Initial Project Document

Environment Adaptive Automotive Headlight

Automotive lighting system that adapts to environmental conditions such as ambient light and weather conditions.

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Senior Design 1

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Project Introduction:

The project being proposed is the Adaptive Headlight. The Adaptive Headlight will enhance the safety of nighttime driving by sensing environmental changes and adapting to them by maximizing the illumination of surroundings. Members of the group who will be working on the project are Michael Zeiher, Justin Kleier, Justin Owle, and Ivan Bernal Garcia. Michael Zeiher and Justin Kleier are Photonic Science and Engineering majors. Ivan Bernal Garcia is an Electrical engineering major, and Justin Owle is a computer engineering major. Currently there are no sponsors for this project.

Motivation

When driving at night, our field of vision is reliant on the illumination of ambient light (i.e. Street lights), and the headlights on the vehicle. In rural areas illumination can be even poorer due to a lack of ambient light. The risk of being in a fatal crash is three times higher at night versus the day. One of the factors increasing the danger of night driving is compromised night vision. Depth perception, color recognition, and peripheral vision can be compromised in the dark. Even the glare from oncoming vehicles can temporarily blind drivers. As humans age our reflexes slow down and it takes us longer to recover from being dazed by bright oncoming lights increasing the hazards for nearby drivers. Our goal is to help increase nighttime vision to make nighttime driving safer by creating an adaptive headlight.

Project Description

For the advancement in safety of ourselves and those around us while commuting we are proposing the idea of designing an environmentally adaptive headlight. This headlight enables betters the visibility of the driver by adapting to the best option of lighting through optimizing the field of view, brightness and position of the projected light. Factors considered will be the weather conditions and ambient factors such as ambient lighting. As for the safety of oncoming traffic we aim to reduce visual impairments of bright headlights by adjusting the light path to keep the light in essential areas like the road and off the driver’s windshield.

Optical design and features

For optical features we will produce a full retrofit for low and high beams to use high output LED’s. The high beam will consist of a bucket reflector to flood the path in front of the vehicle. In depth design of the of the low beam will consist of several LED’s that each will be set to cover a portion of the total FOV such that we can address each LED individually to dim or turn off the LED that is directed at oncoming drivers. As for weather sensing the rain detector will consist of a system of a light source sent through a medium and a detector at the end to measure the power coupled through. Theory for this rain sensor is light is coupled through using principle of total internal reflection and when contaminants such as water land on the medium the TIR angle will change due to the different index of refraction at the interface allowing for light to escape lowering the transmitted power at the end of the medium. This will be used as a true false logic for the image processing to decide between rain and foggy conditions.

Image Processing

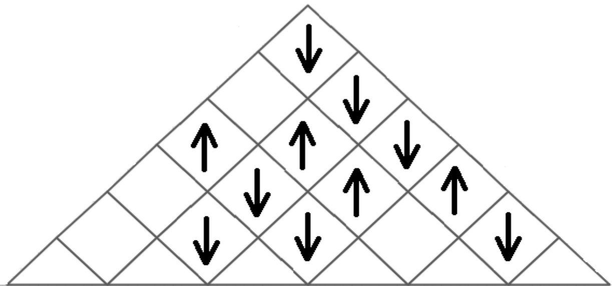
For environmental condition sensing we plan to do image processing to track headlights and ambient lighting conditions. The tracking condition will be used to determine where in the FOV an oncoming driver is located such that we can address the state of the LED associated with the position of the driver. The environmental conditions we will take into account with the camera is ambient lighting such that high beams can be appropriately we will verify ambient lighting with a light sensor as well to make sure the proper conditions are met and verified to avoid misuse of the high beams. There are conditions in which we would want lower lighting systems such as low beams and fog beams when it is raining or there are foggy conditions. The image conditions for such weather events is a large back scatter from the headlights and to determine the verification as to which condition the rain sensor described in the optical design and feature section will be used.

Electronics

In this project a car battery will be used to power the components. The electronics associated with this project will be several high-power LED's for which we will find whether a voltage or current source will be more stable for our demands. As of now there will be 3 major subsystems that need to be powered, the optical sensors, the LED array and the microcontroller or single board computer to control the LED array. The voltage and or current source will be able to be controlled by the microprocessor in which each LED can be controlled in brightness and on off state. To further the power supply demands a main PCB will be established to power the microprocessor, camera and associated sensors. The camera needed for our application does not need to be of high resolution due to the generic tracking of bright spots and an overall backscatter flooding condition. We are looking into processing options that will be able to handle the ability to process images in a quick manner such that the headlight can operate real time and consistently. We will need a light sensor as a verification of our ambient light state given by image processing this sensor does not need to be much more than a photodiode as it will be more as a double check safety feature to keep headlights from turning completely off in a condition of someone direct oncoming with high beams completely saturating the camera.

To control the brightness of the LED a current limiting transistor can be use. There will be a row of five of LEDs how the low beams which will be controlled by the microcontroller, two LEDs for the fog lights and 2 LEDs for the high beams so a total of around 9 LEDs will need to be powered, 18 LEDs in total if we do both headlights. While in the prototyping phase we plan to either use an AC-DC converter connected to a wall outlet to act as a car battery so we to power the components or use the power supplies in the senior design lab. For the prototype through hole components will be used in order to test out ideas and adapt to a method that works. Once the circuits are realized on a prototype board the next step is designing a PCB board.

House of Quality



	- Dimension	- Temperature	+ Optical power	- Weight	+ Power	- Cost
Ease of control +	↑			↑		↑
Beam Quality +		↓	↑↑	↓↓	↑	↓↓
Install Ease +	↑			↑		↓
Build Quality +		↑	↑	↑		↓↓
Cost -		↓	↓		↓	↑↑
Targets for Engineering Requirements	within 12x8x8 inches	less than 85 celsius	Greater than 2000 lumens	less than 15 lb	less than 240 W	Less than 300 headlight

Fig. 1

Requirements specifications

1.	FDOT (Florida Department of Transportation) standards
2.	Rain, fog and ambient light sensor to signal headlights to turn on
3.	Image processing/ software to control the LED brightness and on off state
4.	Measure a significant drop in intensity within the FOV of the oncoming light source. (Significance of the dimming)
5.	12V at 20 Amps supply limit from car battery (Measure both turn on and constant state)
6.	Control current to LED
7.	Low beam LEDs Controlled by a microcontroller
8.	Sensor sampling 2 - 5 Hz
9.	Must determine if there is an oncoming car
10.	Determine the position of the car or light source
11.	Consider back scatter from the headlight to help determine weather
12.	Measure effective sensing distance
13.	Measure effective response time

Table 1

Estimated project budget and financing

This project is self-funded, and the total cost will be evenly split up among the 4 team members. We aim to reduce the total costs of this project since it is not sponsored. These prices are general estimates and do not take into consideration shipping costs. Additionally, some of the items listed below are already owned by some of the team members and will be loaned out to help with the project.

Items	Quantity	Estimated Cost $
MCU (or microprocessor)	1	$50
Custom PCB	3-4	$50
Medium intensity LED chip	14	$20
High intensity LED chip	8	$30
Light sensor/low resolution camera	2	$20
Water sensor	2	$20
Headlight encloser	2	$60
SMD Passive components (resistors, switches, capacitors and inductors)	>50	$10
SMD active components (MOSFET, Op-amp, buck converters)	>20	$15
Car battery	1	$70
Car battery charger	1	$30
Miscellaneous (wires, LED power indicator, heat sinks)		$30
Through hole components for prototype	>70	$25
Lenses	14	$100
Refractor	12	$40
Total		$570

Table 2

Project Block Diagram

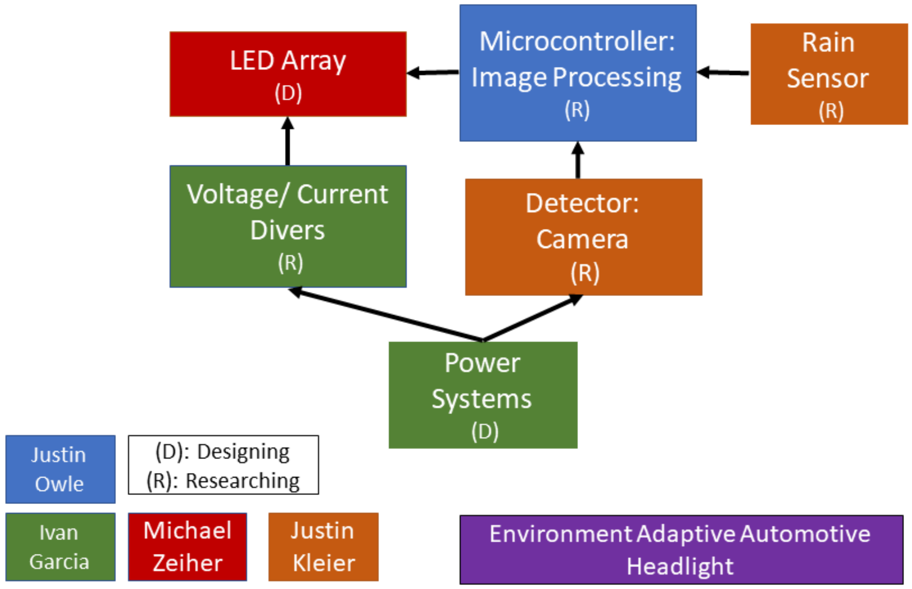


Fig. 2

Project Milestones

Person	Deliverable	Research	Testing	Implement/Due
SD1	Divide & Conq	--	--	9/20/19
SD1	Divide & Conq V2	--	--	10/4/19
SD1	Standards	--	--	10/25/19
SD1	60 page draft	--	--	11/1/19
SD1	100 pg. submission	--	--	11/15/19
SD1	Final 120 pg. Document	--	--	12/2/19
All	Solidify Design	9/20/19	10/1/19	10/8/19
Owle	MCU	10/1/19	10/8/19	10/15/19
Owle	Image Processing	11/4/19	11/11/19	11/18/19
Zeiher	LED Array / Mounting	10/1/19	10/8/19	10/15/19
Zeiher & Kleier	Reflector	10/8/19	10/15/19	10/22/19
Zeiher & Kleier	Housing Unit	11/11/19	11/18/19	11/25/19
Garcia	PSU for everything	10/15/19	10/22/19	10/29/19
Kleier	Rain Sensor	10/8/19	10/15/19	10/22/19
Kleier	Lenses	10/1/19	10/8/19	10/15/19
Owle & Garcia	MCU + Power	11/11/19	11/18/19	11/25/19
Winter Break	--	--	--	--
All	Implement Sensors with MCU	1/10/20	1/17/20	1/24/20
Owle	PCB Design	1/24/20	1/31/20	2/7/20
Owle	PCB Order	--	--	2/7/20
All	Encasing Everything into Housing Unit	1/10/20	1/17/20	1/24/20
ALL SD2 Stuff Goes Here!	SD2 Deliverables			

Table 3