Toward Integrated Human-machine Intelligence for Civil Engineering: An Interdisciplinary Perspective

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ABSTRACT

The purpose of this paper is to examine the opportunities and barriers of Integrated Human-Machine Intelligence (IHMI) in civil engineering. Integrating artificial intelligence's high efficiency and repeatability with humans' adaptability in various contexts can advance timely and reliable decision-making during civil engineering projects and emergencies. Successful cases in other domains, such as biomedical science, healthcare, and transportation, showed the potential of IHMI in data-driven, knowledge-based decision-making in numerous civil engineering applications. However, whether the industry and academia are ready to embrace the era of IHMI and maximize its benefit to the industry is still questionable due to several knowledge gaps. This paper thus calls for future studies in exploring the value, method, and challenges of applying IHMI in civil engineering. Our systematic review of the literature and motivating cases has identified four knowledge gaps in achieving effective IHMI in civil engineering. First, it is unknown what types of tasks in the civil engineering domain can be assisted by AI and to what extent. Second, the interface between human and AI in civil engineering-related tasks need more precise and formal definition. Third, the barriers that impede collecting detailed behavioral data from humans and contextual environments deserve systematic classification and prototyping. Lastly, it is unknown what expected and unexpected impacts will IHMI have on the AEC industry and entrepreneurship. Analyzing these knowledge gaps led to a list of identified research questions. This paper will lay the foundation for identifying relevant studies to form a research roadmap to address the four knowledge gaps identified.