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Human-Machine Cooperation for Automated Trains: Tasks and Workplace Design for Remote-Operated Shunting in Depots

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In the upcoming decade, a serious shortage of train drivers is projected. Automating train operation on open railway tracks may help to decrease the need for train drivers. The automation of specific parts of train drives like shunting maneuvers are the beginning of fully autonomous train transport. Here, teleoperation helps to implement autonomous trains for drives towards and away from the depot until they can perform these drives fully autonomous under all circumstances. The present work presents a hierarchical task analysis of a shunting maneuver, classifies tasks that can be automated and that have to remain with the operator, and derives requirements for the design of work places for remote train operation. Therefore, this study delivers information on the human-centered design of a workplace. A hierarchical task analysis of train drivers' activities during a shunting maneuver was conducted in real world test drives. Also, we conducted follow-up interviews with two experienced train drivers. Based on the task analysis, the technical implementation of the automation was evaluated and discussed in an interdisciplinary team. Results reveal, for example, that train operators will provide train radio communication readiness and driving releases during the implementation of the new system. In cases of problems, they will also plan and release a new route and stop the train manually, if the object detection sensor has failed. Based on the findings, a prototypical workstation for the train operator will be designed in a human-centered process following DIN ISO 9241-210:2021, which will then be iteratively tested and evaluated.

This research extends and complements previous studies. Prior works have shown that monitoring automated trains by a technical supervisor leads to negative consequences, such as prolonged reaction times (Brandenburger & Jipp, 2017) and fatigue (Spring et al., 2009). Other studies have also shown comprehensive concepts for the general design of a train operator's workstation (Brandenburger & Naumann, 2019) and investigated the needs and preferences of future users of a remote-controlled workstation through iterative user testing and simulation studies (Cogan & Milius, 2023). For smooth operation, the future tasks of the train operator must be clarified in addition to workstation design.

The existing concepts address the remote workstation as a fallback level. However, for the implementation of this system on open tracks, certain tasks that must initially be undertaken by a human operator and the present study is one step towards that.

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