International Co-operation on Theories and
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Interactions between automated cars and other traffic participants in mixed urban traffic – insights from video-observation study in Oslo (Norway)

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Introduction, research aims and objectives

In Oslo (Norway), the local public transport provider RUTER has been testing various types of shared automated services since 2019. The latest project has started in 2023 in north-east suburban area of Oslo, in Grorud Valley. Here, RUTER aims at offering a flexible on-demand shared automated taxi service (in 2025-2026). The total service area is 22 km^2 with 290 km of serviced road (from residential low speed roads to motorway up to 90 km/h speed limit). The automated vehicles (AVs) that will be used are SUVs NIO ES8 equipped with Mobileye selfdriving technology. Once fully deployed, this technology will enable to operate without a safety driver (i.e., SAE level 4 of automation). In the initial, validation phase of the project, five AVs have been driving in the area. The aim of this phase is to adapt the AVs to local conditions. During the adaptation drives there is always a safety operator presented on driver's seat, and there are no passengers inside. The AVs have uniform design with red colour, and Norwegian text "*We are testing self-driving cars; Soon you can sit in them!*" and RUTER logo on both sides. Furthermore, there are visible sensors placed on the roof of the vehicles.

TØI has been involved in the validation phase to conduct research on safety in interactions between AVs and other traffic participants. The aim is to answer three exploratory Research Questions (RQ):

- RQ1: What are the characteristics of interactions between AVs and various traffic participants on different infrastructure under various traffic /environmental conditions?
- RQ2: Are these interactions different from those with conventional cars?
- RQ3: Do we observe examples of a negative behavioural adaptation towards AVs?

Research methodology

To answer the RQs, we use the method of external video observations. The methodology is described separately in several steps below.

Data collection

Using several portable Miovision Scout recording units, we have been recording traffic on selected locations since May 2024. We selected the locations combining the following criteria:

- Locations with frequent accidents between personal cars and other traffic participants
- Locations reported by cyclists as subjectively risky and unpleasant (De Jong & Fyhri, 2023)
- Proximity to "sensitive" places (e.g., schools, train stations, public transport stops, shopping areas)
- Sufficient exposure (both AVs driving frequency and other traffic participants)

Detection of AVs in video

Observed AVs are red colored vehicles. To detect them in the recordings, we developed an algorithm, that is built upon a pre-trained model, YOLOv9, with a custom modification for the color mask that allows spotting cars of a specific red color. When a red car is within the predefined area on the video frame, an automatic screenshot is taken with a corresponding timestamp. Furthermore, object tracking was implemented using the DeepSORT module to follow the detected cars with a unique ID on the videos, ensuring only one screenshot and timestamp detection per vehicle. From these screenshots we manually selected (in generic photo viewer software) the screenshots that contained AVs and marked corresponding timestamps.

Creating and selecting video clips
Using the timestamps, we searched for AV occurrences in corresponding video files in Mangold INTERACT software, created "an event" for every AV occurrence and consequently trim out those events into separate clips. While creating the events, the researcher determined whether the situation is worthy for further analysis (i.e., if it contains any interaction with other traffic participants or any odd behaviour of AV itself).

Behavioural analyses
Clips marked as worthy for further analyses were coded by a safety researcher with the following codes:

- Site and Clip ID
- Date and Time of the situation
- AV manoeuvre (turning, straight)
- Presence of interaction (Yes/No)
- Type of situation (Primary/secondary)
- Other traffic participant manoeuvre (turning, straight, crossing etc)
- Type of other traffic participant (car, truck, bus, cyclist, pedestrian)
- Place of situation (infrastructure layout)
- According to the traffic rule (Yes/No. If NO, who in fault)
- Reaction of AV (descriptive)
- Reaction of other traffic participant (descriptive)
- Road surface condition (dry/wet)
- Weather condition (sunny/cloudy/rainy)
- Traffic conditions (peak/moderate/low)
- Comment (descriptive, related to safety)

Based on these codes, we developed a categorisation of the observed situations. It consists of a main category and two subcategories (level 1 and level 2). Safety analyses of situations are of qualitative nature. Three researchers with various backgrounds watched the clips and discussed the situations. In addition to that, we discussed the selected situations with vehicle operators from the company HOLO.

Preliminary results
Here we present the preliminary results from recordings conducted in May and June 2024 on three sites. From 510 hours of recordings, we identified 297 passages of AVs through the observed sites. Of these, we identified, categorised and analysed 138 situations. Most of the situations were primary situations (80 %). The most frequent main category was a right-hand rule situation with motorised vehicles (70 %), followed by situations with vulnerable road users (21 %). Overall, we did not observe any accidents, or an obvious conflict and AVs performed well. The main findings are summarised below in two points:

Inconsistent performance of AVs: During the validation phase, AVs' abilities are evolving, and AVs programming differs one from another. This raises concerns regarding the expectancy of other road users towards AVs reactions during the validation phase. This inconsistancy can be demonstrated on two situations:

- *Right-hand rule situations:* There were several right-hand rule situations (especially under peak traffic conditions) that could be considered as a traffic rule violation. However, according to the vehicle operator, AVs were not yet programmed for those situations at the time of recording.
- *Zebra crossing situations*: At the time of video recordings, the Maps used for the AVs were not optimally programmed yet to give priority on some zebra crossings. For example, we observed an AV not giving way to the cyclist approaching the zebra crossing. However, the future policy of AVs in such situations will be to stop for anybody who is going to cross.

Traffic islands on zebra crossings: When a zebra crossing is divided by a traffic island, AVs consider it as two separate crossings and, in some situations, do not stop for pedestrians who are approaching the island from further sidewalk (from left). This might create confusion in some situations, especially when traffic islands are narrow.

Discussion and limitations

Our experience with using external video-observations during validation phase of AVs' deployment demonstrates the limited applicability of such method in this phase. The main reasons are:

- The objective of validation phase is to teach AVs how to drive in the deployment area. Therefore, their performance is in flux, their abilities have been constantly evolving. Furthermore, the performance abilities of each of five observed AVs are not similar. Such variable conditions mean that the results of the safety analyses are valid only under certain circumstances and the transferability of such findings is very limited.
- Conducting meaningful safety observations of AVs requires at least the knowledge of AV status (manual/autonomous) in moment of observation. However, obtaining such info might be challenging because of limited willingness of software producers to share such data with independent researchers.
- L4 AVs in validation phase have a driver inside. Furthermore, their overall design driving style are very similar to conventional cars. Thus, other traffic participants might not consider them as automated cars, which might be the reason that we did not observe any examples of behavioural adaptations.
- The performance of level 4 AVs to drive in mixed urban traffic has advanced since 2020 and thus it is difficult to observe the differences between AVs and conventional cars. We can see this improvement when comparing the videos that we collected in 2020-2021 in projects involving L3 shuttles in Oslo region, with videos of corresponding situations with L4 vehicles collected in 2024 in Grorud valley.

Conclusion

The project is ongoing and is scheduled to be completed by April 2025. At this stage, video recordings have been paused while we await approval to access data from AVs. Once this issue is resolved, our focus will shift to studying locations with a high concentration of vulnerable road users and driving conditions during the winter months. Additionally, we are considering incorporating supplementary methods to analyze AV interactions more thoroughly, such as engaging in discussions with safety drivers or experts involved in AV driving and testing. Another option could be to compare the behaviour of AVs and non-AVs in a quantitative matter (e.g., comparing the frequencies of traffic violations).

References

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