayed. This includes accelerometer and gyroscope data.

9. Specifications / Constraints

The overall design, prototype and system, must be accessible to do-it-yourselfer (DIYers). That means that all major components should be available commercially, as low-cost as possible, and if possible, have second sources.

It is not necessary to include the OBD-II simulator.

There are few other constraints as the team should be as free as possible in terms of design.

10. Information Resources / Links

References:

[1] Wikipedia contributors, "On-board diagnostics," *Wikipedia, The Free Encyclopedia,* https://en.wikipedia.org/w/index.php?title=On-board_diagnostics&oldid=1242847271 (accessed October 21, 2024).

[2] Wikipedia contributors, "OBD-II PIDs, "*Wikipedia, The Free Encyclopedia,* https://en.wikipedia.org/w/index.php?title=OBD-II_PIDs&oldid=1245575104 (accessed October 24, 2024).

[3] Node-Red, Low-code programming for event-driven applications, nodered.org, https://nodered.org, accessed October 24, 2024

[3] Vasilev, Pavel, "On-Board Diagnostics II", Cornell University Electrical and Computer Engineering, 2012, https://people.ece.cornell.edu/land/courses/ece4760/FinalProjects/s2012/ppv5/index.html

[4] Wikipedia contributors, "ELM327," *Wikipedia, The Free Encyclopedia,* https://en.wikipedia.org/w/index.php?title=ELM327&oldid=1252305363 (accessed October 21, 2024).

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[5] OBD Solutions, ECUSIM 2000, information page, obdsol.com, https://www.obdsol.com/solutions/development-tools/obd-simulators/ecusim-2000/, accessed October 24, 2024

[5] ScanTool, Product page, scantool.net, https://www.scantool.net/scantool/downloads/74/stn_dist_price_list.pdf , accessed October 24, 2024

11. Prototyping / Testing Resources

The University of Alberta Electrical and Computer Engineering Department shall provide an OBD-II emulator and various components. The sponsor may provide components.

12. Intellectual Property Restrictions

Note: Public presentation and, hence, disclosure is a course requirement.

- All results and intellectual property created will be owned by the student capstone group with the client having the right to use same royalty-free in the course of client's business (written agreement required).

13. Contacts

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