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Human-Machine Interaction for Vehicles: Review and Outlook

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Full text available at: http://dx.doi.org/10.1561/1100000069

Foundations and Trends® in Human-Computer Interaction

Published, sold and distributed by:
now Publishers Inc.
PO Box 1024
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The preferred citation for this publication is

A. Kun. *Human-Machine Interaction for Vehicles: Review and Outlook*. Foundations and Trends® in Human-Computer Interaction, vol. 11, no. 4, pp. 201–293, 2018.

ISBN: 978-1-68083-415-4
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Volume 11, Issue 4, 2018

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Full text available at: http://dx.doi.org/10.1561/1100000069

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Human-Machine Interaction for Vehicles: Review and Outlook

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ABSTRACT

Today's vehicles have myriad user interfaces, from those related to the moment-to-moment control of the vehicle, to those that allow the consumption of information and entertainment. The bulk of the research in this domain is related to manual driving. With recent advances in automated vehicles, there is an increased attention to user interactions as they relate to automated vehicles. In exploring human-machine interaction for both manual and automated driving, a key issue has been how to create safe in-vehicle interactions that assist the driver in completing the driving task, as well as to allow drivers to accomplish various non-driving tasks. In automated vehicles, human-machine interactions will increasingly allow users to reclaim their time, so that they can spend time on non-driving tasks. Given that it is unlikely that most vehicles will be fully automated in the near future, there are also significant efforts to understand how to help the driver switch between different modes of automation. This paper provides a review of these areas of research, as well as recommendations for future work.

Andrew L. Kun (2018), "Human-Machine Interaction for Vehicles: Review and Outlook", Foundations and Trends® in Human-Computer Interaction: Vol. 11, No. 4, pp 201–293. DOI: 10.1561/1100000069.

Full text available at: http://dx.doi.org/10.1561/1100000069

1

Introduction

Road vehicles, from cars, to buses, to trucks, are an inseparable part of modern life. People use cars and buses to commute to work, go shopping, and visit vacation spots. They use trucks to transport goods over long distances, deliver packages to a customer's doorstep, and to provide a mobile base for electricians, plumbers, and first responders. It is not surprising then that industry, academia, and government have been spending a considerable amount of effort to create road vehicles that are safe, efficient, pleasant to drive, and can help us to effectively accomplish different tasks. Much of this effort is focused on problems such as how to design brakes that can halt the vehicle quickly, and how to design fuel-efficient engines. In this paper, we explore the efforts to design in-vehicle user interfaces.

User interfaces in vehicles have gone through a significant transformation since the invention of the automobile in 1886 by Karl Benz (Figure 1.1). Akamatsu and colleagues document this transformation (Akamatsu *et al.*, 2013): early vehicles only provided interfaces that allowed steering and braking; instrument clusters appeared in the 1920s; by the 1980s navigation systems began to appear in vehicles; and starting with the 1990s brought-in devices, primarily cell phones (and later

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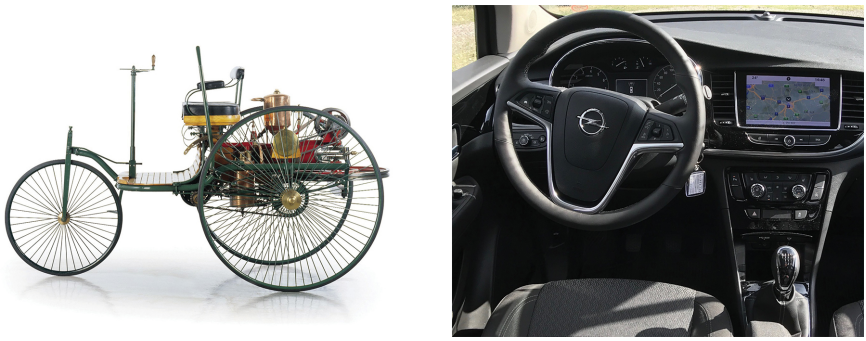

Figure 1.1: Human-machine interaction for vehicles has become more complicated over the years. On the left is the Benz's 1886 Patent Motorwagen, the world's first automobile (image by DaimlerChrysler AG, CC-BY-SA-3.0, via Wikimedia Commons). On the right is the interior of a 2017 Opel. The operator of the Benz interacted with the vehicle through inputs to control lateral and longitudinal position. The 2017 vehicle has myriad displays and inputs.

smartphones), became a major presence in vehicles. The drastic transformation of in-vehicle user interfaces is also documented by Kern and Schmidt who compared two vehicles from the same manufacturer, one from 1954 and another from 2007 – the newer vehicle had 113 in-vehicle devices, which is almost four times more than the older vehicle (Kern and Schmidt, 2009). In general, today's vehicles have myriad functions, and related user interfaces. These can be quite confusing to the driver – this is such a significant problem that since 2015 there is a website dedicated to explaining to consumers which safety technologies are available in their vehicles, and how to use these technologies, including how to use their user interfaces (www.mycardoeswhat.org).

In this paper we focus on discussing work related to modern in-vehicle user interfaces. The bulk of this work in the recent past and the present is related to manual driving – the case when the driver's primary task is the control of the vehicle, and all other activities in the vehicle, such as interacting with a navigation system, or communicating with remote conversants, are considered secondary tasks. In exploring user interfaces for manual driving a key issue has been assessing the effects of the interfaces on driving safety. Very frequently this is done in the context of an application, such as navigation, entertainment, or

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communication. In this paper we will review key findings from this line of work.

Yet another topic that has received attention is the user experience (UX) of in-vehicle user interfaces. This type of work is aimed both at the driver, as well as at passengers who have become more frequent subjects of exploration in recent times. This is especially true with the advent of automated vehicles, given that all occupants of highly automated vehicles will be passengers for at least part of the journey. And, with automated vehicles there is increasing attention to user interactions for work and play (Kun *et al.*, 2016). Given that it is unlikely that most vehicles will be fully automated in the near future, there are also significant efforts to understand how to help the driver switch between different modes of automation. This paper will review work in all of these areas, and it will provide recommendations for future research.

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