

---

# FUNDAMENTALS OF ROBOTICS ENGINEERING

---

Harry H. Poole

*Poole Associates*



VAN NOSTRAND REINHOLD

————— *New York*

---

# CONTENTS

---

Preface ix

## PART I: AN OVERVIEW OF ROBOTICS

- 1. Introduction 1
  - 1.1 Brief History of Robotics, 3
  - 1.2 Working Definition of Robot, 12
  - 1.3 Growth of the Industry, 15
  - 1.4 Introduction to Robotics Engineering, 23
  
- 2. Types of Robots 27
  - 2.1 Classification by Degrees of Freedom, 27
  - 2.2 Classification by Robot Motion, 33
  - 2.3 Classification by Platform, 39
  - 2.4 Classification by Power Source, 42
  - 2.5 Classification by Intelligence, 45
  - 2.6 Classification by Application Area, 45

## PART II: ROBOTIC TECHNOLOGY

- 3. Introduction to Robot Mechanics 55
  - 3.1 Robot Arm Kinematics, 55
  - 3.2 End-Effectors, 64
  - 3.3 Dynamic Considerations, 70
  - 3.4 Obstacle Avoidance, 73
  
- 4. Robot Electronic Design 77
  - 4.1 Robot Electronic Subsystems, 77
  - 4.2 Robot External Sensing Systems, 87
  - 4.3 Motor System Design, 92
  - 4.4 Servo System Design, 98
  - 4.5 Hall-Effect Technology, 101

<b>5. Robotic Sensors</b>	<b>104</b>
5.1 Internal Sensors, 104	
5.2 External Sensors, 110	
5.3 Sensor Processing, 117	
<b>6. Vision Systems</b>	<b>119</b>
6.1 Human Vision Considerations, 120	
6.2 Machine Vision Approaches, 123	
6.3 Image Acquisition, 125	
6.4 Image Analysis, 137	
6.5 Summary of the State of the Art, 146	
6.6 Applications and Available Systems, 148	
6.7 Ranging Techniques, 151	
<b>7. Ultrasonic Systems</b>	<b>157</b>
7.1 Sonar Fundamentals, 158	
7.2 Theoretical Acoustics, 159	
7.3 Practical Considerations, 167	
7.4 Advanced Considerations, 171	
7.5 Ultrasonics in Bats, 179	
7.6 System Considerations, 180	
7.7 Applications, 187	
<b>8. Mobile Robots</b>	<b>189</b>
8.1 Approaches to Mobility, 189	
8.2 Design Considerations, 195	
8.3 Locomotion, 196	
8.4 Steering, 202	
8.5 Power and Stability, 209	
8.6 Intelligence, 213	
8.7 Error Considerations, 218	
8.8 Current Applications, 219	

**PART III: COMPUTER HARDWARE AND SOFTWARE**

<b>9. Computers for Robots</b>	<b>223</b>
9.1 History, 223	
9.2 Functions, 225	

9.3	Program Entry, 226	
9.4	Computer Hardware, 231	
9.5	Program Tasks, 236	
9.6	Robot Simulation, 240	
9.7	Work Cell Considerations, 243	
9.8	Other Hardware Considerations, 246	
<b>10.</b>	<b>Robot Languages</b>	<b>249</b>
10.1	Early Languages, 250	
10.2	Current Languages, 257	
10.3	Language Command Review, 260	
10.4	Program Example, 261	
10.5	Language Approaches and Limitations, 264	
<b>11.</b>	<b>Robot Intelligence</b>	<b>271</b>
11.1	Application of AI, 271	
11.2	Techniques, 274	
11.3	Vision System Research, 279	
11.4	AI Language, 283	
11.5	Applications, 292	
<b>PART IV: ROBOTIC APPLICATIONS</b>		
<b>12.</b>	<b>Robot Standards</b>	<b>299</b>
12.1	Japan Industrial Robot Safety Standards, 299	
12.2	RIA Standards Program, 301	
12.3	Testing Standards, 304	
12.4	Other Standards Activity, 304	
12.5	Device Communication Standards, 305	
12.6	Network Standards, 307	
12.7	Safety, 310	
<b>13.</b>	<b>Applications Engineering</b>	<b>312</b>
13.1	Systems Analysis, 312	
13.2	System Example, 324	
13.3	Work Cell Systems, 325	
13.4	Safety in the Plant, 327	

<b>14. Application-Oriented Requirements</b>	<b>334</b>
14.1 Application-Oriented Requirements, 334	
14.2 Clean-Room Environments, 342	
14.3 Mobile Robot Requirements, 344	

**PART V: FUTURE CONSIDERATIONS**

<b>15. Trends in Robotic Systems</b>	<b>351</b>
15.1 Current Research Projects, 351	
15.2 Surveys and Predictions, 355	
15.3 Technological Trends, 357	
15.4 Predictions, 364	
<b>16. New Technology</b>	<b>366</b>
16.1 Natural Language Processing, 366	
16.2 Speech Recognition, 369	
16.3 Walking Vehicles (legged Locomotion), 374	
16.4 Collision Avoidance, 379	
16.5 Neural Network Computing, 383	
<b>17. New Application Areas</b>	<b>390</b>
17.1 Tasks for Robots, 390	
17.2 Current Applications, 391	
17.3 Future Robotics Applications, 399	
<b>Appendix 1: Robotic Systems Manufacturers</b>	<b>407</b>
<b>Appendix 2: Major University Robotics     Laboratories</b>	<b>415</b>
<b>Appendix 3: International Robotics     Organizations</b>	<b>417</b>
<b>Glossary</b>	<b>421</b>
<b>Index</b>	<b>429</b>