STEVENS INSTITUTE OF TECHNOLOGY 1870

Ph.D. DISSERTATION DEFENSE

Candidate:	Shawn Dullen
Degree:	Doctor of Philosophy
School/Department:	Charles V. Schaefer, Jr. School of Engineering and Science/ Systems & Enterprises
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Title:	Achieving Effective Performance using Set-Based Design Framework during the Concept Stage and Early Development Stage of the Life Cycle
Chairperson:	Dr. Dinesh Verma, Department of Systems & Enterprises, School of Engineering and Science
Committee Members:	Dr. Mark Blackburn, Department of Systems & Enterprises, School of Engineering and Science Dr. John Dzielski, Department of Civil, Environmental and Ocean Engineering, School of Engineering and Science Dr. Clifford Whitcomb, Systems Engineering Program, Cornell Engineering, Cornell University

ABSTRACT

The systems engineering and product development community can benefit from a methodology that can significantly reduce the likelihood of engineering rework when decisions are made within the context of moderate to high information uncertainty. This condition is predominant in the concept design stage and early lifecycle development stages when data is scarce, model fidelity is low, and stakeholder needs and requirements are expected to change. Often product design solutions under these conditions turn out to be inadequate in that they do not meet customer needs, product performance and/or product costs. Conceptually, set-based design (SBD) can address these challenges but unfortunately the time it takes to obtain a solution set that achieves high operational performance is too long which prevents the complete application of SBD. This research developed a novel SBD framework that increases the likelihood that a design engineer develops a set of design alternatives that achieve effective operational performance with resource constraints under epistemic uncertainty in less time and fewer iterations than previous methods. The SBD framework was developed around addressing three key areas: 1) iterate between distributed design teams due to conflict between shared attributes during the integrate by intersection and establish feasibility before commitment principles of the set-based concurrent engineering (SBCE) process, 2) iterate when information and requirements change, and 3) iterate due to misclassification.

The SBD framework hybridized supervised machine learning, unsupervised machine learning, layered classification, all-in-one classification, design heuristics, data visualization, and systems engineering activities. A mixed study was conducted to obtain knowledge for the development of the SBD framework which consisted of four observation studies and two experimental studies. Four experiments were conducted to validate the framework wherein three of the experiments performed statistical hypothesis testing using several two sample proportions tests and one sample proportion tests with statistical significance at an alpha level of 0.05. Experiment 1 evaluated SBD framework classification error rate against previous methods for sixty-six scenarios using one sample proportion test. Experiment 2 and 3 evaluated the SBD framework against other quantitative methods using the proportion of samples that satisfy the change in criteria for up to sixteen scenarios. The scenarios considered changes in performance requirements, material constraints, packaging constraints, and information uncertainty. In all the scenarios the SBD framework outperformed the other quantitative methods wherein the two sample proportion tests had α significantly less than 0.0001 in more than 80 percent of the scenarios.