IOP Conf. Series: Materials Science and Engineering **453** (2018) 012036 doi:10.1088/1757-899X/453/1/012036

# Proposed Simple Determining Sleepiness Scale Driver with EAR, MAR and HR the SLIFA devices on Truck and Bus

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**Abstract**. The enhancement of road safety is a major concern to societies due to the losses in human lives and the economic and social costs. Tremendous efforts have been dedicated by transportation researchers and practitioners to improve road safety. This paper will purpose developing new speed limiter integrated with fatigue control to improve the safety for vehicle, and also to analyse if there is an accident. The device develops and then integrated into one system fatigue control by SLIFA sleepiness scale. The testing held to prove the fatigue control base on sleepiness scale 1-9 parameter driver fatigue, and it show the system can work well and speed slow down if 6-9 scale. The next improvement for this system can be develop the server to collect data scale sleepiness scale from internet, so the driver and the vehicle owner can monitor the also the driver fatigue condition.

## 1. Introduction

The enhancement of road safety is a major concern to societies due to the losses in human lives and the economic and social costs. Tremendous efforts have been dedicated by transportation researchers and practitioners to improve road safety. In European Union there has been a consistent reduction in fatalities. In 1991, 76,230 fatalities were recorded in EU, whilst in 2013 the total number of fatalities was 25,938 [1]. More specifically, a 5-year period was considered for this study, namely from 2004 to 2008. Totally, 59,316 road accidents were recorded and 105,074 injured persons were involved. Table 1 illustrates the distribution of injuries per vehicle type for the aforementioned time period in Greece. It is observed, that the largest percentage of fatalities occur when trucks are involved (12.7%), while the lowest percentage (3.6%) when a bus is involved. On the other hand, when mopeds are involved, the percentage of fatalities is still relatively low (6.3%) but the share of severe injuries reach their maximum (12.3%). It is noted that cars refer to both private vehicles as well as vehicles used for commercial purposes (like taxis) [2].

**Table 1.** Distribution of injuries per vehicle type

| Vehicle type | Car (%) | Truck (%) | Bus (%) | Moped (<50cc) (%) | Motorcycle (>50cc) (%) |
|---|---|---|---|---|---|
| **Fatalities** | 8.4 | 12.7 | 3.6 | 6.3 | 5.3 |
| **Severe injuries** | 9.0 | 9.9 | 5.4 | 12.3 | 9.8 |
| **Slight injuries** | 82.6 | 77.4 | 91.0 | 81.4 | 84.9 |

Based on the Indonesia Police report 2014, it was identified that in 2012, the death (fatality) cases caused by contrary, serious injured cases in 2012 reached 39,704 victims, in 2013 it was 72,054 victims (increasing by 81.47%). Minor injury cases in 2012 reached 128,312 victims, in 2012 it reached 104,976 victims decreasing by 18.18% [3]. The Indonesia Police together with the Transportation Ministry, Public Work Ministry and Indonesia community have been struggling to reduce traffic accident by implementing the National Traffic Safety Plan (RUNK), 2011-2035 encompassing 5 major pillars, such as; safety management, safety roads, safety drivers, safety vehicles and post-crash actions [4].

There are several factors that cause traffic accident, such as external (34%), attitude (24%), fatigue (20%), over speed (17%) and technical vehicle (maintenance shortfalls) (5%) [5]. Other factors might be caused by rapid growth of vehicles and industries, which increase significantly. The average annual vehicle growth from 1996 to 2006 is 20% (Table 1.5), which might take a higher possibility in increasing road fatalities [6].

Fuel truck and busses become main concern in this research due to a commercial transportation, which might be used by many people. Fuel trucks require the safety driving because it distributes fuel, which might cause the hazardous materials when accident happens [9,10,11]. Buses become mass transportation which is needed high standard of safety [9,11,12]. Based on data that fatigue and over speed were observed as main factors of traffic accident. Therefore, need to develop the system that can cover that problem such as by developing new speed limiter that integrated with fatigue control (SLIFA).

## 2. Methodology

To achieve the purpose of this research, we propose a methodology in Figure 1, and the methodology consists of the steps how we develop the system.

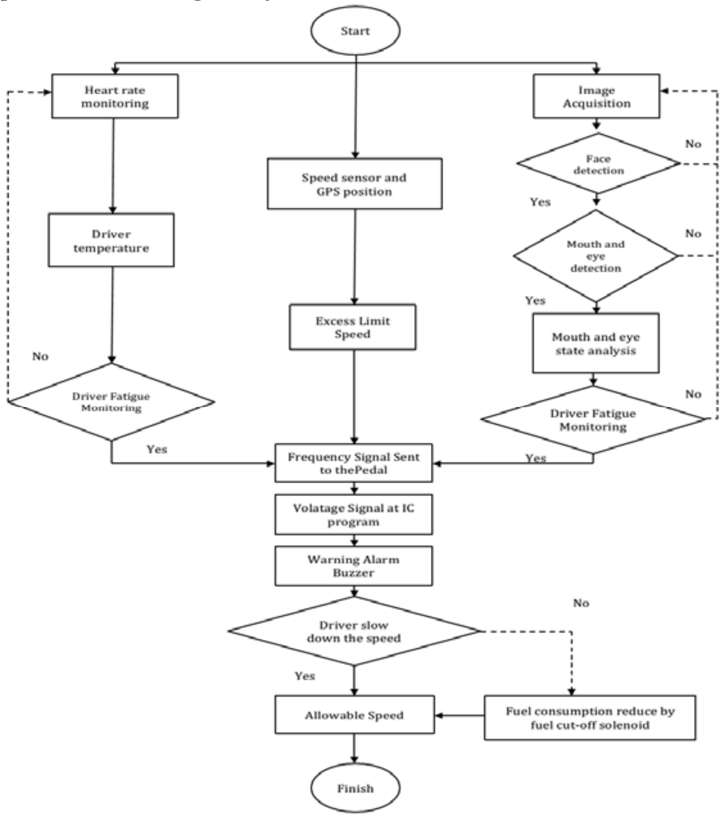


**Figure 1.** The Proposed Methodology

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Image processing with camera and heart rate used as input fatigue detection which is occurring on the driver. When fatigue detected, new speed limiter that integrated with fatigue control (SLIFA) will give warning via buzzer. If driver gives no responses to the buzzer by resetting it using horn as reset switch, the new gadget will decrease slowly vehicle speed to maximum 30 km/h.

### *2.1. Determine eye ratio (EAR)*

Eye ratio measurements were performed by modifying real time algorithms facial landmark detection [7].

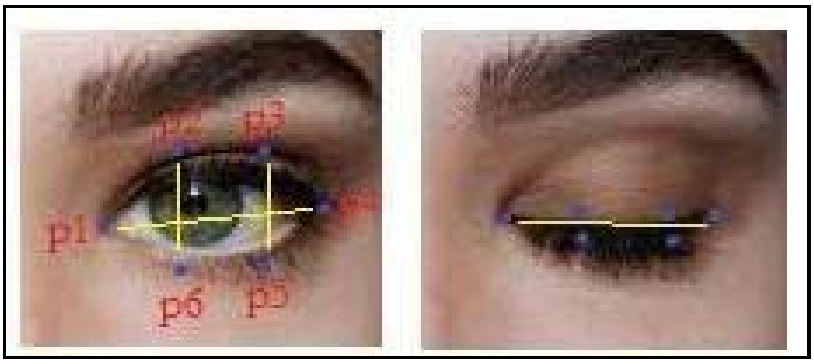


**Figure 2.** Visualization of open and closed eye conditions

The detected eye area on each video frame taken will be calculated with the following algorithms:

$$\mathbf{EAR} = \frac{||p2-p6||+||p3-p5||}{2||p1-p4||} \quad (1)$$

The ratio of eye opening and closing between one person and another has a small variation, so with this alghorithma it becomes quite easy to determine the person opening or closing the eyes. The measurements of the right and left eyes are summed and averaged in the following algorithms.

$$\overline{EAR} = \frac{left\ eye\ EAR + right\ eye\ EAR}{2} \quad (2)$$

Calculation of eye state will give scale and weight to the next measurement. The higher the eye state value will be directly proportional to one's sleepiness level. The calculation of eye conditions can be explained in the graph and the interpolation formula below.

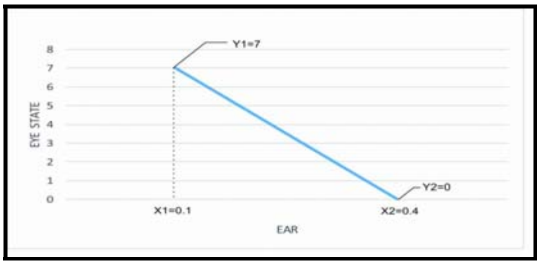


**Figure 3.** Eye state diagram

The diagram shows that with the included parameters from the initial data collection. EAR is inversely proportional to the size of the eye state. The size of the driver's eye dimension will decrease the level of drowsiness. The diagram shows the following linear equations:

$$\frac{(X - X1)}{(X2 - X1)} = \frac{(Y - Y1)}{(Y2 - Y1)} \quad (3)$$

Which;

Y = Eye state value obtained from EAR value interpolation
Y1 = The highest scale of mouth state
Y2 = lowest scale of mouth state
X = EAR value obtained in real time
X = Average minimum value of EAR
X2 = Average value of maximum EAR

*2.2. Determine Mouth Ratio (MAR)*

Measurement of the mouth or Mouth Apect Ratio (MAR) was done by modifying real time algorithms facial landmark detection [7].

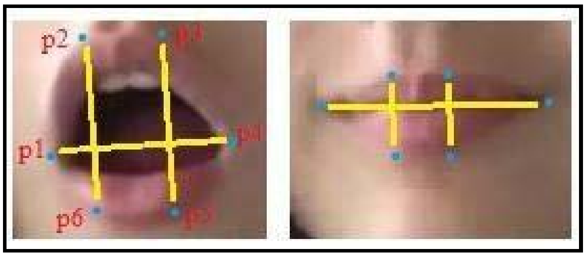


**Figure 4.** Visualization of open and closed mouth conditions

The detected mouth area of each video frame taken will be calculated with the following algorithms:

$$MAR = \frac{||p2 - p6|| + ||p3 - p5||}{2||p1 - p4||} \quad (4)$$

Calculation of mouth condition or mouth state will give scale and weight to the next measurement. The higher the mouth state value will be directly proportional to one's sleepiness level. Calculation of oral conditions can be explained in the graph and the interpolation formula below.

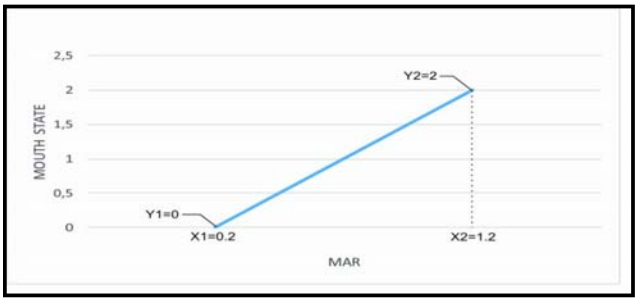


**Figure 5.** Mouth state diagram

The above diagram shows that with the included parameters from the initial data collection. MAR is directly proportional to the size of the mouth state. The dimensions of the evaporating dimensions of the driver will increase the level of drowsiness. The diagram above shows the following linear equations:

$$\frac{(X - X1)}{(X2 - X1)} = \frac{(Y - Y1)}{(Y2 - Y1)} \quad (5)$$

Which;
Y = The value of mouth state obtained from the interpolation of the MAR value
Y1 = lowest mouth state scale
Y2 = The highest scale of mouth state
X = Real-time MAR value
X1 = Average minimum MAR value
X2 = Average maximum MAR value

### *2.3. Determine Heart Rate (HR)*

In the measurement of the heartbeat and thermometer of the driver body, the sensor is placed in the seatbelt and then connected to the new speed limiter that integrated with fatigue control (SLIFA), the resulting sensor data becomes one of the parameters to determine the driver fatigue cause, below is the heart rate table 2 and the temperature of the driver body

**Table 2.** Heart rate value standard [8]

| No. | Heart Rate (Db) | Condition | Temperature(°c) |
|---|---|---|---|
| 1 | 100-120 | Normal Condition | 37 |
| 2 | <80 and >100 | Fatigue Detected | <34 and > 38 |

Interpolation formula for heart rate value under 80bpm
If heart rate value above 120bpm, formula interpolasi can be view as on formula this below,

$$\frac{(X-X3)}{(X4-X3)} = \frac{(Y-Y3)}{(Y4-Y3)} \quad (6)$$

Which;
Y = The value of the heart rate obtained from the interpoltaion of the HR value
Y3 = The highest scale of heart rate state
Y4 = The lowest sacle of heart rate state
X = Real time heart rate
X3 = Average minimum heart rate value
X4 = Average maximum heart rate value

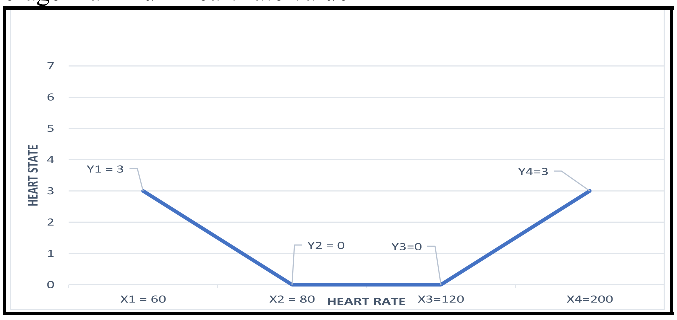


**Figure 6.** Heart rate state diagram

### *2.4. Testing and Calibration SLIFA Sleepiness Scale*

Fatigue calibration conducted by mapping 68 facial point to obtain specific face for facial detector. This 68 mapping point used to describe driver condition from their face. Mouth and eye condition used as main parameter to determine fatigue which is occurring.

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**Figure 7.** Sleepines driver noticed from image processing SLIFA device

Mouth and eye condition data obtained from facial detector satated as ES and MS value. This value will be converted into 1-9 SS scale after integrated with heart rate value and driver body temperature. SS value stated in the figure 2.

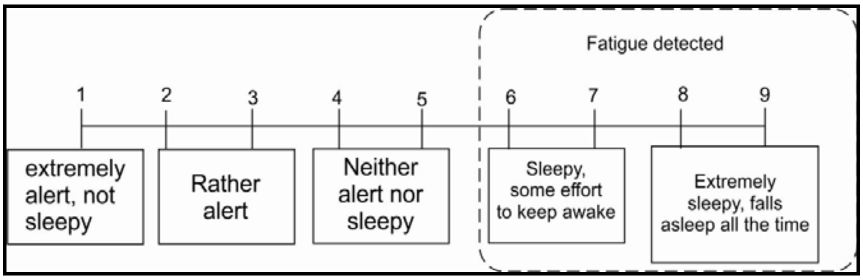


**Figure 8.** SLIFA sleepiness scale adapted from Karolinska sleepiness scale

Sleepiness scale (SS) is the scale used to describe the driver's sleepiness level adapted from Karolinska Sleepiness Scale [12]. SS has a scale from one to nine with algorithm as follows:

$$SS = ES + MS + HR \tag{7}$$

Where SS is Sleepiness Scale (SS), ES is Eye State, MS is Mouth State and HR is Heart Rate.

**Table 3.** SLIFA Sleepiness Scale

| Scale | Respond Time (s) | Decision |
|---|---|---|
| 1-5 | 0.03 | Fatigue undetected, this condition buzzer on and driver restart by switch horn for the normally condition, figure 8 Scale 1-5 |
| 6-9 | 0.8 | Fatigue detected, if driver no response restart switch horn, speed automatically slow down until 30km/h, figure 8 Scale 6-9 |

## 3. Conclusion

The development of SLIFA was purposed to limiting speed by automatic fuel cut-off and fatigue detection through detecting heart rate, temperature body of the driver and image processing for the mesurement level drowsiness with by focusing eye ratio (ER) and mouth ratio (MR). The testing held to prove the fatigue control base on sleepinees scale 1-9 parameter driver fatigue, and it show the system can work well and speed slow down if 6-9 scale.

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