

CONTENTS

Chapter I: Introduction	24
1. Context	24
2. Goals and Objectives.....	26
3. Research Scope.....	27
4. Contribution to Knowledge	29
5. Research Methodology.....	30
6. Dissertation Outline.....	31
Chapter II: Literature Review	33
1. Introduction	33
2. Model-Based Engineering (MBE).....	33
2.1. Standards supporting Model-Based Engineering	38
2.2. Product and Manufacturing Information in CAD Systems	41
3. CAD Quality and Reusability.....	43
4. CAD Modeling Strategies for Reusability	45
4.1. Delphi's Horizontal Modeling.....	47
4.2. Explicit Reference Modeling.....	48
4.3. Resilient Modeling Strategy	52
5. Data, Information, and Knowledge	54
6. Design Intent Communication.....	55
7. Annotations in Engineering Design.....	58
7.1. Classification of Annotations	61
7.2. Annotations in Software Development	65
7.3. State of the Art in 3D Annotation.....	67
7.4. The Problem of Visual Clutter	69

8. Collaborative Engineering and Computer Supported Cooperative Work 71

 8.1. Multimedia Supported Communication Technology for Collaborative Design 74

Chapter III: Parametric CAD Modeling Practices 76

 1. Introduction 76

 2. Approaches to 3D CAD Solid Modeling 77

 2.1. Parametric Modeling vs. Direct Modeling 77

 3. Feature-Based Parametric Solid Modeling 80

 3.1. Modeling Strategy 81

 3.2. Modeling Example 82

 4. Internal Representation of Parametric CAD models 84

 4.1. Complexity Metrics 86

 4.2. Software Prototype 87

 5. Case Study: A Comparison of Modeling Methodologies 89

 6. Concluding Remarks 94

Chapter IV: Communication using Design Annotations 97

 1. Introduction 97

 2. Hypothesis Definition 97

 3. Experimental Analysis 98

 3.1. Experiment 1 99

 3.2. Experiment 2 113

 4. Concluding remarks 116

Chapter V: Extended Design Annotations 118

 1. Introduction 118

 2. Implementation Challenges 118

2.1.	Annotation Storage.....	119
2.2.	Annotation Content	119
2.3.	Annotation Interface.....	120
2.4.	Annotation Visualization.....	120
2.5.	User Motivation.....	121
3.	Extended Annotations	121
3.1.	Annotation Storage.....	125
3.2.	Annotation Content	128
3.3.	Annotation Interface.....	129
3.4.	Annotation Visualization.....	132
3.5.	User Motivation.....	133
4.	Evaluation.....	134
4.1.	Experiments 1 and 2: User performance	134
4.2.	Experiment 3: Visual Clutter.....	138
5.	Concluding Remarks	143

Chapter VI: Integration in Collaborative Environments 144

1.	Introduction	144
2.	Product Lifecycle Management Systems	144
3.	PLM Integration	148
4.	Annotation History	150
5.	Video Conferencing Component.....	153
5.1.	Workflow.....	156
6.	Concluding Remarks	157

Chapter VII: Conclusions and Future Work..... 159

1.	Summary of Achievements	159
2.	Contribution to Knowledge	161

2.1.	Understanding parametric model complexity.....	162
2.2.	Determining the effects of annotations in design intent communication	162
2.3.	Extended annotations model and development of software prototype.....	163
2.4.	Connection of extended annotation model to other communication tools in collaborative design environments ..	164
3.	Summary of Findings	164
4.	Conclusions	166
5.	Limitations	168
6.	Future Work	169
6.1.	CAD Model Complexity	169
6.2.	Extended Annotation Processing.....	170
6.3.	User Interaction	171
6.4.	Further Experiments	171
6.5.	Communication	172
REFERENCES	174
APPENDIX A:	Part Alteration. Activity 1	189
APPENDIX B:	Part Alteration. Activity 2.....	191
APPENDIX C:	Experiments 1 and 2	193