Defining Roles of the Remote Operator in Autonomous Vehicles

Hannah Parr[1], Catherine Harvey[1], Gary Burnett[1]

[1]University of Nottingham

SUMMARY

This paper proposes four distinct roles of a remote operator in supporting future SAE Level 4 and 5 autonomous vehicles (AVs). These are Remote Monitoring, Remote Assistance, Remote Management and Remote Driving. A set of scenarios were created based on academic literature and industry reports to represent an extensive range of interactions which might occur between Remote Operators, AVs and other human agents. Operator sequence diagrams were created to represent the task in each scenario and analysed to identify the involvement of the different Remote Operator roles. This is used to draw conclusions on aspects of work for future Remote Operators and as a starting point for further investigation into information requirements and workstation design.

KEYWORDS

Remote Operation, Autonomous Vehicles, Operator Sequence Diagrams

'Levels' of Remote Operation

Although remote operation itself is not a new concept, new challenges are posed by introducing it to on-road vehicles. The focus of this research is autonomous vehicles (AVs) at SAE Level 4 and 5, where the user is not expected/able to monitor or take over control. The aim of this paper is to investigate the different roles of an AV remote operator (RO) through Operator Sequence Diagrams (OSDs) created for a range of possible scenarios. There is currently no widely accepted definition of RO roles. For example, some authors have distinguished between the type of control an operator has over the dynamic driving task (DDT), as either direct or indirect (Kettwich, et al., 2021). Other authors have taken a more task-based approach, distinguishing between remote assistance and remote driving (SAE International , 2021). In this work, a comprehensive literature review was conducted and four 'levels' proposed. These are believed to be representative of all possible RO tasks and take a human-centred approach to describing roles of the RO:

Remote Monitoring (RMo): *Remote observation of AV, user state and environmental factors, supporting the prediction and identification of issues to inform decision making.*

Remote Assistance (RA): *Remote provision of assistance and/or information to the AV user or external agents in close proximity to the AV (e.g. emergency services or vehicle recovery).*

Remote Management (RMa): *Remote provision of instructions to AV to initiate system actions where the AV systems are unable to proceed independently. May also cover fleet management.*

Remote Driving (RD): *Remote control over the dynamic driving task (DDT) of an AV for a limited time period, where RA, RMa and RD are unable to resolve issues of vehicle function.*

These four levels are hierarchal in terms of the extent of influence over the behaviour of the AV. RMo represents the lowest level of influence, through RA, RMa and finally RD at the highest level. This hierarchal structure will be helpful when thinking about the design of work for a RO, where tasks may need to be distributed amongst different operators with different skill sets and/or escalated to higher levels of influence depending on the evolving situation.

Development and Analysis of RO/AV Scenarios and OSDs

To test the proposed levels, a number of scenarios were developed to represent likely future RO/AV interactions. These were based upon academic literature (e.g. Kettwich, et al., 2021) and industry reports (including on-road testing in the US). A final 21 scenarios were identified. Work by Kettwich et al. (2022) compiled a taxonomy of scenarios for remote operation from several context, including observations of public transport control centre staff, videos of road events and interviews with existing AV safety operators. This taxonomy was used to cross reference and validate the scenario list developed as part of this study. From this, 8 scenarios which appeared both in the Kettwich et al. taxonomy and in the list produced as part of this work were selected to represent a range of tasks involving ROs interacting with an AV and human agents in the system, including AV users and external agents.

Previous work by Banks, et al., (2014) successfully demonstrated the use of OSDs to explore the effects of different levels of vehicle automation on system network dynamics. Several cycles of iteration were used to create the OSD's used for analysis, with experts chosen for their experience in AV research and in other Human Factors contexts as a part of this process. For each scenario OSD, roles (RMo, RA, RMa, RD) were assigned to the tasks identified. The frequency with which these roles occurred was then analysed to provide an indication of the relative importance of each. In addition, the OSDs indicated at what points RO roles occur within a scenario and whether they overlap in time.

Findings and Conclusions

The OSDs showed that the roles of RA and RMa occur most frequently in the RO/AV scenarios and the option for RD is required very infrequently (i.e. only when all other roles are unable to resolve the AV control issue). Much research in the sector appears to focus on RD as the main form of remote operation, but the current work suggests that more attention is needed on indirect forms of remote operation (RA and RMa). Remote management appeared most frequently within the analysed OSDs, reflecting the importance of high-level decision-making support for AV behaviour as well as the importance of communication with other system agents and the AV network as a whole. The analysis also showed that RA and RMa often occur simultaneously within a scenario. This has important implications for job design, i.e., to achieve appropriate workloads it may be necessary to have operators taking on different roles and working collaboratively on a single AV scenario, rather than a single RO being responsible for all levels of operation within a geographically-defined area. This also suggests that workstations will need to be designed to support multiple roles and collaborative working. Future work is planned to investigate the information requirements for ROs, particularly at the management and assistance levels, working with Level 4/5 AV services.

References

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