

# Contents

<b>Preface</b>	<b>v</b>
<b>Chapter 1     Robotic Grasp and Workpiece-Fixture Systems</b>	
1.1   Introduction.....	1
1.2   Robotic Manipulation and Multifingered Robotic Hands .....	1
1.3   AMT and Fixtures .....	4
1.4   Comparison between Grasping and Fixturing.....	8
1.5   Bibliography .....	8
<b>Chapter 2     Qualitative Analysis and Quantitative Evaluation of                   Form-Closure Grasping/Fixturing</b>	
2.1   Introduction.....	11
2.2   Qualitative Analysis .....	13
2.2.1   Kinematic Characteristics of Grasping/Fixturing.....	13
2.2.2   Discriminances of Form-Closure Grasping/Fixturing.....	16
2.2.3   Minimum Number of Contacts with Frictionless .....	17
2.3   Quantitative Evaluation.....	21
2.3.1   Evaluation Criteria .....	21
2.3.2   Numerical Example.....	22
2.4   Summary .....	26
2.5   Bibliography .....	26
<b>Chapter 3     Stability Index and Contact Configuration Planning                   of Force-Closure Grasping/Fixturing</b>	
3.1   Introduction.....	30
3.2   Description of Contacts with Friction .....	31

3.3	Conditions of Force Closure Grasp.....	33
3.4	Grasp Stability Index.....	34
3.4.1	Definition of the Grasp Stability Index .....	34
3.4.2	Some Properties of the Index .....	36
3.4.3	Contact Configuration Planning.....	38
3.5	Examples.....	39
3.6	Summary .....	43
3.7	Bibliography .....	43

## **Chapter 4 Active Grasp Force Planning**

4.1	Introduction.....	45
4.2	Nonlinear Programming in Grasp .....	47
4.3	Force Planning Using Neural Networks.....	49
4.4	Simulation .....	58
4.5	Summary .....	61
4.6	Bibliography .....	61

## **Chapter 5 Grasp Capability Analysis**

5.1	Introduction.....	64
5.2	Evaluation of Multifingered Grasp Capability .....	66
5.3	Numerical Example.....	68
5.4	Summary .....	76
5.5	Bibliography .....	76

## **Chapter 6 Compliant Grasping with Passive Forces**

6.1	Introduction.....	79
6.2	The Model of Compliant Grasping/Fixturing .....	82
6.3	Local Elastic Contact Model.....	85
6.4	Deformation Compatible Constraints for All Contacts .....	88
6.5	Stability of Grasping/Fixturing Systems .....	89

6.6 Passive Force Closure Prediction.....93  
 6.7 Numerical Example.....97  
 6.8 Summary .....101  
 6.9 Bibliography .....102

**Chapter 7 Kinematics of Contacts and Rolling Manipulation**

7.1 Introduction.....105  
 7.2 Kinematics of Pure Rolling Contact.....106  
 7.3 Kinematics of Manipulation with Rolling Contact .....113  
 7.4 Coordinating Manipulation of Multifingered Robotic Hands .....116  
     7.4.1 Classification of Grasp Phases .....116  
     7.4.2 Coordinating Manipulation Strategy .....116  
 7.5 Adjustment of Fingertip Contact Forces .....117  
 7.6 Experimental Results .....123  
 7.7 Summary .....125  
 7.8 Bibliography .....126

**Chapter 8 Dynamic Stability of Grasping/Fixturing**

8.1 Introduction.....129  
 8.2 Dynamic Equations of Motion for a Grasped/Fixtured Object .....130  
 8.3 Dynamic Stability Conditions and Quality Measure.....135  
 8.4 Summary .....142  
 8.5 Bibliography .....143

**Chapter 9 Locating Error Analysis and Configuration Planning of Fixtures**

9.1 Introduction.....146  
 9.2 Error Mapping Model .....150  
     9.2.1 Fully Constrained Localization .....154  
     9.2.2 Over Constrained Localization.....154  
     9.2.3 Under Constrained Localization.....154

9.3	Locator and Clamp Configuration Characteristics .....	159
9.3.1	Locator Configuration Characteristics .....	159
9.3.2	Clamp Configuration Characteristics .....	159
9.4	Evaluation Indexes of Fixturing .....	166
9.4.1	Evaluation Index of Locator Configurations .....	166
9.4.2	Stability Index of Fixturing .....	168
9.4.3	Fixturing Resultant Index .....	169
9.5	Configuration Planning of Fixturing .....	169
9.5.1	Constraints .....	169
9.5.2	Planning Methods.....	171
9.6	Summary .....	180
9.7	Bibliography .....	181

## **Chapter 10 Clamping Planning in Workpiece-Fixture Systems**

10.1	Introduction .....	185
10.2	Planning of Magnitudes and Positions of Clamping Forces.....	188
10.2.1	Objective Function .....	188
10.2.2	Kinematic Conditions.....	189
10.2.3	Solution of Optimal Clamping Forces.....	191
10.3	Verification of Force Constraints .....	193
10.4	Numerical Example.....	195
10.5	Summary .....	209
10.6	Bibliography .....	210

## **Index**

**215**