Fei-Yue Wang, Editor

The Story of IEEE ICVES: The Dark Days Before China's Boom in New Energy Vehicles

EDITOR'S NOTE

Please send your submissions for the "History and Perspectives" column to Fei-Yue Wang at feiyue.wang@ia.ac.cn.

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Earlier this year, one of my former students told me that electric vehicles (EVs) are taking over the Chinese automobile market: despite having their worst year during the COVID-19 pandemic, China's passenger EV sales almost doubled in 2022, growing 87% year over year. EVs now account for one in four cars sold in China, or nearly 59% of the global EV sales volume.

According to analyst S. Mandal, "China's EV market is the most vibrant globally. More than 94 brands cumulatively offer over 300 models ranging from just $5,000 to over $90,000. Local brands command 81% of the EV market." I must admit that I was surprised by this, as before the pandemic, I had been in deep doubt about China's EV policy and worried about its outcome.

This also brought me back to the memory of creating the IEEE International Conference on Vehicular Electronics and Safety (ICVES), the long journey and fast rise of China's automobile industry, and important roles played by major foreign automakers.

It was at the 2000 IEEE Intelligent Vehicles Symposium (IV), in Dearborn, MI, USA, and 2001 IEEE International Conference on Intelligent Transportation Systems (ITSC), in Oakland, CA, USA, that the idea of having a future IV in China was discussed and presented, and at ITSC 2003, in Shanghai, China, the IEEE Intelligent Transportation Systems (ITS) Council Administrative Committee accepted a proposal that IV 2006 be held in Xi'an, China, with a poetic theme, "Embedded Systems and Safety: A New Journey for Intelligent Vehicles on Ancient Silkroad." However, at ITSC 2004, in Washington, DC, USA, a few colleagues in the IEEE Intelligent Transportation Systems Society (ITSS) worried about the participation of Chinese intelligent vehicles professionals since, at the time, China had almost no modern auto industry, let alone intelligent vehicles research, and they filed a motion to relocate IV 2006 to Tokyo, Japan. To my disappointment, the motion passed. I had just been elected president of the newly established ITSS. As a token of appreciation and in support of the local effort that had already been invested in IV 2006, I proposed to have a new conference for China, thus the creation of ICVES, which was launched in October 2005, at Xi'an.

The inaugural meeting was organized by Xi'an Jiaotong (which means *transportation* in Chinese, originally for railways) University. Prof. Nanning Zheng, then the president of the university, was the general chair, and I was the program chair. We invited Prof. Gang Wan—a former auto engineer in Germany who went on to co-organize ICVES 2006, in Shanghai; become president of Tongji University, in Shanghai; and rise to minister of China's Ministry of Science and Technology—as the keynote speaker, for his work on hybrid EVs. Two years later, I organized ICVES 2007, in Beijing, China, and in 2008, Prof. Umit Ozguner, the founding chair of the ITS Council, organized the

Digital Object Identifier 10.1109/MITS.2023.3295396
Date of current version: 7 September 2023

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first ICVES outside China, in Columbus, OH, USA.

Actually, my motivation for ICVES was not just for the compensation. Technically, we did need a new venue to focus on EVs and advanced driver-assistance systems with new and systematic thinking; as for the aspect of service and development, the ITSS was intended to cultivate influence among emerging Chinese ITS and intelligent vehicles professionals, who would eventually form the largest group of such professionals in the world. I had worked toward that goal since the middle 1990s, and in 1998, I organized China's first International Intelligent Vehicles Workshop, in Hangzhou, at Zhejiang University, my alma mater, when I was chair of the Scholarship Selection Committee of the American Zhu Kezhen Education Foundation (AZKEF). That was the only major academic event financially sponsored by AZKEF, and I invited Prof. Ozguner, from The Ohio State University, for ITSC activities, as well as J. Karl Hedrick, then director of Partners for Advanced Transportation Technology at the University of California, Berkeley, for San Diego's "Big Demo"; Chuck Thorpe, then director of Carnegie Mellon University's Navigation Laboratory, for robotic vehicles; and a few others from the United Kingdom and Europe. I learned from this experience that intelligent vehicles funding was hard to get in China, and there would be a long way to go for China's research and development in autonomous driving and intelligent vehicles.

Therefore, the initial goal of ICVES in China was educational and to encourage more professors and graduate students to be involved in autonomous driving. I spoke with several university presidents and tried to convince them that support for intelligent vehicles research would increase their school's name recognition within the general public and inspire students' interest in research. I still remember the typical response: OK with the name recognition but no need for further inspiration of students: there was too much interest in research already.

In 2003, our plan for IV 2006 was to launch an intelligent vehicles competition in simulation [1], called AutOPEN, for conceiving, designing, implementing, and running emulated autonomous driving scenarios via computer programs only, which was intended to support our concept of digital vehicle proving grounds [2]. The idea of AutOPEN fit our educational purpose well, so it was adopted by ICVES 2005, and the project was announced and extended to the concept of parallel testing by including both a virtual test with computer algorithms of autonomous driving and a field test with autonomous physical vehicles. However, actual implementation didn't materialize until 2009, when IV finally arrived in Xi'an four years late, and China's Intelligent Vehicles Future Challenge was installed as the IV 2009 demonstration program, with financial support from the National Natural Science Foundation of China [3], [4], [5], [6], [7], [8]. I am glad that this effort has now grown into a new field of scenarios engineering, i.e., verification and validation, and calibration and certification for autonomous driving and intelligent vehicles [9], [10], [11], [12], [13], [14], [15], [16].

In a failed attempt at ICVES 2005, I made an effort to jump-start research in parallel driving of parallel vehicles as a new direction for networked control systems, i.e., parallel vehicular control and management through the Artificial societies, Computational experiments, Parallel execution (ACP) -based artificial–actual interaction, under the principle of "simple inside cars, complex outside cars," for a network of connected cars. In my paper and presentation at the conference [17], I tried to describe an agent-based approach for parallel driving and parallel traffic control that would build and deploy local, or in situ (a term I borrowed from my NASA and BHP projects), driver agents on specific roads or traffic control agents at specific intersections to assist with driving or traffic regulation and even take over in case of emergencies. Five years later, I published my first full paper on parallel traffic control, in 2010 [18]; 10 years later, we launched our start-up for applying this technique in smart mining operations; and 13 years later, research on parallel driving as a unified approach for transport automation and vehicle intelligence was funded by Intel through its Intel Collaborative Research Institute for Intelligent and Connected Vehicles.

Today, parallel driving and parallel intelligence have emerged as an important research direction in many fields and under various names, from digital twins to virtual–real interaction, especially after AlphaGo and ChatGPT. As this technology grows, our future workforce will consist of 80%-plus digital agents, roughly 15%-minus robotic agents, and 5%-minus or fewer human agents, and I believe a day in our life and work will be like this:

1) *Morning, AM for autonomous mode*: Hopefully, for more than 80% of our time, or about 20 h a day, digital and robotic agents will do our jobs, and we will enjoy our life and let the world run autonomously.
2) *Afternoon, PM for parallel mode*: Hopefully, for less than 15% of our

time, or about 3 h a day, we will interact with the world remotely through clouds or teleoperations.

3) *Evening, EM for expert/emergency mode*: For less than 5% of our time, or about 1 h a day, we will be in the field to handle special or emergency situations that are beyond the capacity of digital and robotic agents [19], [20], [21], [22], [23].

Two decades have passed since our initial effort to have IV and ICVES in China, and huge changes have occurred. China is now the largest auto market, the biggest auto maker, and the number one auto exporter in the world. I never could have dreamed this when I was standing alone at one of our 2005 IEEE Technical Activities Board forums in Washington, DC, debating U.S. automakers' policy on manufacturing in China. I am no longer a university professor in the United States pursuing a liberal research agenda but a Chinese scientist focusing on my funded project obligation. My feelings are complicated, and something does worry me: the general public seems overwhelmed by or obsessed with a university's name recognition, and the interest of students in research as well as learning has become a serious issue. We must renew our effort and emphasize fundamentals and basics in human ethics, social responsibility, and ecological sustainability, from environmental, social, and governance initiatives to diversity, equity, and inclusion. I hope our work in autonomous driving, ITS, and smart cities will help.

On reflection, I feel very lucky to have had these experiences and would like to say thank you to all my friends and colleagues at ITSC and in the ITSS. As an international professional organization, we must lead the way and maintain our effort to support more initiatives like ICVES; help others to grow, especially those in need; and provide opportunities for young generations that are willing to find new and better ways to serve our community and humanity.

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