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Editorial – Recent advances in cyber physical human systems

1. Introduction

Artificial intelligence (AI) is progressing at an unprecedented pace. Regardless of whether Artificial General Intelligence (AGI) will be achieved, engineering systems must support and safeguard humans, not make them irrelevant. This necessity places Cyber-Physical-Human Systems (CPHS) at center stage. CPHS integrate the physical system, the cyber layer (sensing, computation, control, communication), and the human element into a single system.

The design of CPHS requires mathematical models of human cognition, including attention, memory, learning, and decision making. Humans are not isolated entities that merely use automation but team with it, so that humans and AI act as collaborating components of a system pursuing certain performance, safety, and societal objectives. A well-designed CPHS can enable safer transportation, fair resource allocation, better healthcare, and more sustainable food systems.

Putting the human benefit at the hearth of engineering systems is a key pillar of CPHS. This special section highlights recent progress toward this vision. The contributing articles report advances in modeling human behavior in traffic, societal-scale resource allocation methods, precision medicine employing digital twins, systems thinking for large scale dietary change, and perspectives on pathways towards AGI that is safe and aligned with human values.

2. CPHS community and this special section

The flagship event of the CPHS community is the biennial IFAC CPHS conference series, first held in 2016, and subsequently hosted around the globe. The meeting brings together researchers and practitioners to share the latest developments in CPHS and to develop a deeper understanding of the field. The main themes of the series are modeling, analysis, design, control, verification and certification of CPHS.

The five articles in this special section are invited from the 2024 CPHS conference. Each extends the conference contribution into a broader piece that is accessible to the larger control community.

3. Overview of the contributions

3.1. "Path to Artificial General Intelligence: Past, Present, and Future," by Ruhi Sarikaya (Amazon Vice President, leading the Alexa AI organization).

This paper is based on Dr. Sarikaya's plenary lecture at IFAC CPHS'24. In the paper, theoretical foundations of AI, together with algorithmic developments are examined, with particular attention to large foundational models. The article presents recent trends that have

the potential to influence progress toward AGI, and addresses risks (erosion of trust, emergent power-seeking behaviors, manipulation via misinformation) and mitigations (human oversight, human-intent alignment). Human alignment is framed as a primary safety objective for future AI systems.

3.2. "Human-Like Learning in Car Following: An Attention-Based Driving Strategy with Memory-Inspired Adaptation," by Seymanur Al Habboush (Bilkent University), Yildiray Yildiz (Bilkent University), and Anuradha M. Annaswamy (MIT). In the paper, a novel cognitive framework for human drivers is proposed, which is inspired by a well-established human memory model from cognitive psychology. Integrated with an attention mechanism, this model is shown to capture human driving behaviors, based on comparisons with real human driving data. To help practitioners employ the model for traffic simulators, a step-by-step implementation guide is provided.

3.3. "A Vision for Trustworthy, Fair, and Efficient Socio-Technical Control using Karma Economies," by Ezzat Elokda, Andrea Censib, Emilio Frazzoli, Florian Dörfler, and Saverio Bolognani, all from ETH Zurich. The authors propose a methodology, named "karma economies" for the allocation of scarce resources to public, such as energy, transportation privileges, computation, and data. This distribution of scarce resources to human citizens is termed "socio-technical control design" by the authors. The main promise of the study is societal future smart cities that are designed to align with human and societal factors of trust, efficiency, and fairness.

3.4. "Cyber-Physical-Human Systems in Precision Medicine: Advances in Artificial Pancreas for Treatment of Diabetes," by Mohammad Ahmadas, Emirhan Inanc, Efe Ozkara, Mate Siket, Mudassir M. Rashid, Mustafa Bilgic, Laurie Quinn, and Ali Cinar, all from the Illinois Institute of Technology. The paper demonstrates the transformative power of CPHS in the healthcare domain, specifically in diabetes treatment. A modeling framework that combines the first-principles and data-based modeling is presented to obtain accurate digital twins of humans with type-1 diabetes. The digital twin is then used to create advanced control algorithms for automated insulin delivery for the patients. The authors demonstrate the efficacy of automated insulin delivery not only in simulations but also with clinical experiments.

3.5. "A systems perspective on promoting sustainable and healthy food systems," by Angela Fontan (KTH Royal Institute of Technology), Patricia Eustachio Colombo (London School of Hygiene and Tropical Medicine, Karolinska Institutet), Rosemary Green (London School of Hygiene and Tropical Medicine), and Karl H. Johansson (KTH Royal Institute of Technology). The authors investigate one of the pressing societal issues: Food systems. Non-optimal handling of these

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systems contributes to greenhouse emissions, chronic diseases, environmental degradation, and financial burden on healthcare systems. The paper focuses on the specific problem of sustainable food consumption, which requires moving towards diets that are healthy and have low environmental impact. Population-scale diet change is treated as a social diffusion problem within CPHS, where outcomes depend on human behavior, digital communication infrastructure, and policy networks. The authors discuss a systems approach for influencing dietary behavior in humans based on social network dynamics.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence

the work reported in this paper.

Data availability

No data was used for the research described in the article.

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