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Journal of Research and Development

Short Communication

Human Systems Integration Epistemology

Guy Andre Boy*

Department of Human Systems Integration, Paris Saclay University, Gif-sur-Yvette, France

ABSTRACT

This short communication is intended to advertise and support a recent article published by Technology in Society Journal, "An Epistemological Approach to Human Systems Integration" which proposes a contribution to developing a consistent terminology and, to some extent, an acceptable ontology in the rapidly expanding field of Human Systems Integration (HSI).

Keywords: Cognitive engineering; Ergonomics; Information technology; Interface design; Systems engineering

ABOUT THE STUDY

The article integrates three primary sources: (1) more than forty years of experience in human-centered design and cognitive engineering; (2) a compilation of various research contributions in the Human Systems Integration (HSI) field; and (3) incremental work on generic HSI models and knowledge representations in several research and application development efforts within various industrial research projects, such as future air combat, telerobotic oil and gas management, remote maintenance, increasingly autonomous train systems, and healthcare [1].

We often define HSI as a process and a product at the confluence of several areas, such as systems engineering, human factors and ergonomics, information technology, and specific sectors, such as aerospace, health, and energy. It is a broader transdisciplinary field in our increasingly complex human-machine world that focuses on integrating technology, organizations, and people within a complex sociotechnical system throughout its life cycle (i.e., from design to dismantling). Therefore, HSI is no longer a question of usability and user interface design once a complex machine is technologically developed but instead about considering people and organizations early in the design and development processes. Indeed, rooted in industrial engineering research and operational worlds, HSI requires a deeper foundation based on an epistemological approach.

HSI is about dynamically building systems that meet human and organizational requirements while gradually, and with agility, refining needed emergent human skills and appropriate organizational structures. As this article shows, these requirements will likely evolve during the life cycle of a socio-technical system. Discovering emergent behaviors and properties requires testing for tangibility and, therefore, also requires critical principles and metrics. These can be broken down into five factors leading to five design and management processes complexity, maturity in terms of Technology Readiness Levels (TRLs), Human Readiness Levels (HRLs), and Organization for Research and Learning (ORLs), flexibility; stability and resilience in a wide variety of situations; and sustainability (i.e., thinking ahead in terms of possible futures) [2-5].

Today, technology has become predominantly digital, and, more specifically, it leads to the concept of the digital twin that supports model-based HSI [6,7]. In other words, software-based assistant systems are replacing traditional tools. Therefore, appropriate social-cognitive (multi-agent) models and methods are helpful throughout the life cycle of contemporary sociotechnical designs to account for the complexity and tangibility of their human-centered context-sensitive architectures, combining procedural and declarative knowledge [8]. Considering these reasons, this article provides a set of fundamental axioms, some theoretical abstractions, and valuable practical models, which are presented and illustrated through an evolutionary HSI ontology. We hope it will influence people in analyzing, designing, and evaluating sociotechnical systems worldwide.

Taking all this into consideration, we must use digital engineering wisely. Specifically, digital Human-In-The-Loop Simulation (HITLS) systems using virtual prototypes enable the

Correspondence to: Guy Andre Boy, Department of Human Systems Integration, Paris Saclay University, Gif-sur-Yvette, France; E-mail: guy-andre.boy@centralesupelec.fr

Received: 24-Nov-2023, Manuscript No. JRD-23-25334; **Editor assigned:** 27-Nov-2023, PreQC No. JRD-23-25334 (PQ); **Reviewed:** 12-Dec-2023, QC No. JRD-23-25334; **Revised:** 19-Dec-2023, Manuscript No. JRD-23-25334 (R); **Published:** 26-Dec-2023, DOI: 10.35248/2311-3278.23.11.227

Citation: Boy GA (2023) Human Systems Integration Epistemology. J Res Dev. 11:227.

discovery of emergent behaviors and properties that need to be used to improve the incremental development of sociotechnical systems [9]. For this reason, scenario-based design combined with HITLS allows observing and analyzing human activity at depth and is concretely related to the incremental development of digital twins. Moreover, the design of increasingly autonomous machines requires more profound studies of operational performance, trust, and, specifically, human-machine collaboration. Indeed, this epistemological approach to HSI and the resulting ontology are essential to help better articulate and understand how we will live in this upcoming Society 5.0 with artificial intelligence components [10].

CONCLUSION

This article should encourage further research and development on this challenging epistemological enterprise that attempts to improve the clarity, consistency, flexibility, meaning, effectiveness, usefulness, and usability of HSI philosophies, concepts, methods, and tools.

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