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Computational Intelligence Techniques for New Product Design

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Preface

Over the recent years, applying computational intelligence techniques for product design is a fast-growing and promising field. In this book, a wide range of computational intelligence techniques including fuzzy systems, evolutionary computations and neural network are discussed. How to implement these computational intelligence techniques for product design is the core topic addressed in this book. Fundamental concepts and essential analysis on computational intelligence techniques are presented to offer systematic and effective tools for product design. This book discusses common issues on product design including identification of customer requirements in product design, determination of importance of customer requirements for product design, determination of optimal design attributes in new products, relating design attributes of new products and customer satisfaction, integration of marketing aspects into product design, affective product design, as well as quality control of new products. Approaches for enhancement of computational intelligence techniques which include hybridization of various computational intelligence techniques and integration of statistical methods into computational intelligence techniques are discussed. Case studies of product design in terms of development of real-world new products are included to illustrate the design procedures, as well as the effectiveness of the computational intelligence techniques. This book is organized as follows:

- **Chapter 1** discusses fundamental concerns of product design, current issues and needs for product design, as well as roles of product designers. Existing problems in manufacturing new products and marketing the new products are introduced. How and why computational intelligence methods can help address these issues in terms of product design is discussed.
- **Chapter 2** introduces commonly used computational intelligence methods including evolutionary computation, swarm optimization, neural networks and fuzzy systems etc, in order to address product design issues.
- **Chapter 3** discusses a fuzzy weighting method to determine importance weights of customer requirements of a new product. It intends to overcome the limitation of the existing weight methods that ignore fuzziness for new product design. A case study of a bicycle splash guard design is used to evaluate the effectiveness of the fuzzy weighing method.
- **Chapter 4** discusses a new fuzzy weighing method which is an enhanced version of the method discussed in Chapter 3. It intends to improve the imprecise ranking of customer satisfaction inherited from the previous works based on the existing weight methods. A case study of hair dryer design is presented in order to evaluate the effectiveness of the approach.

- **Chapter 5** presents a genetic programming method in order to develop a functional model which relates design attributes to customer requirements for new products. It is intended to overcome the two main limitations of previous modeling approaches: i) ignore nonlinearity of design attributes of new products, which are unavoidable; and ii) are able to generate only black-box models which are not preferred by product development terms. A case study of digital camera design is used to evaluate the effectiveness of the genetic programming approach.
- **Chapter 6** introduces a hybrid fuzzy and genetic programming approach to developing customer satisfaction models that relates customer requirements to the design attributes of a new product. It is intended to address the fuzzy nature of customer survey data, which are unavoidable. A case study of the affective design of mobile phones is used to evaluate the effectiveness of the hybrid fuzzy and genetic programming approach.
- **Chapter 7** discusses a hybrid algorithm which integrates the mechanism of fuzzy regression and generalized least square regression. The hybrid algorithm intends to address the uncertainties of the development of house of quality which contains both human fuzziness and randomness inherent in the survey. A case study of packing machine design is used to evaluate the hybrid algorithm.
- **Chapter 8** presents an enhanced neuro-fuzzy approach for developing customer satisfaction models to link customer requirements with design attributes of a new product. The approach overcomes the limitation of the existing neural-fuzzy approaches that are implicit in nature. A case study of a notebook computer design is used to demonstrate the operations of the enhanced neuro-fuzzy approach.
- **Chapter 9** introduces a hybrid simulated annealing process which integrates the mechanisms of experimental design methods to maximize customer satisfaction of a new product by optimizing the design attributes of the new product. A case study involving the optimization of a packing-machine design is presented to demonstrate the effectiveness of the approach.
- **Chapter 10** discusses a hybrid evolutionary algorithm which is integrated with a statistical method, namely orthogonal design, to optimize customer satisfaction with a new product. A case study of the optimization of a car door design is used to illustrate the effectiveness of the hybrid evolutionary algorithm.
- **Chapter 11** presents a hybrid algorithm which integrates the mechanisms of fuzzy regression and genetic programming to develop models for manufacturing processes in order to improve the quality of the manufactured product. It overcomes the existing fuzzy regression approaches which cannot address the nonlinearity of manufacturing processes. A case study of a solder paste dispenser is used to demonstrate the effectiveness of the hybrid algorithm.

- **Chapter 12** discusses a rule-extraction-based genetic algorithm approach which aims to extract information in rule format from non-informative data (Kwong et al. 2009b). It allows engineers to understand the behaviors of the manufacturing systems, in order to enhance the quality of the manufactured products. A case study of an epoxy dispensing process is used to demonstrate the operations and procedures of the rule extraction approach.
- **Chapter 13** summarizes the research on computational intelligence methods and product design issues. It also provides several suggestions for future research in these areas.

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