International Co-operation on Theories and
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An innovative methodology to perform image recognition assessment for road safety behavioural analysis

[1]*Andrea Paliotto, [2]Monica Meocci, [2]Francesca La Torre, [3]Davide Castellucci & [3]Salvatore Pisciotta.
*lead presenter
[1]andrea.paliotto@unifi.it, University of Florence, Italy
2University of Florence, Italy
[3] Datavision Italia s.r.l., Italy

Introduction

Road safety is still a critical issue for our society. Despite the efforts in this field and the technological updates of vehicles, too many accidents still occur on our roads, and more than 90% of those accidents are related to human errors. If, on one hand, additional efforts should be made to improve the culture of safe driving, on the other hand, many accidents occur because of wrong driver behaviors that are "involuntary". For example, speeding it's not always a conscious behavior. Moreover, sometimes the driver may not see a pedestrian crossing until the last, and so on. Most time, these issues are related also to infrastructure. For this reason, it is essential to understand when some specific infrastructural configurations are not well read and perceived by the driver. In this context, the study of gaze behavior could be crucial to understanding where the attention of the driver is directed, which are the most salient parts of the road, and which elements can be considered eye-catchers. Technologies like eye trackers are useful tools for studying the gaze behaviors of drivers. However, analyzing the recording from eye trackers can be difficult and very time-consuming. For this reason, the main objective of the research was to define a tool able to quickly investigate the gaze-dependent variables due to the road context and environment. The tool should assist the researcher in analyzing the recordings from the eye-tracker, combining the information provided by it, and recognizing the elements in the video. This research focuses on the steps implemented to develop the first version of the tool.

Research Methodology

The software has been developed considering the recordings of Pupil Invisible eye tracker, which is a binocular eye-tracking based on a real-time neural network. The development of the software has been carried out considering three steps:

- Data extraction and synchronization;
- Definition of the algorithm to recognize the object;
- Data computation and evaluation.

In the first step, the synchronization between frames and data from the eye-tracker has been performed, specifically to assign a specific x and y position of the gaze to each frame and timestamps.
In the second step, the synchronized information is then used in an algorithm to identify the object that captures the driver's attention. We decided to use a model with two main branches: one for classification and another for segmentation. The classification branch, responsible for

capturing the semantic information of the scene, identifies and classifies objects, providing initial, coarse masks for them. However, to obtain more precise masks, an interactive segmentation model is used. This model refines the masks based on the driver's gaze coordinates, accurately extracting the objects the driver is focusing on.
In the third step, the outcomes for the algorithm have been defined and the results analyzed. The main outcomes of the algorithm are the total amount of time of fixations on the same object, given a specific period (a single fixation usually varies from 0.2 to 0.8 seconds), and the possibility to identify the timestamp an object has been under a fixation.
Finally, the tool has been used to analyze the outcomes of two case studies: a real-world case study on an urban collector road, and a case study from the driving simulator, considering both a rural environment and an urban environment. The two different environments tested allow both to validate the instrument and to define the main limitations.

Results

The combination between the eye-tracker and the segmentation model provides a clear suggestion on what are the different points of interest of the driver. The trade-off between speed and precision is crucial in this context. Real time solutions have the drawback of being less precise. Therefore, in some cases minor objects cannot be highlighted because they are included in the detection of a bigger object or not considered at all. Moreover, the continuously changing lighting conditions and reflections pose a major challenge in the task. The precision and calibration of the eye-tracker demonstrated to be another relevant issue: fixation must consider a small area rather than a single point and the most relevant object in the area should be considered as the “looked one”. For this reason, a priority classification of each different objects has been defined. Preliminary analysis highlights the significant potential of the eye tracker application. In situations where objects are clearly visible, such as a car at a nearby intersection, the segmentation model can accurately and precisely outline these objects in each frame of the video. The results of the segmentation model have shown a high degree of accuracy in delineating various objects in the driving environment. This ensures reliable identification of key visual elements that the driver interacts with. Moreover, integrating the segmentation model's results with data from the eye tracker reveals what the driver is looking at in real-time, including fixation durations and points of fixation. This synchronization allows for a granular analysis of visual attention, giving information about how long objects capture the driver’s gaze.

Conclusions

The results from the practical application of the developed tool to the case studies, highlights its high utility in this field. The understanding of specific behavioral patterns could help road engineers and road authorities to decide how to intervene on the road to better improve its readability and the safety consequently. Moreover, it provides useful information for automotive industry for the developing of ADAS. Indeed, ADAS can be crucial if able to overcome the perceptive limitations of drivers, and therefore if they are able to intervene when the attention of the driver is missing or focused on the wrong element of the road. For both this reason, the conducted research can provide a great contribute to the improvement of road safety and to the research in this field.