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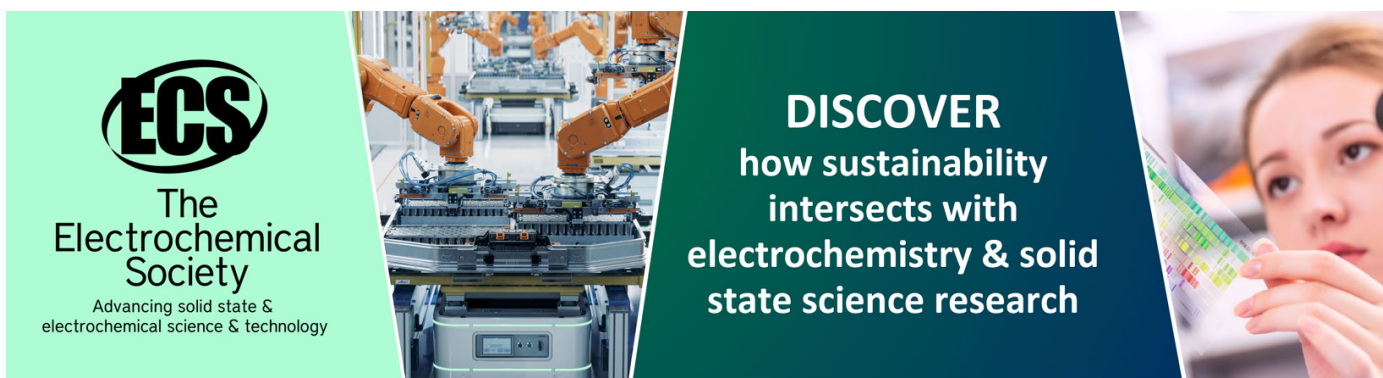
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Comparison of driver awareness in real traffic and driving on a simulator

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Abstract. A driver's awareness is a critical aspect that must be closely monitored at all times. This article proposes a number of experiments that will be carried out in the near future, the findings of which may aid in improving the existing condition. The authors feel that the results of individual measurements can help to improve road freight transportation safety. Furthermore, the contribution focuses on driver drowsiness as a significant factor and mechanism of major and fatal traffic accidents, as well as extensive damage to goods or property in road freight transit. Among other things, detection of driver drowsiness was determined. The individual measurements are described and the result of a driver on the simulator are compared with a motorist driving in real traffic. With this information obtained from the individual measurements, we can evaluate number of driver mistakes and different signs of tired behaviour per one shift and then we could be able to estimate a maximum driving duration of one day for twenty-four hours day.

Keywords: road safety, safety, road accident

1. Introduction

A driver's awareness is an extremely vital component that must be constantly monitored. A drowsy driver can create a variety of mistakes and accidents on highways, resulting in financial loss, physical damage, and, most importantly, human life loss [1]. Accidents caused by fatigue are more prevalent than those caused by drunk driving. Lack of sleep, frequent driving, narcotics, and prescription can all cause drivers to feel sleepy. If a motorist falls asleep for four seconds while driving at 100 km/h, the automobile will have travelled 111 meters without a driver attention. When traveling at high speeds, there is a greater chance of death or serious injury in the event of a collision. Driver drowsiness has a role in around 20% of fatal traffic accidents. Fatigue is a leading cause of collisions in the Australian state of Victoria, with over fifty people killed and 300 seriously injured each year [2]. We must also address sleepiness, since we have convincingly proved that it is a major cause of accidents [3].

The intended research to determine driver sleepiness in road freight transport is detailed in this article. In the Slovak Republic and the European Union, the rules on driving times, breaks and rest periods for drivers engaged in road haulage and passenger transport are laid down in Regulation (EC) No 561/2006 of the European Parliament and of the Council. The aim of this Regulation is to improve working conditions and road safety, to promote better monitoring and enforcement by Member States and to improve working practices in the road transport sector [4].

We think that by organizing measures of driver sleepiness in real-world traffic conditions, as well as measurements on a simulator, we will be able to confirm or contribute to the improvement of present



regulations, particularly in the sector of international road freight transport. The proposed study will be divided into two parts and will include a variety of measurements that will offer us with diverse views on the challenges at hand. Methodology of measurements are presented in the first section, with the findings being assessed and outputs being given in the second part name results. The initial set of measures will be carried out on a simulator, with the driver's face being observed by a camera. The second measurement will take place in real-time traffic, with the faces of the chosen driver being watched by a camera while driving in real-time traffic. The final section of the report focuses on assessment and future measuring recommendations. This research is being used as a pilot test for more extensive measures to be conducted in the future.

2. Detection of driver drowsiness

The raw measurement and the processing steps used to convert measurements into characteristics can be used to identify input sources for drowsiness detection algorithms. Measures explored in the literature include heart rate [5], brain activity [6, 7], eye closure and tracking [6, 8, 9], lane position [10], and steering-wheel angle [11, 12]. Although most previous algorithms focus on a one type of measure, several employ a combination of measures [8, 10, 13, 14]. The most commonly applied and theoretically rigorous measures are electro-encephalogram (EEG), percent eye-closure over a fixed time window (PERCLOS), and steering-wheel angle [15]. EEG has the benefit of having a well-established correlation between spectral patterns in the signal and the transition between awake and sleep [7]. The quantity of pre-processing necessary before categorization, the sensitivity to artifacts, and the feasibility of collecting EEG from drivers in real-world scenarios are all factors that restrict EEG. PERCLOS, developed by Wierwille et al. (1994) [9], is the gold standard measure for drowsiness detection. PERCLOS predicts drowsiness based on the percentage of time an individual's eyes are more than 80% closed over a 2-min period. Dinges et al. (1998) [6] demonstrated that the PERCLOS algorithm had over 90% accuracy in detecting degraded performance during a vigilance task, which was more reliable across drivers than EEG, blinks, and head position in the study. PERCLOS is a ground truth sleepiness measure that has been integrated into aftermarket equipment such as the Co-pilot [9]. PERCLOS, despite its widespread adoption, has a number of practical drawbacks. Because the existing camera technology necessary for its measurement is expensive, has not been fully verified, and may be inaccurate when the driver wears sunglasses or when weather conditions generate large quantities of glare, PERCLOS for real-time detection is limited [15]. Despite these drawbacks, the extensive evidence of PERCLOS' effectiveness implies that it might be beneficial for testing new algorithms [16]. Nor can we forget to use Subjective Methods, which can help improve the level of experiments performed, as well. The Stanford sleepiness scale [17] and Karolinska sleepiness scale [18] are the two most commonly used subjective methods. The Stanford scale is a seven-point scale that describes a person's present level of sleepiness. On the other hand, the Caroline Sleepiness Scale is a 9-point scale. This scale is said to be more comprehensive, as it can classify driver drowsiness into various degrees [19]. The authors are considering applying the Stanford sleepiness scale in future studies, in which the level of tiredness of the driver would be assessed using a questionnaire and expert observation.

Table 1. THE STANFORD SLEEPINESS SCALE. [17]

Value	Description
1	Feeling active, vital, alert, or wide awake
2	Functioning at high levels, but not at peak; able to concentrate
3	Awake, but relaxed; responsive but not fully alert
4	Little foggy; not at peak
5	Foggy; losing interest in remaining awake; slowed down
6	Sleepy; woozy; fighting sleep; prefer to lie down
7	No longer fighting sleep; sleep onset soon; cannot stay awake

3. Methodology

The first experiment will take place in a driving simulator, as its shown in Figure 1. The data acquired while driving on the simulator will form the basis of the first portion of the findings. Throughout the journey, data will be captured and saved utilizing the simulator's software and video camera. The simulator keeps track of the vehicle's condition and the driver's actions (e.g., lane position, maximum and average speed, distance travelled, driving time, shifting without clutch, car collision with external object, clutch pedal position ...). It will take eleven hours to complete the tour, which will feature a genuine driving experience. To avoid the potential learning effect, four alternative driving conditions were employed, one for each ride. The same simulator events appear in each scenario, but they are presented in a different order. Data from each drive will be analysed in a variety of environments. Video inputs such as yawning, head loss, eye movements, blinking, and closure of the eyelids are recorded on the memory card installed inside the camera. Before the measures, the first visit will be a screening, introduction visit, and the second visit will be the measurements, which is expected to be a one-day trip starting early in the morning. The measurement and testing portion of the equipment has already been completed. We will be able to compare the driver's concentration while driving in the simulator to the result of the driver's concentration derived from camera recordings of the driver's driving in actual traffic based on the findings of this measurement



Figure 1. Driving simulator [own processing]

The measurements will be completed in a real vehicle with a professional driver for the second half of results. The second measurement will be based on video footage collected from a motorist who is being observed while driving in actual traffic, as shown in Figure 2. The information will be gathered during the day and will comprise a variety of truck driver journeys from Slovakia to various European nations. The driver's level of driving safety may vary depending on the travel trip. Several indicators are used to reflect various characteristics of dangerous driving behaviour [20]. The driver will provide extensive data, which will be analysed to determine if the present ten-hour driving law is safe and effective.

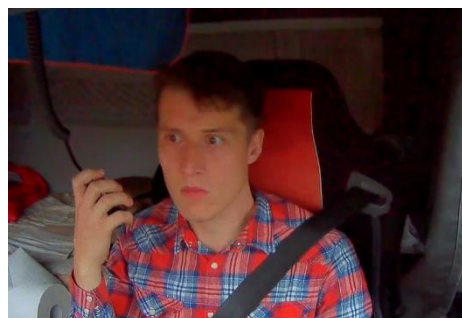


Figure 2. Video record of driver in real traffic [own processing]

At the end of the presented methodology is necessary to report that for evaluation of drivers' awareness will be used subjective method because software with PERCLOS is not available, yet. Authors are aware of possibility that this evaluation could lead to different results than PERCLOS method, which was and is also planning to be used for future measurements. In the future evaluation of extensive data, Junaedi and Akbar drowsiness detection method is expected to be used [21]. To do this, the conventional confusion matrix will be used to generate the positive and negative prediction scores of each model and then deduct several performance measures from those scores [22]. On the other side, it should be noted that using a subjective method can be consider as accurate as PERCLOS due to the detailed and responsible evaluation of authors.

4. Results

The first study we conducted was to see how conscious a driver is when driving in a simulator. With a maximum driving duration of four and a half hours and a break of at least forty-five minutes, the driver complied with existing valid social norms. The identification of yawning, tears, not concentrating, and taking hands off the driving wheel was the result of this investigation. The motorist first drove for four and a half hours on the highway before taking a 45-minute rest. The second time of the ride took place in the city lasting two hours. After a fifteen-minute break, the participants spent driving two and a half hours in a mountain setting. The driver had to take the second portion of the thirty-minute rest before starting the last driving segment. The remaining two hours of driving were spent in hill and curve mode. The overall driving duration for the driver was eleven hours, as intended, and as permitted by a new update to Regulation (EC) No 561/2006 enacted on August 20, 2020. The driver's face and upper body were scanned by a video camera during the simulation, and the simulator program also documented driver errors. Picture of the driver driving on the simulator is shown in Figure 3.

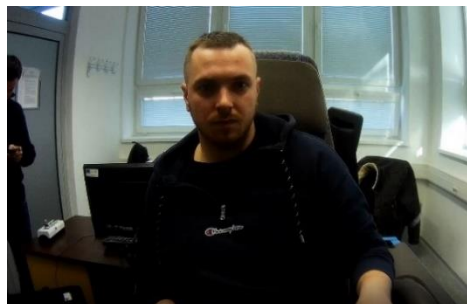


Figure 3. Video record of driver driving on a simulator [own processing]

Not just yawning, but also cases of loss of head and support with one hand, as well as reduced response time, were shown to be more prevalent in the first portion of the assessment than in the second. On the other hand, we can detect multiple errors in the second portion of the assessment that may have resulted in traffic accidents, but the majority of the errors were due to distractions, such as phone calls or SMS messages, rather than indicators of exhaustion. The driver has lost attention to the traffic condition as a result of this major present problem when using a cell phone, and this might jeopardize traffic safety. The evaluation of driver errors and the symptoms of fatigue behavior are shown in Figure 4.

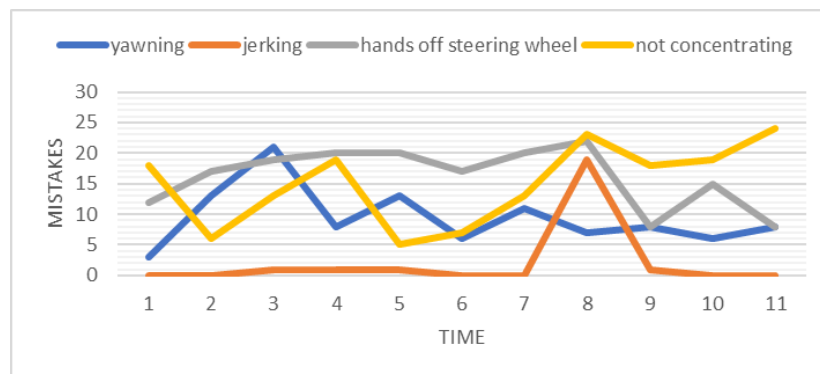


Figure 4. Evaluation of driver on the simulator [own processing]

We ran second research to determine drivers' attention while driving in regular traffic. With a maximum driving time of ten hours every classic day, the driver respected all applicable social requirements. The results of this measurement were the same as in the simulated measurement. We looked for indicators of exhaustion such as yawning, sleepy behavior, loss of concentration, and handshaking behind the wheel. The driver initially drove for half an hour on a standard road in Slovakia, then took a fifteen-minute rest before crossing the border. The driver then drove for over four hours before taking the second half of the thirty-minute rest period. After the break, the route was driven for four and a half hours. He had to take a second 45-minute rest before the driver could begin the final part of the journey. The last hour of the journey took place off the highway at the unloading spot when the driver also stopped for a minimum of nine-hour daily rest. The driver's total driving time and performance on that day was about ten hours, and it took place during sunny days and early evenings. During the whole journey, the driver was observed by a camera that recorded his face and a portion of his body from the waist up, but the camera was switched off during the driver's breaks. During the whole trip, we saw notable indicators of tired behavior. We can see that before the last hour of driving, indicators of exhaustion such as yawning and head dropping began to appear in the second portion of the assessment, but after a 45-minute rest, all symptoms disappeared. On the other side, we can notice a number of mistakes throughout the measurement that might threaten road safety, and the majority of the errors were due to phone distraction, either by calling or texting, as was seen in the simulator measurement, as well. Evaluations of driver errors and fatigue behavioral symptoms are shown below in Figure 5.

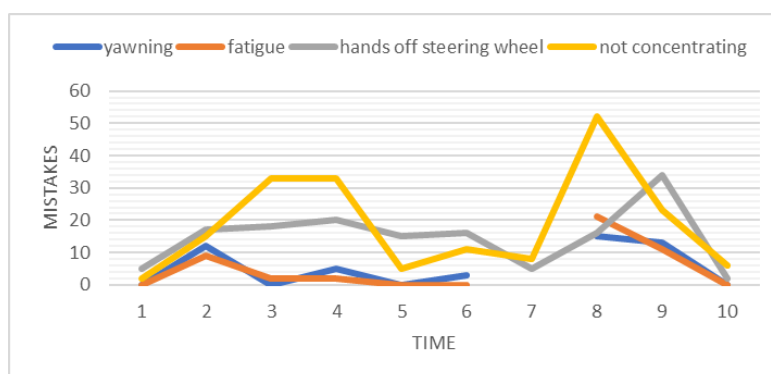


Figure 5. Evaluation of driver in real traffic [own processing]

5. Discussion

According to the World Health Organization's (WHO) road safety study, nearly 1.2 million people died each year due to driver drowsiness between 2001 and 2013 [23]. Because of the sensitivity of this problem, multiple kinds of study have been conducted to prevent tired drivers from operating a motor

vehicle. One option is to educate drivers about the hazards of driving while sleeping. This method entails recognizing the consequences of lack of sleep, exhaustion induced by lengthy periods of repetitive driving, as well as other types of labour [24].

Increasing the safety of goods transport and hauliers themselves is a priority of various international associations [25]. There are around 6 million trucks in use in the EU. Since 2010, the number of trucks has increased by less than 2% per year [26]. Parking is possible for a smaller number of vehicles because of inappropriate parking and more and more drivers face a problem with full parking areas [27]. In addition, it is important to remember that drivers and hauliers must consider the type and size of the vehicle when planning and finding places to take breaks and rest periods, as well as the type of fuel needed [28]. On the other hand, the equipment of parking areas include safety, information and cleanliness are important for drivers' comfort [29].

One of the goals of this research is to develop educational materials for training centres that provide professional driver training on the effects of fatigue, distraction, and rest on drivers while driving by implementing and presenting individual measurements, as well as detailed documentation and evaluation. The driver, with his driving technique, can significantly influence the vehicle's consumption [30]. Different measures are planned to integrate subjective, physiological, and behavioural methodologies for a comprehensive approach to study, which should provide us with a better complete image of the situation. The most accurate approaches include physiological measures such as EEG, ECG, and electrooculogram (EOG). The transmission of electrical impulses from the driver within the body, which can detect immediate changes in the driver's awareness, ensures their great accuracy. These existing technologies are unworkable in their present implementations because they need invasive electrodes, expensive cameras, and complicated equipment that can only be used in laboratory conditions [31]. As a result of this issue, this device will only be utilized to take measurements on the simulator. Simulation tests are conducted worldwide by various institutes and organizations [32].

Our goal is to evaluate the driver's level of awareness while driving a truck for ten hours, which is the maximum daily driving time allowed according to Regulation 561/2006. In this experiment, we extended driving time up to eleven hours and from the result we can review that driver was able to drive safely. In future simulator trials, we would like to prolong daily driving time to maximum levels at which the driver can still drive safely and respond to external stimuli such as answering questions. With this information, we can estimate a maximum driving duration of one day for twenty-four hours day. This will be augmented with data collected in the simulator utilizing a behavioural technique such lane departure, eye opening and closing time, and so on. Behavioural techniques should assist in improving the picture of driver weariness that results. The driver's face will be taken during the two-week operating mode in the second future experiment, which will take place on real trucks, as contrasted to the one-day measures that were done this time as a pilot experiment, right now.

In contrast to the previous experiment, which applied a subjective way to quantify driver weariness, the next assessment will use the most well-known behavioural method and the PERCLOS methodology. When compared to EEG, PERCLOS produces almost identical findings, but it is easier to install and has a lower purchase price. We should be able to recognize and quantify yawns, head loss, attention loss, and concentration based on each driver's facial camera. We think that a variety of investigations and methodologies will generate data that we will be able to maximize in the future to improve driver training and modify present legislation regulating driver shifts in road freight transportation. With our initial simulator study, we hope to demonstrate that drivers are capable of driving safely for greater periods of time than currently defined by law.

We would like to confirm that the existing regulation is insufficient and that drivers may drive for longer than is permitted in a second experiment conducted in partnership with a professional driver. Compared to current social legislation in the United States, European Union drivers can drive four hours less per week and up to thirty hours in two weeks [33]. Based on the analysis of accident statistics from the EU and the USA, it was found that the situation in the EU is better than in terms of accident rates over a period of four years from 2009 to 2012. Even though the total number of fatal accidents in the EU and the USA is similar [34-36]. We consider that detailed study might provide a solid foundation for changing present regulations without increasing the number of traffic offences and accidents.

6. Conclusion

Based on the data obtained from conducted experiments, we intend to collect further data from future individual measurements in order to better identify the current condition of driver behaviour in road freight transport. Information retrieved from large amounts of data may be used to create effective alternative measurements of traffic exposure and help policymakers make better decisions. Although this study employs a very accurate simulator, it does not perfectly duplicate the experience of real traffic, therefore we want to compare two types of independent research from real traffic and the simulator to enhance the results. This future research should use information gathered from a variety of metrics and a total of at least 25 drivers. Driver behaviour is influenced by a variety of circumstances.

We are now unable to fully include personal characteristics of drivers (e.g., age, gender, education...) and psychological problems due to the limited sample size of drivers in individual measures (e.g., agitation, depression...). Despite these disadvantages, this study will offer a systematic strategy to evaluating possible dangers among various truck drivers. One point of contention is which approach and algorithm should be utilized to assess the outcomes. The use of a driving simulator, the research's methodology, the extent of the test results, and the scope of the core fact regarding sleepiness are all limitations of this study. These future results could be combined with safety interventions to address the causes of driving drowsiness, such as incorrect working patterns and sleep disorders, in order to create comprehensive systems that will improve driving safety [20].

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