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Driver reaction time to lateral entering pedestrian in a simulated crash traffic situation

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ABSTRACT

This research is a continuation of study of driver behaviour in accident risk situations, previously conducted by the authors. This research included two new road accident situations. The purpose of this study was to determine the reaction time of drivers to an accident situation involving pedestrians entering in the road area from the left or right side. Research was conducted on the drivers' behaviour in a simulated traffic situations on a track, which introduced pedestrians into the road area. In this study, an analysis has been conducted on the values of drivers' reaction times on the accelerator pedal, brake pedal and on the steering wheel. Driver reaction times have been shown as a function of TTC (Time To Collision) which characterizes accident risk situations. Driver reaction time determined on the pedestrian mock-up entering from the left hand side are longer than the reaction times determined for pedestrian mock-up entering from the right side of road. How often drivers performed defensive driving manoeuvers was also assessed. On the basis of data collected, it can be concluded that drivers are more prone to brake (service brake pedal reaction) when a pedestrian mock-up appears from the right side. Avoidance of obstacle for both test variants are almost identical. The conducted research confirmed that the reaction time is approximately a linear function of TTC time. As a result, we suggest that in order to analyze road accidents one should use reaction times dependent on TTC time.

1. Introduction

Experts conducting reconstruction and analysis of traffic accidents now have at their disposal advanced computerized systems of traffic and collision simulation. Most of them can create a computer animation of a reconstructed complex crash situation, so they are able to present a virtual simulation of an accident. The result of the reconstruction is thus presented not as complex calculations, but in the form of an animated film, in which the background can be a real environment scene of an accident.

This animation is very suggestive for an audience, so it should be performed with utmost care and sense of responsibility. The credibility of the reconstruction carried out by an expert depends on many factors. One of the most important is the selection of the input parameters for the calculation. Some of these parameters are contained in documents drawn up by the police but a significant portion of necessary data must be estimated in an indirect way by an expert, based on data from literature of the topic. For instance, this applies to the adhesion coefficient, coefficient of restitution, reaction time, etc. At the

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same time, calculation models used in the simulation programs have a high sensitivity for many of the estimated parameters. This means that a small change in the value of these parameters results in large changes in some output values, so one can receive different runs of reconstructed road events.

One of the parameters, among the input data to the simulation, is "reaction time" of a driver. This is the time that elapses from appearance of an obstacle, to the start of a driver influencing on vehicle control mechanisms: the steering wheel, pedals and levers. Unfortunately, it is not possible to determine the reaction time for a specific driver by carrying out the experimental process. That is why many centres have for many years been conducting research into driver reaction time, or more broadly speaking, the studies of drivers in crash risk situations. For obvious reasons, experimental studies cannot be made as a real situation with a threat to life or health to participants. The effort of scientists running research is therefore focused on how to safely come "most closely" to such situations. How to simulate this situations artificially? There is no simple, universal answer to this issue. The result of this is a wide variety of testing methodologies and analysis, which entail a wide variation in the published literature of reaction time.

2. The problem of driver's reaction time tests

Methodological diversity of research is mainly related to the environment in which they are carried out. They can be performed in stands for psycho-technical tests (or similar) in driving simulators, on tracks or roads. They may also take the form of real traffic observations. Advantages and disadvantages of each method are discussed in many review works, e.g. (Green, 2000; Hugemann, 2002; Stańczyk & Jurecki, 2007). It is difficult to precisely identify the best methods, and thus recognize obtained values in reaction time, as the only true and valid ones.

Even the simplest of the above-mentioned methods (research on special stationary stands) can sometimes be the only possible test methods to be carried out. An example of this is when the subject of research is to determine the reaction time of disabled drivers after illnesses or surgeries. They can be carried out, among others, to determine the suitability of such people in road traffic, time of their full recovery, rehabilitation progress, etc. Such tests were carried out for people after orthopaedic surgery, for instance, such as total replacement of a knee joint (Spalding, Kiss, Kyberd, Turner-Smith, & Simpson, 1994), or a hip joint (Ganz, Levin, Peterson, & Ranawat, 2003). There have also been tests of the reaction time of drivers (Baulk, Reyner, & Home, 2001) in a state of fatigue, sleepiness (Connor et al., 2002), and tiredness (Philip et al., 2005) and under the influence of alcohol, e.g. (Oxley, Lenné, & Corben, 2006; Zaranka, Guzek, & Pečeliūnas, 2011). The increase in the elderly population creates the need to study the impact of diseases, such as Parkinson's disease, on psycho-motor efficiency and the ability of a driver to use a car (Madeley, Hulley, Wildgust, & Mindham, 1990).

Another important differentiator of the studies is the choice of stimulus or stimuli and their method of implementation. Many older studies determined the reaction time to a simple stimulus such as an illuminating lamp light, a ring or buzzer tone, and brake lights of a pilot car. Sometimes special visual stimulus in the form of a light system is used for this purpose. The values of such determined reaction time were used to analyze the course of a whole range of very different accidents. This approach is criticized in many studies (Dannert, 1998; Green, 2000; Muttart, 2004, Zöller & Hugemann, 1998).

Two groups of subjects have dominated in an ongoing study in recent years. The first is the impact of various factors, mainly (but not exclusively) drivers. The second is the pursuit to take into account the diversity and complexity of crash situations.

The value of the reaction time of drivers can be affected by a number of factors related both to the environment, the driver, and the vehicle itself. These include the state of the environment, weather, age and emotional state of a driver, driver's psycho-motor efficiency, etc. An example is the impact of distraction caused by a mobile phone conversation (with or without a hands-free kit) (Alm & Nilsson, 1995; Consiglio, Driscoll, Witte, & Berg, 2003), the effects of alcohol (Keall, Frith, & Patterson, 2004; Ogden & Moskowitz, 2004; Oxley et al., 2006) and drugs (Hindmarch, 2004; Ogden & Moskowitz, 2004).

In real driving situations, a driver reacts mostly to complex stimuli. In order to avoid an accident, a driver performs various manoeuvers: braking and avoiding the obstacle with varying intensities. In recent years, research studies are conducted on roads or track involving the realization of selected crash scenarios. An example of such a study could be the one conducted and described in the paper (McGehee, Mazzae, & Baldwin, 2000), in which the track simulation involved a vehicle's perpendicular intrusion into the crossroads. More examples include studies in traffic of the reaction to a pushed small pedal bike (from behind parked cars in the right lane) (Krause, de Vries, & Friebel, 2007) or a ball (Dettinger, 2008), or cardboard box thrown into a lane (Hillenbrand, 2008).

The studies that have been published by the authors for some years also relied on the implementation of selected scenarios of situations. The authors selected scenarios which can be considered as representative for a large number of accidents and road traffic collisions. The diagram of research scenario carried out in the period 2004–2005 is shown in Fig. 1.

A mock-up of a passenger car entered the road area depth 1.5 m at (mapped on the track) the crossroads of two two-lane, two-way roads width 5 m, with reduced visibility from both the right and left side of road. The behaviour of a driver was recorded using special equipment installed in the test vehicle. The same scenario was carried out both on the track and in a driving simulator. The study has been published in many papers (Jurecki & Stańczyk, 2009, 2011a, 2011b).

In the years 2006–2010, the authors carried out research for three consecutive crash scenarios (Stańczyk, Jurecki, Jaskiewicz, Walczak, & Janczur, 2011; Stańczyk, Jurecki, Zuska, Walczak, & Maniowski, 2012; Stańczyk, Lozia, Pieniazek, & Jurecki, 2010).