Analysis of Eye Movement Data in Field Operational Tests

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Driver inattention is frequently cited as the most prevalent contributory factor in crash causation, and whether or not your eyes are off the road when something unexpected happens can often be the difference between a harmless event and one that turns into a crash. Although naturalistic driving data shows that crash-relevant events are strongly associated with a preceding period of large eyes-off-road times, the data does not necessarily prove the opposite – that large eyes-off-road-times are strongly predictive of crash-relevant events. Until now, the latter statement has not been possible to show since it is just too time consuming to manually encode videos of all (or at least a representative sample of) baseline periods with large eyes-off-road times. The Sweden-Michigan Field Operational Test (SeMiFOT) dataset offers a unique opportunity to study naturally occurring distractions in what is likely the largest continuous eye movement dataset collected – 47 unique drivers, 10718 hours of data and 10719 trips from 13 eye tracker equipped vehicles (two SmartEye Pro systems, three SmartEye Antisleep systems and eight Seeing Machines Driver State Sensor systems).

The aim of this abstract is to describe data extraction and data analysis of eye tracking data in an FOT setting. Especially, practical issues and quality problems will be highlighted. The workflow (along with some practical concerns) that has been used for eye movement analysis in the SeMiFOT project can be summarized as:

1. Data retrieval: Different data sources have different data acquisition demands, and in order to keep the storage requirements to a minimum, it is necessary to adapt sample rates and quantization levels to the demands of individual signals. This means that all data can not be stored in the same database table and that data retrieval and data analysis tools have to be adapted to deal with multi-rate data.
2. Quality filtering: Many issues arise when measuring eye movements with remote eye trackers over an extended period of time. A rough exclusion of low quality trips can be based on uptime, percent road centre, standard deviation of radial gaze, trip duration etc.
3. Noise reduction: The precision of a remote eye tracker is often worse than several degrees and tracking is often lost when the driver is looking at peripheral targets. The loss of tracking could range from one or a few samples up to tens of seconds. In order to obtain useful eye tracking data it is necessary to interpolate and filter data in several steps. The requirements on the filters are high since eye movements consists of very fast changes (saccades) as well as slow changes (smooth pursuit) and nearly constant segments (fixations). Therefore, it is necessary to make use of fast model based data dependent filters that are based on physiological constraints of the eye movements. One of the steps is also to determine if a signal segment is too corrupt to be used in subsequent analyses.
4. Derived measures: The most important derived measure when it comes to eye movements in driving is whether the driver has his/her eyes on the road or not. This road centre area (on-road) should be adaptive to road curvature, intersections, changes in posture etc. This could readily be handled using offline analysis of GPS data in combination with change-in-mean tracking of the gaze direction data.
5. Performance indicators: Classic signs of distraction include long glances and frequent glances away from the road. Both of these performance indicators can easily be calculated as soon as the on/off-road measure has been determined.

The most crucial problems that we have encountered are lost tracking and erroneous tracking. For example, it is very uncommon to have an entire visual time sharing sequence that is not interrupted by data loss. Another common source of errors is when the driver is aiming his/her head in between the forward roadway and a peripheral target while using the eyes to switch between the two. If the nose direction is used to classify single long glances, this behaviour will result in a very long single long glance. Concerning the five processes listed above, all of them are highly important for the end result. Many of the issues can be taken care of with modern data analysis techniques, however, if the sensors are unable to deliver data, or worse, if the sensors are delivering erroneous data, there isn't much one can do. In summary, eye tracking data that has been acquired in the field differs a lot from what is acquired in a laboratory setting or a driving simulator. It is therefore essential to put a lot of effort into the design of the analysis software and also into the interpretation of the results.

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