CAN Enabled Automatic Headlight Levelling System

Project Proposal

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Abstract
Driving at night is a dangerous activity that necessitates maximum driver awareness for safe operation of a motor vehicle. A relatively cheap and effective way to increase a driver’s situational awareness is by proving the best view of the road and existing obstacles possible. Until the perfection and proliferation of night vision systems in cars this will be accomplished using headlights. There are two common problems with headlights, first is that many of them are improperly adjusted either blinding on coming drivers or providing a poor view of the road ahead. The second problem is headlights on the majority of road vehicles, once adjusted, remain fixed while in operation. They are thusly unable to adapt to conditions. The solution to this is to offer dynamically adjusting headlights that can be aimed by the driver in the cabin and then will automatically compensate for dips in the road, inclines, and the cars loading. This project seeks to produce such a system that can be retrofitted to existing vehicles with two modules, the control module consisting of an accelerometer sensor to measure the change in the vehicle tilt, and user input. The second module will be the headlight module, with stepper motor controlled headlight tilt, and a tilt sensor for feedback. The two modules will communicate over a CAN network.
This system will result in an increase in useful light emitted from the vehicles headlights while simultaneously decreasing glare for other road vehicles, which will significantly improve night time road safety.

Introduction
According to the Washington State Fatal Car Accident Statistics the night-time automobile fatality rate is consistently three to four times greater than the daytime rate. Many factors enter into the equation that result in the increased rate of accidents, which gives all the more reason to take every measure to mitigate as many risks as possible. A major problem of night-time driving is situational awareness. Maximizing night-time awareness involves providing the maximum amount of information to the driver about road conditions and surrounding obstacles, which for the foreseeable future involves providing the best possible lighting to the driver, while at the same time minimizing glare for oncoming traffic.

The problem with good road lighting on the majority of cars on America’s roads today lies with the fact that they are manually adjusted, and many drivers never adjust their headlights properly. According to an AAA traffic safety study headlight glare can negatively impact driver vision for up to 10 seconds. With this in mind, even properly aimed headlights will fail to compensate for changing car loading, bumpy road conditions and inclines resulting in increased glare, and decreased effective road lighting. This project proposes to develop a SAE compliant automatic headlight levelling system that will adjust itself to an angle set by the user and automatically compensate for changes in the angle of the vehicle. This system should result in improved lighting for the vehicle occupants and for other road users, with the added benefit of allowing the driver to adjust headlight angle on the fly to adapt to road conditions.

Description
In an attempt to comply with SAE regulations this project will communicate between control
module, and headlight module over a Controller Area Network (CAN). The in-module communication will likely be through SPI or I2C depending on protocol support of the peripheral devices. The entirety of the project will consist of the Freescale 9S12 microcontroller taking input from an analogue dial or digital control from the user to determine the desired angle for the headlights to maintain. It will use an accelerometer to determine the pitch of the platform, and determine what adjustments need to be made. The control module will then send the information to the headlight module controller, possibly another 9S12 unit depending on requirements, to adjust the headlight stepper motor. The headlight module controller will also take input from a Tilt sensor attached to the headlights as a feedback loop. The scope of this project will limit the module to a single vertical axis for adjustment.

Figure 1: System Block Diagram

The factors that effect vehicle tilt are loading, acceleration, road angle and road imperfections. The preliminary plan for dealing with these factors is as follows.

Vehicle acceleration should register as a change in the degree of tilt to the platform, and will be one of the main factors which this system will attempt to compensate for.

High frequency road imperfections will likely be ignored for two reasons. High frequency road imperfections are unlikely to have a significant effect on overall road lighting, and compensating for them will impose rigid timing requirements that could be difficult to meet without significant
development costs. Dynamic compensation for lower frequency changes to the vehicle angle, such as speed bumps is the other main factors for this project. Traffic calming devices in particular exist around residential and commercial areas, where any blinding due to glare can be a serious hazard for pedestrian traffic.

Differentiating between vehicle load and road slope will be an issue for the proposed set up. OEM systems do this by sensing front and rear axle positions. The proposed system, being limited to an accelerometer sensor, will need to do this through signal processing. The scheme for this will probably be to limit the low G, low frequency response to only 2 to 3 degrees for upward slopes, and loads that tilt the vehicle lights upwards. Vehicle load will be relatively static and is unlikely to exceed 2 to 3 degrees, so additional compensation for load can potentially be left up to the user via the included in cabin control. This will prevent the system from over compensating for up hill uphill slopes, which would result in the lights pointing down into the hill. Downhill slopes on the other hand often cause bad glare for on coming traffic, and the system will be programmed to tilt the headlights further down into the roadway as a trade off between reduced glare, and driver visibility.

Development and Hardware

The project will be largely developed in the ET340 lab using the available Codewrite development environment. A headlight module with vertical adjustment will be required. Other equipment will include a stepper motor, accelerometer, tilt sensor, and CAN controller for the Headlight Module, the accelerometer, and the user interface. Either a cooperative real time kernel or a pre-emptive real time operating system such as microC/OS will be used to guarantee deterministic real time execution of tasks.

Comparison and Benefits

It is envisioned that this proposed project would theoretically be implemented as a small single aftermarket package, requiring a minimum of wiring and modification. As such it is possible that the vehicles current headlight adjustment system simply be replaced with the stepper motor package, with the sensor and control package included as part of the module. The only wiring required would be the knob to allow the user to select the preset angle for the headlights.

Comparable units currently exist incorporating automatic headlight levelling using similar stepper motor implementations. A product from Hella KGaA Hueck & Co incorporates such a device as part of their High Intensity Discharge (HID) headlight package. This package claims to use an ultra sonic sensor on the rear axle to detect the vehicles pitch due to rear load and a similar sensor on the front axle to detect the vehicles movement due to road imperfections.

Automotive Lighting Reutlingen GmbH also produce a similar product using stepper motors for
dynamic control of the headlight level, and front and rear axle sensors to determine the required
the headlight level.

The proposed system will attempt to offer the automatic levelling function as an independent
package, without the High Intensity Discharge (HID) projector kits offered by manufacturers.
With the presence of older vehicles on the road for the foreseeable future, an easily installed
package that requires minimal modification to the existing headlight module with relatively
simple installation offers a distinct advantage over systems such as that offered by Hella.

The societal benefit of such a system being retrofitted to existing vehicles would be the
significant increase in night time road safety by the reduction in glare for other road users, and
the increased effectiveness of the vehicles current lighting system by being able to compensate
for situations in which the vehicles lights are traditionally less effective, such as under heavy
braking or acceleration.

Potential Features
If time permits, it would be desirable to expand the user interface to include an LCD screen
allowing the user to visually select headlight angle, and view the state of the system, and error
messages.

Demonstration
It is envisioned that the project will be demonstrated with the headlight module mounted to a
platform with the headlight module, controller, tilt sensor and stepper motor all as a single
module. The accelerometer will be kept separate, possible free to manipulate by hand or on a
mount with clearly marked angle notches. A laser could also be mounted co-axially to the
headlight module for precise measurement of the angle of adjustment. As such it may be that a
nearby wall would improve the quality of the demonstration along with a background with
degrees from horizontal marked to project the headlight or laser at.