

Contents

Series list	xi
Introduction	xvi
Part 1 Information gathering and processing	
1 Proximal crop sensing	3
<i>Richard B. Ferguson, University of Nebraska-Lincoln, USA</i>	
1 Introduction	3
2 The evolution of crop sensors	4
3 Current issues in sensor development	8
4 Case studies	11
5 Conclusion: sustainability and environmental implications	23
6 Future trends for research	24
7 Where to look for further information	24
8 References	24
2 Proximal soil surveying and monitoring techniques	29
<i>R. Gebbers, Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Germany</i>	
1 Introduction	29
2 Key challenges in monitoring soils	30
3 Soil sampling methods	31
4 Proximal soil sensing: definitions and principles	34
5 Electrical soil sensors	36
6 Optical soil sensors	49
7 Soil temperature sensors	54
8 Electrochemical soil sensors	55
9 Soil radioactive radiation sensors	56
10 Mechanical soil sensors	59
11 Other sensors	61
12 Integration of proximal soil sensing into agricultural management	62
13 Summary	64
14 Future trends	67
15 Acknowledgements	68
16 Where to look for further information	69
17 References	70
3 Airborne and satellite remote sensors for precision agriculture	79
<i>Chenghai Yang, USDA-ARS, USA</i>	
1 Introduction	79
2 Airborne imaging systems: overview and multispectral systems based on industrial cameras	80
3 Airborne imaging systems: multispectral systems based on consumer-grade cameras	84

4	Airborne imaging systems: hyperspectral sensors	86
5	Airborne imaging systems: application examples	88
6	High-resolution satellite sensors: overview and varieties	96
7	High-resolution satellite sensors: application examples	99
8	Challenges and future trends	101
9	Summary	102
10	Where to look for further information	102
11	Disclaimer	103
12	References	103
4	The use of unmanned aerial systems (UASs) in precision agriculture <i>Chunhua Zhang, Algoma University, Canada; and John M. Kovacs and Dan Walters, Nipissing University, Canada</i>	107
1	Introduction	107
2	Platforms and sensors	108
3	Flight planning and imagery acquisition	110
4	Image processing: stitching and ortho-rectification	111
5	UAS imagery applications	112
6	Image analysis	116
7	Case study	117
8	Future trends and conclusion	119
9	Acknowledgements	120
10	Where to look for further information	121
11	References	121
5	Key challenges and methods in identifying management zones <i>Spyros Fountas, Evangelos Anastasiou and Zisis Tsiropoulos, Agricultural University of Athens, Greece; Aristotelis Tagarakis, BioSense Institute - Research Institute for Information Technologies in Biosystems, Serbia; and Athanasios Balafoutis, Centre for Research and Technology Hellas, Institute of Bioeconomy & Agro-technology, Greece</i>	129
1	Introduction	129
2	Methods to delineate management zones	131
3	Case study on delineation of management zones in wine grapes	133
4	Case study on delineation of management zones in table grapes	135
5	Case study on delineation of management zones in olive oil tree plantation	138
6	Summary	139
7	Where to look for further information	139
8	References	140
6	Modelling and decision support systems in precision agriculture <i>Nicolas Tremblay, Agriculture and Agri-Food Canada, Canada</i>	145
1	Introduction	145
2	Key issues	148
3	Human and social aspects	152
4	Case studies with an emphasis on nitrogen management	153
5	Research options for decision support systems to improve productivity in a precision agriculture framework	160

6	Conclusion	163
7	Future trends	163
8	Where to look for further information	165
9	References	165

Part 2 Delivery systems

7	Variable-rate application technologies in precision agriculture <i>Kenneth A. Sudduth, USDA-ARS, USA; Aaron J. Franzen, South Dakota State University, USA; and Heping Zhu and Scott T. Drummond, USDA-ARS, USA</i>	171
1	Introduction	171
2	Characteristics of VRA control systems	172
3	Liquid VRA systems	176
4	Dry VRA systems	178
5	Case studies	181
6	Current status	187
7	Future trends and conclusion	189
8	Where to look for further information	189
9	References	190
8	Spray technologies in precision agriculture <i>Paul Miller, Silsoe Spray Applications Unit Ltd, UK</i>	195
1	Introduction	195
2	Features of field crop sprayers for precision agriculture	197
3	Case study 1: designing and developing a system for spot treatment of volunteer potatoes	206
4	Case study 2: a patch spraying system for applying herbicides to field crops	210
5	Conclusion	211
6	Future trends	213
7	Where to look for further information	214
8	References	214
9	Intelligent machinery for precision agriculture <i>Qin Zhang, Washington State University, USA; Joseph Dvorak, University of Kentucky, USA; and Timo Oksanen, Aalto University, Finland</i>	219
1	Introduction	219
2	Automated guidance systems: overview and global navigation satellite system (GNSS)-based systems	220
3	Automated guidance systems: vision-based systems	222
4	Path planning	225
5	Automated actuation systems	229
6	Implement controls	231
7	Future trends: increasingly autonomous systems and their potential impacts	232
8	Where to look for further information	235
9	References	235

10	Controlled traffic farming in precision agriculture	239
	<i>Diogenes L. Antille, National Centre for Engineering in Agriculture, University of Southern Queensland, Australia; Tim Chamen, Controlled Traffic Farming Europe Ltd, UK; Jeff N. Tullberg, National Centre for Engineering in Agriculture, University of Southern Queensland, Australia; Bindi Isbister, Department of Primary Industries and Regional Development, Agriculture and Food, Australia; Troy A. Jensen, Guangnan Chen and Craig P. Baillie, National Centre for Engineering in Agriculture, University of Southern Queensland, Australia; and John K. Schueller, Department of Mechanical and Aerospace Engineering, University of Florida-Gainesville, USA</i>	
	1 Introduction	239
	2 Controlled traffic farming systems: definition and requirements	241
	3 Sustainability of controlled traffic farming	247
	4 Coupling controlled traffic farming with precision agriculture	254
	5 Future trends and conclusion	258
	6 Disclaimer	259
	7 Where to look for further information	259
	8 References	259
Part 3 Applications		
11	Precision tillage systems	273
	<i>Pedro Andrade-Sanchez, University of Arizona, USA; and Shrinivasa K. Upadhyaya, University of California-Davis, USA</i>	
	1 Introduction	273
	2 Depth-prescribed tillage to control subsoil compaction	274
	3 Soil sensing to enable precision tillage	275
	4 Extracting information from soil sensors	277
	5 Implementing depth control	278
	6 Tractor/implement guidance technology	279
	7 Conclusion	280
	8 Where to look for further information	280
	9 References	281
12	Variable-rate seeding systems for precision agriculture	285
	<i>John Fulton, The Ohio State University, USA</i>	
	1 Introduction	285
	2 Variable-rate seeding technology	288
	3 Variable-rate seeding strategies	292
	4 The value of variable-rate seeding	294
	5 Conclusion and future trends	295
	6 Where to look for further information	296
	7 References	296
13	Site-specific nutrient management systems	299
	<i>Dan S. Long, USDA-ARS, USA</i>	
	1 Introduction	299
	2 Processes to inform site-specific nutrient management	301
	3 Regional perspectives	307

4	Conclusions and future trends	313
5	Where to look for further information	316
6	References	316
14	Site-specific irrigation systems	323
	<i>Amir Hagverdi, University of California-Riverside, USA; and Brian G. Leib, University of Tennessee-Knoxville, USA</i>	
1	Introduction	323
2	Field-level mapping of soil variability	325
3	Delineation of irrigation management zones	328
4	Quantifying the potential impact of variable rate irrigation	332
5	Site-specific irrigation management	335
6	Future trends and conclusion	340
7	List of abbreviations	341
8	Where to look for further information	342
9	References	342
15	Precision crop protection systems	347
	<i>E. C. Oerke, University of Bonn, Germany</i>	
1	Introduction	347
2	Variability of pest incidence and pest management strategies	349
3	Sensor use for disease management	356
4	Sensor use for the management of invertebrate pests	369
5	Perspectives	374
6	References	379
16	Precision weed management systems	399
	<i>Roland Gerhards, University of Hohenheim, Germany</i>	
1	Introduction	399
2	Weed detection	399
3	Dynamics of weed populations	404
4	Spatial and temporal stability of weed distributions	405
5	Spraying technologies for precision weed control	406
6	Precision weed hoeing and harrowing	409
7	Future trends and conclusion	416
8	References	416
17	Precision livestock farming and pasture management systems	421
	<i>Mark Trotter, Central Queensland University Institute for Future Farming Systems, Australia</i>	
1	Introduction	421
2	Individual animal management in extensive grazing systems	424
3	Precision pasture and range management	431
4	Case study 1: using a basic farm GIS to determine sustainable long-term stocking rates	432
5	Case study 2: integrating satellite MS imaging with plant growth modelling to manage livestock rotations	442
6	Future trends and conclusion	451
7	Where to look for further information	452
8	References	452

18	The economics of precision agriculture	461
	<i>James Lowenberg-DeBoer, Harper Adams University, UK</i>	
	1 Introduction	461
	2 Adoption of PA technology	463
	3 PA adoption and economics	470
	4 Predicting future trends based on recent studies of PA profitability	472
	5 Future trends and conclusion	476
	6 Where to look for further information	477
	7 References	478
	Index	483