# ECE 445 Senior Design Lab Proposal
# Auto Sun Visor

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## 1. Introduction

### 1.1 Problem

As drivers go through urban areas or blocks on sunny days, it's common practice to use sun visors when sunlight interferes with visibility. However, the frequent turns encountered in such environments can make sunlight seem erratic. Attempting to adjust the sun visor while driving the vehicle can lead to brief periods of distraction and reduced visibility, which is not only unsafe but increases the risk of accidents, including potential collisions with pedestrians. According to data from the National Highway Traffic Safety Administration, sun glare contributes to approximately 9,000 traffic accidents annually in the United States. This statistic shows the need for drivers to exercise caution and seek alternative solutions to manage sunshine interruption while driving, especially in densely populated areas where the risk of accidents is heightened.

### 1.2 Solution

An auto-adjustable sun visor that is powered by car electricity and reacts to the direction of the sun relative to the vehicle can be a safe choice for drivers to avoid manually modifying the visor position. While sunglasses offer a portable and straightforward solution, we must consider certain detailed scenarios. For instance, drivers who already need prescription glasses would have to wear an additional pair of sunglasses, which can be inconvenient. Moreover, wearing sunglasses while driving could potentially lead to accidents due to reduced visibility under certain conditions. Additionally, some drivers might prefer photochromic (transition) lenses but cannot afford the cost. Our solution seeks to provide a compromise between the expense of photochromic glasses and the manual adjustment of sun visors or wearing sunglasses.

### 1.3 Visual Aid

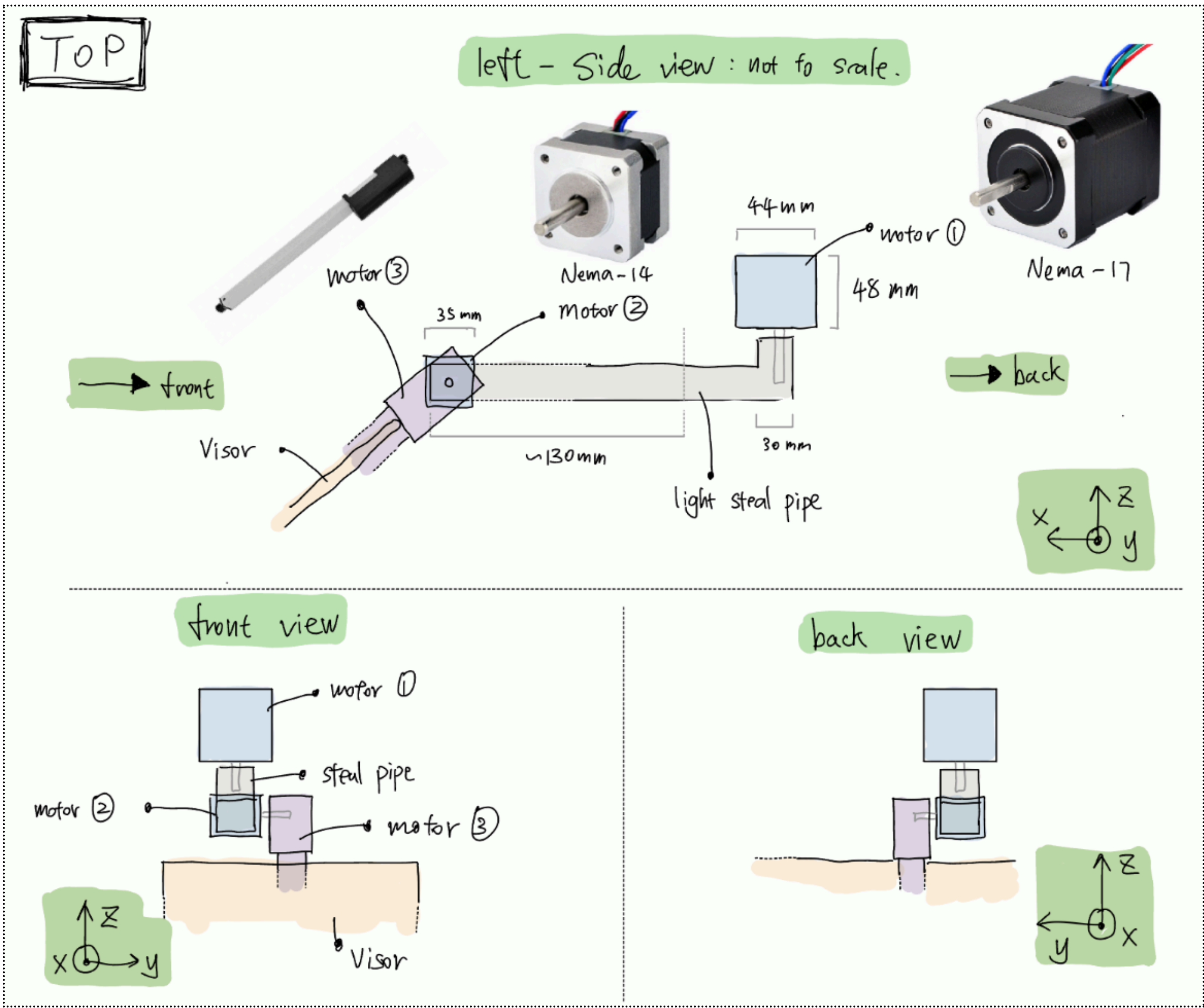



*Figure 1 - Visor Mechanics*

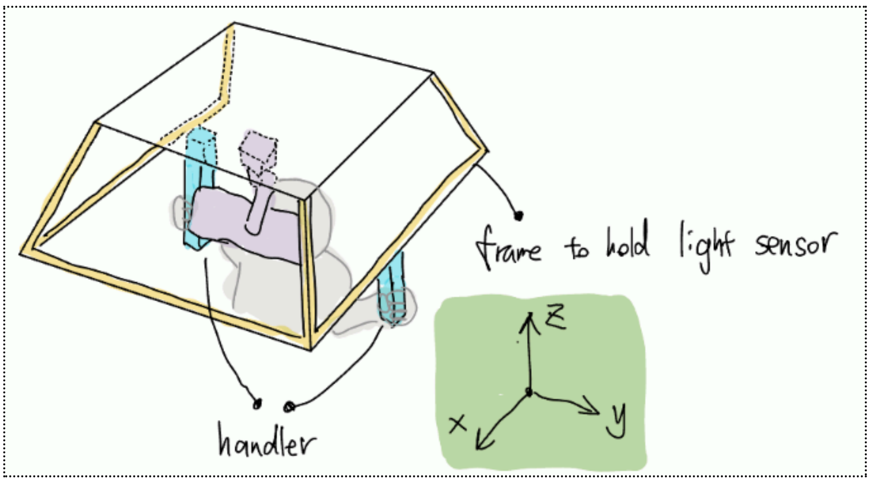



*Figure 2 - Demo Frame*

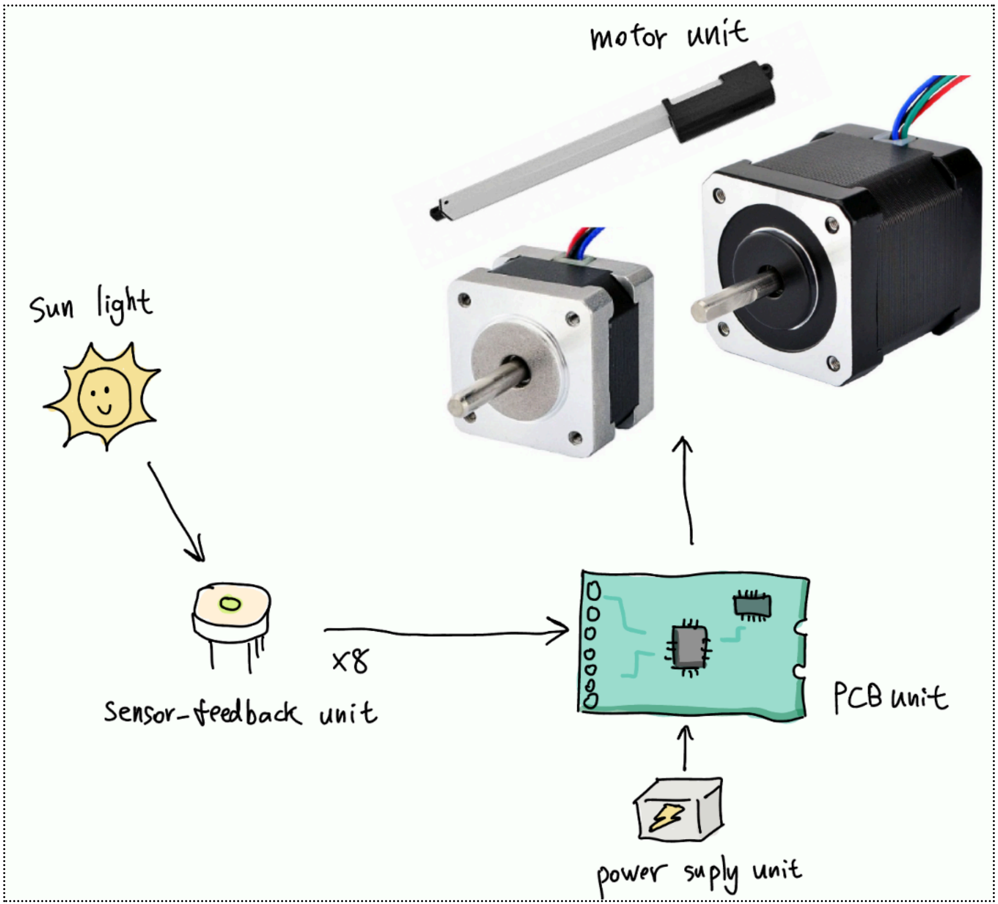


*Figure 3 - Breakdown Relation*

## 1.4 High-level Requirement List

- The power supply should provide 12 V power to the whole system to simulate the vehicle power supply. The 12V backup battery should be able to connect to the remaining systems within 3 seconds in case the vehicle's power source fails to support the system. Also, the 12V backup battery should provide enough power to return the visor back to the original place.

- The microcontroller ESP32-S3 needs to identify the different levels of light intensity and therefore provide a proper visor angle to cover the sunshine in 2 seconds. The system should be able to correctly handle situations such as vehicles entering tunnels, the constant change of sunlight (on winding roads), and weather transitions (from sunny to overcast).

- The light sensor and microcontroller must be able to accept light intensity(lux) as data input and correctly send the data into the PCB unit within 1 second. According to the statistics, direct sunlight has a luminosity between 32,000 lux and 100,000 lux[3], and the luminosity of ambient daylight is between 10,000 lux and 25,000 lux. Since the sensors are installed outside the car and are supposed to face the sunlight directly, we will consider direct sunlight luminosity instead of ambient light luminosity. We will use TSL2591 with a range of 188u lux to 88,000 lux to detect light intensity. According to research, 6,000 lux is a relatively high intensity for humans to see, so we will set the threshold as 6,000 lux. The motor should move the shading board to the correct position within 0.5 seconds after receiving a move command.

## 2. Design

### 2.1 Block diagram

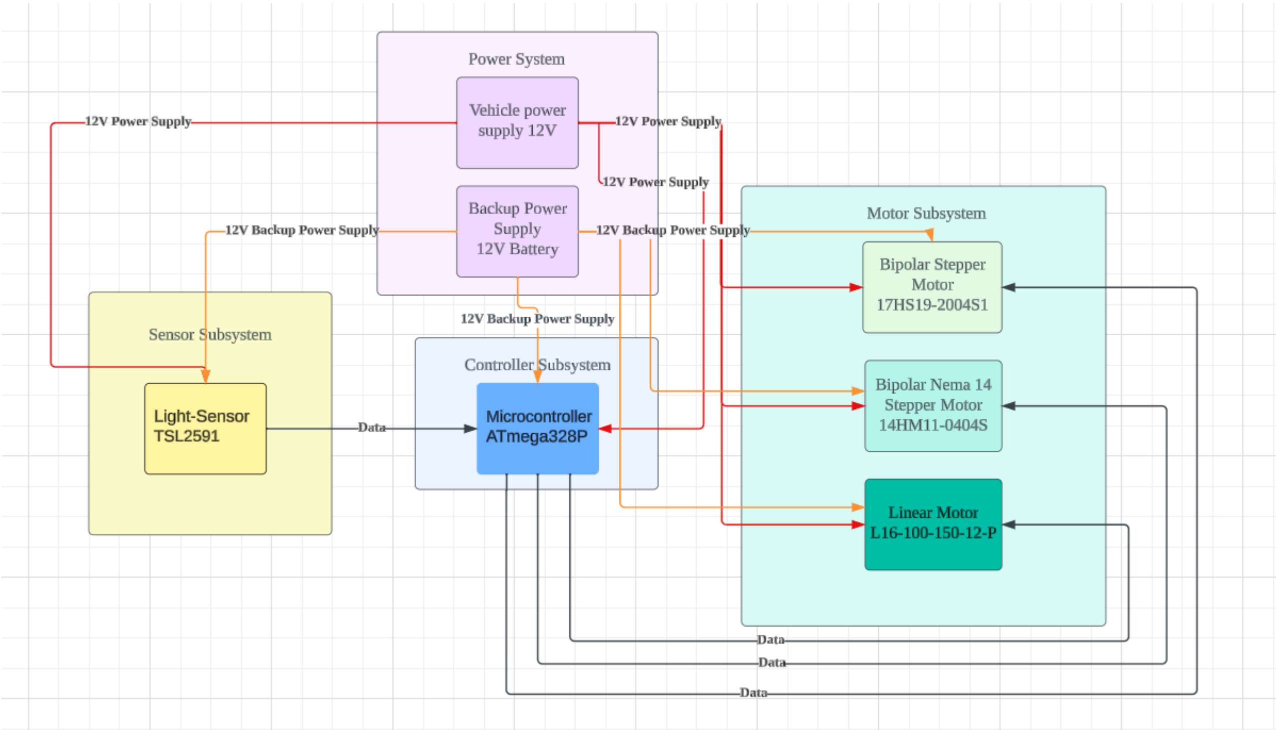



*Figure 4 - Block Diagram*

### 2.2 Subsystem Overview

- Sensor Subsystem: A total of six light sensors will receive light intensity information, enabling the control system to determine how the visor should rotate. These sensors will be placed at different positions at the front of the vehicle window to facilitate the determination of the visor's optimal position.

- Controller Subsystem: The control system receives information from all the light sensors and converts it into a packet that is transmitted via a data cable to the motor, enabling the motor to adjust the control arm according to the instructions received.

- Motor Subsystem: The motor system comprises three motors, a steel pipe, and a visor. The main motor is responsible for controlling the steel pipe, while the remaining two motors facilitate the rotation and movement of the visor.

- Power Subsystem: This is a straightforward power system to supply all the rest of the subsystem.

### 2.3 Subsystem Requirement

● **Motor Unit:** The initial motion should finish within 5 seconds, and the adjustment motion should react within 0.5 seconds.

- ○ **Motor**$^{1}$ Nema-17 stepper motor: should be solidly fixed on the ceiling and with enough torque be controlled to move in both directions (clockwise and counterclockwise) under a prepared threshold to move the light-weighted steel pipe. PID control system enabled to compromise the inertia effect with right/left turns (y-axis).
- ○ **Motor**$^{2}$ Nema-14 stepper motor: should be solidly attached to the end of the steel pipe and with enough torque be controlled to move in both directions (clockwise and counterclockwise) under a prepared threshold to move the Motor$^{3}$. PID control system enabled to minimize the jitter caused by driving and stopping (x-axis), and car bouncing (z-axis).
- ○ **Motor**$^{3}$ L16-100-150-12-P linear actuator: solidly attached with the light-weighted visor and be programmed to move up/down accordingly.

● **Power Supply Unit:**

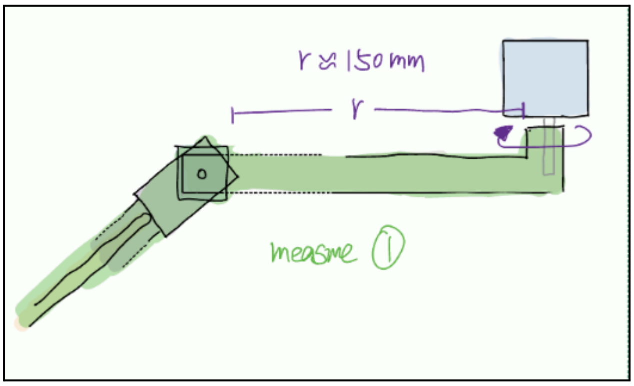
- ○ 12V DC lithium battery ($B^{2}$): as the backup power supply. Should be able to connect to the remaining systems within 5 seconds in case the vehicle's power source fails to support the system when the car engine is cut off.
- ○ 12V DC main power supply ($B^{1}$): to simulate the real vehicle electricity. It can charge the whole visor system.

● **Sensor-feedback Unit**: Use TSL2591 light sensors to get Luminosity (lux) feedback as input into the PCB algorithm. The range of Lux for this sensor is 188µ lux - 88,000 lux (*AMS*) which is sufficient since the sunlight Luminosity is 32,000 to 100,000 lux (*Lux, Lumens and Watts: Our Guide*). The data will be filtered by a threshold (lux) to determine the necessity (true/false) of generating the visor. Totally 8 light sensors.

- ○ Front sense (+x) will have one up and one down.
- ○ Left sense (+y) will have one up and one down.
- ○ Right sense (-y) will have one up and one down.
- ○ Back sense (-x) will have both installed on the side frame.

● **PCB Unit**: The control board contains enough ports for wire connection, correct chips, and microcontroller ATmega328P. This part should take the 8 outputs' data of the sense-feedback unit as input and transfer it into the microcontroller to generate three outputs back to the motor unit to control each motor. The output of the sensor chip should be lux thus our receiving microcontroller should be able to read in lux, and our programing algorithm should be also in lux units to reflect in the real-world simulation. Enable pull-up resistor to stabilize power supply to motor. The algorithm used to get the position of the sun will be based on real-world light sensitivity experiments and data, and the actual installation of the demo frame. Edge cases like entering a tunnel and having different weather conditions will also be considered and tested.

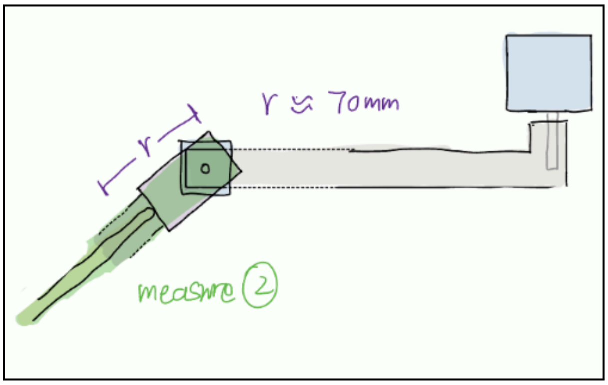
**2.4 Tolerance Analysis**




After discussing with the machine shop, we found a potential issue that our motor may not be able to hold the weight of our entire system. First, we should make sure that the motor1(torque = 59N·cm) can support the whole system, which includes steel pipe (mass = 0.3N), visor (mass = 0.1N), motor2 (mass = 0.14kg*9.8N/kg = 1.372N, torque = 11N·cm), and motor3(mass = 0.074kg*9.8N/kg = 0.7252N). To calculate the torque, we use equation T = F*r*sinθ, for sinθ = 1 to calculate the largest torque.

T1=(0.3+0.1+1.372+0.7252) *15 = 37.458N·cm

The torque of motor1 can support the entire system.




Second, we should make sure that motor 2 (torque = 11N·cm) can support motor 3 and visor. To calculate the torque, we use equation T = F*r*sinθ, for sinθ = 1 to calculate the largest torque.

T2 = (0.1+0.7252) *7 = 5.7764N·cm

The torque of motor 2 can support motor 3 and the visor.

## 3. Ethic & safety

- While the primary goal of the project is to improve driving safety by reducing sun glare, the system's reliability and response time are critical. If the system fails to operate correctly or introduces a delay, it could distract the driver or obscure their vision, leading to accidents. We should ensure the final system would not cause anything to interrupt the driving process.

- In critical situations where the vehicle's power supply is compromised, or the system's electronics fail, the ability to manually adjust the visor should remain straightforward and accessible to the driver to ensure visibility is maintained.

- Before engaging in tasks such as soldering, team members should receive proper training and follow proper safety protocols.

- For the final demonstration, we’ll use a frame to model the light changing and car movement instead of using a real car. Also, we will make sure that everyone won’t get hurt when we are managing the frame.

## Reference:


[1] *AMS TSL25911 ambient light sensor ambient light, color, spectral & Proximity Sensors - AMS-Osram* (n.d.) *ams*. Available at: https://ams-osram.com/products/sensors/ambient-light-color-spectral-proximity-sensors/ams-tsl25911-ambient-light-sensor

[2] *Read our ultimate guide to lux vs lumens vs Watts for lighting installations: Warehouse & Factory Lighting* (n.d.) *Green Business Light*. Available at: https://greenbusinesslight.com/resources/lighting-lux-lumens-watts/

[3] *Read our ultimate guide to lux vs lumens vs Watts for lighting installations: Warehouse & Factory Lighting* (no date) *Green Business Light*. Available at: https://greenbusinesslight.com/resources/lighting-lux-lumens-watts/ (Accessed: 21 February 2024)