

# **Unsettled Issues in Vehicle Autonomy, Artificial Intelligence, and Human- Machine Interaction**

**Fang Chen, PhD**

# Unsettled Issues in Vehicle Autonomy, Artificial Intelligence, and Human-Machine Interaction

**Fang Chen, PhD**  
*FAW Group Corporation*

**EDGE DEVELOPMENT TEAM**

---

Qinyuan Ren, PhD, *Zhejiang University*  
Zaifeng Gao, PhD, *Zhejiang University*  
Zhengqi Wen, PhD, *National Laboratory of  
Pattern Recognition*

Henry Yang, *Chalmers University of  
Technology*





### About the Publisher

SAE International® is a global association of more than 128,000 engineers and related technical experts in the aerospace, automotive, and commercial-vehicle industries. Our core competencies are lifelong learning and voluntary consensus standards development. Visit [sae.org](http://sae.org)

### SAE EDGE™ Research Report Disclaimer

SAE EDGE™ Research Reports focus on topics that are dynamic, in which knowledge is incomplete, and which have yet to be standardized. They represent the collective wisdom of a group of experts and serve as a practical guide to the reader in understanding unsettled subject matter. They are not meant to provide a recommended practice or protocol. The experts have assembled as a community of practitioners to contribute and collectivize their thoughts and points of view. These are not the positions of the institutions or businesses with which they are affiliated, nor is one contributor's perspective advanced over others. SAE EDGE™ Research Reports are the property of SAE International® and SAE alone is responsible for their content.

### About This Publication

SAE EDGE™ Research Reports provide state-of-the-art and state-of-the-industry examinations of the most significant topics in mobility engineering. Contributors to SAE EDGE™ Research Reports are experts from academia, government, industry, and research who have come together to explore and define the most critical advancements, challenges, and future direction in areas such as vehicle automation, unmanned aircraft, cybersecurity, advanced propulsion, advanced manufacturing, Internet of Things, and connectivity.

### SAE Team

Frank Menchaca, Chief Growth Officer  
Michael Thompson, Director of Standards, Information and Research Publications  
Monica Nogueira, Director of Content Acquisition and Development  
Beth Ellen Dibeler, Product Manager  
William Kucinski, Managing Technical Editor

---

Copyright © 2021 SAE International. All rights reserved.

No part of this publication may be reproduced, stored in a retrieval system, distributed, or transmitted in any form or by any means without the prior written permission of SAE International. For permission and licensing requests, contact SAE Permissions, 400 Commonwealth Drive, Warrendale, PA 15096-0001 USA; e-mail: [copyright@sae.org](mailto:copyright@sae.org); phone: +1-724-772-4028; fax: +1-724-772-9765.

Printed in USA

Information contained in this work has been obtained by SAE International from sources believed to be reliable. However, neither SAE International nor its authors guarantee the accuracy or completeness of any information published herein and neither SAE International nor its authors shall be responsible for any errors, omissions, or damages arising out of use of this information. This work is published with the understanding that SAE International and its authors are supplying information but are not attempting to render engineering or other professional services. If such services are required, the assistance of an appropriate professional should be sought.

**EPR2021010**

**ISSN 2640-3536**

**e-ISSN 2640-3544**

**ISBN 978-1-4686-0330-9**

**To purchase bulk quantities, please contact:** SAE Customer Service

E-mail: [CustomerService@sae.org](mailto:CustomerService@sae.org)

Phone: 877-606-7323 (*inside USA and Canada*)  
+1-724-776-4970 (*outside USA*)

Fax: +1-724-776-0790

<https://www.sae.org/publications/edge-research-reports>

## About the Editor



In 1997, **Fang Chen** received her PhD from Linköping University in Sweden. Since then, her main research areas have included cognitive science, interactive design, and human-machine interaction with a theoretical background involving physiology, behavioral psychology, and visual and auditory interaction. Her research has been widely applied in multimedia system usability, automatic control, aerospace and automotive driving control, public safety, and crisis management. As an expert in interaction design, Dr. Chen serves as a member and consultant to several international academic research institutions. She has published hundreds of papers in international journals and conferences.

# contents

**About the Editor**

**Unsettled Issues in Vehicle Autonomy, Artificial Intelligence, and Human-Machine Interaction . . . . . 3**

- Introduction . . . . . 4**
  - State of the Industry* . . . . . 4
  - Unsettled Issues Concerning In-Vehicle Autonomy, AI, and HMI* . . . . . 4
- Enabling AVs with AI . . . . . 4**
  - Perception in AVs* . . . . . 4
  - Interaction in AVs* . . . . . 6
  - Decision-making in AVs* . . . . . 7

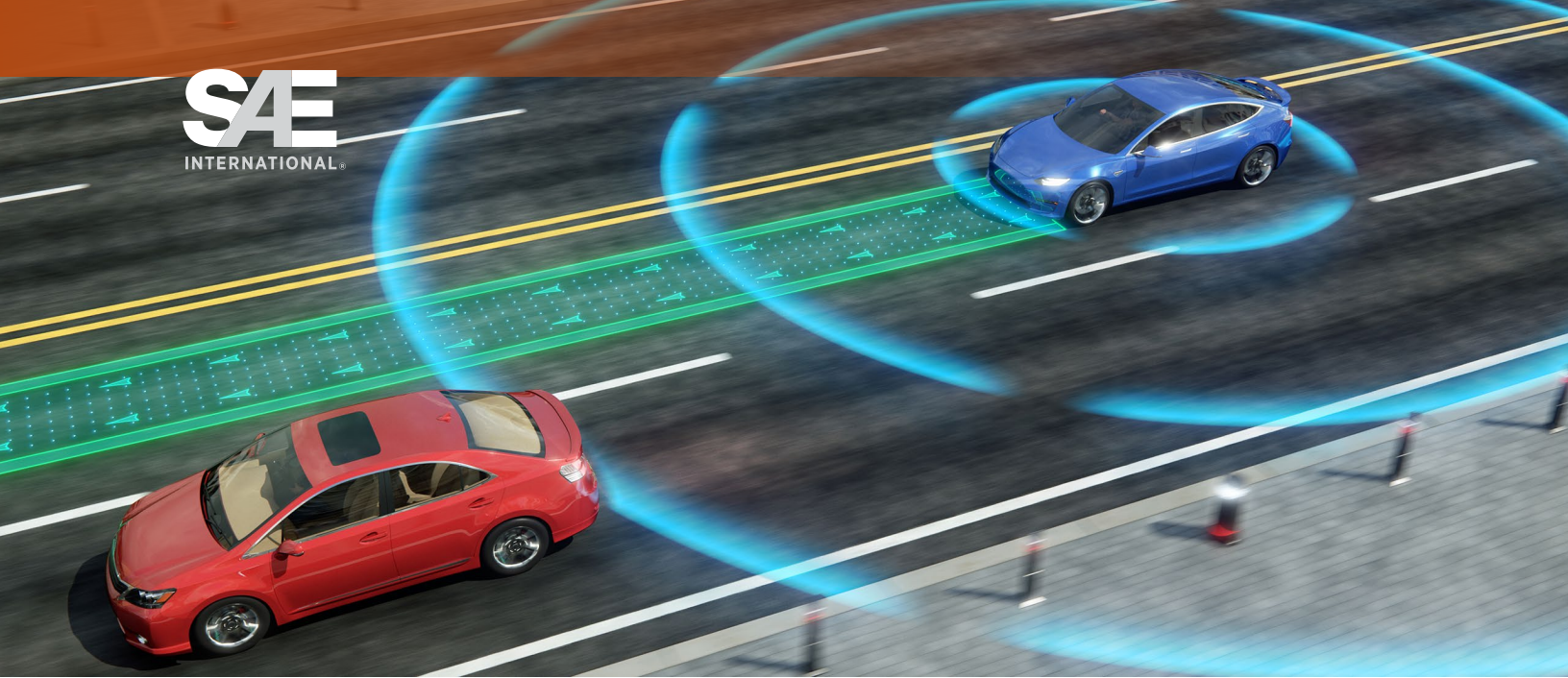
- Designing the Personalized HMI . . . . . 8**
  - Code-switching Automatic Speech Recognition* . . . . . 8
  - Lack of Data* . . . . . 9
  - Multimodal Emotion Detection* . . . . . 9
  - Recommendations* . . . . . 10

- Recognizing the Driver’s State and Regulating Negative Emotions . . . . . 11**
  - Classification of Emotion* . . . . . 11
  - Triggering Factors* . . . . . 11

- Cognitive Behavior of Angry Drivers and Their Physiological Reflections* . . . . . 12
- Changes in Driver Behavior* . . . . . 12
- Measurement of Anger* . . . . . 12
- Using AI for Emotion Detection* . . . . . 13
- Research Methodology Limitations* . . . . . 15
- The Need to Help an Angry Driver* . . . . . 15
- Recommendations* . . . . . 15

- Enhancing the Trust in AVs . . . . . 16**
  - Trust in Autonomous Driving* . . . . . 16
  - Dynamic Trust Framework* . . . . . 16
  - Recommendations* . . . . . 17
    - Trust Monitoring* . . . . . 17
    - Optimizing HMI Design* . . . . . 17
    - Driving Training* . . . . . 18

- Summary . . . . . 18**
  - SAE EDGE Research Reports* . . . . . 19
  - Next Steps for Vehicle Autonomy, AI, and HMI* . . . . . 19
  - Recommendations* . . . . . 19
  - Definitions* . . . . . 19
  - Acknowledgments* . . . . . 19
  - References* . . . . . 20
  - Contact Information* . . . . . 24



# Unsettled Issues in Vehicle Autonomy, Artificial Intelligence, and Human-Machine Interaction

## Abstract

Artificial intelligence (AI)-based solutions are slowly making their way into mobile devices and other parts of our lives on a daily basis. By integrating AI into vehicles, many manufacturers are looking forward to developing autonomous cars. However, as of today, no existing autonomous vehicles (AVs) that are consumer ready have reached SAE Level 5 automation. To develop a consumer-ready AV, numerous problems need to be addressed. In this report we present a few of these unaddressed issues related to human-machine interaction design. They include interface implementation, speech interaction, emotion regulation, emotion detection, and driver trust. For each of these aspects, we present the subject in detail—including the area's current state of research and development, its current challenges, and proposed solutions worth exploring.

NOTE: SAE EDGE™ Research Reports are intended to identify and illuminate key issues in emerging, but still unsettled, technologies of interest to the mobility industry. The goal of SAE EDGE™ Research Reports is to stimulate discussion and work in the hope of promoting and speeding resolution of identified issues. These reports are not intended to resolve the challenges they identify or close any topic to further scrutiny.

**FANG CHEN, PhD**  
*FAW Group Corporation*

### EDGE Development Team

Qinyuan Ren, PhD, *Zhejiang University*  
Zaifeng Gao, PhD, *Zhejiang University*  
Zhengqi Wen, PhD, *National Laboratory of  
Pattern Recognition*  
Henry Yang, *Chalmers University of  
Technology*

ISSN 2640-3536