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Artificial Intelligence



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Research Statement

My research has focused on applications of artificial intelligence (AI) in engineering design and optimization. Specifically, I have used AI tools such as decision trees, multivariate regression trees and genetic algorithms to address various engineering design problems arising in single- and multiple-objective design environments. For instance, in most engineering design problems mechanical assemblies must be built with the concept of tolerances in mind. Unfortunately, presence of tolerances may result in unacceptable functional variations in the product/process response. The main observation is that elimination of manufacturing/environmental variations and tolerances is impossible and all that can be done is to reduce the sensitivity of the product at hand to uncontrollable variations.

I worked on multivariate optimization using genetic algorithms and a new technique, which I developed during my Ph.D. research, based on multivariate regression trees. The main motivation is that in presence of multiple competing objectives, designer must opt for Pareto optimal solutions where a product's response can be improved only at the cost of degrading other responses. A multivariate regression tree is able to successfully address these design concerns using a variety of methods ranging from non-parametric statistical optimization concepts to fuzzy logic. The utility of such technique from standpoint of practitioners in the field is that designers can identify optimal hyper-rectangular design regions as opposed to traditional 'single-point' design vectors.

I have developed a novel methodology that utilizes genetic algorithms by identifying optimal ellipsoidal design regions, where design variables fall within a pre-specified range of values (the required manufacturing tolerances), and the produced product yield exhibits minimal statistical variation from the desired target value. This work relies on the stochastic optimization method of *manufacturing capability index* that has been used successfully in a different context in the past by the Six-Sigma community. Genetic algorithms are in general more robust than other traditional approaches in worst-case tolerance design in that they perform successfully without assumptions of continuity and differentiability of underlying objective functions.

I have pursued an interesting problem in the area of concurrent engineering where design knowledge is distributed among many hosts on the Internet. Traditionally, design and optimization methods assume that all the necessary knowledge resides in one site. In today's world, however, the sheer volume of engineering data makes this assumption totally invalid. It is therefore imperative for designers to develop intelligent techniques where optimization can be performed in a distributed manner. My work involves development of efficient mobile, intelligent agents that can migrate from one design site to

another, collect the pertinent data, make appropriate design decisions, and finally, report back their findings to some central site.

My specific research requires a great deal of engineering and optimization background, but I am also interested in performing research with my students in other computer science and artificial intelligence related areas. I worked with one of my undergraduates in the areas of artificial intelligence and design of intelligent web search engines for an entire academic year. This research emphasized on the role of artificial intelligence search techniques in retrieving documents from the Internet and resulted in a poster session at the Sigma Xi's annual meeting and was subsequently published at the society's conference proceedings. Another one of my undergraduate students worked under my supervision in the areas of Internet security and public/private key cryptography; I have also worked with students in the areas of Ant Colony Optimization and Particle Swarm Optimization (PSO).

I am currently pursuing a new approach to multi-objective optimization, and engineering tolerance and parameter design using PSO, which is being modified to allow efficient search of the design space while attempting to optimize several objectives many of which may be contradictory in nature.