

Editorial

# Introduction to the Special Issue on “Human Factors in Systems Engineering”

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This paper summarizes the aim and the results of this Special Issue. Overall, it is observed that the papers illustrate that human variability arises due to human adaptation to the affordances of the systems with which they interact. The papers within this Special Issue provide methods for understanding and applying knowledge of this variability during system design to provide more robust means of predicting these influences on system application, permitting designers to understand and consider these differences during system design.

Systems engineering is rapidly adopting model-based methods to support development of system requirements, design, analysis, verification, and validation activities throughout the system life cycle [1]. In human factors, modeling is increasingly used to provide early insight into human physical, perceptual, and cognitive performance. These models include static models, such as cognitive maps, analytic hierarchies, or task analyses, as well as dynamic models, including models such as anthropometric simulation models, computational cognitive human performance models, and agent-based models. Integration of human factors models with model-based systems engineering tools has been explored and discussed to aid traceability of human-based requirements [2,3], analyze tradeoffs, and to verify that design alternatives potentially fulfill system requirements [4,5].

An important driving force in the increasing use of modeling is the ever-present pressure to increase the rate of development of increasingly complex systems, requiring improvements in rapid systems integration. The complexity of systems that include humans arises from increasing integration of larger geographically separated teams, the incorporation of automation, and the increasing complexity of the underlying hardware and software. This Special Issue focuses on models useful for understanding human influences in man-made system designs.

This Special Issue includes six papers which generally address different aspects of the human as a component in a complex-adaptive, socio-technical system. The variability introduced by the human is addressed differently within the papers of this Special Issue.

The Special Issue begins with a pair of papers which discusses methods to include human variability during system design. The first of these papers discusses a method to address selection of design parameters which are likely to be sensitive to variability in the target human population and the selection of the population to evaluate alternative system designs [6]. The second paper considers that not only anthropometric and biomechanics variability, but interaction variability, should be considered when designing the physical attributes of systems or products. Specifically, this paper illustrates that mechanical engineering students, even after receiving rudimentary education regarding these principles, often do not anticipate the same levels of human interaction with the product. These differences can lead to less than optimal designs [7].

The third paper explores methods to reduce variability in human response. Specifically this paper demonstrates that information presentation methods can reduce the variability and bias in human

responses while providing value judgements [8]. Thus, specific presentation methods can reduce the confidence intervals associated with these value judgements. Methods such as pairwise value comparisons may be useful for improving multi-attribute decision making. As illustrated in the sixth paper, it is often difficult to understand the attributes that are likely to influence human decision making. Specifically, this paper explores attributes that influence a software engineer's willingness to reuse existing code [9]. As this paper illustrates, software engineers were less willing to reuse code created by automated software repair tools than by other humans. However, the source of this difference is unclear as multiple possible explanations are provided.

The two final papers in this Special Issue address variability in execution during operations. The fourth paper demonstrates a novel method of understanding operator information needs and decision making in novel situations through wargaming [10]. This interesting method facilitates cognitive task analysis to be conducted for "to-be" systems which differ significantly from any extant systems. The use of cognitive task analysis is commonly applied in generating requirements for extant systems [11]. By applying the proposed method, designers can obtain a glimpse into how humans are likely to adapt their behavior in response to a future technical system. Thus, this method has the potential to provide insight into relatively robust requirements for a first-generation system before investing in software development and may provide a useful boot-strapping method for Agile software development in novel systems.

The final paper looks at the level of task abstraction for system control where it is assumed that automation can be designed to take on tasks with increasing levels of abstraction, as might be applied in the robotics subsumption architectures [12]. However, in this paper, the level of control abstraction is characterized from the human's viewpoint [13]. At lower levels of abstraction, the human is responsible for continuously controlling the system, requiring the human to continuously focus their attention on the control of the system. At higher levels of abstraction, continuous control of the system is provided by the automation and the human is not required to continuously focus their attention on control of the system. Importantly, the paper suggests that the human operator should have the flexibility to control the level of abstraction. Thus, the human can adapt the level of system control allocated to the automation and thus control the level of attention and mental resources they are required to dedicate to system control.

As discussed by Norman, humans adapt their use of systems and behavior based upon the affordances the system provides and the environmental demands [14]. This theme runs throughout the papers in this Special Issue. The papers within this Special Issue demonstrate methods to provide insight into this adaptive behavior and subsequent application of this knowledge to aid system design. It is important that these descriptions of behavior, while not mathematical or prescriptive, provide estimates of future human behavior. Thus, they provide methods to model and apply human interaction with the system under design, improving the robustness of the deployed system.

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