Fatigue Driving Detector

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

Advisor: Prof. Pouraghily

Hongyu Ba
Jiong Wang (leader)
Yachen Liu
Contents

• Problem statement
• Feasibility analysis and system description
• Equipment
• Block diagram and software flowchart
• Future work, Schedule Chart and Demo
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

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

Table – Driver Reaction Time Summary Table
Feasibility Analysis

In this study, the cerebral oxygen saturation decreased significantly by $6.94 \pm 1.74\%$ 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:
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 SpO₂ value at this time as the fatigue critical value.
System description

SpO2 System (during driving):

- Calculate the customer's real-time SpO₂ value and compare it with the fatigue critical value from Reaction Time System.

- When the customer's SpO₂ value is equal to or less than the fatigue critical value, the system will issue an alarm (LED), to avoid fatigue driving.
The MAXREFDES117# reference design

- A low power, optical heart rate and SpO₂ 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 SpO₂ value.
Three chips:

- a SpO₂ 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.
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 reprogramming for advanced users.
Equipment
Block diagram

Finger

Heart-rate / SPO2 Sensor
MAX30102

Step-down converter
MAX1921

Level translator
MAX14595

Control, calculate, store

FLORA

PC

Alarm system
Light(#7)

USB
Core Algorithm

\[ \text{SpO}_2 = C_1 \times \text{AverageRatio}^2 + C_2 \times \text{AverageRatio} + C_3 \]

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:
Core Algorithm

```c
//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, 98, 98, 98, 98, 99, 99, 99, 99,
  99, 99, 99, 99, 99, 100, 100, 100, 100, 100, 100, 100, 100, 100, 100, 100, 100, 100, 100, 100, 100, 100,
  97, 97, 96, 96, 96, 96, 95, 95, 95, 94, 94, 94, 93, 93, 93, 93, 92, 92, 92, 91, 91, 90, 89, 89, 89,
  88, 88, 87, 87, 86, 86, 85, 85, 84, 84, 83, 83, 82, 82, 81, 81, 80, 79, 78, 78, 77, 76, 76, 75, 74,
  73, 72, 72, 71, 71, 70, 69, 69, 68, 68, 67, 66, 66, 65, 64, 63, 62, 62, 61, 61, 60, 59, 58, 58, 57,
  56, 56, 55, 55, 54, 54, 53, 53, 52, 52, 51, 50, 49, 48, 47, 46, 45, 44, 43, 42, 41, 40, 39, 38, 37,
  36, 35, 34, 33, 31, 31, 30, 29, 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

WEEK 1
(From 10/21)

PDR

Material purchase

Website Design

Circuit welding

Algorithm research

Coding

Adaptive testing

Debug

Relevant data acquisition
(Reaction time)

Build up prototype

Testing

Wang

Wang & Ba

Ba

Liu
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
<table>
<thead>
<tr>
<th>OUTCOME</th>
<th>COMS</th>
<th>COMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>01:10:57.005</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:57.052</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:57.093</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:57.146</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:57.193</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:57.240</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:57.288</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:57.333</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:57.381</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:57.425</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:57.476</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:57.522</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:57.568</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:57.615</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:57.655</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:57.702</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:57.748</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:57.795</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:57.848</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:57.899</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:57.949</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:57.993</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:58.030</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:58.093</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:58.140</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:58.187</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:58.234</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:58.281</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:58.327</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:58.376</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:58.438</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:58.486</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:58.532</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:58.580</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:58.626</td>
<td>m9</td>
<td>m9</td>
</tr>
<tr>
<td>01:10:58.678</td>
<td>m9</td>
<td>m9</td>
</tr>
</tbody>
</table>
Thank you!
Questions?