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Linking Normative and Descriptive Research with Serious Gaming

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Abstract

The human element in the design of large, complex systems continues to be a limiting factor for projects to stay on budget and realize their potential. Current systems engineering research produces methods validated against the human element in different ways, but they, on their own, do not necessarily contribute to a fundamental understanding of systems engineering. This paper proposes a research framework that couples normative and descriptive approaches for studying human behavior to search for regularities in engineering decision making and stress claims and methods against scenario perturbations. The framework is built upon serious gaming as a mechanism for experimentation. Serious gaming has a long history in the domain of education and training but has been sparsely used as a research tool; therefore, its effectiveness in this capacity is not readily known. To test the viability of the proposed framework and the quality of data it produces, a game is designed to assess the sunk cost effect in engineers and results are compared to those found in the literature. Preliminary gameplay results from an undergraduate subject pool correlate to survey results found in the literature lending to the credibility of gaming as a mechanism of experimentation.

Keywords: research methodology; serious gaming; decision making; human behavior; sunk cost effect

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1. Introduction

Although engineers build large, complex systems today, their design and realization is often wrought with setbacks that strain resources to their limits or result in designs that fall short of what is possible. Systems engineering research is tasked with mitigating such setbacks by studying the way in which systems are designed and managed then creating methods to support and promote best practices. As systems engineering is largely a human-driven process, setbacks are largely human-driven as well, and methods should be resilient against the human-component. At present, systems engineering research lacks the kind of foundational knowledge required to evaluated candidate methods and tools effectively in this regard.[1] In particular, there exists no sound theory by which one can compare methods.

Advances in systems engineering are primarily driven through three research approaches: (1) normative research, (2) descriptive research, and (3) prescriptive research. The normative approach studies what engineers *should* do according to accepted norms and theories, such as rationality, but can make assumptions on human behavior. The descriptive approach, on the other hand, makes little assumptions on human behavior as this approach observes and studies what engineers *actually* do, but lacks an explanatory power. The prescriptive approach recommends practices, procedures, and processes to be followed by systems engineers. This represents a majority of current systems engineering research. Prescriptive research can support claims that can be difficult to generalize, and little insight is provided to the fundamental understanding of systems engineering.

The problem with systems engineering research is twofold: (1) there is an over-reliance on prescriptive research that provides no general understanding of systems engineering, and (2) there exists a disconnect between normative and descriptive research. The first problem can be mitigated by solving the second. Where normative research can provide a mathematical backbone for understanding systems engineering, descriptive research can reveal what actually results in a scenario. However, existing results from cognitive, social, and clinical psychology literature are of limited direct use for understanding systems engineering as experimental scenarios are not necessarily representative of systems scenarios and the experimental subjects may be poor analogs for practicing engineers.

This paper proposes a research framework that combines normative and descriptive research approaches. The research framework is aimed at (1) discovering behavioral regularities in engineering decision makers and (2) stressing new claims against normative and actual decision makers. This framework is built upon computer-enabled serious gaming as a mechanism for empirical study as games allow researchers to construct a wide array of complex scenarios. Serious gaming is the practice of using games for purposes beyond entertainment.[2] The use of virtual worlds and human-in-the-loop simulation are already used in engineering research[3,4]; the use of gaming is an extension of this trend.

Serious gaming is prominent in the domain of education and training[5] but has been sparsely used as a research tool; therefore, its effectiveness is not readily known. To gain insight into the viability of the framework, described in the next section, a game is designed to assess the sunk cost effect in engineers; Section 3 illustrates the framework though this game and compares preliminary gameplay results with results found in the literature. Section 4 discusses the benefits and potential pitfalls of the framework and concludes with a path forward.

2. Research Framework

As with any research method, study objectives must be defined such that all other activities complement the objectives; since this activity is general to all research methods, it is not discussed here. The proposed framework has four basic activities to complement study objectives: (1) scenario abstraction, (2) game design, (3) normative analysis, and (4) gameplay analysis. The process involving these activities is shown in Fig. 1. These remaining activities are further discussed in the remainder of this section.

2.1. Modeling decisions

Modeling decisions and decision maker interaction are well-studied topics.[6,7] This section will only briefly summarize representing decisions mathematically. Decisions are defined mathematically by the set of available