Slippage Detection and Traction Control

February 24, 2004
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1. Project Summary

1.1 Objectives

The main objective of this project is to design, construct, test, and implement a working traction control system for the University of Idaho’s formula one vehicle. The formula one vehicle team would like to incorporate this technology on the 2005 vehicle for racing, so a working prototype is needed soon.

1.2 Background

Dr. Edwin Odom, Associate Professor at the University of Idaho, would like to implement a traction control system on the UI formula one vehicle because of the advantages it afforded the winning team at the 2003 Formula Society of Automotive Engineers (FSAE®) race. Dr. Odom would like to reduce, if not eliminate, the possibility of a spinout when accelerating too fast out of a corner. Implementing a traction control system could minimize this problem.

1.3 Methods

Using sensors the wheel velocity signals will first be measured. Then the signals will be analyzed with a control algorithm from a micro-controller. The output from the micro-controller will interact with the engine to bring the vehicle back into a controllable state if necessary.
2. Project Description

2.2 Objectives

The objective of this project is to implement a traction control system for the University of Idaho’s formula one vehicle. The traction control system will use sensors to monitor wheel velocities and send the signals to a microcontroller. The microcontroller will compare the signals to determine if any slippage amongst the tires has occurred. The U of I formula one vehicle team will determine the amount of allowable slippage. Using a control algorithm the microcontroller will analyze the four signals to determine whether the amount of allowable slippage has been exceeded, if so action will be taken to minimize power and gain control of the slipping wheel or wheels. This action could consist of cutting the fuel and/or spark. The system needs to deliver the maximum amount of power to the wheels of the vehicle, without slippage, giving the car the ability to accelerate at its maximum rate.

2.1.1 Secondary Objectives

- **Override Switch**- In the event that the traction control system malfunctions the driver would have the option to override the system by shutting it off.

- **Interface with Data Acquisition Unit**- The pre-existing data acquisition unit (DAU) is a device that collects certain data from the vehicle, such as speed, RPM, battery voltage, and lap times. The team would like the DAU to provide them with information about the slippage and wheel speed, which they could then use to adjust the percent of allowed slippage.

- **Adjustable Slip Allowance**- A switch or dial will be provided, which will allow the driver to set the percent difference of slippage between all four wheels to a desired amount, which may depend on driving conditions or the experience of the driver.
- **System Expandability**- The system should be expandable for future modifications to the vehicle, including such advanced features as anti-lock braking (ABS) and Yaw Control\(^4\).

2.1.2 Constraints

- **Dirty Environment**- Due to the possibility of a dirty environment, which may include dirt, water, mud, oil, gas, etc. an enclosed system is necessary.
- **Temperature**- The extreme temperatures from the vehicle's engine will make it necessary to design the system to withstand a wide range of temperatures.
- **Space & Weight**- The formula one vehicle team has provided a space approximately 6”x6”x3” on the vehicle for the processing unit and has requested it be no heavier than 5 lbs.

2.1.3 Requirements

This project must comply with the FSAE\(^\text{®}\) rules\(^1\). The current 2004 rules, of the Formula Society of Automotive Engineers, specify that there are to be no electronic throttle controls, so they must remain mechanical. This limits the options in constructing the traction control system to other areas such as the engines' spark or fuel injection.

2.2 Background

The University of Idaho Formula SAE\(^\text{®}\) vehicle team is interested in incorporating a traction control system on the 2005 vehicle. The team’s technical advisor, Dr. Edwin Odom, was interested in the system because of the possible improvement of control. Since the drivers have limited experience this system could result in lowering the risk of a spinout and reducing wasted power.

There have been no attempts at designing a traction control system for the FSAE vehicle, however some other teams in the competition have used such systems to increase their performance. The winning vehicle in the 2003 competition had such a system, but
how this specifically helped their performance is unknown. However, based on the performance of vehicles with such systems in today’s market, it can be seen that this system holds great opportunities for advancement in the performance of any vehicle\textsuperscript{[4]}. 

2.3 General Plan of Work

2.3.1 Phase I: Choosing Appropriate Equipment

The first step is to choose velocity sensors and a microcontroller. The sensors will need to measure the velocity of the wheels and output a usable signal that can be evaluated by the microcontroller. The microcontroller will need to receive and evaluate the sensor’s signal to calculate the wheel velocity differences and then send a signal to the engine control unit to either cut the spark, fuel, combination of both or other solution not yet conceived\textsuperscript{[2]}.

2.3.2 Phase II: Programming & Interfacing Equipment

The microcontroller will be programmed to receive a signal from the wheel velocity sensors and then will need to utilize the information to determine if the above-mentioned action will need to be taken. This will most likely involve the use of control algorithms and communication between the sensors, microcontroller, the Electronic Control Unit (ECU) and other necessary hardware.

2.3.3 Phase III: Testing Equipment

A test will be devised to evaluate the effectiveness of the system in different slip and non-slip situations. This will involve simulating four wheel velocity signals to determine if the control algorithm of the microcontroller initiates the correct action. Other tests may need to be performed at this phase that have yet to be determined. The results will determine the adjustments that are needed to increase the performance of the system.
2.3.4 Phase IV: System Integration

At this point the system will be installed on the vehicle to determine the system’s actual performance. This will include any necessary troubleshooting and final revisions to the microcontroller code and hardware to complete the project as requested. The sensors will have to be mounted in a secure fashion to reduce the chance of the sensor slipping and taking inaccurate measurements.

2.4 Methods and Procedures

2.4.1 Choosing Appropriate Equipment

- **Velocity Sensors**—The sensors will be chosen due to space restriction, power consumption, wiring requirements, and signal output. The sensor’s size will be dependent on tire and axle set-up. The ECU has a 5-Volt supply for user specific sensors. The wiring will be an issue due to moving parts in the vehicle. If wireless is not an option, the wiring will have to find a safe path to the ECU. The output signal will have to be compatible with the microcontroller that is chosen.

- **Microcontroller**—It will be necessary for the microcontroller to accept inputs from the sensors and calculate percent differences of the velocity measurements. It will also be necessary for the microcontroller to send a compatible signal to the ECU. A microcontroller built by Rabbit Semiconductor is a proposed method of processing information and implementing control of the vehicle’s engine.

2.4.2 Programming and Interfacing Equipment

- **Microcontroller**—Data sheets from the velocity sensors and microcontroller will be used to find the most efficient way to input the signal from the sensors to the microcontroller. A control algorithm will be utilized through the C-programming language to calculate percent differences in the wheel velocities and decide on an appropriate action to correct any major differences.
• **Engine Control System** - The ECU has space for three analog inputs which can be used to control fuel and ignition events. The User and Installation Manual\textsuperscript{[5]} will be used to wire the components correctly. The ECU can be programmed using one of these Windows systems: 95, 98, or 2000.

2.4.3 Testing System

• **Initial Tests** - Once the system has been configured it will be tested on a special apparatus. A wheel can be mounted here and the system can be tested to make sure it is receiving accurate measurements. The system will be monitored to ensure that a signal to cut the spark and/or fuel is being sent out from the ECU when appropriate. One option for testing the control algorithm is to use a signal generator to replicate a wheel velocity signal.

• **Field Test** - After the system has passed the initial tests it may have the opportunity to be temporarily installed in the 2004 vehicle for further testing. This will give an accurate portrayal of the reactions and effects of the system on an actual vehicle. This will allow the driver to voice any concerns or suggestions that would help improve the effectiveness of the traction control system.

2.4.4 System Integration

Once the system is completely tested and working at a satisfactory level and the 2005 vehicle is ready for the system to be installed, the system will be permanently connected. Each component will be secured to insure proper functioning and connections will be soldered in accordance with the client’s specifications.
2.5 Considerations

- **Reliability and Sustainability**- The reliability of this project depends on the care taken during programming and quality of design. The traction control system should be easily sustainable due to the ease of reprogramming of the microcontroller and replacement of damaged hardware.

- **Ethical and Safety Considerations**- This project is governed by rules set forth by the FSAE® [1] and to ignore these would have many ethical implications, one of which would be the disqualification of the U of I formula one vehicle team. Although safety issues are minimal due to the low voltages of the system an override switch will be installed in consideration of the driver’s safety as well as abiding by the competition rules.

2.6 Technical Advisor

The technical advisor for the portion of this project will be Dr. Richard Wall, Associate Professor at the University of Idaho. Dr. Wall will provide the team with technical advice and direction upon request. At least one e-mail a week will be exchanged listing problems, concerns, advancements and success.
3. Schedule

Tasks will be divided evenly among the three team members.

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(Notes: One Block Per Week)

4. Budget

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| Expense Total         | $375.00  |
| Total                 | $9,375.00|
5. Bibliography


6. Biographical Information

The following pages contain biographical information of the three team members.
Nick Carter
1302 2nd Street
Lewiston, ID 83501
(208) 746-4686
E-mail: cart7009@uidaho.edu

Education:
Senior Electrical Engineering Undergraduate Student, University of Idaho
Graduation Date: December 2004

Experience:

Fall 2003: Programmed a microcontroller and implemented a control algorithm to automatically adjust the speed of an electric motor depending upon the velocity input.

Relevant Course Work:
• Electronics I & II
• Signals and Systems I & II
• Energy Systems I & II
• Electromagnetic Theory
• Microcontrollers
• Technical Writing
Brian C. McConnel
668 SW Fountain Street,
Pullman, WA
E-mail: mcco7543@uidaho.edu
Phone: (208) 310-1511

Education:

Senior Electrical Engineering Undergraduate Student, University of Idaho
Expected Graduation Date: May 2005

Experience:

Spring 2003: Development Team for Award Winning Christmas Tree Stand Design
• Worked as part of a development team to improve the modern
  Christmas tree stand.
• I was the team Electrical Engineer and developed a water level sensor
  so customers could see the water level in the basin without needing to
  get under the tree.
• I worked with a team of five individuals from different disciplines to
  develop the product and a marketing plan. I learned much about team
  building and project development.
• Currently our Christmas Tree Stand is Patent Pending.

Fall 2003: Programmed a micro-contoller to control the speed of a 12-volt motor
using a control algorithm and an input to determine the speed. Included in
this project was communication with a computer and the display of
information on a LCD screen. I also added diagnostic display information
for trouble shooting purposes.

Relevant Course Work:
• Microcontrollers
• Energy Systems I & 2
• Electronics I
• Signals & Systems
• Thermodynamics/Heat Transfer
• Technical Writing
Kellee J. Korpi
215 W. Taylor St. #4
Moscow, ID 83843
(208) 883-0734
E-mail: korp7524@uidaho.edu

Education:

Senior Electrical Engineering Undergraduate Student, University of Idaho
Graduation Date: December 2004
University of Iowa
University of Alaska, Anchorage

Experience:

Fall 2003: Used a micro-controller to control the speed and acceleration of a stepper motor.

Relevant Course Work:

- Electronics I & II
- Signals and Systems I & II
- Energy Systems I
- Electromagnetic Theory & Application
- Microcontrollers
- Technical Writing