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Dr. Ian S. Osborne
Senior Editor, Science Magazine

September 18, 2023

Dear Dr. Osborne,

I am writing to submit our manuscript titled "*Collective Knowledge Sharing Allows Minimum Learning Time and Sustainable Energy Balance in Embodied AI*" as a research article for consideration and potential publication in Science. This work is co-authored by Professor Sami Haddadin.

Our research is centered on tackling the substantial energy demands of embodied artificial intelligence (EAI) systems, i.e., AI systems that move and interact in the world, within the current landscape of machine learning paradigms. Our study delves into the intricate energy requirements of EAI systems fueled by the rapid proliferation of operational units. With a keen emphasis on the necessity for EAI systems to maintain continuous interaction with their physical environment for data acquisition and learning, our research critically assesses the limitations and inherent challenges within current learning paradigms. Our analysis explicitly centers on the computational energy required for the learning processes of EAI systems, akin to purely computational AI. We demonstrate that these energy demands increase significantly when employing conventional learning approaches where large groups of robots learn multiple skills without effectively harnessing the accumulated knowledge.

We also advocate collective learning as the ideal learning paradigm for networked AI agents, positioning it as the natural solution to the pressing energy challenges posed by the growing population of EAI systems. Collective learning thrives on the numbers of networked EAI agents fostering active and efficient sharing, aggregation, and utilization of past and current knowledge. By employing a model of the idealized target dynamics of knowledge exchange, our research demonstrates the substantial benefits of collective learning in reducing the energy and time requirements necessary for acquiring multiple skills. Ultimately, we position collective learning as a promising general solution to the grand energy demands associated with EAI.

I would like to confirm that the contents of this manuscript have not been previously published and are not under consideration by any other publisher.

For all correspondence related to this manuscript, please contact me at fernando.diaz@tum.de.

Thank you for your time and consideration. Please inform me of your decision at your earliest convenience.

Sincerely,

Fernando Díaz Ledezma
Research Associate
Munich Institute of Robotics and Machine Intelligence