

John Billingsley • Robin Bradbeer (Eds.)

---

Mechatronics and Machine Vision in Practice

John Billingsley • Robin Bradbeer (Eds.)

# Mechatronics and Machine Vision in Practice

With 245 Figures

 Springer

Prof. Dr. John Billingsley  
Faculty of Engineering and Surveying  
University of Southern Queensland  
Toowoomba, QLD  
Australia  
*billings@usq.edu.au*

Prof. Dr. Robin Bradbeer  
Department of Electrical Engineering  
City University of Hong Kong  
88 Tat Chee Avenue  
Kowloon, Hong Kong  
P.R. China  
*eersbrad@cityu.edu.hk*

ISBN 978-3-540-74026-1

e-ISBN 978-3-540-74027-8

DOI 10.1007/978-3-540-74027-8

Library of Congress Control Number: 2007933848

© 2008 Springer-Verlag Berlin Heidelberg

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilm or in any other way, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer. Violations are liable for prosecution under the German Copyright Law.

The use of general descriptive names, registered names, trademarks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

*Cover design:* Erich Kirchner, Heidelberg

Printed on acid-free paper

9 8 7 6 5 4 3 2 1

springer.com

# Foreword

Research papers on the subject of mechatronics cover a great variety of topics. Among them are those that explore new techniques and applications, but all too often there are those others that seek to paint old, tired techniques with a patina of new jargon. You will find none of the latter here. There is a heavy emphasis of the ‘in Practice’ that completes the title of the conference series from which these papers have been drawn.

The papers were originally reviewed as full manuscripts and now a selection of authors have been invited to rewrite their work for inclusion in this volume.

In the first section, papers with an educational theme have been gathered. Most of them focus on practical experiments that will reinforce a mechatronics course. A variety of techniques for vision analysis form the next section, again stressing a practical emphasis.

The third section focuses on practical applications of machine vision, several of which have been implemented in industry, while the fourth is concerned with techniques within robotics other than vision.

Some of the medical applications of the fifth section might not be for the squeamish. The book is completed with a number of applications that have an agricultural theme.

University of Southern Queensland, Australia  
City University, Hong Kong

John Billingsley  
Robin Bradbeer  
November 2007

# Contents

---

## Education

---

Emergent Behaviour Real-time Programming of a Six-Legged Omni-Directional Mobile Robot: <i>Planning of Viennese Waltz Behaviour</i> .....	3
<i>Frank Nickols</i>	
The Hong Kong Underwater Robot Challenge .....	17
<i>Robin Bradbeer</i>	
Dynamics and Control of a VTOL Quad-Thrust Aerial Robot .....	27
<i>Joshua N. Portlock and Samuel N. Cubero</i>	
Project-oriented Low Cost Autonomous Underwater Vehicle with Servo-visual Control for Mechatronics Curricula .....	41
<i>C. A. Cruz-Villar, V. Parra-Vega, and A. Rodriguez-Angeles</i>	
Coordination in Mechatronic Engineering Work .....	51
<i>James Trevelyan</i>	

---

## Vision Techniques

---

A Vision System for Depth Perception that Uses Inertial Sensing and Motion Parallax .....	65
<i>Vlatko Bećanović and Xue-Bing Wang</i>	
Rate Shape Identification Based on Particle Swarm Optimization .....	77
<i>P.W.M. Tsang and T.Y.Y. Yuen</i>	
Advanced 3D Imaging Technology for Autonomous Manufacturing Systems .....	87
<i>A. Pichler, H. Bauer, C. Eberst, C. Heindl, J. Minichberger</i>	
Vision Based Person Tracking and Following in Unstructured Environments .....	99
<i>Mahmoud Tarokh and John Kuo</i>	

Simple, Robust and Accurate Head-Pose Tracking Using a Single Camera.....	111
<i>Simon Meers, Koren Ward and Ian Piper</i>	

---

**Vision Applications**

---

Machine Vision for Beer Keg Asset Management .....	125
<i>Michael Lees, Duncan Campbell, Andrew Keir</i>	
Millimetre Wave Radar Visualisation System: Practical Approach to Transforming Mining Operations.....	139
<i>E. Widzyk-Capehart, G. Brooker, S. Scheduling, A. Maclean, R. Hennessy, C. Lobsey and M. Sivadurai</i>	
An Underwater Camera and Instrumentation System for Monitoring the Undersea Environment .....	167
<i>Kenneth K.K. Ku, Robin Bradbeer and Katherine Lam</i>	
Visual Position Estimation for Automatic Landing of a Tail-Sitter Vertical Takeoff and Landing Unmanned Air Vehicle.....	181
<i>Allen C. Tsai, Peter W. Gibbens and R. Hugh Stone</i>	
Minutiae-based Fingerprint Alignment Using Phase Correlation.....	193
<i>Weiping Chen and Yongsheng Gao</i>	

---

**Robotic Techniques**

---

A Snake-like Robot for Inspection Tasks .....	201
<i>Bin Li, Li Chen and Yang Wang</i>	
Modelling Pneumatic Muscles as Hydraulic Muscles for Use as an Underwater Actuator .....	209
<i>Kenneth K.K. Ku and Robin Bradbeer</i>	
Automated Tactile Sensory Perception of Contact Using the Distributive Approach.....	219
<i>X. Ma, P. Tongpadungrod and P.N. Brett</i>	
Blind Search Inverse Kinematics for Controlling All Types of Serial-link Robot Arms .....	229
<i>Samuel N. Cubero</i>	

---

**Medical Applications**

---

Distributive Tactile Sensing Applied to Discriminate Contact and Motion of a Flexible Digit in Invasive Clinical Environments..... 247  
*Betty Tam, Peter Brett, David Holding, and Mansel Griffiths*

Intelligent Approach to Cordblood Collection..... 255  
*S.L. Chen, K.K. Tan, S.N. Huang and K.Z. Tang*

An Autonomous Surgical Robot Applied in Practice ..... 261  
*P.N. Brett, R.P. Taylor, D. Proops, M.V. Griffiths and C. Coulson*

Development of an Intelligent Physiotherapy System ..... 267  
*S.L. Chen, W.B. Lai, T.H. Lee and K.K. Tan*

Visual Prostheses for the Blind:  
 A Framework for Information Presentation ..... 275  
*Jason Dowling, Wageeh Boles and Anthony Maeder*

Computer-based Method of Determining the Path of a HIFU Beam Through Tissue Layers from Medical Images to Improve Cancer Treatment..... 289  
*E. McCarthy and S. Pather*

---

**Agricultural Applications**

---

On-the-go Machine Vision Sensing of Cotton Plant Geometric Parameters: First Results ..... 305  
*Cheryl McCarthy, Nigel Hancock and Steven Raine*

Robotics for Agricultural Systems ..... 313  
*Mario M. Foglia, Angelo Gentile, and Giulio Reina*

More Machine Vision Applications in the NCEA ..... 333  
*John Billingsley*

**Authors** ..... 345

**Index**..... 347

## Authors

Bauer, H., PROFACTOR Research, Austria 87  
Bećanović, Vlatko, Kyushu Institute of Technology, Japan 65  
Billingsley, John, University of Southern Queensland 333  
Boles, Wageeh, Queensland University of Technology 275  
Bradbeer, Robin, City University of Hong Kong 17, 167, 209, 17, 167, 209  
Brett, P.N., Aston University, Birmingham 219, 247, 261, 219, 247, 261  
Brooker, G., University of Sydney, Australia 139  
Campbell, Duncan, Queensland University of Technology 125  
Chen, Li, Shenyang Institute of Automation 201  
Chen, S.L., National University of Singapore 255, 267, 255, 267  
Chen, Weiping, Griffith University 193  
Coulson, C., Aston University, Birmingham 261  
Cruz-Villar, C., InvEstAv I.P.N., Mexico 41  
Cubero, Samuel N., University of Southern Queensland 27, 229, 27, 229  
Dowling, Jason, Queensland University of Technology 275  
Eberst, C., PROFACTOR Research, Austria 87  
Foglia, Mario M., Politecnico of Bari, Italy 313  
Gao, Yongsheng, Griffith University 193  
Gentile, Angelo, Politecnico of Bari, Italy 313  
Gibbens, Peter W., University of Sydney 181  
Griffiths, M.V., Saint Michaels Hospital, Bristol 247, 261, 247, 261  
Hancock, Nigel, University of Southern Queensland 305  
Heindl, C., PROFACTOR Research, Austria 87  
Hennessy, R., University of Sydney, Australia 139  
Holding, David, Aston University, Birmingham 247  
Huang, S.N., National University of Singapore 255  
Keir, Andrew, Queensland University of Technology 125  
Ku, Kenneth K.K., City University of Hong Kong 167, 209, 167, 209  
Kuo, John, San Diego State University, USA 99  
Lai, W.B., National University of Singapore 267  
Lam, Katherine, City University of Hong Kong 167  
Lee, T.H., National University of Singapore 267  
Lees, Michael, Foster's Australia, Brisbane 125  
Li, Bin, Shenyang Institute of Automation 201  
Lobsey, C., University of Sydney, Australia 139  
Ma, X., Aston University, Birmingham 219  
Maclean, A., University of Sydney, Australia 139  
Maeder, Anthony, Queensland University of Technology 275



- McCarthy, Cheryl, University of Southern Queensland 305  
McCarthy, E., University of Southern Queensland 289  
Meers, Simon, University of Wollongong, Australia 111  
Minichberger, J., PROFACTOR Research, Austria 87  
Nickols, Frank, Dhofar University, Sultanate of Oman 3  
Parra-Vega, V., CInvEstAv I.P.N., Mexico 41  
Pather, S., University of Southern Queensland 289  
Pichler, A., PROFACTOR Research, Austria 87  
Piper, Ian, University of Wollongong, Australia 111  
Portlock, Joshua N., Curtin University of Technology 27  
Proops, D., Queen Elizabeth Hospital Birmingham 261  
Raine, Steven, University of Southern Queensland 305  
Reina, Giulio, University of Lecce, Italy 313  
Rodriguez-Angeles, A., CInvEstAv I.P.N., Mexico 41  
Scheding, S., University of Sydney, Australia 139  
Sivadorai, M., University of Sydney, Australia 139  
Stone, R.Hugh, University of Sydney 181  
Tam, Betty, Aston University, Birmingham 247  
Tan, K.K., National University of Singapore 255, 267, 255, 267  
Tang, K.Z., National University of Singapore 255  
Tarokh, Mahmoud, San Diego State University, USA 99  
Taylor, R.P., Aston University, Birmingham 261  
Tongpadungrod, P., King Mongkut's Institute of Technology, Bangkok 219  
Trevelyan, James, University of Western Australia 51  
Tsai, Allen C., University of Sydney 181  
Tsang, P.W.M., City University of Hong Kong 77  
Wang, Xue-Bing, Kyushu Institute of Technology, Japan 65  
Wang, Yang, Shenyang Institute of Automation 201  
Ward, Koren, University of Wollongong, Australia 111  
Widzyk-Capehart, E., CSIRO, Brisbane, Australia 139  
Yuen, T.Y.Y., City University of Hong Kong 77

# Index

- 3D machine vision 87
- 3D object recognition 88, 89, 91, 93, 95
- 3D object reconstruction 91
- 3D scanning 90
  
- Aerial robot 27
- agricultural crop canopy 306
- artificial human vision 275
- asset management 125, 126
- AUV (Autonomous Underwater Vehicle) 41
  
- beam path 292
- blind search 229, 233
- blindness 279
- blob tracking 113
- bounding box 325
  
- CD34+ cell 259
- cochleostomy 262, 263
- CompactRIO 267, 270
- continuous computation architecture 4
- Coordination in Mechatronic engineering work 51, 53
  
- deformation 127
- drilling bone tissue 262
  
- education 17
- Engineering education, implications 59
  
- fibre-optic cable 167, 169
- field camera enclosure 310, 311
- Field Programmable Gate Array (FPGA) 270
  
- fingerprint 193–196
- fixed object plane 306
- flexible digit 248, 252
- FMCW 149
- framework 275, 276
- Freeman chain 335
- fuzzy control 102, 108
  
- gaze-tracking 111
- genetic algorithm 78, 80, 83, 84
- grasping 314
  
- harvesting 316
- head-pose 111, 112, 119
- hydraulic operation 210
  
- illumination 128
- inertial sensor 65, 66, 68
- infrared LEDs 112, 113
- inspection 201, 205
- intelligent physiotherapy 267
- internode length 305, 306
- invariant moment 183
- invasive clinical environment 247
- inverse kinematics 229
  
- Kalman filter 70, 71, 75
  
- LabVIEW 268
- landing 183
- livestock identification 334
- localisation 318
  
- macadamia nuts 333, 336
- marine conservation 17, 23, 24
- Mechatronics curricula 41, 50
- Mechatronics integration 41
- millimetre wave 139

- mining 148, 159
- minutiae direction image
  - 194, 195
- mobility 275
- monocular 65, 68, 74
- mononucleotide cell (MNC) 259
- Monte-Carlo 65, 70
- motion parallax 65, 68, 74, 75
  
- neural network 125, 134–136
- neuromorphic 66
  
- object matching 78, 80
- optical character recognition 125,
  - 126, 133
- outdoor navigation 108
  
- particle swarm 77
- PD control 49
- person identification 101, 108
- phase correlation 194, 196
- placenta 255, 256
- plant node detection 311
- pneumatic muscles 209
- pneumatic pressure
  - application system 258
- position estimation
  - 181, 182, 190
  
- Quad rotor 28
  
- radar 139–142
- robot planning 88
- robot workspace 231, 232, 243
  
- robotic person following 99, 100,
  - 107
- sensing 139
- sensing dynamic loading 226
- serpentine movement 203
- Shadow group air muscles 210
- simulation 275
- simultaneous translation
  - and rotation 3
- six-legged robot rotation about
  - instantaneous centre 13
- snake locomotion 201
- spectacles 111, 112, 120
- s-psi 335
- standalone system 270, 271
- sun and planet wheel model 9
  
- tactile sensing array 219
- template 325
- template matching 133–135
- tomography 292
  
- UAV 181, 184, 188, 190
- UAV dynamics 28
- ultrasound (HIFU) 289
- umbilical cord blood (UCB) 255
- underwater monitoring 167
- underwater robots 18
  
- Viennese waltz pattern 6
- vision guidance 341
- visual prosthesis 275, 276
- visualisation 139, 141
- Visual-servoing 43, 49