Midterm Design Review

Fatigue Driving Detector

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- Feasibility analysis and system description
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Problem statement

How significant is the fatigue driving?

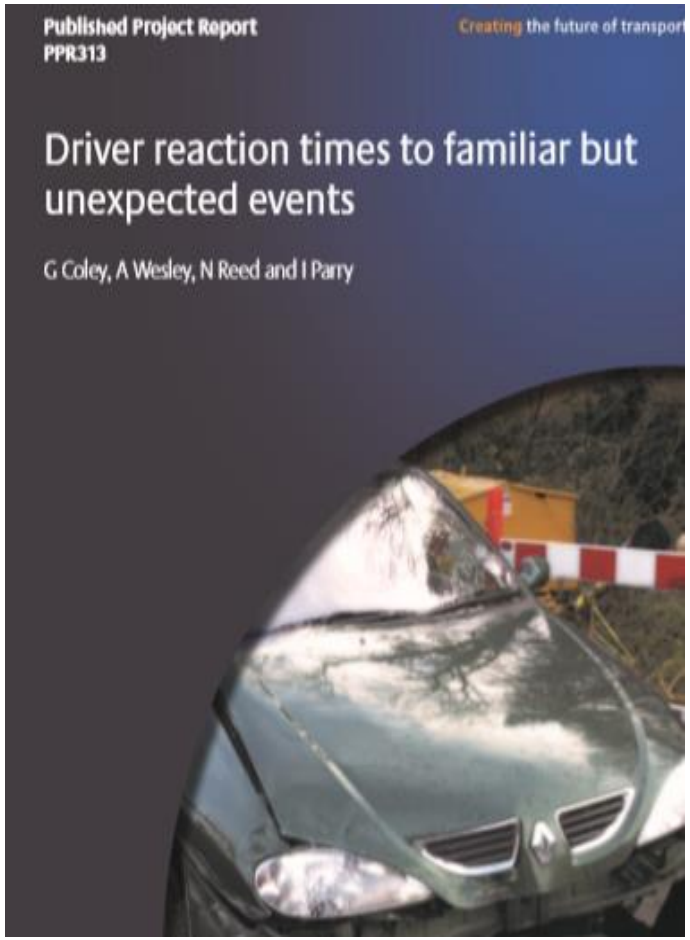
- In China, The number of traffic accidents caused by fatigue driving is 100,000 per year.
- 71,000 people are injured in accidents by fatigue driving in China
- In the freight industry across the world, 57% of fatal truck traffic accidents are due to fatigue driving.

Feasibility analysis

The reaction time of fatigue driving

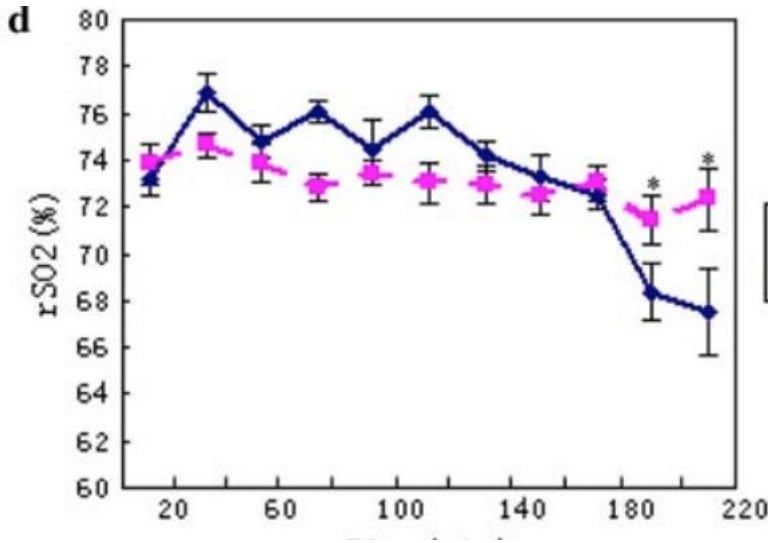
	Average	15th Percentile	50th Percentile	85th Percentile
Brake Assist				
Run 1 (Cars / Pedestrians Emerging)	0.85	0.67	0.81	1.02
Run 1 (Braking Vehicle Ahead)	1.30	0.80	0.99	2.01
Gantry Collapse				
Time to Apply Brake	1.53	1.18	1.35	1.84
Time to Apply Steering	1.54	1.08	1.45	2.15
Unexpected Stationary Vehicle				
Time to Apply Brake	3.52	2.17	3.35	4.79
Time to Apply Steering	5.08	4.23	5.00	6.34
Driver Fatigue				
Run 1, All Reaction Tasks	1.12	0.86	1.05	1.38

Table – Driver Reaction Time Summary Table



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

System description

Reaction Time System（before driving）：

- Calculate the costumers' real-time reaction time and compare it with the fatigue driving reaction time(0.86s) from the reference

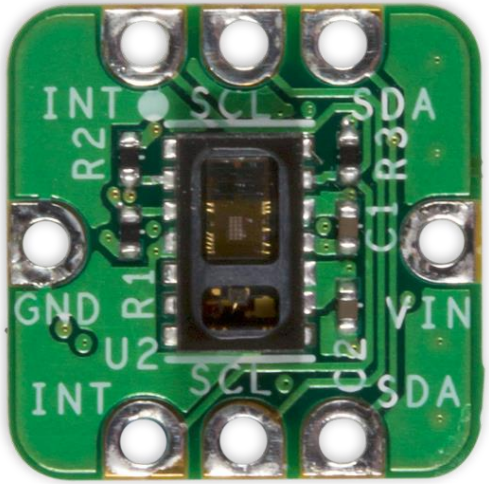
- Test the reaction time 5 times every 20 minutes and take the average value. When the average customer reaction time is found to be greater than or equal to the reaction time of fatigue driving, record the SpO_2 value at this time as the fatigue critical value.

System description

SpO2 System（during driving）：

- Calculate the costumers' real-time SpO_2 value and compare it with the fatigue critical value from Reaction Time System.
- When the customer SpO_2 value is equal to or less than the fatigue critical value, the system will issue an alarm (LED), to avoid fatigue driving

Equipment

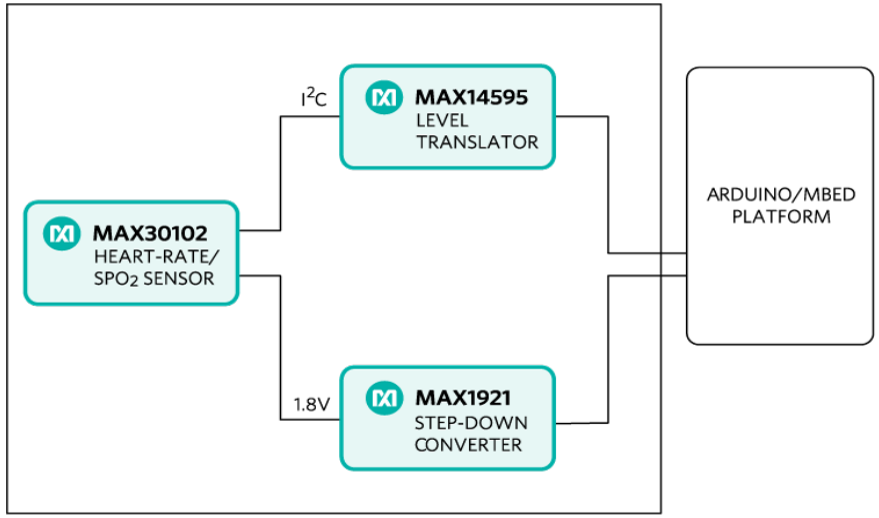


MAXREFDES117# Board

The MAXREFDES117# reference design

- A low power, optical heart rate and SpO_2 module complete with integrated red and IR LEDs.
- This board works with both Arduino and Mbed platforms
- This board can be placed on a finger (steeling wheal) to accurately detect heart rate and SpO_2 value

Equipment

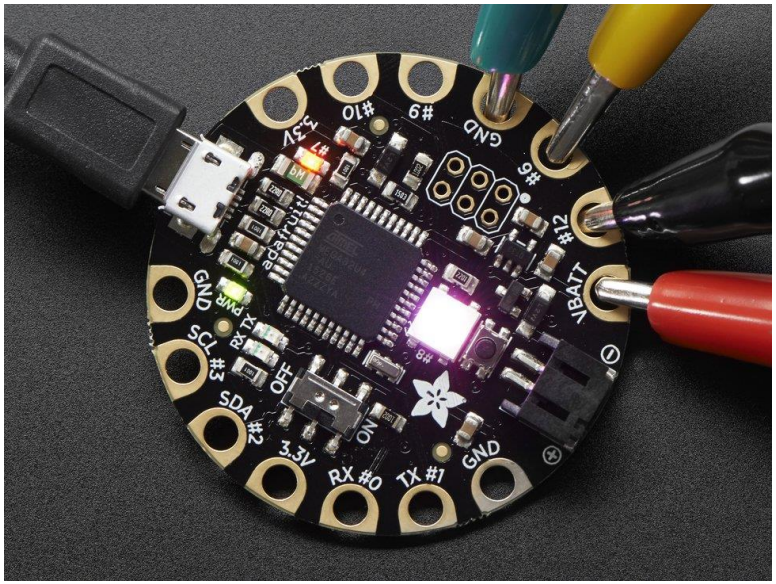


Three chips:

- a SpO_2 and heart-rate sensor (MAX30102);
- an efficient, low-power step-down converter (MAX1921);
- an accurate level translator (MAX14595).

The board requires only a single 2V to 5.5V supply

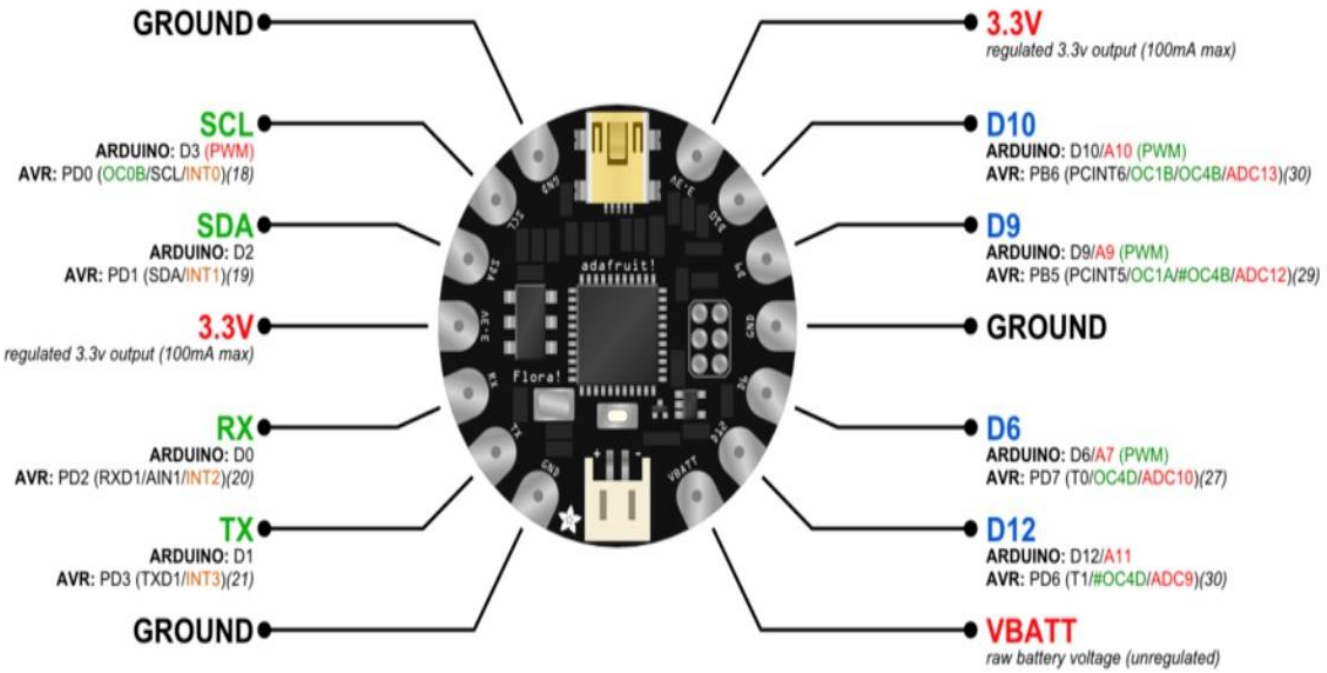
Equipment Adafruit FLORA - v3



FLORA is Adafruit's fully-featured electronics platform.

- an Arduino-compatible microcontroller
- has built-in USB support.
- has 4 indicator LEDs
- An ICSP connector for easy reprograming for advanced users.

Equipment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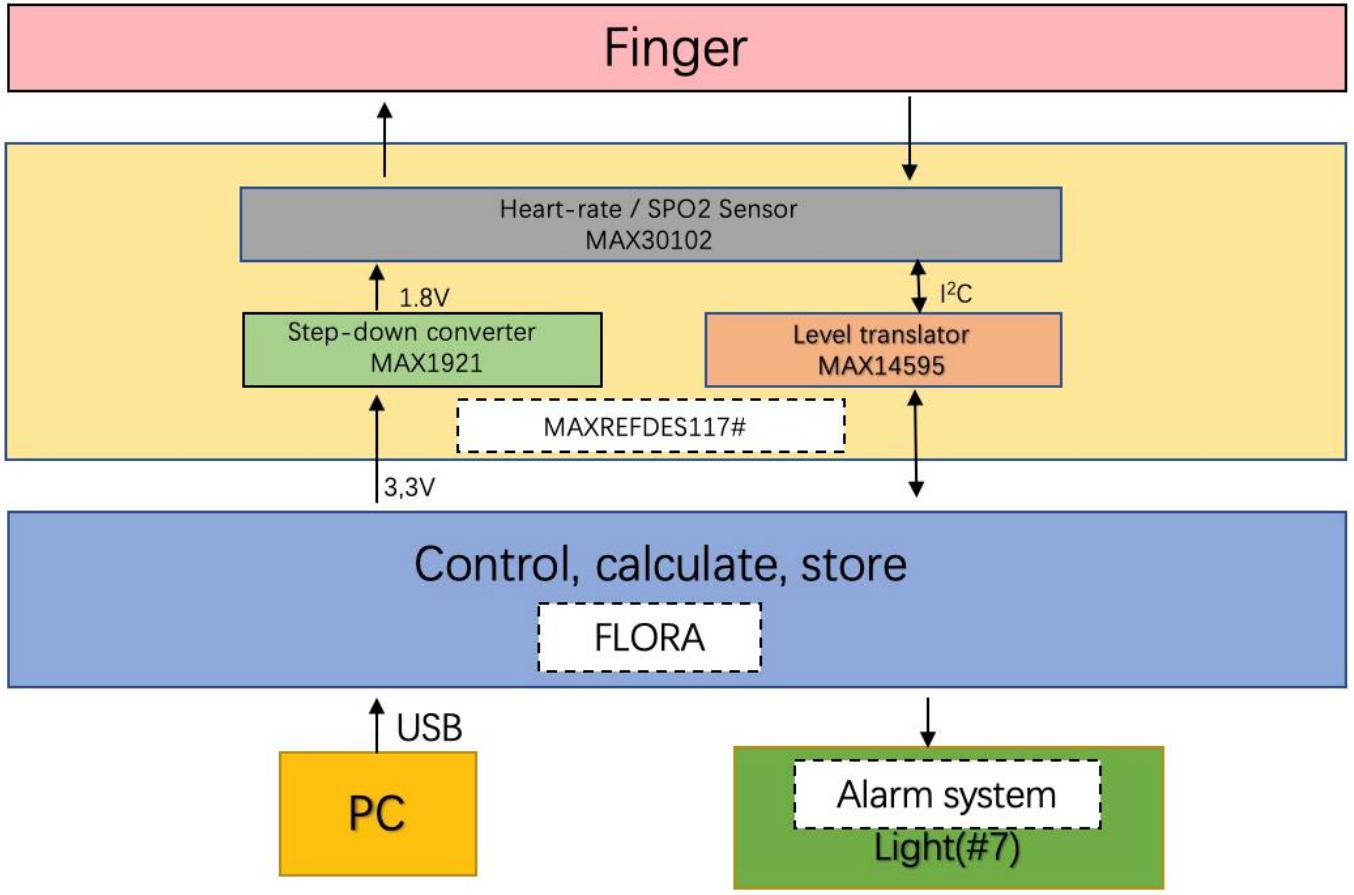
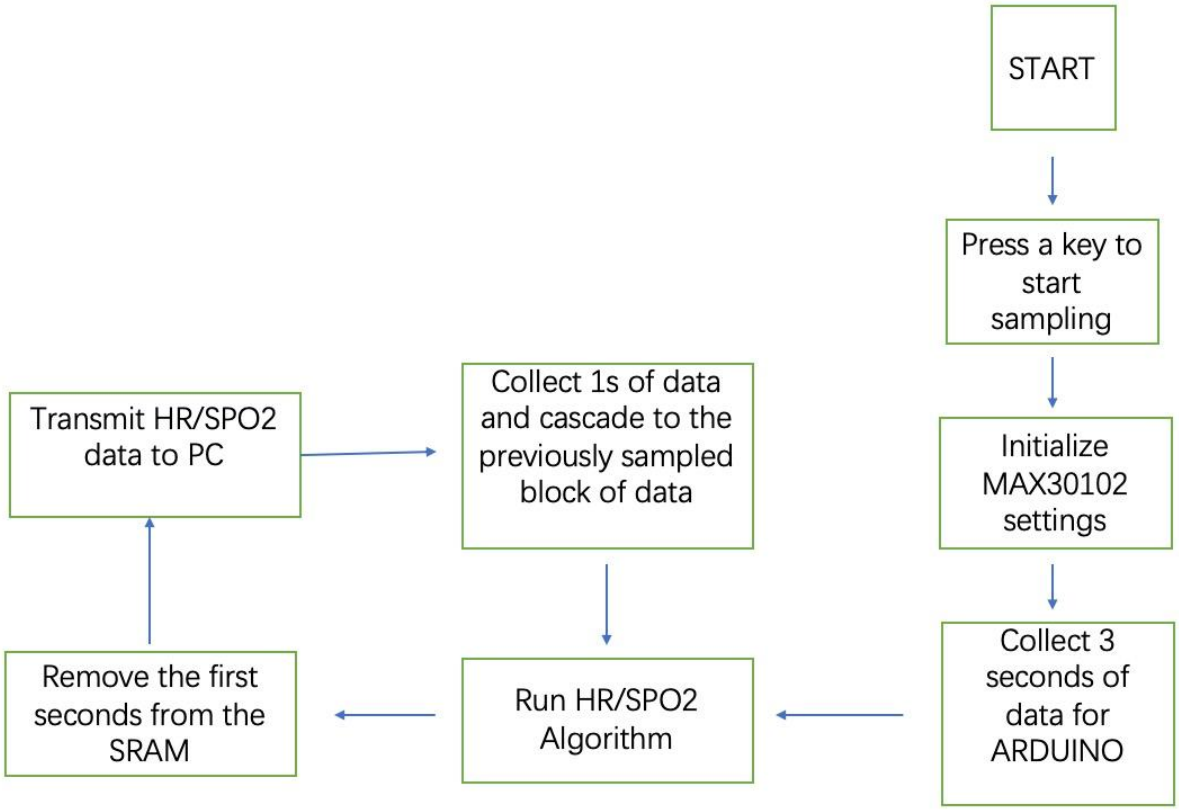
SCL
ARDUINO: D3 (PWM)
AVR: PD0 (OC0B/SCL/INT0)(18)
SDA
ARDUINO: D2
AVR: PD1 (SDA/INT1)(19)
3.3V
regulated 3.3v output (100mA max)
RX
ARDUINO: D0
AVR: PD2 (RXD1/AIN1/INT2)(20)
TX
ARDUINO: D1
AVR: PD3 (TXD1/INT3)(21)
GROUND
3.3V
regulated 3.3v output (100mA max)
D10
ARDUINO: D10/A10 (PWM)
AVR: PB6 (PCINT6/OC1B/OC4B/ADC13)(30)
D9
ARDUINO: D9/A9 (PWM)
AVR: PB5 (PCINT5/OC1A/#OC4B/ADC12)(29)
GROUND
D6
ARDUINO: D6/A7 (PWM)
AVR: PD7 (T0/OC4D/ADC10)(27)
D12
ARDUINO: D12/A11
AVR: PD6 (T1/#OC4D/ADC9)(30)
VBATT
raw battery voltage (unregulated)

Block diagram



Software flowchart



Core Algorithm

$$SpO_2 = C_1 \times AverageRatio^2 + C_2 \times AverageRatio + C_3$$

Where AverageRatio is the average ratio of IR and red LED readings. C_1, C_2, and C_3 are constants.

$C_1 = -40.060$
$C_2 = 30.354$
$C_3 = 94.845$

Reference:
https://www.maximintegrated.com/en/design/reference-design-center/system-board/6300.html/tb_tab1

Core Algorithm

```
//uch_spo2_table is approximated as  -45.060*ratioAverage* ratioAverage + 30.354 *ratioAverage + 94.845 ;
const uint8_t uch_spo2_table[184]={ 95, 95, 95, 96, 96, 96, 97, 97, 97, 97, 97, 98, 98, 98, 98, 98, 99, 99, 99, 99,
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                                    28, 27, 26, 25, 23, 22, 21, 20, 19, 17, 16, 15, 14, 12, 11, 10, 9, 7, 6, 5,
                                    3, 2, 1 } ;
```
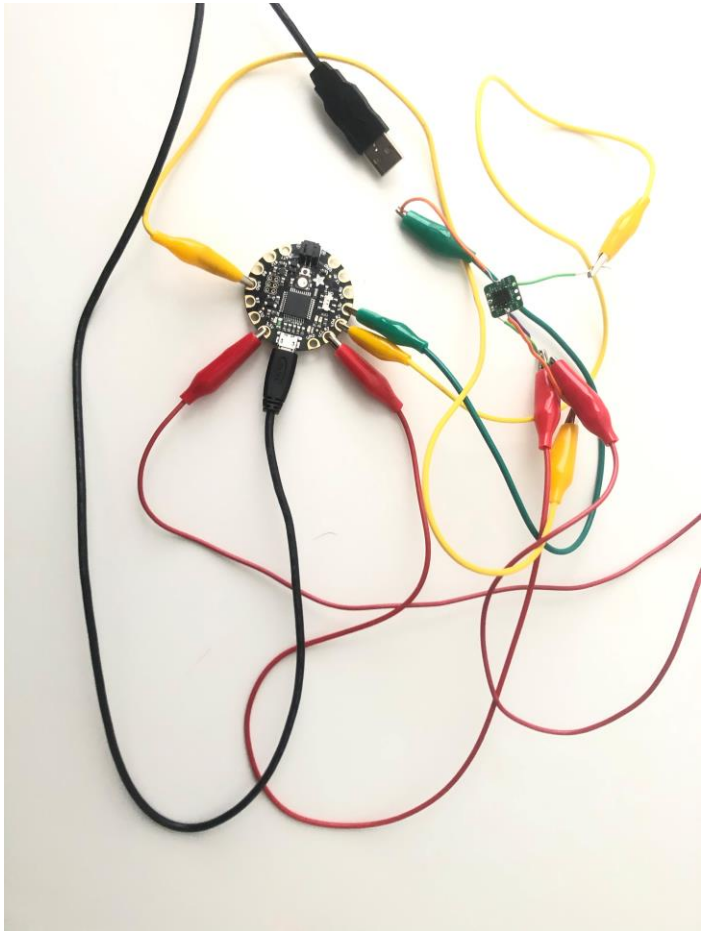
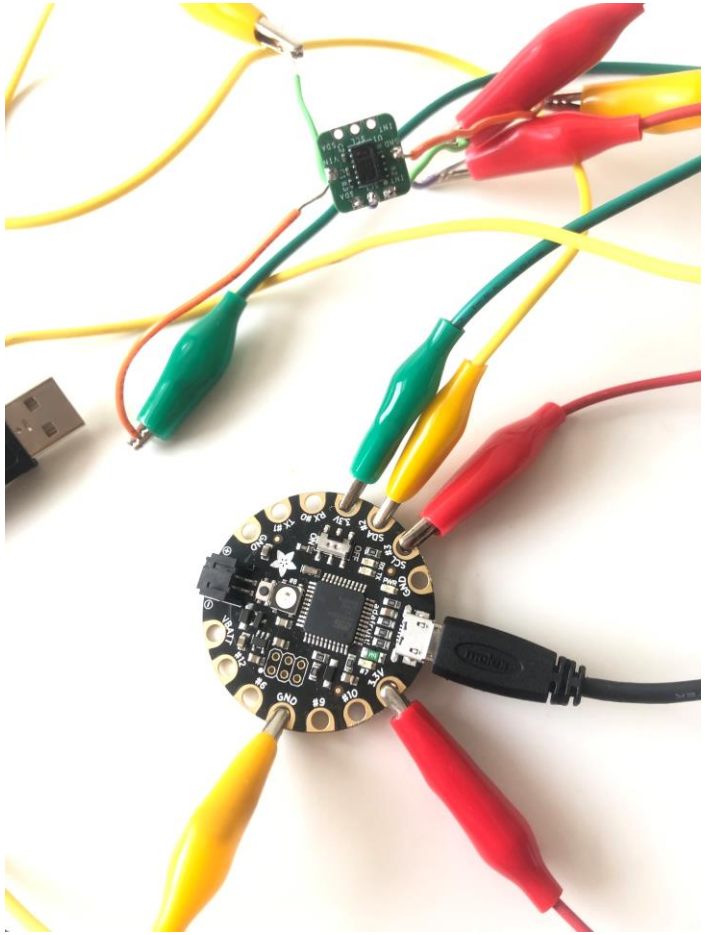
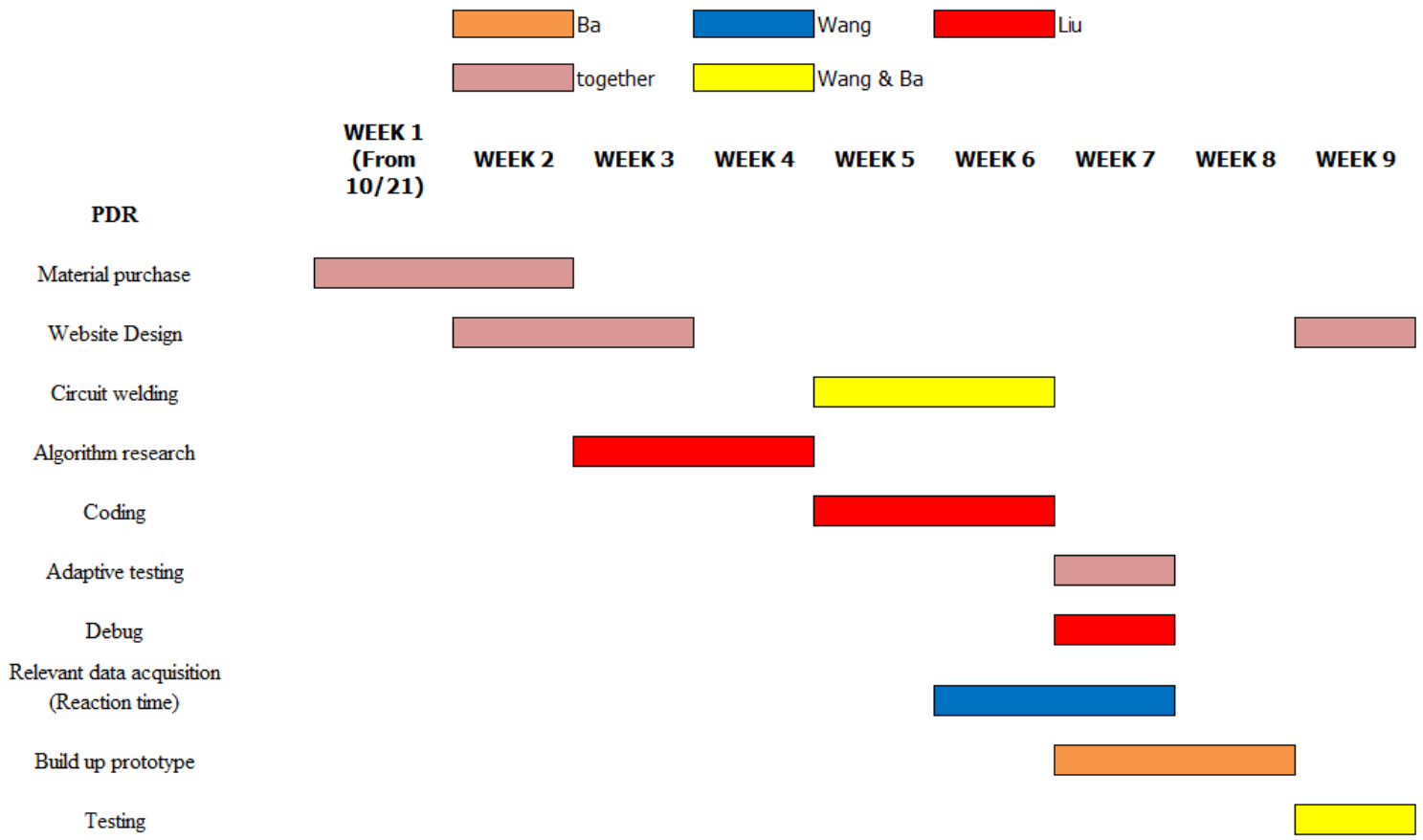

```
if( n_ratio_average>0 && n_ratio_average <184){
  n_spo2_calc= uch_spo2_table[n_ratio_average] ;
  *pn_spo2 = n_spo2_calc ;
  *pch_spo2_valid  = 1;
}
else{
  *pn_spo2 =  -999 ;
  *pch_spo2_valid  = 0;
}
}
```

Our Design



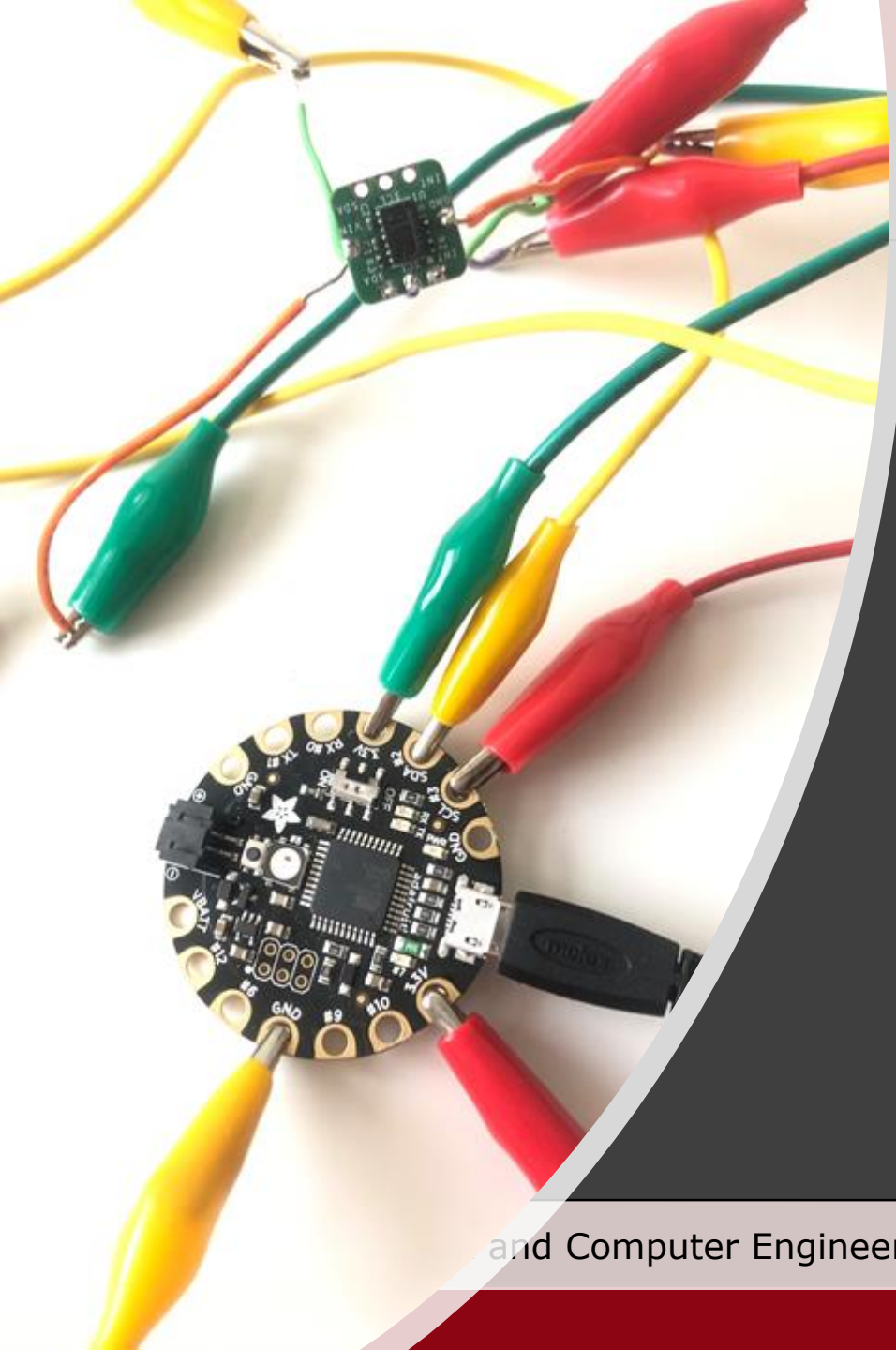


Schedule Bar Chart



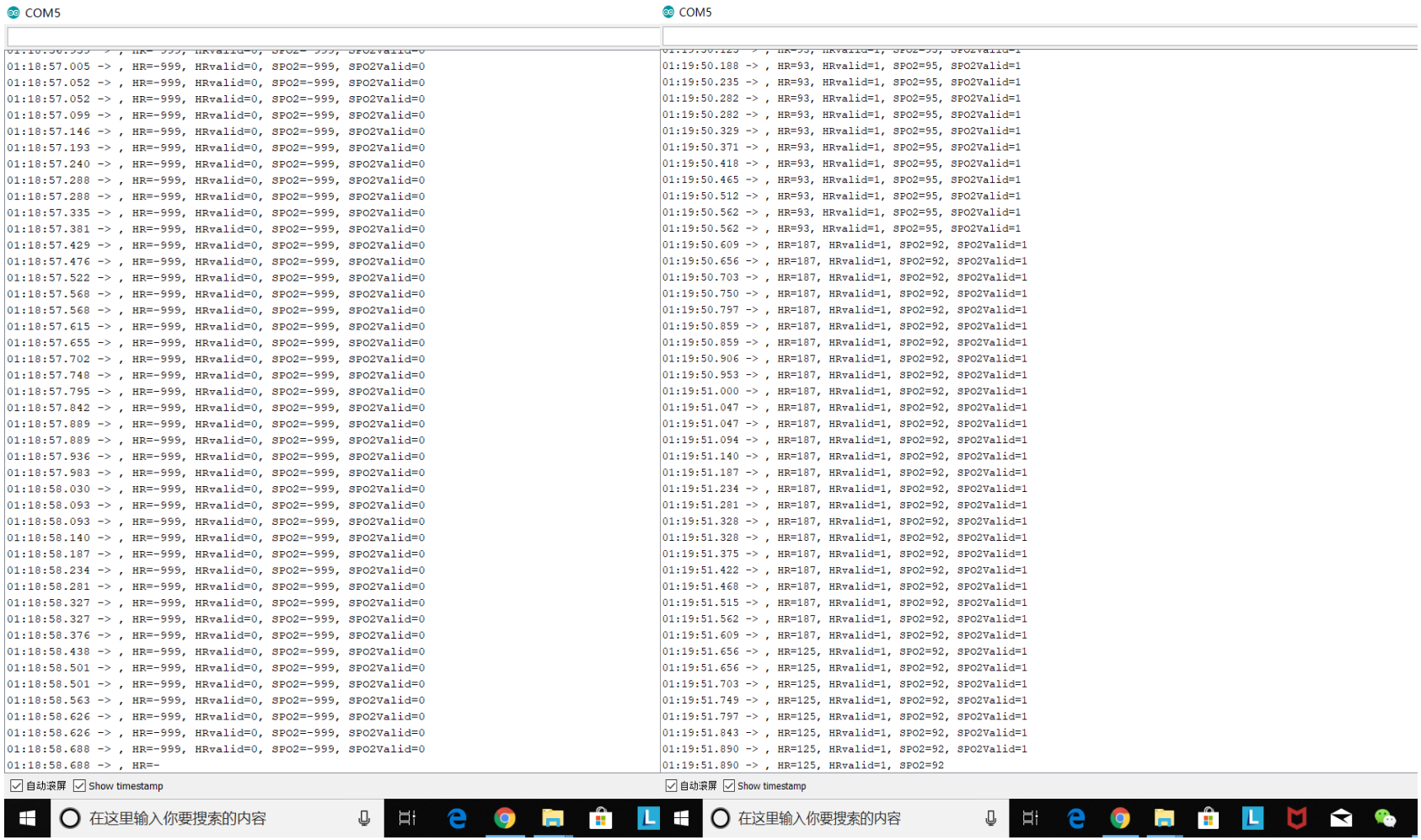
Future work

- Improve system stability and accuracy of data acquisition
- Establish detailed reaction time testing procedures
- Analyze and process data to develop more accurate fatigue states



Demo

Outcome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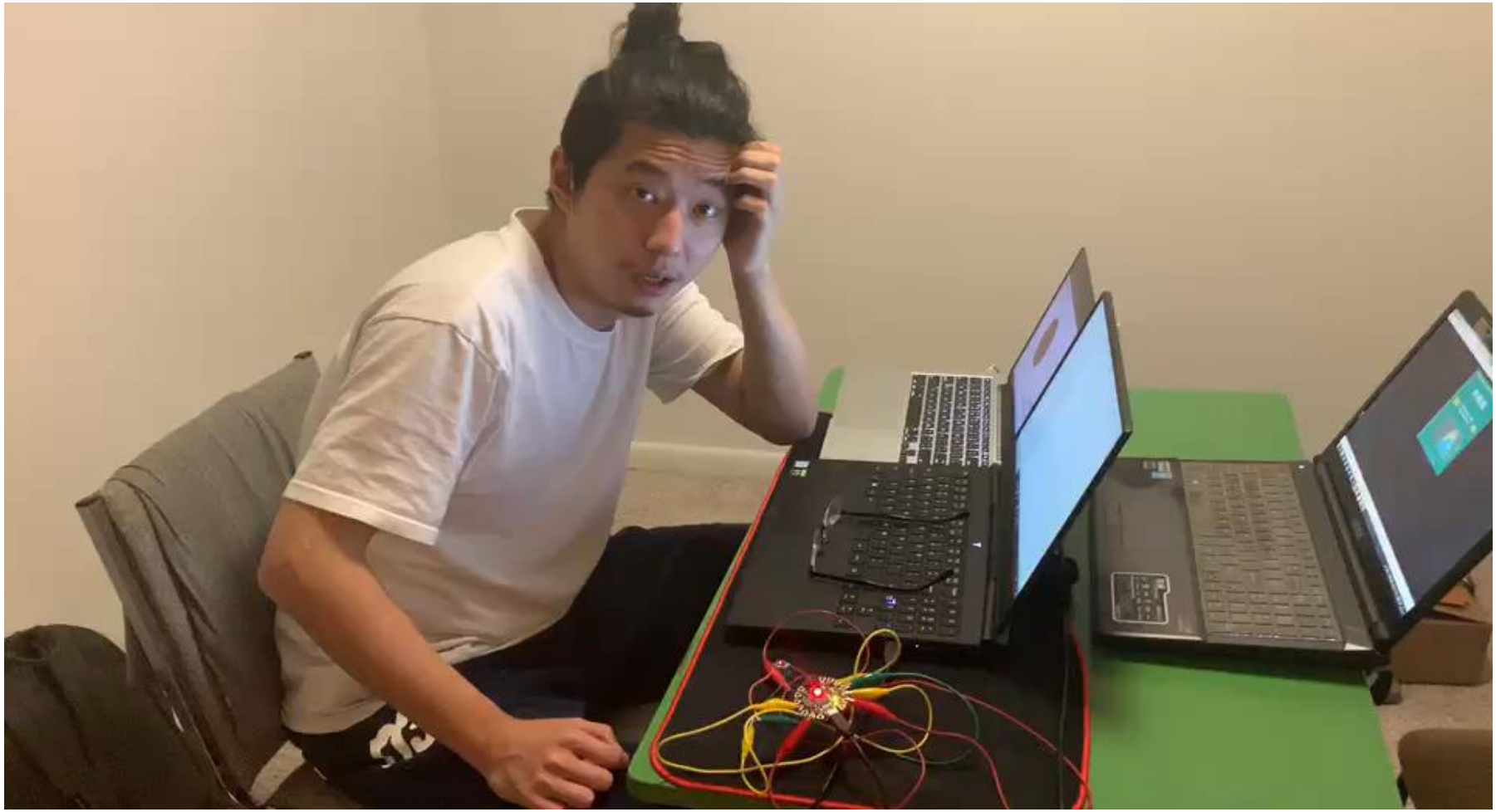
Outcome



Fatigue Driving Detector

Thank you!
Questions?