Foundation Vehicles: From Foundation Intelligence to Foundation Transportation for Future Mobility

Dear All,

I would like to share the following news with you:

- IEEE TIV has received its 3251 manuscript submissions, which is nearly twice as many as that of last year, 236 submissions are still being reviewed in our system, and 18 are overdue for review scoring. I would like to express my sincere gratitude to all authors, reviewers, and editorial board members for your invaluable contributions and unwavering support. Your dedication has been instrumental in maintaining the high quality and great service of our journal and fostering a vibrant scholarly community [1], [2], [3], [4], [5], [6], [7].
- The two key indices of IEEE TIV: from January to September 2023, our acceptance rate is 11.51%, and our average days from submitted to accepted is 36.25 days. TIV is in a great state.
- According to the latest Essential Science Indicators, IEEE TIV boasted 41 articles that are listed as highly cited papers (HCP), along with 2 articles selected as hot papers (see Fig. 1). Among these HCPs, 36 are from the first six months of all papers published during that period 2023, accounting for 13.9%. For hot papers, both are from 2023. Congratulations to the authors of HCP.
- Our Transactions has been officially an SCIE publication since 2021. The first impact factor (IF) in 2021 is 5.009, and the following IF in 2022 is 8.2. The tracking IF of IEEE TIV in 2023 is 8.67, a new record for our periodical [8], [9].

In addition, I would like to repeat the following for our review process [10], which is an urgent matter since we need to move fast in order to process the new submissions: 1) When a negative review report is returned, for example, reject or reject and resubmit, and other reports are overdue, our AEs and SEs are authorized to make recommendations based on the available reports. 2) For submissions under the category of "Overdue Reviewer Response", "Overdue Reviewer Scores", or "Make Recommendation", EiC will look into the situations and make proper decisions without prior notification to AEs and SEs.

This issue comprises 3 letters and 12 regular papers. The first letter is the report of the recent Distributed/Decentralized Hybrid Workshop on Sustainability for Transportation and Logistics (DHW-STL) that aims to explore new opportunities for vehicle carriers and the potential of various carrier types in different domains, including seabed, underwater, maritime, ground-based, aerial, and space applications. The second one is a summary report of the Ninth Distributed/Decentralized Hybrid Workshop on Autonomous Mining (DHW-AM) that aims at enhancing the intelligence of future mining operations with Parallel Intelligence. The last one is a result of a series of reports resulting from the DHW on Scenarios Engineering for Smart Mobility (DHW-SE4SM). It proposes a scenario engineering-based calibration and validation framework for trajectory prediction of autonomous vehicles to validate more effectively the performance of the method in challenging scenarios.

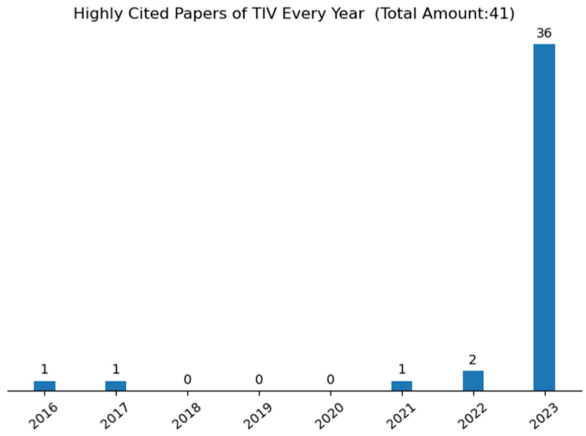

Fig. 1. Highly cited papers of TIV every year.

After Scanning the Issue, I have invited our AE Prof. Lv to talk about foundation vehicles and the issue of moving from foundation intelligence to foundation transportation for future mobility.

Scanning the Issue

Communication and Letters

Intelligent Vehicle Carriers to Support General Civilian Purposes

H. Huang et al.

On Intelligent Mining With Parallel Intelligence

J. Yang et al.

A Vectorized Representation Model for Trajectory Prediction of Intelligent Vehicles in Challenging Scenarios

L. Guo et al.

Digital Object Identifier 10.1109/TIV.2023.3326636

Regular Papers

Integrated Inertial-LiDAR-Based Map Matching Localization for Varying Environments

X. Xia et al.

Localization is vital for automated vehicles, enabling accurate motion planning and control. This research introduces an integrated localization method merging an inertial dead reckoning model with 3D LiDAR-based map matching. By using GNSS, INS, and 3D LiDAR data, a unique point cloud map, emphasizing only crucial elements like buildings and roads, is generated. This method combined with an error-state-constrained Kalman filter enhances localization accuracy. Real-world tests in diverse conditions verify its efficiency and computational simplicity.

Decoupled Real-Time Trajectory Planning for Multiple Autonomous Mining Trucks in Unloading Areas

Q. Yang et al.

Cooperative trajectory planning for autonomous vehicles has gained attention in structured environments, but remains underexplored in unstructured environments like open-pit mines' unloading areas. Optimizing autonomous mining trucks (AMTs) in these areas is vital for safety and productivity. This paper addresses real-time cooperative trajectory planning challenges in such spaces with a decoupled multi-vehicle trajectory planning (MVTP) approach. It combines driving behavior-enhanced path planning and sequential real-time cooperative speed planning, outperforming other MVTP methods in security and efficiency.

Finite-Time Command-Filtered Lateral-Longitudinal Formation Control of Vehicles on Rough Roads

G. Guo and Q. Zhang

An adaptive sliding mode road disturbance observer is introduced, based on which, a finite-time conmand-filtered vehicular formation controller is derived. The resulted error compensation-based backstepping control algorithm can achieve lateral-longitudinal vehicle formation control in practical rough road environments. The effectiveness of the method is demonstrated by numerical simulations.

Object-Level Data-Driven Sensor Simulation for Automotive Environment Perception

L. Lindenmaier et al.

A generic stochastic sensor model is proposed that simulates the object-level data, i.e., detections or tracks, of automotive smart sensors using the data of commonly used 3D simulation environments. The model's parameters are identified using real-world measurements; therefore, the end-to-end simulation can reproduce the object-level data of the specific sensors with high fidelity. The simulation results are validated by comparing them with the actual measurements of the simulated sensors.

Real-Time Operations of Autonomous Mobility-on-Demand Services With Inter- and Intra-Zonal Relocation

J. Yeo, S. Lee, K. Jang and J. Lee

This paper presents a real-time relocation model for shared connected autonomous vehicles (SCAVs) in autonomous mobility-on-demand (AMoD) services. It introduces a novel bi-level framework to handle computational burdens, decomposing the problem into inter-zonal and intra-zonal relocations. The contributions include a computationally feasible method for real-time AMoD operations and an analytical formulation to aid decision-makers in understanding relationships between costs and decision factors.

Identifying Critical Test Scenarios for Lane Keeping Assistance System Using Analytic Hierarchy Process and Hierarchical Clustering

R. Song et al.

Lane keeping assistance system (LKAS) is critical components of autonomous driving technologies, and their reliable operation is crucial to ensure passenger safety and maintain traffic flow. Inspired by Scenarios Engineering, the present study introduces a novel approach that includes being the first to combine analytic hierarchy process (AHP) and hierarchical clustering (HC) to identify critical test scenarios for the comprehensive evaluation of LKAS. The proposed approach first utilizes the AHP to rank the key factors that contribute to the failure of the LKAS.

Robust Adversarial Attacks Detection Based on Explainable Deep Reinforcement Learning for UAV Guidance and Planning

T. Hickling, N. Aouf and P. Spencer

The dangers of adversarial attacks on Uncrewed Aerial Vehicle (UAV) agents operating in public are increasing. Adopting AI-based techniques and, more specifically, Deep Learning (DL) approaches to control and guide these UAVs can be beneficial in terms of performance but can add concerns regarding the safety of those techniques and their vulnerability against adversarial attacks. Confusion in the agent's decisionmaking process caused by these attacks can seriously affect the safety of the UAV. This paper proposes an innovative approach based on the explainability of DL methods to build an efficient detector that will protect these DL schemes and the UAVs adopting them from attacks. The agent adopts a Deep Reinforcement Learning (DRL) scheme for guidance and planning.

Semantic Loop Closure Detection for Intelligent Vehicles Using Panoramas

D. Xiao, S. Li and Z. Xuanyuan

This paper proposes a novel method for loop closure detection in intelligent driving systems. Semantic information is utilized from panoramas to address the challenge of inconsistent visual content from different viewpoints. Proposed approach includes

an efficient pipeline for extracting and matching semantic information between frames and introduces a polar coordinate-based panorama representation. Experimental results show significant improvements in loop closure detection accuracy. This research has potential applications in SLAM and other robot tasks.

Left Gaze Bias Between LHT and RHT: A Recommendation Strategy to Mitigate Human Errors in Left- and Right-Hand Driving

J. Xu, K. Guo, X. Zhang and P. Z. H. Sun

Driver errors, such as distraction, perceptual blindness, and incorrect control manipulation, can either cause road accidents or reduce driving performance in daily driving tasks. Several works in literature have illustrated perceptual blindness and distraction are associated with insufficient attention to those activities vital for safe driving. Also, inappropriate driving-related eye movements may subsequently result in manipulation errors, such as inappropriate control of the throttle or steering wheel. Although many studies have examined drivers' visual performance, there have been few attempts to compare left-hand traffic (LHT) and right-hand traffic (RHT) conditions. Even driving in the same driving scene, different eye movement patterns may also be induced due to drivers' left gaze bias. Motivated by this human factor, this research investigates potential human errors in driving from the perspective of eye movements (i.e., saccades and fixations) and corresponding control manipulations.

Awareness Messages by Vulnerable Road Users and Vehicles: Field Tests via LTE-V2X

L. Lusvarghi et al.

This work presents the results of an extensive measurement campaign, aimed at investigating the awareness messages generated by cars and vulnerable road users in real-world urban, suburban, and highway scenarios. The paper details the conditions that trigger the generation of awareness messages, presents the probability mass function of the time interval between consecutive messages, and evaluates the achievable communication range. The paper also proposes an adjustment to the standard that shows a notable improvement with respect to the original setting.

Dynamic Resource Allocation in Queue-Constrained and Delay-Sensitive Vehicular Networks

J. Su et al.

This paper focuses on the dynamic resource allocation framework with queue and delay constraints in vehicular relay networks, where vehicle users and roadside users are in cooperative communications. To reduce data fluctuation and tackle channel uncertainty, the Lyapunov optimization theory is integrated into the long-term dynamic resource allocation framework, which addresses multiple performance indicators including queue backlog, communication delay, and user utility. In particular, the hierarchical competitive relationship between vehicle users and roadside users is captured, and the Stackelberg game structure is adopted to maximize the utilities of all users.

Intelligent Connectivity Through RIS-Assisted Wireless Communication: Exact Performance Analysis With Phase Errors and Mobility

V. K. Chapala and S. M. Zafaruddin

This paper presents an exact analysis of reconfigurable intelligent surface (RIS)-assisted vehicular communication over generalized fading channels with phase errors and the random waypoint model for the moving vehicle. The authors use a novel approach to represent the probability density function of the resultant channel using a univariate Fox-H function. The study concludes that phase errors can be minimized by increasing the number of elements in the RIS module and adopting a higher quantization level.

From Foundation Intelligence to Foundation Transportation for Future Mobility

In the evolving landscape of Foundation Models and Foundation Intelligence [11], [12], the concept of "Foundation Vehicles" is emerging as a significant progression in intelligent vehicles and transportation systems. These Foundation Vehicles are anchored around the key enablers: Foundation Models, Scenarios Engineering [13], [14], and Human-Oriented Operation Systems (H2OS).

Central to this is the foundation model, which provides the underpinning intelligence, adept at processing vast datasets and generalizing across multifaceted driving scenarios. This intelligence is further honed by Scenarios Engineering, which continually exposes and refines the model against diverse driving conditions, ensuring its real-world robustness and adaptability [15]. At the nexus of this technological convergence lies the H2OS [16], [17], [18], binding the machine's sophisticated decision-making with human-centric priorities.

In the realm of "Foundation Vehicles", Foundation Models stand as the bedrock of their intelligent capabilities. These extensive machine learning architectures, trained on vast datasets, equip the vehicles with the cognitive prowess to generalize across diverse driving tasks. Serving as the vehicle's primary decision-making engine, these models process and interpret real-time environmental data, enabling adaptive, informed, and autonomous responses to myriad driving conditions. The sophistication and breadth of Foundation Models thus ensure that Foundation Vehicles not only operate autonomously but also adapt seamlessly to ever-evolving road scenarios, epitomizing the fusion of advanced AI with practical vehicular functionality.

Scenarios Engineering [15] also plays a pivotal role in the conception and refinement of "Foundation Vehicles". It involves the meticulous design and simulation of diverse driving scenarios, both from real-world data and hypothesized situations, serving as the proving grounds for the foundational vehicle models. By continuously exposing these models to a spectrum of scenarios, from routine to rare edge cases, Scenarios Engineering ensures that Foundation Vehicles are not only trained comprehensively but also validated for adaptability, resilience, and safety in dynamic real-world environments. It also provides standardized situations to measure the performance of different autonomous

systems, enabling comparison and ranking. Through this iterative process, Scenarios Engineering bridges the gap between theoretical AI capabilities and practical on-road robustness, solidifying its key role for the vehicle's intelligence and operational integrity.

In addition, in future autonomous vehicles, communications between humans and vehicles are still critical [19]. H2OS emerges as the essential bridge between advanced vehicular AI and human users. Prioritizing a human-centric philosophy, H2OS ensures that while vehicles operate with sophisticated autonomy, the human experience remains paramount. This system facilitates intuitive interactions, prioritizes safety and comfort, and continuously adapts to user needs and preferences. Through H2OS [20], [21], [22], [23], Foundation Vehicles transcend mere mechanical autonomy, evolving into adaptive entities that harmoniously align with human expectations, aspirations, and well-being, making them not just intelligent, but also deeply empathetic companions on the road.

Looking beyond mere vehicular intelligence, "Foundation Vehicles", when viewed through the lens of the whole lifecycle, hold the potential to drive a profound evolution of the automobile industry. By seamlessly integrating advanced AI and user-centric design from initial conception through to recycling, they redefine our understanding of vehicles [24]. Every phase, from design and manufacturing to operation, maintenance, and eventual retirement, is infused with sustainability, smartness, adaptability, and an unmatched user experience, marking a new epoch in our new relationship with vehicles and reshaping the trajectory of future mobility solutions [25].

Therefore, we will enter a new stage of Foundation Transportation with Foundation Intelligence, as envisioned for Transportation 5.0 and Industry 5.0 [26], [27].

Call for Participation: Decentralized Hybrid Workshops

At IEEE TIV we will continue to organize decentralized and hybrid workshops or symposia (DHW or DHS) on various issues in ITS and IVs.

Welcome to participate in our investigations online or offline. Our discussions will be summarized and reported as perspectives, letters, or regular papers at IEEE TIV. The following DHWs have been organized so far:

1) Verification and Validation for IVs (V&V4IV)
2) Autonomous Mining (AM)
3) Ethics, Responsibility, and Sustainability (ERS)
4) Intelligent Vehicles for Education (IV4E)
5) Data Science for Intelligent Vehicles (DSiV)
6) Vehicle 5.0 (V5)
7) Scenarios Engineering for Smart Mobility (SE4SM)
8) CrowdSensing Intelligence (CSI)
9) Sustainability for Transportation and Logistics (STL)

Any suggestions or proposals for future topics of DHW/DHS are greatly appreciated. Looking forward to having you in IEEE TIV DHW/DHS.

The "3323" Review Guideline

As reaffirmed in [28], our review guideline for EIC/SE/AE is "3323":

- 3 weeks for the first decision
- 3 rounds of revision in maximum
- 2 weeks for minor revisions
- 3 weeks for major revisions

Under this guideline, we expect a maximum total 15-week review process for a submission.

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