Combining direct and indirect control for teleoperated autonomous vehicle.

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ABSTRACT

Despite the rapid progress in machine learning, sensor technology, and communication infrastructure, in certain situations self-driving cars will need human situational assessment. For example, upon recognising an obstacle on the road a request might be routed to a teleoperator, who can assess and manage the situation with the help of a dedicated workspace. Besides providing adequate views to assess the remote traffic situation, the workspace needs to enable the operator to remotely move the vehicle. A common solution to this problem is direct remote steering. However, constraints of real-world traffic scenarios, in particular the availability of high-bandwidth mobile networks, have led to concepts not relying on ultra-low latency, such as path-planning or maneuver selection. Future work, should focus on integrating different remote operating concepts into a teleoperator workspace design in order to support the variety and complexity of real-world autonomous driving challenges.

CCS CONCEPTS

• **Human-centered computing** → **Graphical user interfaces**;

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KEYWORDS

Teleoperation, Remote Driving, User Interface (UI), Human-Machine Interface (HMI), Adaptive Automation, Direct controls, Indirect controls, Human-Computer Interaction (HCI)

INTRODUCTION

In situations of infrastructure failure (e.g. broken signaling devices), recognition and interpretation of traffic controls (e.g. by police hand signals), or in situations when the autonomous vehicle (AV) has to deal with obstacles (e.g. trucks unloading, pedestrians, animals), are a few examples that can raise the need of human assistance. At some intersections, may also happen that other vehicles need more space to turn, demanding a reset of the AV's position. Likewise, forming a rescue lane sometimes involve to cross a stop line, or occupy the cycle- and/or foot-path.

Therefore, despite the full functionality of the AV, on occasion, human situational assessment will be needed. Teleoperation models can be distinguished between three different control paradigms: direct control, collaborative control, and automatic controls [5]. Direct manual controls have been traditionally the most common and used operating concept (fig. 1) [1], however, they require a stable high-bandwidth communication channel which cannot be guaranteed at all time. To overcome high latency issues, indirect teleoperating concepts as collaborative and automatic control have been developed for example by [2–4] (fig. 2). Indirect driving releases the operator from the stabilization task [3, 5] and enables high-level commands to be initiated by the operator and executed by the vehicle, e.g. maneuver such as "pull-over".

Vehicle teleoperation is a multidimensional domain which shows the tension between automation limitation and teleoperation requirements. That is, one the one hand the difficulty to automate arbitrarily all complex driving situations, on the other hand, the need to master real-time low and high communication delay. The first challenge we need to face has to deal with the effect of the communication delays on the remote driving task. Secondly, by detaching the operator from the actual environment, it is also necessary to ask what kind of information need the teleoperator to conduct a vehicle.

Figure 1: In this image an example of a direct teleoperation HMI for Unmanned Aerial Vehicles (UAV). The drone takes off and lands under manual control [1].

FUTURE OUTLOOK

For the design of suitable HMI concepts for teleoperated driving, vehicle teleoperation HMIs should have an adaptive character, adaptive to the actual driving situation and to the communication delay. For instance, as Kauer et al. suggested [3], indirect steering might not only be relevant when the latency is too high, but also when the maneuver is simple enough that can be solved by sending a single command to the vehicle (e.g. "overtake"), or by temporarily altering the constraints of the automation.

Figure 2: In this image the User Interface (UI) for maneuver based driving. The driver passes maneuver commands to the vehicle that are then translated into driving functions. The authors pointed out that it is questionable if this concept could work for every driving scenario or may it better for a context-based application (e.g. highway scenario) [3].

One great advantage that might be presented by employing different teleoperating models, i.e. direct and indirect controls, is the opportunity to provide both low- and high level of assistance and strategy [1]. Adaptive adjustment of authority between operator and vehicle, i.e. a potential transition between high and low authority must be considered, e.g. when facing great latency and when the situation does not require complex maneuvers.

REFERENCES

[1] Terrence Fong, Charles Thorpe, and Charles Baur. 2001. *Collaborative control: A robot-centric model for vehicle teleoperation.* Vol. 1. Carnegie Mellon University, The Robotics Institute Pittsburgh.

[2] Sebastian Gnatzig. 2015. *Trajektorienbasierte teleoperation von straßenfahrzeugen auf basis eines shared-control-ansatzes.* Ph.D. Dissertation. Technische Universität München.

[3] Michaela Kauer, Michael Schreiber, and Ralph Bruder. 2010. How to conduct a car? A design example for maneuver based driver-vehicle interaction. In *Intelligent Vehicles Symposium (IV), 2010 IEEE.* IEEE, 1214–1221.

[4] Jennifer Kay. 1997. *STRIPE: remote driving using limited image data.* Technical Report. Carnegie-Mellon Univ Pittsburgh Pa Dept Of Computer Science.

[5] Thomas B Sheridan. 1983. *Supervisory control of remote manipulators, vehicles and dynamic processes: Experiments in command and display aiding.* Technical Report. Massachusetts Inst Of Tech Cambridge Man-Machine Systems Lab.