(Non-) Driving-Related Activities in the Car: Defining Driver Activities for Manual and Automated Driving

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Abstract
The multitude of communication and infotainment features of modern cars enable drivers to perform many tasks on the go. If these tasks are not directly related to maneuvering the vehicle (i.e., the primary driving task), literature usually refers to such tasks as secondary or tertiary driving tasks. For automated driving the traditional separation into different driving tasks needs to be adapted since the "old" primary driving task will become obsolete. In order to prevent the necessity of different driving task definitions for automated and manual driving, we foster the use of alternative terms and provide a definition therefore: Driving-related activities comprise all tasks to safely control the vehicle while non-driving-related activities comprise all activities beyond maneuvering the vehicle. These terms can be used consistently for both automated and manual driving situations.

Author Keywords
Automotive user interfaces; automated driving; driving task; driving-related activities; manual driving; non-driving-related activities

ACM Classification Keywords
H.5.2 [Information interfaces and presentation (e.g., HCI)]: User Interfaces.

The Driving Scenario

When the first cars were invented and built at the end of the 19th century, their only utility was to bring passengers from one location to another. As a successor of horse-drawn carriages, early cars mainly consisted of mechanical parts that were needed to offer seats to the passengers, control the engine, and maneuver the vehicle. Gradually, auto makers increased the driving comfort (e.g., by adding comfortable seats, roof, and windows) as well as the utility and safety of the vehicles [1]. Also, technical components found their way into the car such as turn signals, windshield wipers, and headlights. More and more such components were electric and electronic parts and often replaced their mechanical ancestors.

Today, driving a modern car is much more than just sitting in a vehicle to get to the destination. Besides the car radio as the first entertainment source, today content such as music or videos (for passengers) can be played from multiple sources, including USB sticks, hard drives, and streamed content from the Internet.

Similarly, mobile communication found its way into the car. With smart phones becoming the ubiquitous companion for the majority of people today, we see a growing need for communication while driving a car (e.g., phone calls, text messages, or e-mails) . Drivers and passengers either use their nomadic devices (e.g., smart phones and tablets) or they use the functions integrated into the in-vehicle infotainment system (IVIS).

Many of the advanced IVIS offer features that are specially designed for the automotive use case. For instance, sharing information to Twitter or Facebook with such IVIS makes use of available context information like time to destination or outside temperature. By also restricting the choice of options (e.g., to send only pre-defined messages instead of free text entry), the complexity and driving distraction [9] of such interaction shall be kept low to allow the driver to focus on the primary driving task, i.e., maneuvering the vehicle.

Considering the latest generation of cars and those that are currently under development, more and more advanced driving assistance systems are integrated into the car. We see a clear transition from manual driving over assisted driving towards highly or fully automated driving modes [4] where the driver needs to pay less or no attention to the road situation anymore. With these assisted and automated driving modes, we expect an increased desire of the driver for non-driving-related activities in the car such as (visual) entertainment trough reading news, watching a movie, or preparing for or reflecting the (business) day. For the near future, we expect a typical car ride to still consist of different levels of automation. In order to not compromise driving safety or limit the driver's capabilities, interaction with in-car technology needs to be designed and modeled [8] so that it supports the right activities for each level of automation.

From Driving Tasks to (Non-) Driving-Related Activities

Up to now in literature the tasks and activities a driver needs or wants to perform on the go are mainly referred to as *driving tasks*. To distinguish different tasks, it is common to split the driving task (in traditional, non-automated cars) into two [10] or three [3, 5] classes:

Primary Driving Task The primary driving task comprises all activities that are required to maneuver the vehicle. This includes all activities regarding lateral and longitudinal control of the vehicle as well as "maintaining alertness to traffic and other potential hazards" [10]. The primary task itself is a hierarchically cascaded

task [2]: On the highest level, the goal of the *navigation task* is the overall transportation task, i.e., getting to the intended location. From this task, details such as route and speed details can be derived, which are then part of the *guidance task*. This includes choosing the exact path as well as adapting to appropriate driving speeds. On the lowest level the *stabilization task* is the actual lateral and longitudinal control of the car, i.e., the continuous adjustment of the pedals to control the speed, shift gears, and steer the car.

Secondary Driving Task (A) When dividing the driving task into two classes (e.g., [10]) the term secondary driving task is used collectively for all other tasks other than the primary driving task. This includes for instance operating wipers or turning indicators but also all tasks related to comfort (e.g., heating), infotainment, communication with the outside or passengers, or drinking and eating.

Secondary Driving Task (B) Referring to the trisected the driving task [2], the secondary task only refers to functions that increase driving performance or safety like activating headlights, cruise control, or wipers.

Tertiary Driving Task Tertiary tasks refer to all other tasks such as operating comfort, infortainment, and communication systems, or eating and drinking [2].

Using the trisected definition, many of the tasks done while driving manually today are classified as tertiary tasks. With increasing driving assistance and automation however, at some point the car takes over some or all of the former primary and secondary tasks. Now, the traditional definitions of these tasks become obsolete and would require redefinition: When driving is fully automated, the driver can dedicate the time in the car to any activity beyond maneuvering and monitoring the vehicle. Thus, the former tertiary tasks from manual driving will be the remaining tasks and could become the (automated) primary tasks.

Since we expect drivers to experience different driving situations even during one ride, it is beneficial to not have to distinguish between different driving task definitions for various levels of automation. Thus, we propose to use alternative terms for the driving tasks that focus on a task's relation to maneuvering the vehicle–independent of the driving situation and automation:

Driving-Related Activities As driving-related activities we define all activities that are related to safely control the vehicle (i.e., the traditional primary driving task) or to increase driving safety or performance (i.e., the former secondary task B). With assisted or partially automated driving, these activities might be less time-consuming than with manual driving, but would still comprise tasks such as monitoring the vehicle operation. With fully automated driving, such activities would almost diminish, leaving simple tasks such as defining the destination when entering the vehicle. (see also [6])

Non-Driving-Related Activities Tasks and activities that are not related to driving, such as operating comfort or infotainment systems, communicating with passengers or remote people, eating and drinking (i.e., the former tertiary task) are examples for non-driving related activities. This will also include new activities that become possible with automated driving such as reading, watching motion pictures, or even sleeping. With an increasing level of automation, the amount of non-driving-related activities will increase and make up the most part of the activities in the car in a fully automated driving scenario.

Even though these terms have partly been used in literature (e.g., [6, 7, 11]), they have not yet been widely

adopted and were so far often used without a clear definition. With the definition provided above, it should be easier to clearly describe tasks and activities in the car for manual, assisted, and automated driving situations alike.

Conclusion

With a clear definition of *(non-) driving-related activities* and their relation to the terms of primary, secondary, and tertiary driving tasks, we hope to draft a common terminology to be used to describe tasks and activities in the car. The benefit of these terms and definitions is that they can be used across all levels of automated driving–from manual to fully automated driving.

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