World Academy of Science, Engineering and Technology
International Journal of Computer and Information Engineering
Vol:12, No:05, 2018

Sensor and Sensor System Design, Selection and Data Fusion Using Non-Deterministic Multi-Attribute Tradespace Exploration

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Abstract : The conceptualization and design phases of a system lifecycle consume a significant amount of the lifecycle budget in the form of direct tasking and capital, as well as the implicit costs associated with unforeseeable design errors that are only realized during downstream phases. Ad hoc or iterative approaches to generating system requirements oftentimes fail to consider the full array of feasible systems or product designs for a variety of reasons, including, but not limited to: initial conceptualization that oftentimes incorporates a priori or legacy features; the inability to capture, communicate and accommodate stakeholder preferences; inadequate technical designs and/or feasibility studies; and locally-, but not globally-, optimized subsystems and components. These design pitfalls can beget unanticipated developmental or system alterations with added costs, risks and support activities, heightening the risk for suboptimal system performance, premature obsolescence or forgone development. Supported by rapid advances in learning algorithms and hardware technology, sensors and sensor systems have become commonplace in both commercial and industrial products. The evolving array of hardware components (i.e. sensors, CPUs, modular / auxiliary access, etc…) as well as recognition, data fusion and communication protocols have all become increasingly complex and critical for design engineers during both concpetualization and implementation. This work seeks to develop and utilize a non-deterministic approach for sensor system design within the multi-attribute tradespace exploration (MATE) paradigm, a technique that incorporates decision theory into model-based techniques in order to explore complex design environments and discover better system designs. Developed to address the inherent design constraints in complex aerospace systems, MATE techniques enable project engineers to examine all viable system designs, assess attribute utility and system performance, and better align with stakeholder requirements. Whereas such previous work has been focused on aerospace systems and conducted in a deterministic fashion, this study addresses a wider array of system design elements by incorporating both traditional tradespace elements (e.g. hardware components) as well as popular multi-sensor data fusion models and techniques. Furthermore, statistical performance features to this model-based MATE approach will enable non-deterministic techniques for various commercial systems that range in application, complexity and system behavior, demonstrating a significant utility within the realm of formal systems decision-making.

Keywords : multi-attribute tradespace exploration, data fusion, sensors, systems engineering, system design
Conference Title : ICSES 2018 : International Conference on Software Engineering and Systems
Conference Location : Montreal, Canada
Conference Dates : May 24-25, 2018