
Vision for Service Robots

Current and Emerging Technologies, Applications, and Markets

TABLE OF CONTENTS

iii	Acknowledgments	
vi	List of Figures	
vii	List of Tables	
viii	Executive Summary	
1	Preface—Service Robots: The coming profound impact on human life	
3	1.0 Introduction	
3	1.1 Scope and Methodology	
6	1.2 Vision Technologies	
7	1.3 Summary of Findings	
8	2.0 Global Forecast for Vision in Service Robots	
8	2.1 Overview of Forecast Methodology	
9	2.2 Global Forecast for Vision by Service Robot Class	
9	2.2.1 Aerospace Applications	
11	2.2.2 Land Applications	
17	2.2.3 Water Applications	
20	3.0 Critical Technologies and Definitions	
21	3.1 Vision	
21	3.1.1 Vision Products	
23	3.1.2 Robot Guidance	
24	3.1.3 Sensor Fusion for Service Robots	
27	3.2 Data Interpretation and Computation	
27	3.2.1 Software Interfaces	
28	3.2.2 Communication, Analysis, and Decision-Making	
28	3.3 Robots	
29	3.3.1 Safety: Industrial and Service Robots	
29	3.3.2 Control Systems: Industrial and Service Robots	
30	3.3.3 Classification of Industrial Robots	
31	3.3.4 Classification of Service Robots	
31	Master Tables of Robot Classes	
34	4.0 Vision for Service Robots in Aerospace Applications	
34	4.1 Spacecraft	
34	4.1.1 Robotic Spacecraft	
35	4.1.2 Autonomous Vehicles	
36	4.2 Satellites	
37	4.2.1 Humanoids in Space	
38	4.2.2 Robotic Arms	
39	4.2.3 Satellite Capture	
39	4.3 Aircraft	
39	4.3.1 Unmanned Drones	
42	4.3.2 Aircraft Support	
44	5.0 Vision for Service Robots in Land Applications	
44	5.1 Defense and Security	
46	5.1.1 Requirements for Robotics in Defense and Security	
49	5.1.2 EOD Robots with Upgraded Vision	
50	5.1.3 Persistent Stare in Ground Surveillance	
50	5.1.4 Transport	
51	5.1.5 Combat	
53	5.1.6 Developments in Vision for Unmanned Ground Vehicles	
55	5.2 Farming	
55	5.2.1 Developments in Robotics for Farming	
56	5.2.2 Harvesting with Robotic Systems	
57	5.2.3 Zoos and Wildlife Management	
58	5.3 Food Processing	
58	5.3.1 Developments in Robots for Food Processing	
59	5.3.2 Robotic Milking	
60	5.3.3 Handling Vegetables	
	cont. >>	

Vision for Service Robots in Land Applications cont.

60	5.4 Transportation	83	5.10 Education and Entertainment
61	5.4.1 <i>Developments in Robotic Transportation</i>	83	5.10.1 <i>Developments in Education and Entertainment Robots</i>
62	5.4.2 <i>Autonomous Cars</i>	84	5.10.2 <i>Robots for Education</i>
63	5.4.3 <i>Autonomous Convoys</i>	85	5.10.3 <i>Robots for Entertainment</i>
63	5.5 Mining, Construction, and Maintenance	86	5.11 Home: Convenience
64	5.5.1 <i>Developments in Mining, Construction, and Maintenance Robots</i>	86	5.11.1 <i>Current Commercially Available Convenience Robots</i>
65	5.5.2 <i>Aboveground Mining</i>	87	5.11.2 <i>Convenience Robots in Community Service</i>
65	5.5.3 <i>Underground Mining</i>	87	5.11.3 <i>Research Programs</i>
66	5.5.4 <i>High-Voltage Transmission Line Maintenance</i>	88	
66	5.6 Office and Warehouse	93	6.0 Vision for Service Robots in Water Applications
67	5.6.1 <i>Developments in Robots for Office and Warehouse Applications</i>	93	6.1 <i>Underwater Robots and Sensor Fusion</i>
67	5.6.2 <i>Telepresence Robots</i>	94	6.2 <i>Surface and Underwater Robots</i>
69	5.6.3 <i>Service Robots for Warehousing</i>	95	6.3 <i>Defense and Security</i>
71	5.7 Health: Assistive Living and Care	97	6.4 <i>Commercial</i>
72	5.7.1 <i>Developments in Assistive Robots for Healthcare</i>	99	6.5 <i>Scientific Research</i>
73	5.7.2 <i>Wheelchair Robots</i>	101	7.0 Resources
74	5.7.3 <i>Personal Care</i>	101	7.1 <i>Academia</i>
75	5.7.4 <i>Consulting</i>	103	7.2 <i>Competitions</i>
75	5.7.5 <i>Pickup/Delivery and Lifting</i>	104	7.3 <i>Corporations</i>
76	5.8 Health: Rehabilitation	106	7.4 <i>Government/NGOs/Research</i>
76	5.8.1 <i>Developments in Rehabilitation Robots</i>	109	7.5 <i>Publications/Reports</i>
77	5.8.2 <i>Relearning to Walk</i>		
78	5.8.3 <i>Walking Assistance</i>		
78	5.8.4 <i>Force-Based Relearning</i>		
78	5.8.5 <i>Haptic Robot</i>		
79	5.9 Health: Surgical		
80	5.9.1 <i>Developments in Robotic Surgery Systems</i>		
81	5.9.2 <i>Surgical Robots in Detail</i>		