

Contents

Preface	v
1 Introduction	1
1.1 Design Reuse – What and Why	2
1.1.1 Types of design reuse	2
1.1.2 The importance of design reuse	3
1.2 Product Conceptual Design	6
1.2.1 Product family design	8
1.3 Major Issues in Design Reuse	10
1.3.1 Design reuse process	11
1.3.2 Product information modeling	12
1.3.3 Product information analysis	13
1.3.4 Design synthesis	13
1.3.5 Solution evaluation	14
1.4 Engineering Design Reuse Applications	15
1.4.1 Design reuse in software engineering	15
1.4.2 Design reuse in mechanical and electro-mechanical engineering	18
1.4.3 Design reuse in manufacturing	20
1.5 Barriers to Design Reuse	22
1.6 Summary	24
2 Design Reuse Systems and Enabling Tools	27
2.1 Engineering Design Reuse Approaches	27
2.1.1 Case-based reasoning	28
2.1.2 Catalog-based design	29
2.1.3 Modular design	31
2.1.4 Adaptable design	33
2.1.5 Expert systems	35
2.1.6 Innovative design using TRIZ	37
2.2 Reasoning in Design Reuse	38
2.2.1 Machine learning	38

2.2.2	Data mining	40
2.2.3	Design structure matrix	41
2.2.4	Artificial neural networks	43
2.2.5	Genetic algorithms	46
2.2.6	Agent-based method	47
2.3	Summary	49
3	Product Information Modeling	51
3.1	Data, Information and Knowledge	51
3.2	Information Modeling – State-Of-The-Art Review	53
3.2.1	Content of information model	53
3.2.2	Modeling languages	58
3.2.3	Taxonomies	61
3.2.4	Database system and web-based environment	63
3.3	Function-Based Product Information Model	66
3.3.1	A multiple facet product information model	66
3.3.2	Representation of function using key element vector	69
3.3.3	Function taxonomies	71
3.3.4	An illustrative example	74
3.4	Summary	78
4	Design of Product Platform	81
4.1	Role of Product Platform	81
4.2	Product Platform and Product Family Design	83
4.2.1	A top-down perspective	84
4.2.2	A bottom-up perspective	85
4.3	Computational Tools for Product Architecture Building	87
4.3.1	QFD-based approach	87
4.3.2	DSM-based approach	88
4.3.3	Heuristic and quantitative approaches	90
4.4	Product Architecture Building Using Self-Organizing Map	91
4.4.1	Introduction of SOM	91
4.4.2	Function clustering based on SOM	94
4.4.3	A case study	99
4.4.4	Evaluation of the SOM method	103
4.5	Other Relevant Issues in Product Platform Design	106
4.5.1	Extraction of KCs as performance criteria	107
4.5.2	Formation of component catalog	109
4.5.3	Establishment of mapping route using correlation matrices	109
4.6	Summary	111

5	Optimization in Product Design	113
5.1	Introduction	113
5.1.1	Weighted sum method	116
5.1.2	Goal programming	117
5.1.3	Multi-level programming/rank ordering	118
5.1.4	Genetic algorithms	118
5.2	Automated Design Synthesis	121
5.2.1	Configuration design	121
5.2.2	Design synthesis techniques	122
5.3	Multi-objective Struggle Genetic Algorithm Design Synthesis	128
5.3.1	Problem formulation	128
5.3.2	The MOSGA algorithm	131
5.3.3	Implementation of MOSGA in product configuration design	133
5.3.4	Precautions and limitations	139
5.4	Post-optimal Solution Selection	140
5.5	A Case Study	142
5.5.1	Experience-based design	144
5.5.2	Product design using the design reuse approach	146
5.5.3	Comparison of the two methods	151
5.6	Summary	151
6	Cost Estimation in Product Development	153
6.1	Introduction	153
6.2	Product Development Cost	155
6.2.1	Cost structure	155
6.2.2	Cost modeling techniques	158
6.3	Cost Estimation in Product Family Development	166
6.3.1	Commonality index	167
6.4	An Empirical Cost Model for Design Reuse	169
6.4.1	Fixed cost	170
6.4.2	Development cost	171
6.4.3	Component cost	171
6.5	Summary	173
7	Product Performance Evaluation	175
7.1	Introduction	175
7.1.1	Relating performance to design parameters	175
7.1.2	Aggregating performance criteria	177
7.2	Robust Design	178
7.3	The Information Content Assessment Method	182
7.3.1	Background – information axiom and information content	183
7.3.2	The information content assessment process	186

7.3.3	Establishing system range from existing products	187
7.3.4	Assessing information content	193
7.3.5	Precautions and limitations	197
7.3.6	A case study	198
7.4	Summary	203
8	A Product Family Design Reuse Methodology	205
8.1	Introduction	205
8.1.1	Scale-based approach	206
8.1.2	Model-based approach	211
8.1.3	Graph-based approach	211
8.1.4	Module-based approach	211
8.2	An Integrated Design Reuse Process Model	212
8.2.1	Product information modeling	213
8.2.2	Knowledge extraction	214
8.2.3	Design synthesis and evaluation	216
8.3	A Web-Based Product Family Design Reuse System	216
8.4	Design of Cellular Phone Product Family	222
8.4.1	Settings	222
8.4.2	Results	226
8.4.3	Analysis	228
8.5	Design of TV Receiver Circuits	229
8.5.1	Settings	229
8.5.2	Solution generation and results	232
8.5.3	Comparison	233
8.6	Summary	234
9	Design Reuse for Embodiment and Detailed Design	237
9.1	Introduction	237
9.2	Online Design Reuse System	239
9.2.1	System architecture	239
9.2.2	Product information representation	241
9.3	Embodiment Design	241
9.3.1	Product case retrieval method	242
9.3.2	Optimal search for alternative solution	247
9.3.3	Exhaustive search	254
9.3.4	GA-based search	255
9.3.5	Solution generation in washing machine design	260
9.4	Detailed Design	263
9.4.1	Architecture of the detailed design transformation	263
9.4.2	Feature-based parametric modeling	265
9.4.3	Product family and variant method	266

9.4.4 Operation of detailed design reuse	267
9.4.5 System implementation	271
9.5 Summary	271
Bibliography	273
Index	293