Senior Design Project

Ice Breaker Report

Mechatronic system

Team Pedibus

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Mechatronic systems link together mechanical, electrical, and control systems to further enhance efficiency, ease of operation for the consumer, and overall effectiveness of a product or component. More simply stated, a mechatronic system will respond with some controlled electrical or mechanical output based on a recognized sensory input. There is limitless opportunity for integration of mechatronic systems from the simplest of household products to the most complex of industrial applications. Mechatronics aid in optimizing systems, and delivering or performing necessary actions to maintain or achieve the systems goals or parameters with minimal user input.

By controlling an operation with a mechatronic system instead of human being control the benefits can range from simple convenience to increased speed or increased efficiency. An example of a mechatronic system that is used by millions of commuter’s everyday on a typical drive to work, is the cruise control system in their automobile. The cruise control system uses sensors and actuators to maintain a desired speed of the vehicle without the driver having to adjust pressure on the gas petal to maintain that desired speed. By taking over control of the throttle it fulfills several needs of the driver. Cruise control aids in preventing driver fatigue allowing the driver to not have to focus on a consistent pressure on the gas pedal while also checking speed, with cruise control the driver no longer needs to worry about subconsciously increasing speed and getting an expensive speeding ticket. In addition gas mileage tends to increase with the use of cruise control because the driver isn’t feathering the throttle to maintain speed, the throttle is smoothly applied. These two benefits of cruise control show how a cruise control mechatronic system is not only more convenient for long trips but can also be more fuel efficient.

Most of today’s cruise control systems perform a lot more functions than just control the speed of a vehicle. Along with turning the actual cruise control on and off, the system can also set/accelerate, resume, and coast (decelerate). These commands are simple enough and efficient enough to make driving long distance a little less miserable. When the driver of the vehicle hits the ‘On” button, this sends a signal to system that states that the user is about to initiate another command. In contrast the “Off” will turn off the cruise control system even if it is engaged in another command.

Once the system is turned on and the driver has reached a desired speed, the “set/accelerate” button will be engaged. This command tells the computer in the vehicle to maintain the speed of the car until told otherwise. When engaged in cruise control if the set/accelerate button is held or tapped again, the engine will begin to increase speed while enabling itself to maintain that new desired speed. Another feature that was mentioned before was the “resume” command. If the driver were to hit the brakes for some reason, which disengages the system, the action of this button will resume the cruise control and accelerate it back to the most recent speed setting. The last feature is the “coast” button. This acts as a decelerator in the means of the vehicles speed. If the button is engaged then the speed of the vehicle will start to decelerate about one mph at a time until the driver lets go of the button or engages a different command.

Knowing the commands of cruise control provides the driver to initiate the feedback control system of the car that aids in the reduction of driving stress. Mechatronics typically involves an assortment of feedbacks, whether open or closed, so it is important to understand how the sensors and computer of a vehicle allow such a simple yet complicated system to be involved in everyday driving. The system of the cruise control is brained by a small computer, typically under the hood of the vehicle, which connects several sensors and the throttle control. The system controls the speed by adjusting the throttle position, so it needs sensors to tell it the speed and throttle position and monitors the controls when the desired speed is engaged or disengaged. The sensors observe and report the rpm of the vehicle to regulate proper speed control. Most cruise control systems today use a PID control (proportional-integrated-derivative control).

The proportional factor adjusts the throttle proportional to the error, the error being the difference between the desired and actual speed. Thus, the closer the vehicle is to its desired speed the slower the cruise control acceleration. The integral factor of the control system is based on the time integral of the vehicle speed error. This factor helps the vehicle deal with hills and helps it settle at the correct speed and stay there. The final part of the PID control system is the derivative function. This factor helps the cruise control respond quickly to changes, whether it involves increasing or decreasing the throttle position to maintain desired speed.

Though the cruise control mechanism has many advantages there are some drawbacks associated with the current design of cruise control. On long road trips some drivers experience what is called highway hypnosis which is basically day dreaming with your eyes open. This is more of a driver flaw than an equipment shortcoming but could be corrected if the cruise control system tracked eye movement and warned you if your attention was off the road for too long. Another drawback that has since been dealt with in newer model vehicles is when using cruise control in inclement weather, if a wheel starts to hydroplane the cruise control continues to deliver power to the wheel and this can lead to a spin out and loss of control of the vehicle. Newer vehicles implement traction control and stability control sensors that in such an event cut the power to the wheel almost instantaneously. This is a good example of how mechatronic systems can and are being improved. With continued improvements cruise control may just be a precursor to fully automated car control. Instead of just controlling the speed of the vehicle it could control the steering and breaking.

If our three man team was to design a cruise control system the project could be broken into smaller parts. The example mechatronic system of cruise control has three major components. The first component is the sensors used to determine the speed of the vehicle. The second component is the mechanical apparatus used to change the throttle of the vehicle. And the third component is the control software used to adjust the throttle based on the speed determined by the sensors.

The team member in charge of the sensors would need to pick a type of sensor that could be used to determine the current speed of the vehicle. One example would be using an optic sensor to track the time interval between when one shiny spot on the tire is detected by the sensor. From this sensor data an rpm value could be determined. If the radius of the tire and the rpm of the tire are both known than the current speed of the car can be calculated. An important thing to focus on in this portion of the project is the read time of the sensor. It is important to pick a sensor that takes readings with a high enough frequency to accurately determine the speed of the car.

The team member in charge the mechanism for controlling the throttle would need to design a system for controlling the throttle that does not interfere with regular operation of the vehicle. One example of this would be a stepper motor that adjusts the gas petal height but is not connected when cruise control is off. An important design criteria to focus on for this portion of the project would be that the mechanism control the throttle very accurately. It is also important that the mechanism be able to adjust the throttle quickly to allow for accurate control of the vehicle speed.

The team member in charge of the control software would need to develop software that would read the sensor data and output instructions for how to adjust the throttle. This portion of the project would also require picking an appropriate microcontroller and other appropriate electronics. The focus of this portion of the project would be on developing a robust control program. A PID controller would be useful as it would have more accurate control than just simple proportional control. Another important design criteria for this portion of the project would be reliability. The software needs to provide accurate output for any conceivable user input.

There are many tasks to be done in designing a cruise control system that do not neatly fall into one of the three components listed above. Safety is a good example. A cruise control system si designed to control the speed of a vehicle. If any portion of the design fails it could result in serious injury or death. All members of the project should pay special attention to the overall safety of their component of the project to ensure the safe operation of the vehicle. In addition extensive safety testing should be performed by all members of the team on all sections of the project before the cruise control system is implemented.