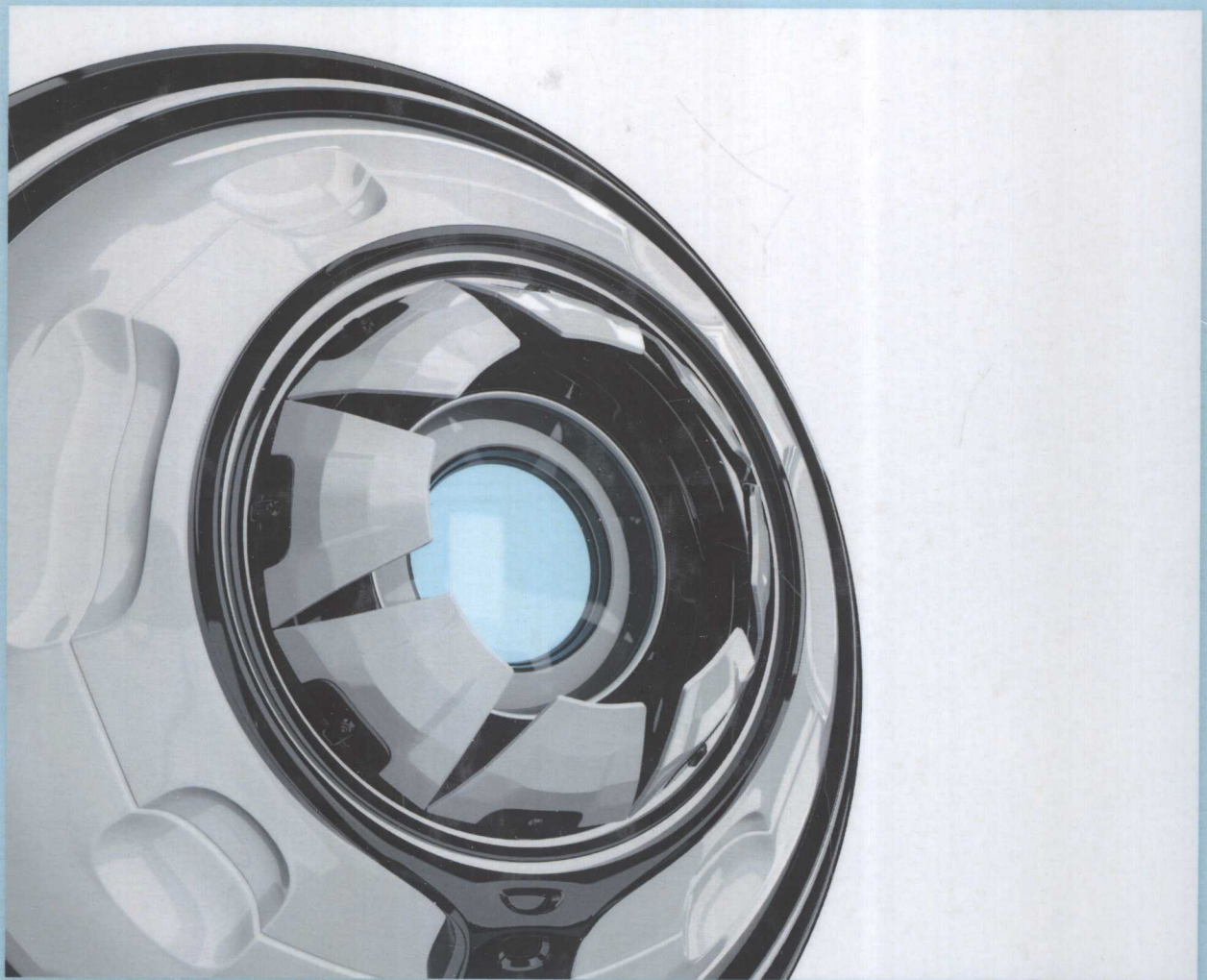


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# Robotic Vision

Technologies for Machine  
Learning and Vision Applications



Jose Garcia-Rodriguez & Miguel A. Cazorla Quevedo

# Robotic Vision: Technologies for Machine Learning and Vision Applications

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## Foreword

The application of vision to robotics has seen an enormous progress in the last decade with the introduction on new algorithms and very powerful computer hardware. This progress has also been extended to a number of very dissimilar areas such as automation, medicine, and surveillance to name a few. Computer vision has seen very successful application in field and service robots, in particular in autonomous machines and automotive applications. This has been possible not only by the improvement of computer hardware but from the development of new very efficient algorithms.

Until a few years ago, fundamental problems affected computer vision that makes most algorithms not viable for real time application. This has started to change dramatically. Over the last few years, we have seen an enormous growth of very successful practical implementation of computer vision for robotics. Furthermore, some of them have exploited mass production of proprietary hardware to make the deployment of impressive applications at very reduced costs. This has also been possible due to a number of significant breakthroughs in the underlying algorithms and techniques, including feature detectors, classifiers and a large variety of very efficient machine learning algorithms.

This book presents a comprehensive introduction and the latest development to the fields of computer vision and applications to robotics, social robotics, visual control, and visual attention. The material is organized in various sections with a number of contributions from world experts in the different areas.

The target audience of this book includes robotics scientist, engineers, and students interested in getting a comprehensive background in the rapidly developing field of robotics and computer vision.

It is impossible to select a number of papers to cover all the recent progress in computer vision. Nevertheless, the editors have chosen a number of fundamental aspects of robotic vision that are addressed in a very comprehensive manner in this book. The material presented is intended to be a fundamental first step towards understanding the main challenges involved in robotic vision application.

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*University of Sydney & Australian Centre for Field Robotics, Australia*

**Eduardo Nebot**, BSc. EE, UNS, Argentina and MS and PhD CSU, USA, is a Professor at the University of Sydney and the Director of the Australian Centre for Field Robotics. His main research areas are in field robotics automation. The major impact of his fundamental research is in autonomous system, navigation, and mining safety.

# Preface

Computer vision and robotics connections have grown dramatically in the last years. Any robotic system includes object or scene recognition, vision-based motion control, vision-based mapping, and dense range sensing. Developments in hardware and sensing permit most vision algorithms to work in real-time and using cheap and flexible sensors.

“Robotic Vision: Technologies for Machine Learning and Vision Applications” is an edited collection of contributed chapters of interest for both researchers and practitioners in the fields of computer vision and robotics.

Written by leading researchers in the field, the chapters are organized into six sections. The first two sections deal with computer vision basics and computer vision applications. Section 3 is devoted to 3D data processing applied to robotics. In section 4, some works describing social robotics systems are presented, while section 5 presents works related with vision control, and section 6 introduces some research in visual attention.

## SECTION 1: COMPUTER VISION

Barros de Lima Klavdianos, Mattos Brasil, and Simão Santana Melo propose a systematic and practical approach regarding to one of the most current techniques applied on face recognition, known as AAM (Active Appearance Model). Different methodologies of uniform sampling over the 3D rotation group,  $SO(3)$ , for building unbiased 2D shape models from 3D objects are introduced and reviewed by Perez-Sala, Igual, Escalera, and Angulo. A comparative analysis of basic segmentation methods of video sequences and their combinations is presented by Saval-Calvo, Azorín-López, and Fuster-Guilló.

## SECTION 2: COMPUTER VISION APPLICATIONS

Sasi presents a system for identifying what are valuable, what can be ignored, and what demands immediate attention, in a vision security system. In the chapter “Visual Detection in Linked Multi-Component Robotic Systems” by Lopez-Guede, Fernandez-Gauna, Moreno, and Graña, a system to identify the different elements of a Linked Multi-Component Robotic System (L-MCRS) is specified, designed, and implemented. Almomani and Dong propose a novel multiple objects tracking system in video sequences that deals with occlusion issues. The proposed system is composed of two components: An improved KLT tracker, and a Kalman filter. Moreno, Graña, and Madani introduce a watershed and region merg-

ing segmentation algorithm based on the zenithal and azimuthal angles of the spherical representation of colors in the RGB space. Garcia-Rodriguez et al. demonstrate the capacity of self-organizing neural networks to solve some computer vision and image processing tasks presenting different examples like image segmentation and compression, tracking, or 3D reconstruction.

### **SECTION 3: 3D COMPUTER VISION AND ROBOTICS**

In chapter “A Review of Registration Methods on Mobile Robots” by Morell-Gimenez, Orts-Escolano, García-Rodríguez, Cazorla, and Viejo, the authors provide a review of the main registration methods in the literature, where registration is a process to find the transformation between two consecutive poses, from 3D data. In “Methodologies for Evaluating Disparity Estimation Algorithms” by Cabezas and Trujillo, the chapter is dedicated to present and discuss methodologies for evaluating disparity estimation algorithms. An online method for estimating 3D structure (with proper scale) of moving objects seen by a moving camera is developed by Dani, Kan, Fischer, and Dixon. Two different intelligent approaches to assess the traversability of the terrain in front of a stereo vision-equipped robot are presented by Nalpantidis, Kostavelis, and Gasterato.

### **SECTION 4: SOCIAL ROBOTICS**

Bandera, Rodríguez, Molina-Tanco and Bandera describe a learning by imitation architecture that uses stereo vision to perceive, recognize, learn and imitate social gestures. An overview of a typical scenario of Ambient Assisted Living (AAL) in which a robot navigates to a person for conveying information is presented by Yan, Torta, van der Pol, Meins, Weber, Cuijpers and Wermter. Da Silva and Romero deals with Computer Vision for learning to interact socially with humans presenting a robotic architecture for a simple interaction between a caregiver and a robot face. Sridharan describes an integrated framework that jointly addresses the learning, adaptation, and interaction challenges associated with robust human-robot interaction in real-world application domains.

### **SECTION 5: VISION CONTROL**

The chapter by Puig and Aviles presents a framework for simultaneous localization and mapping based on an active coordination of a team of robots. Cavestany Olivares, Herrero-Pérez, Alcaraz Jiménez, and Martínez Barberá describes their vision system used in the Standard Platform League (SPL), one of the official leagues in RoboCup competition. Alkurdi and Fisher applied visual control by using a fuzzy logic controller on the robotic blimp to achieve autonomous waypoint tracking.

## SECTION 6: VISUAL ATTENTION

García, Rodríguez, and Matellán make a review of some of the most representative visual attention models, which can be used for reducing the time to process images by a robot. Vega, Perdices, and Cañas propose a visual perceptive system for a robot with a mobile camera on board that copes with two challenges arising when using cameras: to extract useful information from captured images and to manage the small field of view of regular cameras. The chapter by Antúnez, Haxhimusa, Marfil, Kropatsch, and A. Bandera proposes a visual attention model using a hierarchical grouping process that encodes the input image into a Combinatorial Pyramid.

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<i>Lourdes Mattos Brasil, Universidade de Brasília (UnB), Brazil</i>	
<i>Jairo Simão Santana Melo, Universidade de Brasília (UnB), Brazil</i>	

Recognition of human faces has been a fascinating subject in research field for many years. It is considered a multidisciplinary field because it includes understanding different domains such as psychology, neuroscience, computer vision, artificial intelligence, mathematics, and many others. Human face perception is intriguing and draws our attention because we accomplish the task so well that we hope to one day witness a machine performing the same task in a similar or better way. This chapter aims to provide a systematic and practical approach regarding to one of the most current techniques applied on face recognition, known as AAM (Active Appearance Model). AAM method is addressed considering 2D face processing only. This chapter doesn't cover the entire theme, but offers to the reader the necessary tools to construct a consistent and productive pathway toward this involving subject.

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<i>Xavier Perez-Sala, Universitat Politècnica de Catalunya, Spain</i> <i>&amp; Computer Vision Center of Barcelona, Spain</i>	
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Different methodologies of uniform sampling over the rotation group,  $SO(3)$ , for building unbiased 2D shape models from 3D objects are introduced and reviewed in this chapter. State-of-the-art non uniform sampling approaches are discussed, and uniform sampling methods using Euler angles and quaternions are introduced. Moreover, since presented work is oriented to model building applications, it is not limited to general discrete methods to obtain uniform 3D rotations, but also from a continuous point of view in the case of Procrustes Analysis.



### Chapter 3

Comparative Analysis of Temporal Segmentation Methods of Video Sequences .....43

*Marcelo Saval-Calvo, University of Alicante, Spain*

*Jorge Azorín-López, University of Alicante, Spain*

*Andrés Fuster-Guilló, University of Alicante, Spain*

In this chapter, a comparative analysis of basic segmentation methods of video sequences and their combinations is carried out. Analysis of different algorithms is based on the efficiency (true positive and false positive rates) and temporal cost to provide regions in the scene. These are two of the most important requirements of the design to provide to the tracking with segmentation in an efficient and timely manner constrained to the application. Specifically, methods using temporal information as Background Subtraction, Temporal Differencing, Optical Flow, and the four combinations of them have been analyzed. Experimentation has been done using image sequences of CAVIAR project database. Efficiency results show that Background Subtraction achieves the best individual result whereas the combination of the three basic methods is the best result in general. However, combinations with Optical Flow should be considered depending of application, because its temporal cost is too high with respect to efficiency provided to the combination.

## Section 2

### Computer Vision Applications

### Chapter 4

Security Applications Using Computer Vision .....60

*Sreela Sasi, Gannon University, USA*

Computer vision plays a significant role in a wide range of homeland security applications. The homeland security applications include: port security (cargo inspection), facility security (embassy, power plant, bank), and surveillance (military or civilian), et cetera. Video surveillance cameras are placed in offices, hospitals, banks, ports, parking lots, parks, stadiums, malls, train stations, airports, et cetera. The challenge is not for acquiring surveillance data from these video cameras, but for identifying what is valuable, what can be ignored, and what demands immediate attention. Computer vision systems attempt to construct meaningful and explicit descriptions of the environment or scene captured in an image. A few Computer Vision based security applications are presented here for securing building facility, railroad (Objects on railroad, and red signal detection), and roads.

### Chapter 5

Visual Detection in Linked Multi-Component Robotic Systems .....78

*Jose Manuel Lopez-Guede, Basque Country University, Spain*

*Borja Fernandez-Gauna, Basque Country University, Spain*

*Ramon Moreno, Basque Country University, Spain*

*Manuel Graña, Basque Country University, Spain*

In this chapter, a system to identify the different elements of a Linked Multi-Component Robotic System (L-MCRS) is specified, designed, and implemented. A L-MCRS is composed of several independent robots and a linking element between them which provide a greater complexity to these systems. The identification system is used to model each component of the L-MCRS using very basic information about each of the individual components. So, different state models that have been used in several works of the literature that have been reviewed can be covered. The chapter explains the design of the system and shows its frontend. This work is the first step towards a realistic implementation of L-MCRS.