

Communication and Letters

Future Directions of Intelligent Vehicles: Potentials, Possibilities, and Perspectives

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This is the brief report of the first IEEE Distributed/Decentralized Hybrid Workshop on Future Directions of Intelligent Vehicles (IEEE DHW-FDIV), part of the IEEE Distributed/Decentralized Hybrid Symposia on Intelligent Vehicles (IEEE DHS-IV) organized by the IEEE Transactions on Intelligent Vehicles (TIV). This DHW was conducted through two events on January 12 and February 7, 2022 with 23 and 12 participants from Asia, Europe, and North America, respectively. Various issues related to the current state of IEEE TIV and potential topics for future research and development of intelligent vehicles are addressed. Based on the suggestion of Professor Fei-Yue Wang, the new Editor-in-Chief of TIV, the first report of DHW-FDIV focuses on meta-vehicles and metaverses for smart mobility and intelligent transportation. Specifically, six directions are discussed and debated at the two events and followed through email/WeChat communications by the participants, as summarized briefly in a sequential order in the following sections.

I. NEW ECOLOGY FOR INTELLIGENT VEHICLES WITH 6I

As pointed out in [1], we need a new ecological mind and systems thinking for future research and development of intelligent vehicles, specifically, we need to study and build six types of intelligent vehicles with six types of intelligence that would drive our societies into smart ones, from “6V” to “6S”: Cognitive Vehicles with Cognitive Intelligence and Parallel Vehicles with Parallel Intelligence for vehicular

Manuscript received March 3, 2022; accepted March 3, 2022. Date of current version April 21, 2022. This work was supported in part by Intel Collaborative Research Institute for Intelligent and Automated Connected Vehicles (“ICRI-IACV”). (*Corresponding author: Fei-Yue Wang.*)

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Digital Object Identifier 10.1109/TIV.2022.3157049

science and technology, Crypto Vehicles with Crypto Intelligence and Federated Vehicles with Federated Intelligence for vehicular operation and management, Social Vehicles with Social Intelligence and Ecological Vehicles with Ecological Intelligence for vehicular ethics and sustainability. Those 6Vs would make our societies Safe in the physical world, Secure in the cyberworld, Sustainable in the ecological world, Sensitive to individual needs, Servable for all, and Smart in all. Blockchains, smart contracts, DAOs, Web 3.0, Mobile Intelligent Spaces, Brain Computer and Human Machine Interfaces, New Driving Mechanism and Green Power Systems will be key technologies and methods for intelligent vehicles in this 6V to 6S transformation.

II. META-VEHICLES IN METAVERSES

Metaverse is a reflection of the coming revolution of cyberspace and intelligent industries. The true nature of this intelligent technology and also for many related topics including, mirror worlds, shadow systems, digital twins, parallel systems is to turn human “attention” and “trust” into commercial commodities of mass production and mass circulation. This is a historical breakthrough against Herbert Simon’s curse, as the founding father of Artificial Intelligence had famously claimed: “Attention and trust are the two things that cannot become commodities because they could not be massively produced and massively circulated due to the inherent limitation in human cognitive capacity”. For meta-vehicle in the metaverse, this is a technological expression of AI, Robotics, Blockchain, Knowledge Automation, Intelligent Vehicles, and Intelligent Transportation Systems. This was also the seed for many pioneer studies on computational experiments, shadow systems, and parallel intelligence [2], [3], and especially an extension of recent Cyber-Physical-Social Systems (CPSS), and Parallel Driving and Parallel Testing of Parallel Vehicles in CPSS [4], [5]. To this end, metaverses are specific realizations of CPSS which allow us to design meta-vehicles or parallel vehicles with transparent virtual-real interaction for future intelligent transportation and smart mobility.

III. TRUE DAOs FOR INTELLIGENT VEHICLES WITH BLOCKCHAINS

It is also important to explore the “TRUE DAO” to intelligent systems for smart societies by integrating blockchains, smart contracts, along with Decentralized Autonomous Organizations (DAOs, Type I) and their Distributed Autonomous Operations (DAOs, type II). DAOs are widely considered a major form of organization in the crypto world. In recent years, the DAO practice has been witnessed to evolve fast towards maturing with the continuous improvement of blockchain ecosystems [6], [7]. Interestingly, the “Dao” or “Tao” in Chinese means “Journey” or “Meta”, and is actually the core concept of Chinese philosophy, as stated by Chinese philosopher Laozi. The Dao produces

The One, The One produces The Two, The Two produces The Three, and The Three produces The All. With Parallel Intelligence in CPSS, and helps from blockchains, smart contracts, cloud/edge computing, and DAOs, this philosophical thinking is becoming a technical process of producing Big Data from small data and generating deep intelligence from Big Data, which will form a TRUE journey for intelligence and smartness.

IV. INTELLIGENT MOBILE SPACES FOR INTELLIGENT VEHICLES

Intelligent mobile spaces [8], [9] are environments that can continuously monitor what are happening in intelligent vehicles, can communicate with their inhabitants and neighborhoods, can make related inference and decisions and act on these decisions. With the availability of a large numbers of smart sensors and context-aware appliances with embedded processors and communication capability, the spaces [10] around intelligent vehicles are becoming increasingly intelligent. As a novel breakthrough [11], PARALLEL VEHICLES (PAVE) can maintain intelligent control of the actual intelligent vehicles and achieve the global optimization via software-defined intelligent vehicles, intelligent infrastructure construction, and parallel control center. From software-defined intelligent vehicles, we have cyberculture, cyberspace, virtual reality, mirror worlds, digital twins, metaverses and parallel intelligence, but for their actual materialization we must have actual and solid advances in hard technologies of control and communication, including but not limited to: Internet, iPhones, Internet of Things, 5G, Internet of Minds, Brain Computer Interface, and more. These theories and technologies that help intelligent vehicles aren't new, but combining them with cutting edge digital tools opens a world of new opportunities.

V. INTELLIGENT VEHICLES FOR CARBON NEUTRALITY AND GREEN TRANSPORTATION

Road transportation is currently responsible for over 15% of global carbon dioxides (CO₂) emissions [12]. With the increasing demand for passenger and freight transport, road transportation is set to become one of the largest emitters in the next decade. In order to limit global warming to 1.5 degrees Celsius – a threshold laid down in the Paris agreement signed by 196 countries in 2015, carbon neutrality by 2050 is essential. Achieving this target would require continuous research into and development of green transportation technologies.

For passenger transport and short-haul road freight, battery electrification with renewable electricity provides a truly viable pathway [13]. Promoting intelligentization in energy management and powertrain control for battery electric vehicles is often regarded as the key requirement for cutting vehicle energy consumption and well-to-wheel emissions. On this basis, implementation of intelligent vehicular systems, e.g. advanced sensing and telematics, Advanced Driver Assistance Systems (ADAS), vehicle-to-X communication systems, etc. can lead to further improvement of vehicle energy efficiency. The contribution of Connected and Autonomous Vehicles (CAVs) towards global carbon neutralization is debatable – CAVs may increase driving efficiency and smooth traffic flow but are likely to increase the rate of vehicle renewal, causing increase in vehicle lifecycle emissions [14]. For long-haul road freight where the viability of battery electrification is yet unclear [15], research on the measures for improving traditional diesel engine efficiency should not be discouraged, while that on alternative fuels, e.g. gas and biofuels and corresponding propulsion systems should be encouraged. Meanwhile, intelligent systems that support eco-driving, e.g. adaptive cruise control, real-time driver feedback and platooning systems should be promoted. Moreover, close attentions are being paid to emerging zero-emission long-haul transportation technologies, such as Hydrogen fuel cell and Electric Road System (ERS) [16].

While it is impossible to know which technology portfolio for decarbonizing road transportation will ultimately roll out, the DHW-FDIV will continue to track and present advances in the research, development, trialing and practice of intelligent vehicle systems towards the target of global carbon neutrality.

VI. DRIVING INTO 6S SOCIETIES WITH INTELLIGENT VEHICLES

Intelligent vehicles must be the vehicle to make our human societies have Safety in the physical spaces, Security in the information or cyberspaces, Sustainability in both the ecological and artificial/knowledge spaces, Sensitivity to our individual needs such as privacies and desires for happiness, and provide Services of Smartness to everyone in the way that will benefit our humanity and welfare [17]. We need a Systems of Intelligent Vehicular Systems (SoIVS) approach for this goal since no single method or technology can achieved such purpose and multi-disciplinary, inter-disciplinary, and trans-disciplinary thinking and methods must be adapted with a new level of emphasis and effort in the field of intelligent vehicles. For example, how can we make the “Hanoi” Intelligence that combines human, natural, and organizational skills and knowledge be a reality for design, testing, manufacturing, marketing/sales, operations/maintenance, and remanufacturing/recycle of intelligent vehicles? This should be investigated further in our future DHW-FDIVs.

VII. CALL FOR SUGGESTION AND PARTICIPATION

The field of intelligent vehicles and smart mobility is ever-expanding! It is the golden opportunity for all of us to be part of it and think, write, and contribute! Thanks to all associate editors and attendees of the first workshop for your insights and contribution!

Welcome to participate in the future Decentralized Hybrid Workshop on Future Directions of Intelligent Vehicles (DHW-FDIV). The discussion will be summarized and reported in our Scanning the Issue and Beyond at IEEE TIV. Any suggestions, comments, or proposals for topics of future workshop are greatly appreciated.

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