Preliminary Design Presentation

Driver Fatigue Detector

Advisor: Professor Pouraghily
Member: Jiong Wang
Hongyu Ba
Yachen Liu

Team Members

Hongyu Ba
Hardware

Jiong Wang(leader)
Hardware

Yachen Liu
software

Contents

- Problem statement
- Feasibility analysis
- Design alternative
- Team roles and schedule

Problem statement

How significant is the problem?

- In China, The number of traffic accidents caused by driver fatigue is 100,000 per year.
- 71,000 people are injured in accidents by driver fatigue in China
- Worldwide, In the freight industry, 57% of fatal truck traffic accidents are due to driver fatigue.

Problem statement

The disadvantages of current products

- Mercedes-Benz：The "Blink Monitoring" system
  - driver's blink frequency and the duration of each closed eye.
  - only has a fatigue driving monitor for more than two million.

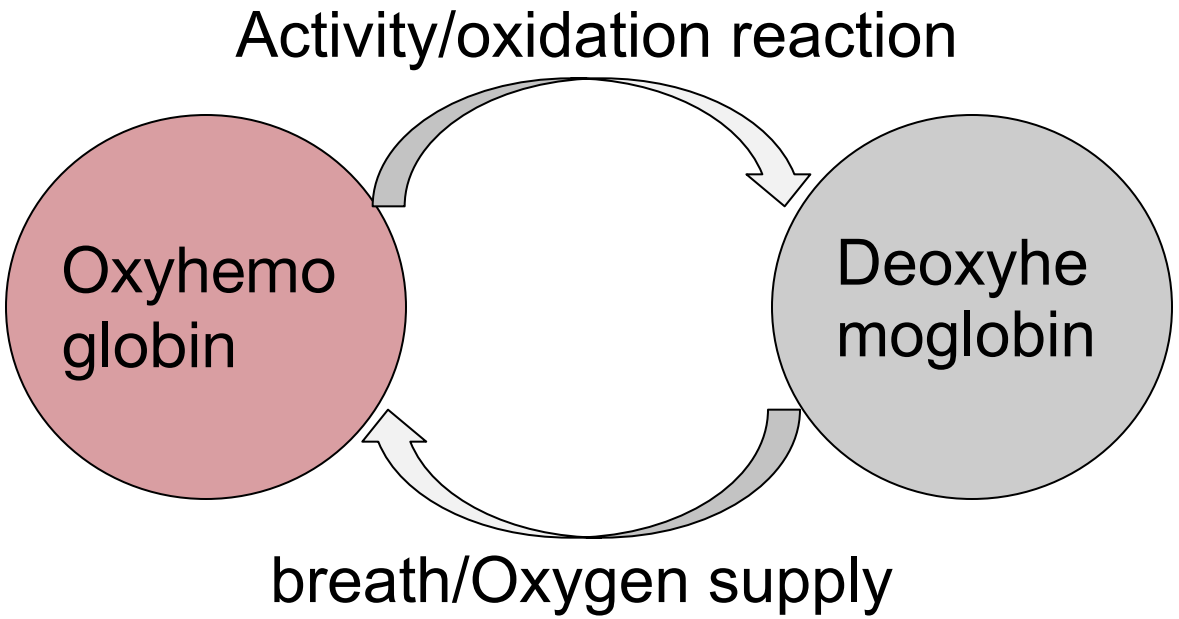
- “SMART EYE” Company in Sweden
  - eye detection and facial expression detection.
  - multiple cameras

Problem statement

The aims of our design

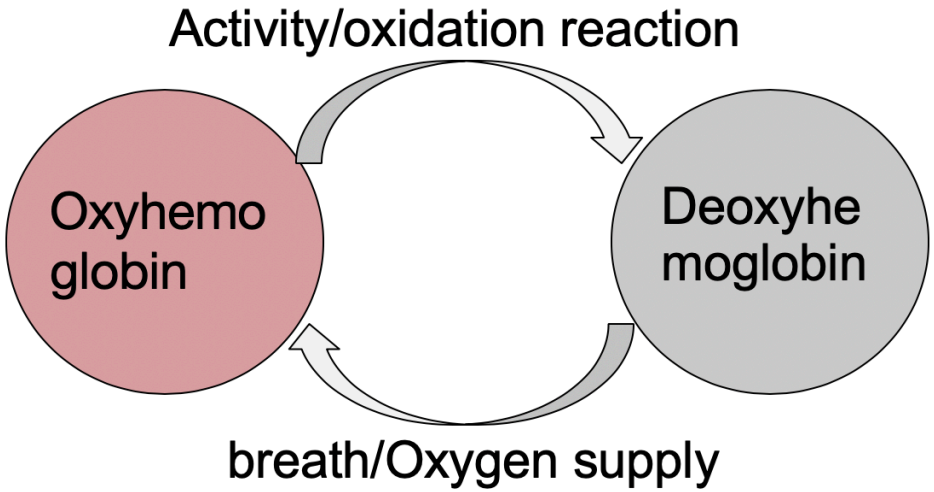
- Non-invasive
- Continuous
- Real-time
- Accurate

Feasibility Analysis



- Normally, the blood oxygen content maintains a relative dynamic balance.

Feasibility Analysis



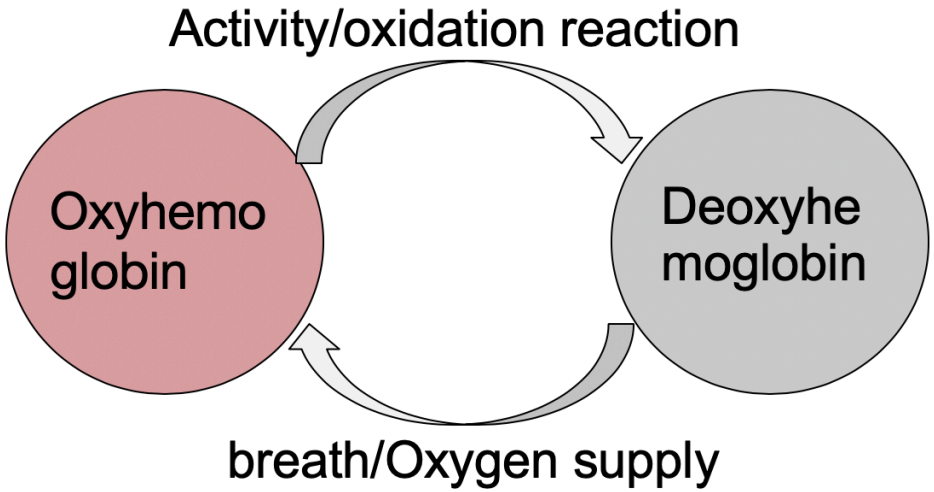
- Biology:

  Fatigue state ⟶ The ability of HbR to bind the oxygen↓⟶

  The activity needs to kept going ⟶

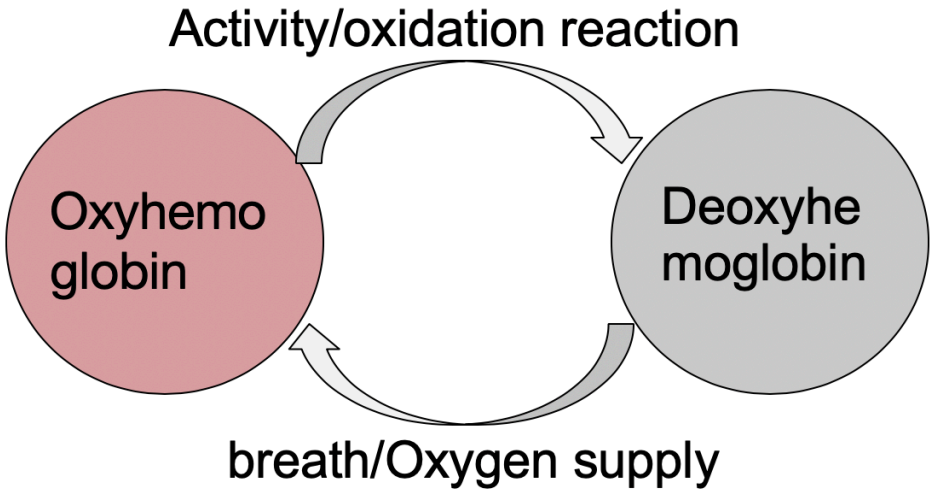
  The content of HbR ↑ and the content of HbO ↓.

Feasibility Analysis



- Clinical Medicine:
  Blood oxygen content < normal value⟶
  The content of HbR ↑ and the content of HbO ↓⟶
  Main symptoms : fatigue, drowsiness and lethargy.

Feasibility Analysis



- The content of HbR and HbO in the blood can reflect the physiological state of the human body.
- the change of the two can be used to understand the activity level of the human body.

Feasibility Analysis

Philips Medical Systems SpO_2 Monitoring

Understanding Pulse Oximetry SpO_2 Concepts

What is SpO_2?

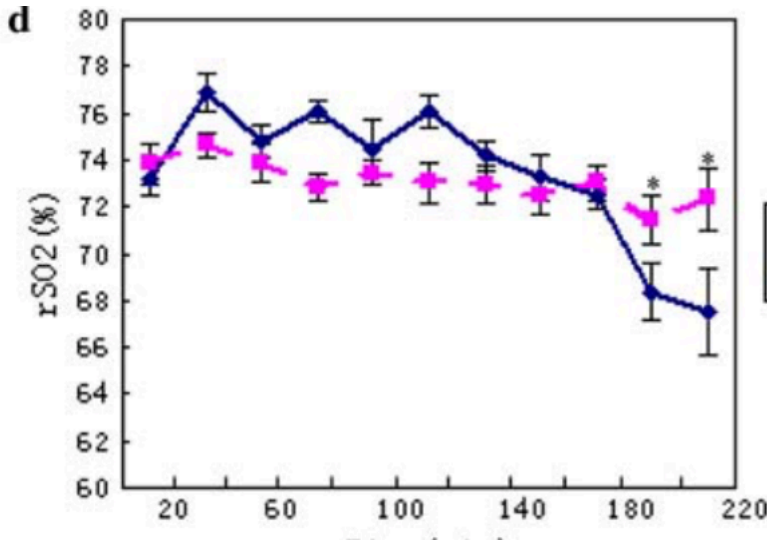
A blood-oxygen saturation reading indicates the percentage of hemoglobin molecules in the arterial blood which are saturated with oxygen. The reading

Pulse oximeters usually assume there are no non-functioning hemoglobins in the arterial blood and measure the blood oxygen saturation as:

$$100 \times \frac{HbO_2}{Hb + HbO_2}$$

Feasibility Analysis

In this study, the cerebral oxygen saturation decreased significantly by 6.94 ± 1.74% following 3-h driving task. The subjects reported exhibiting evident fatigue symptoms such as tiredness, irritability, mentally sluggishness, the lack of energy, headache, and sleepiness after the task.



"Gold standard" for fatigue monitoring

Reference:
Zengyong L .Assessment of cerebral oxygenation during prolonged simulated driving using near infrared spectroscopy: its implications for fatigue development Eur J Appl (2009) 107:281–287

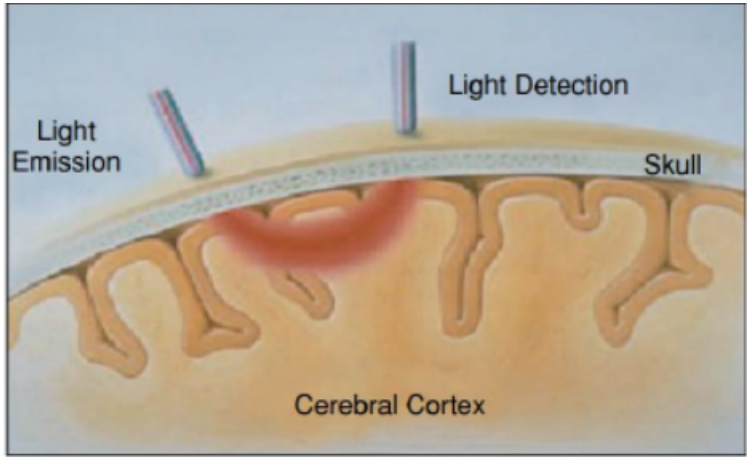
Feasibility Analysis

Principle

- FNIRS (Functional Near Infrared Spectroscopy)

➢ Jobsis in 1977 demonstrated NIRS could detect the oxygen changes in blood

➢ HbR , HbO in the blood and their total blood volume have three absorption peaks at 735 nm , 850 nm and 805nm respectively.



Reference:
Jöbsis, F.F.(1977) Noninvasive, Infrared Monitoring of Cerebral and Myocardial Oxygen Sufficiency and Circulatory Parameters. Science, 198, 1264-1267.

Feasibility Analysis

Principle

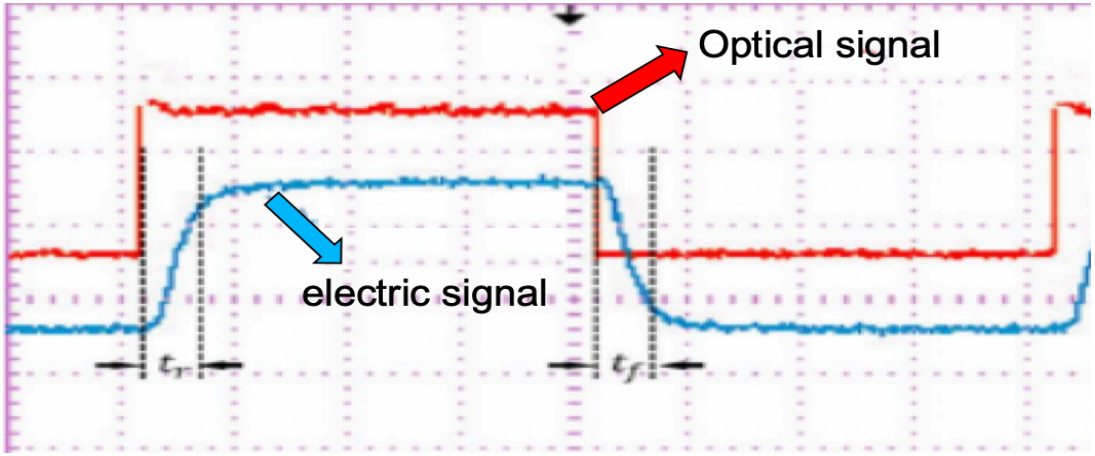
Photoelectric Effect

This change in the electrical properties of the object due to the illumination of light is the photoelectric effect.

- the object emits electrons,
- or changes the electrical conductivity of the object,
- or causes the object to generate a photoelectromotive force.

Feasibility Analysis

Photoelectric Sensors



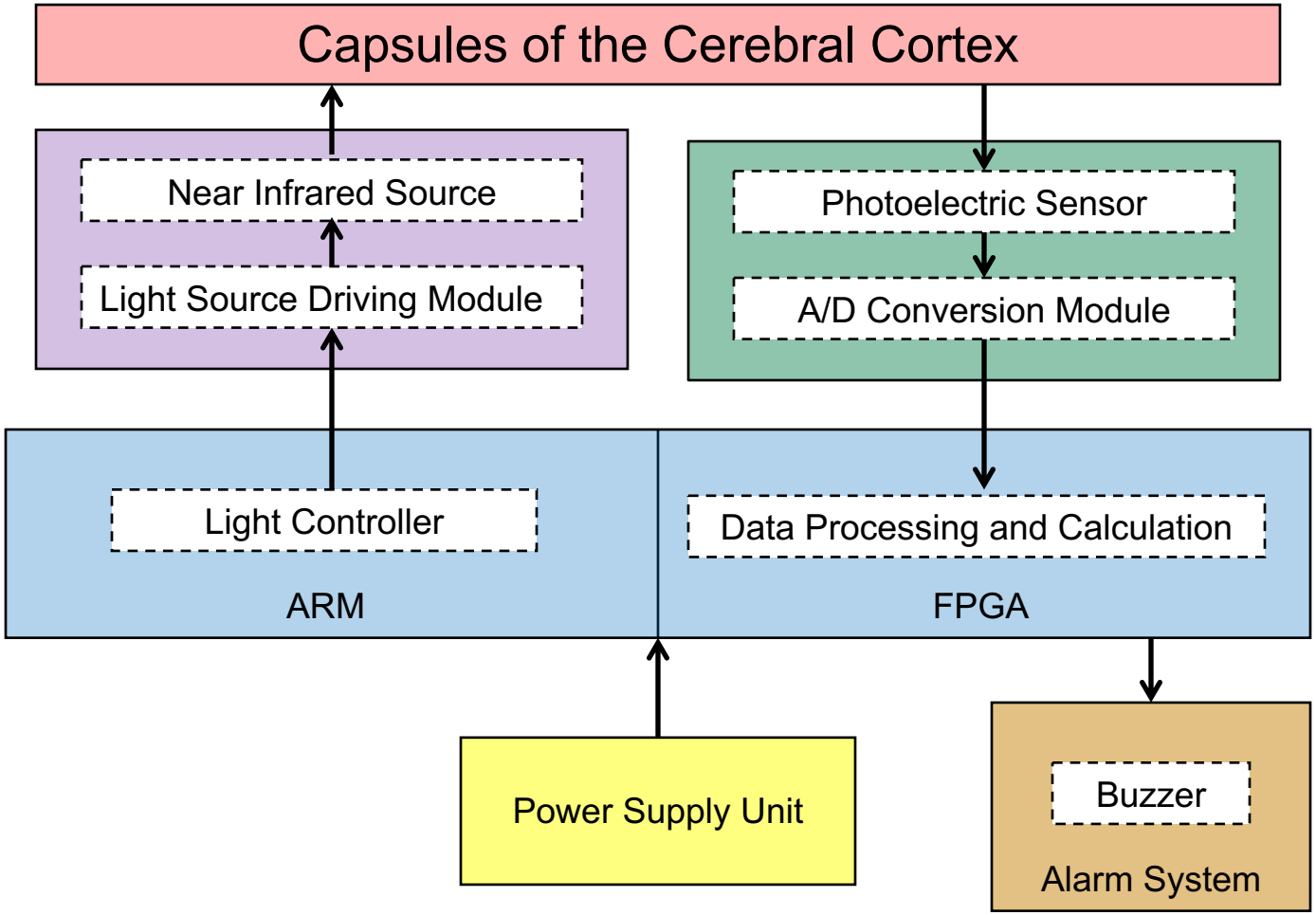
- Two significant parameters:
  - Responding speed
  - Sensitivity

Feasibility Analysis

Multiple Photoelectric Sensors

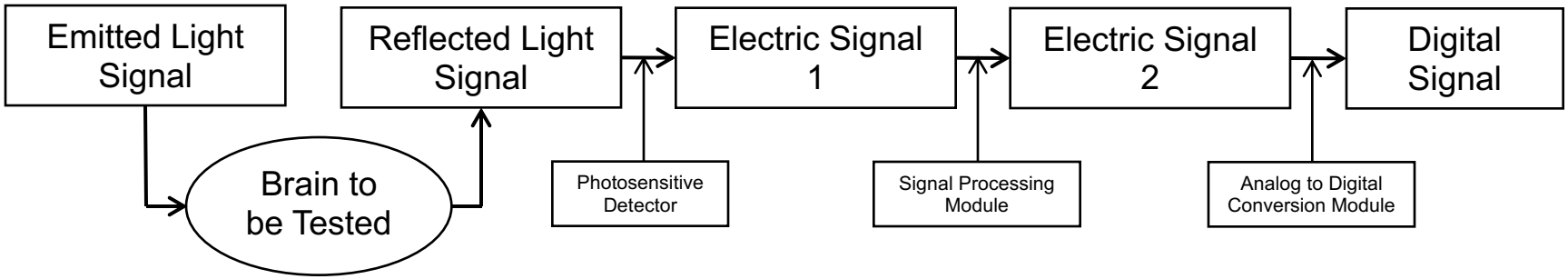
Types	Responding speed	Sensitivity
Silicon photodiode	Medium（10KHz）	low
Avalanche photodiode	Fast（>100MHz）	High
Photomultiplier tube（*）	Fast (>100MHz)	high
Charge-coupled device	Slow (1KHz)	medium

Design Alternatives



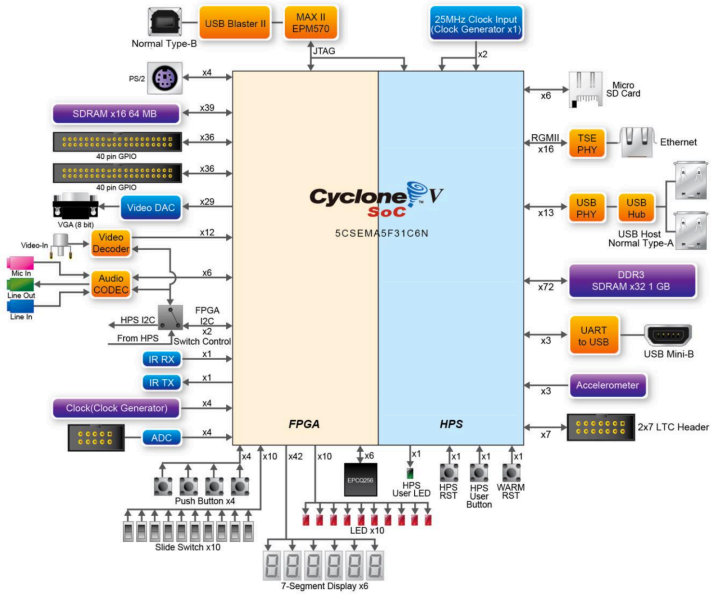
Design Alternatives

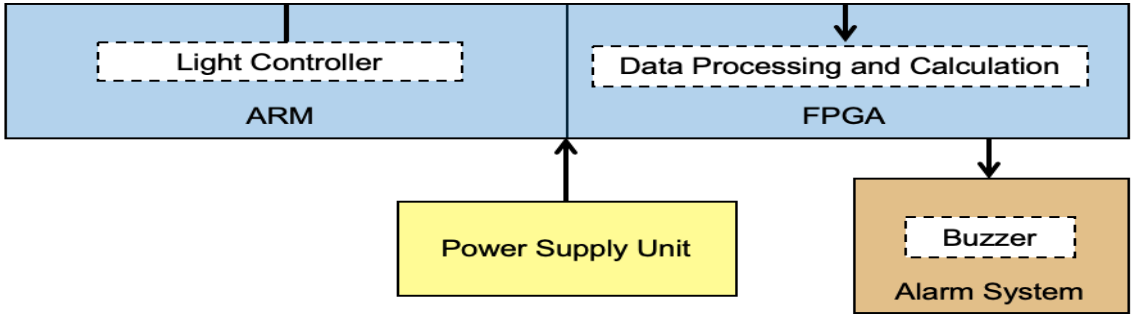
Signal Conversion Process



Design Alternatives

- DE1-SoC
- Hardware
  - FPGA -- Dealing with Data and Calculation
  - ARM -- Control Module
- Algorithm
  - Light Source Driving Algorithm
  - Data operation Algorithm

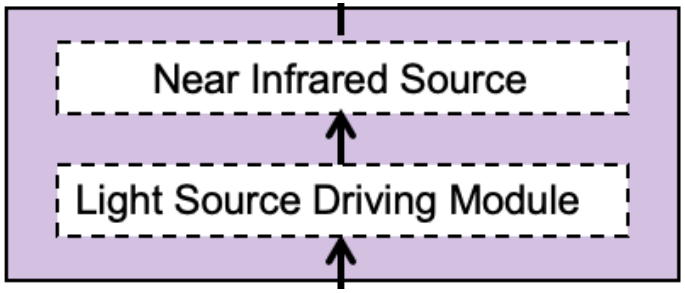




Design Alternatives

Hardware

- LEDs
  - 735nm -- HbR
  - 850nm – HbO
  - 805nm -- blood volumn
- Light Source Driver chip
  - Driving three LEDs with different wavelength

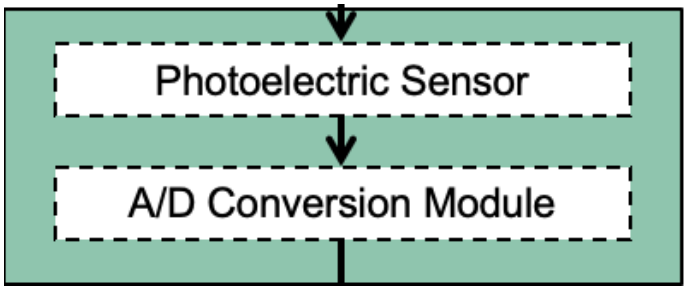


Design Alternatives

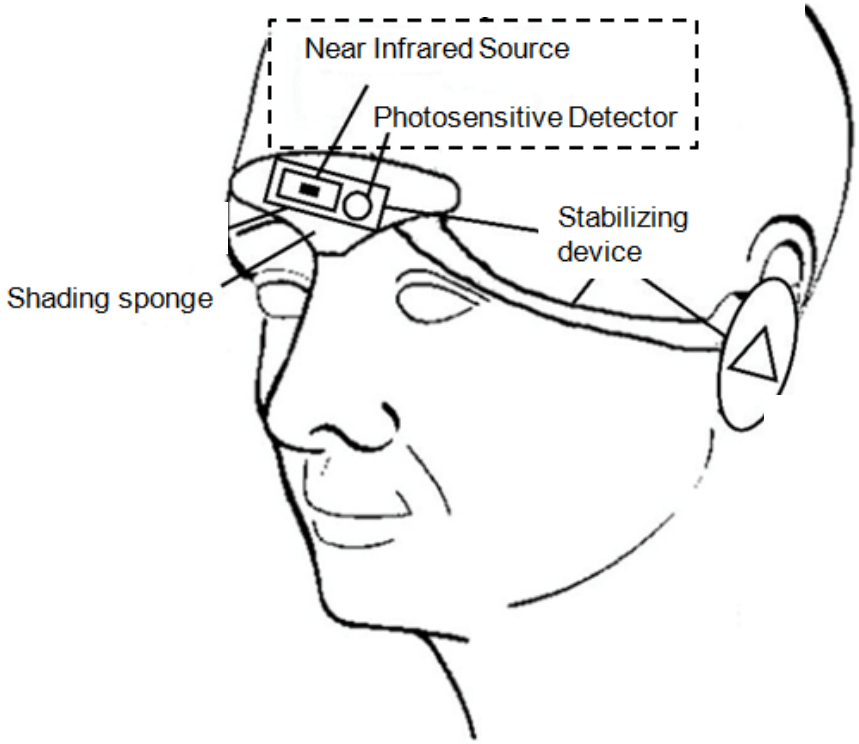
Hardware

- Photoelectric sensor
  - ➢ Convert optical signals into analog signals

- A/D converter
  - ➢ Convert analog signals into digital signals



Feasibility Analysis



Buget

Infrared Sources：50$ * 3 =150$
AD Convertor : 70$
Photoelectric Sensor :70$
Driver chips : 30$
Others : 150$
Total : 470$

Fatigue Driving Detector

Thank you!
Questions?