Daniel Watzenig
Martin Horn *Editors*

Automated Driving

Safer and More Efficient Future Driving

Springer

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Foreword

Automation of processes and products is a key step into next generation of our economy. Due to the high economic impact of transportation industry and especially of the automotive sector, automated driving and all related ingredients act as strong technology drivers for many other application domains. Therefore, this book with a comprehensive treatment of the relevant elements is very helpful for the advancement of the domain itself, but will also help to spread the technological and procedural essentials towards other applications.

Automation of vehicles is enabled by digitization, which means by the pervasive penetration of interconnected digital technology into our products and systems. This allows us to provide better integration, achieve higher performance, and provide the required intelligence and communication to the environment, especially to the human user.

In aeronautic systems, a high degree of automation already exists and has a certain track record, ranging from many assistance systems up to fully automated aircrafts, including all phases of operation, from taxiing to take-off, cruising, and landing. Sense and avoid is implemented, but based on well-established procedural rules and safety margins. Further on the participants (pilots) are well trained and subject to regular checks. Automotive automation could learn a lot from this profound source of experience, but it has to adapt to its own requirements and operational conditions: The distances are much shorter, the reaction time is very short, and the analysis of the environmental situation is much more complex.

New technologies will gain relevance in the automated vehicles: Software will play a key role, especially in embedded real-time systems. Smart components and subsystems will exchange huge amounts of data, on board of the vehicle, and also with the infrastructure. We will need communication links with high levels of availability and high immunity against undesired penetration from outside. Thus, safety and security will become mutually dependent couples. High performance computing capacities will be needed to process the incoming information and drive the decisions to control the vehicle in a safe way. Despite all this high tech, the human user shall always understand what is going on and have the chance to control the system as ultima ratio decider.

Mastering this chain of new technologies will be a key enabler for families of products in many other domains. This book will provide the reader with considerations and key insight how to achieve the different steps. Therefore, we have to thank the editors and the authors for this comprehensive work!

Heinrich Daembkes

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Preface

Automated vehicle technology has the potential to be a game changer on the roads, altering the face of motoring as we experience it today. Many benefits are expected, ranging from improved safety, reduced congestion, lower stress for car occupants, social inclusion, lower emissions, and better road utilization due to optimal integration of private and public transport.

Over the last decade, vehicle automation has attracted considerable attention of the public, governments, the scientific community, and the industry around the world, mainly driven by the evolution of driver assistance and active safety. Many cars sold today are already capable of some level of automation while higher automated prototype vehicles are continuously tested on public roads, especially in the United States, Europe, and Japan. Automated driving technology has arrived rapidly on the market, and the future deployment is expected to accelerate over the next years. As a matter of fact, most of the core technologies required for fully autonomous driving (SAE level 5) are available today, many are mature, and some are already on the way being deployed in commercially available vehicles.

During the last three years, public authorities from many countries presented action and innovation plans to facilitate the development and stepwise introduction of automated vehicles. Those plans cover actions for a multitude of technical and non-technical aspects that need to be taken into account. In particular, road safety is expected to substantially improve with vehicle automation since more than 90 % of the crashes involve human errors. However, most often driving involves no crashes. The ultimate safety test for automated vehicles will have to point out how well they can replicate the crash-free performance of human drivers especially at the level of partial and conditional automation within mixed traffic.

In order to move towards a significant market penetration of automated vehicles, different technological configurations have to be considered. Most of the state-of-practice vehicles and prototypes rely on in-vehicle sensor platforms and require little digital infrastructure communication, while a greater connectivity between vehicles and their infrastructure is identified to be beneficial. This entails the development of common communication protocols, encrypted security standards, and investment in new types of infrastructure or upgrading existing ones. Nevertheless, both models

require accurate digital representations of their environment at any time, for any weather condition, and in any traffic situation.

Beyond the technical issues, several action items for faster introduction of automated vehicles have to be solved by the governments in order to ensure the full compatibility with the public expectations regarding legal responsibility, safety, and privacy. Authorities have to create the legal framework to remove liability traps, to encourage test regions, to review long-term infrastructure investments, to provide open access, and to set up legal frameworks for inter-car communication.

The challenging technical topics still to be solved and the constant endeavours around the world to drive this exciting technology forward have motivated the creation of this book. In order to get a balanced view on the state of development, the editors have invited authors from different stakeholders including public authorities, car manufacturers, suppliers, and research organizations. Within this book, the state of practice and the state of the art of automated driving building blocks are extensively reviewed and future trends are envisioned. The book encompasses the importance of control engineering, recent advances in environment sensing and perception, in-vehicle architectures, and dependable power computing as well as active and functional safety in automated driving. Furthermore, we have put a strong focus on the validation and testing of automated driving functions. A sampling of relevant industrially driven research projects and industrial initiatives concludes the book.

We strongly believe that this book on automated driving provides an overview of current and emerging technical challenges in that field and gives deep insights into industrial demands. We hope that the reader will be inspired by the different technical articles, selected project summaries, and introductions of renowned national and European initiatives.

Finally, we would like to express our sincere appreciation and gratitude to all authors and co-authors, who made the publication of this book possible. We are grateful to Silvia Schilgerius at Springer for her professionalism and support.

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Part I
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