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The use of volumetric projections in Digital Human Modelling software for the identification of Large Goods Vehicle blind spots

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ABSTRACT

The aim of the study is to understand the nature of blind spots in the vision of drivers of Large Goods Vehicles caused by vehicle design variables such as the driver eye height, and mirror designs. The study was informed by the processing of UK national accident data using cluster analysis to establish if vehicle blind spots contribute to accidents. In order to establish the cause and nature of blind spots six top selling trucks in the UK, with a range of sizes were digitized and imported into the SAMMIE Digital Human Modelling (DHM) system. A novel CAD based vision projection technique, which has been validated in a laboratory study, allowed multiple mirror and window aperture projections to be created, resulting in the identification and quantification of a key blind spot. The identified blind spot was demonstrated to have the potential to be associated with the scenarios that were identified in the accident data. The project led to the revision of UNECE Regulation 46 that defines mirror coverage in the European Union, with new vehicle registrations in Europe being required to meet the amended standard after June of 2015.

1. Introduction

This paper concerns research into the identification and quantification of blind spots in the driver's view from Large Goods Vehicles (LGVs). The current design of LGVs in Europe generally places the driver above the engine of the tractor unit which results in the driver's eye position typically being between 2 and 2.7 m above the ground plane. Fig. 1 shows the eye height of a driver above the ground plane that was captured during the research described in this paper. The height of the driver above the ground combined with the obscuring effect of the vehicle structure makes it difficult for the driver to directly see other vehicles, pedestrians, and cyclists that are in close proximity to the side and front of the tractor unit.

To account for the limited visibility from the cab, up to six mirrors are mandated for use on Category N_2 & N_3 LGVs that increase the visibility of the area around the cab. Where Category N_2 vehicles have a gross vehicle weight between 7.5 and 12 tonnes, and Category N_3 vehicles have a gross vehicle weight above 12 tonnes.

Fig. 1 shows the location of the mirror classes on an example Category N_3 vehicle. The Class II mirror provides a view down the side of the vehicle in same manner as the wing mirrors on passenger cars. The Class IV mirror provides a wide angle view of the area adjacent to the side of the vehicle; the Class V mirror provides a wide angle view of the area directly adjacent to the passenger door, and the Class VI mirror provides a wide angle view of the area directly in front of the vehicle. The minimum field of view afforded to the driver via these mirrors is defined by standard UNECE Regulation 46 (2009). Fig. 2 shows the area of the ground plane that is required to be visible to the driver. UNECE Regulation 46 also defines the minimum radius of curvature of these mirrors. For example, the Class V mirror has a minimum radius of curvature of 300 mm and the Class VI mirror has a minimum radius of curvature of 200 mm.

The design and use of mirrors that are fitted to LGVs has been the subject of a number of research papers. These research activities generally focus upon the difficulty in using the combination of

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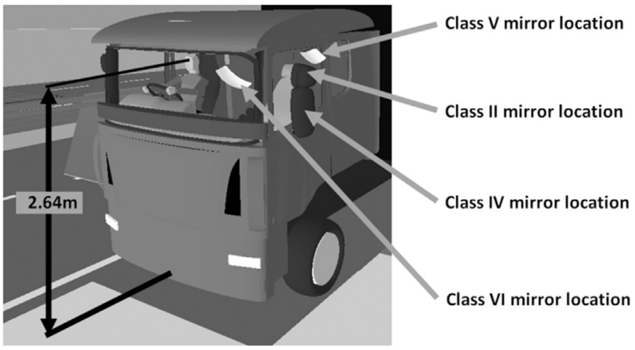

Fig. 1. The Category N_3 vehicle mirrors and their mounting locations that allow greater visibility of the areas directly adjacent to the vehicle.

direct vision (through window apertures) and indirect vision (through mirrors) to allow a driver to see the spaces around the vehicle during manoeuvring. Examples include Porter and Stern (1986), where Digital Human Modelling (DHM) was used to simulate mirror specifications with the aim of improving mirror coverage. Tait and Southall (1999) performed research using real world testing and DHM analysis to make recommendations for the improvements of direct and indirect vision, including the addition of a Class VI mirror (see Fig. 1). This involved the analysis of direct vision of vulnerable road users (VRUs) directly in front of the vehicle. Dodd (2009) performed a real world study that modelled the mirror coverage of LGVs by plotting the location of cones around the vehicle placed in positions which were visible to the driver at the edges of each mirror view. Each of these references used two dimensional methods for the presentation of results of mirror coverage by showing the area of the ground plane that is visible to the driver. Two dimensional views are also the method of presentation for information in standards which regulate the areas around a vehicle which should be seen through mirrors by driver, e.g. UNECE Regulation 46 (2009).

Despite the on-going research activity and updating of the international standards that define visible areas through mirrors, there have been a number of highly publicised accidents in the UK that involved collisions between LGVs and VRUs such as cyclists and pedestrians, as well as other vehicles. One such accident fostered the creation of the 'See Me Save Me' campaign (SMSM, 2015) which lobbies for the reduction of those killed or seriously injured by collisions with LGVs.

Accidents continue to happen which led the UK government Department for Transport to commission the authors to determine if blind spots exist for the drivers of Category N_2 & N_3 vehicles, and if these blind spots have the potential to contribute to accidents. In order to explore the potential for blind spots a two phase project was defined. The work packages of the research project were designed to define the current understanding of blind spot locations through stakeholder consultation. This involved interviews with a range of UK national bodies, charities and also interviews with the drivers of Category N_2 & N_3 vehicles. In addition to this, accident data were analysed to determine the proportion and severity of accidents that are caused by the drivers of LGVs being unable to see other road users, which resulted in the definition of specific scenarios in which accidents occur between LGVs and VRUs. The results of these initial research activities highlighted the need to explore the potential blind spots in a manner that allowed the interaction between direct vision and indirect vision to be modelled, allowing potential blind spots to be identified. The following paper presents the application of an innovative Digital Human Modelling (DHM) technique which has been designed to model the volume of space that is visible to the driver through multiple windows and mirrors, allowing blind spots to be visualised and quantified in terms of the size of objects that can be obscured from driver's vision.

2. Methods

The methods employed in the research project were designed to support the ultimate aim of quantifying the size and location of key blind spots that were associated with accident scenarios derived from the UK national STATS-19 and in-depth On-the-Spot (OTS) accident databases (Hill and Cuerden, 2005). The following sections describe (a) the methods used in the processing of the UK accident databases, (b) the methodology used in the data collection process that was used to derive accurate geometric data for the vehicles analysed and (c) the methods used during the DHM analysis stages.

2.1. Cluster analysis of UK accident databases to establish key accident scenarios

In order to examine the prevalence of accidents that occur with Category N_2 & N_3 vehicles where blind spots are a potential contributing factor, the UK STATS-19 accident database from 2008 was interrogated. The method employed to move from accident data to accident scenarios was the data mining technique known as agglomerative or hierarchical ascending cluster analysis (Romesburg, 2004). This progressively groups together the most similar records of a dataset, where the notion of similarity is

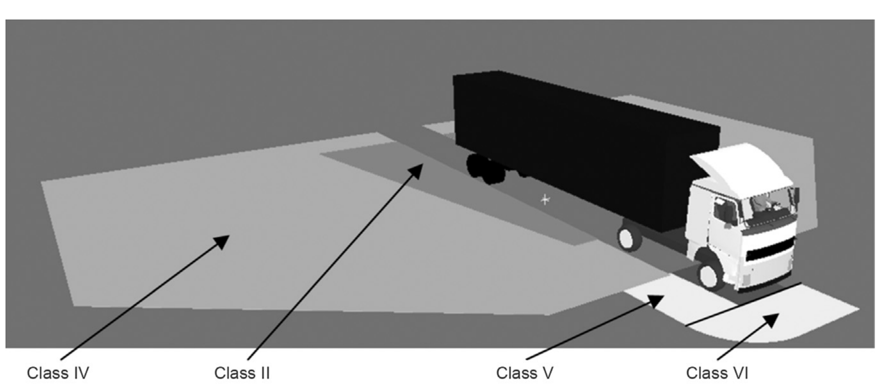

Fig. 2. The ground plane areas that are required to be viewed by the driver through the vehicle mirrors as defined in UNECE Regulation 46 for a left hand drive vehicle.

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