Overview

- Introduction
- Objective
- Design
  - Hardware
  - Software
  - Mechanical Structure
- Functional Test
- Successes and Challenges
- Future Work
Introduction
Common Construction Helmet

Problem: Helmet only shield the sunlight from front but not other directions.
Our Solution: Self-Adjusting Helmet
Objective
Objective

- Brim rotates to the correct directions
- Detect the falling down cases
  - LEDs flash
  - Alarm rings
- Overall cost is affordable
Demo
Design
Hardware Design

- Power Module
- Sensing Module
- Control Module
- Actuator
Power Module

LDO (5V)

LDO (3.3V)
LDO Circuit
LDO Circuit

● Adjustable Output Voltage

\[ V_{out} = \left(1 + \frac{R_1}{R_2}\right)V_{ref} \Rightarrow \frac{R_1}{R_2} = \frac{V_{out}}{V_{ref}} - 1 \]

● Choose Appropriate Resistors

○ Reference Voltage: 0.4V

○ 3.3V Output: R1=33k  R2=4.7k

○ 5.0V Output: R1=23.5k  R2=2k
Sensing Module - Light Sensor

OPT 3001
Light Sensor
Light Sensor Circuit

- I2C Communication
- Wide Detection Range: 0 - 83,000 lux
Sensing Module - Accelerometer

LIS3DHTR Accelerometer
Accelerometer Circuit

- Fall Detection: Interrupt Pin to Controller
Control Module
# Microcontroller - Control Signal Flow

<table>
<thead>
<tr>
<th>Pin Number</th>
<th>Control Signal Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC6</td>
<td>Reset Button</td>
</tr>
<tr>
<td>PD2 (Digital Pin 2)</td>
<td>Accelerometer (Interrupt)</td>
</tr>
<tr>
<td>PD5, PD6, PD7, PB0 (Digital Pin 5,6,7,8)</td>
<td>Motor Driver</td>
</tr>
<tr>
<td>PB1 (Digital Pin 9)</td>
<td>Speaker</td>
</tr>
<tr>
<td>PB2 (Digital Pin 10)</td>
<td>LED Bar</td>
</tr>
<tr>
<td>PB3, PB4 (Digital Pin 11,12)</td>
<td>Limit Switch</td>
</tr>
<tr>
<td>PC4</td>
<td>SDA</td>
</tr>
<tr>
<td>PC5</td>
<td>SCL</td>
</tr>
</tbody>
</table>
Actuator - Stepper Motor

- 28BYJ-48 Stepper Motor
- ULN2003 Motor Driver
Alarm LED - Circuit
Software Design

// Atmega328p digital pins:
// Accelerometer: pin 2;
// Speaker: pin 9;
// Leds: pin 10;
// Motors: pin 5, 6, 7, 8;
// Limit switch: pin 11, 12;

Setup motor, IMU;
Initialize communication protocols;
while (not hit switch):
    rotate brim clockwise
Center brim;

while true:
    collect light information and rotate brim
    check fall flag and alarm
Software Design - Light Detection

Start

- Initialize the brim angle t0 0

- Read the light intensity data d1,d2,d3,d4.

- All the data are greater than a threshold t1
  - Yes: Find the maximum m1 and the second largest value m2.
  - No: Keep the brim in the central position

- [m1-d]> t2 for any d in {d1,d2,d3,d4} is m1
  - Yes: Calculate the output angle and update the brim position.
  - No: Keep the brim in the current position

- Send signal to the motor driver

End
Software Design - Light Detection

- **Output Angle Calculation**
  - $m_1$: maximum light intensity
  - $m_2$: second largest light intensity

\[
r = \frac{m_1}{m_1 + m_2}
\]

Output Angle $= r \times m_1 + (1 - r) \times m_2$
Mechanical Structure

PULLEY
(ATTACHED TO STEPPER MOTOR)

HELMET
(TOP VIEW)
Functional Test
Power Module - 3.3V DC Output Test

Tests with Different Input Voltages

Input: 4V
Output: 3.144V

Input: 5V
Output: 3.144V

Input: 6V
Output: 3.146V
Power Module - 5.0V DC Output Test

Tests with Different Input Voltages

Input: 5V
Output: 4.941V

Input: 6V
Output: 5.038V
Light Sensor - Light Intensity Measurement

Sensor Consistency Test

Light intensity (Lux)

- Blue
- Orange
- Gray
Light Sensor - Light Intensity Measurement

Light intensity from different angles

Sensor value from different incidence angle
Conclusion
Success

- Accurate Light Detection
- Brim Rotation
- Fall Detection with Few False Alarms
Challenges

● Lithium Battery and Battery Charger
   ○ Abandoned Because of Voltage Issues

● Light Sensor Board
   ○ 4 Configurations

● Mechanical Structure
   ○ Confort
   ○ Material
Future Work
Future Work

● A magnet that embedded inside the track
  ○ Brim is driven by attraction of the magnets.

● Integrate the charger module into the design.

● rebuild the software as multiple threads
Credit

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Thank you!