A virtual reality experiment on driving speed in smoke during a wildfire evacuation

Until recently, there has been little knowledge on how people change their driving behaviour when driving through smoke during a wildfire evacuation. Using a virtual reality (VR) experiment, it has been possible to develop a correlation between the choice of speed among individual drivers and the smoke density. It was also possible to investigate whether the presence of smoke had an impact on the road positioning.

In order to develop a correlation between the choice of speed among individual drivers and the smoke density (measured in optical density), 46 trials with students from Lund University was performed in VR. In these trials, the participant had to perform an evacuation by car in order to reach a safe location. The participants used a steering wheel and pedals to steer a car in VR and used a VR-headset to see the environment from the perspective of the driver. The aim of these experiments was to 1) develop a correlation between the smoke density and choice of speed, 2) investigate whether there is a difference in the choice of speed depending on whether the driver previously had been driving in thicker or thinner smoke and, 3) to determine if the distance from the centre of the car to the centre line is different at different smoke densities. The environment was simple with a flat road with trees placed by the side of it. No other vehicles than the participant's or intersections were present, although the participants were not aware of this.

During the experiments, the driver drove in nine different parts, separated by a change in smoke density. In the first and ninth part there was no smoke, part two and part eight had a smoke density equivalent to about 46 m visibility, part three and seven had a smoke density equivalent to about 23 m visibility, part four and six had a smoke density equivalent to about 15 m visibility, and part five had a smoke density equivalent to about 11.5 m visibility. Having the same order of smoke density for all participants allowed comparison of the case of previously driving in thicker smoke and the case of previously driving in thinner smoke.

In order to compare the behaviour at different smoke densities, datasets consisting of the instantaneous speed, coordinates of the car, and the smoke density was logged every 0.5 second. The coordinates were used to calculate the road positioning for each dataset. In total, over 84 000 datasets were collected during the 46 trials. Data was also collected through a survey which each participant filled out after they had completed the driving simulation. This data was used to investigate the participants experiences in the virtual environment.

By plotting the data collected at different smoke densities, it was possible to correlate the choice of speed and the smoke density. A clear trend in reduced speed as the smoke density increased could be found. The equations derived used the optical density of the smoke, but as the optical density can be used to calculate the visibility, it was also possible to express the choice of speed as a function of the visibility instead. This can be seed in Figure 1. Two models were developed; one which uses a linear correlation, and one which uses a polynomial correlation. When going from optical density to visibility, the linear model becomes nonlinear as seen in the figure.

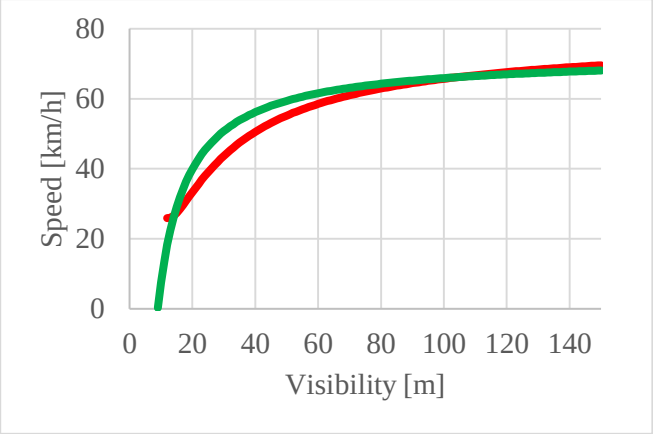

Figure 1 - Choice of speed as a function of visibility. Linear model in green, and polynomial model in red.

No statistical significance could be found to support a difference in the choice of speed depending on whether the driver previously had been driving in thicker or thinner smoke. Although, some of the participants did mention that they chose to drive faster when the smoke density decreased than when the density increased. No statistical significance could be found regarding the distance to the centre line. There was however a slight increase in the average distance to the centre line as the smoke density increased.

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