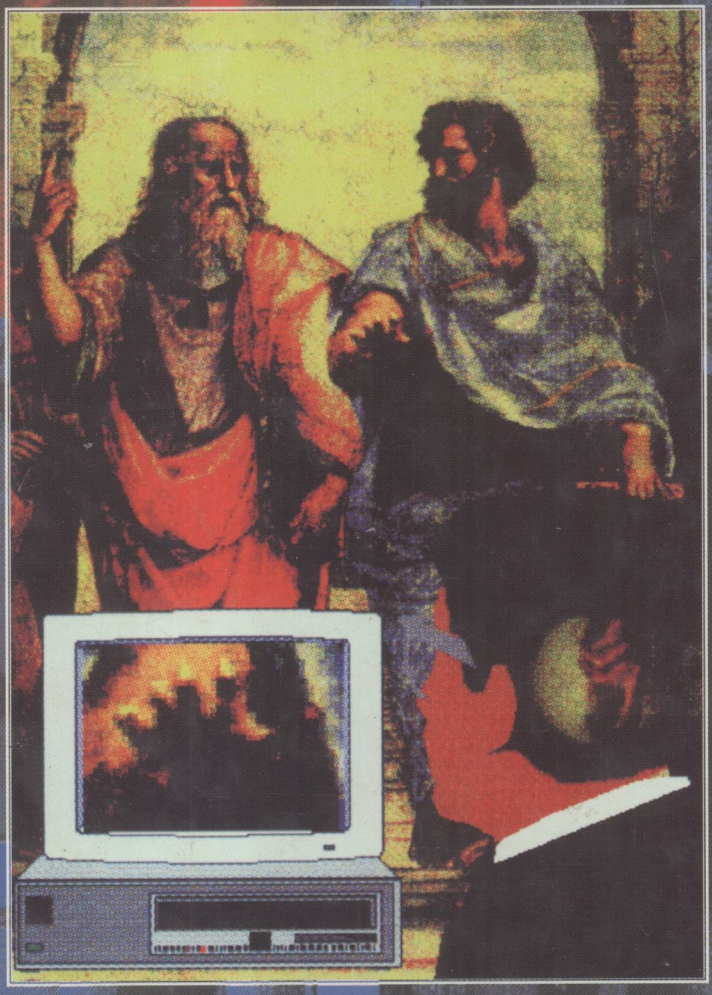
ARTIFICIAL VISION

Image Description, Recognition and Communication



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SIGNAL PROCESSING AND ITS APPLICATIONS

ACADEMIC PRESS

Artificial Vision

Image Description, Recognition and Communication

edited by

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Artificial Vision

Image Description, Recognition and Communication

Signal Processing and its Applications

SERIES EDITORS

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Series Preface

Signal processing applications are now widespread. Relatively cheap consumer products through to the more expensive military and industrial systems extensively exploit this technology. This spread was initiated in the 1960s by introduction of cheap digital technology to implement signal processing algorithms in real-time for some applications. Since that time semiconductor technology has developed rapidly to support the spread. In parallel, an ever increasing body of mathematical theory is being used to develop signal processing algorithms. The basic mathematical foundations, however, have been known and well understood for some time.

Signal Processing and its Applications addresses the entire breadth and depth of the subject with texts that cover the theory, technology and applications of signal processing in its widest sense. This is reflected in the composition of the Editorial Board, who have interests in:

(i) Theory – The physics of the application and the mathematics to model the system;
(ii) Implementation – VLSI/ASIC design, computer architecture, numerical methods, systems design methodology, and CAE;
(iii) Applications – Speech, sonar, radar, seismic, medical, communications (both audio and video), guidance, navigation, remote sensing, imaging, survey, archiving, non-destructive and non-intrusive testing, and personal entertainment.

Signal Processing and its Applications will typically be of most interest to postgraduate students, academics, and practising engineers who work in the field and develop signal processing applications. Some texts may also be of interest to final year undergraduates.

Richard C. Green
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About the Editors

Virginio Cantonio is presently Full Professor of Computer Programming at Pavia University. His most recent work is concerned with object recognition and parallel architectures for image processing and computer vision. He has been the coordinator of an Italian National Project involving a consortium of seven universities for the design and construction of a pyramidal system for image analysis. He is author or co-author of more than 120 journal or conference papers and book chapters and has edited or co-edited 12 books while being co-author of *Pyramidal Architectures for Computer Vision.*

Stefano Levialdi, Full Professor of Computer Science at Rome University, is the Director of the Pictorial Computing Laboratory. He has published over 180 scientific papers and edited over 20 books on image processing. He is founder and co-editor of the *Journal of Visual Languages and Computing* and Associate Editor of *Pattern Recognition, Computer Vision and Image Understanding, Pattern Recognition Letters, Machine Vision and Applications* and *Signal Processing.*

Vito Roberto is Associate Professor at the Computer Science Faculty, University of Udine, Italy. His research interests concern the design of intelligent systems for image interpretation and communication, in several application domains. He is responsible for the Machine Vision Laboratory at the same University. Professor Roberto is author of several articles and editor of many volumes in the field of pattern recognition and artificial intelligence.

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Preface

Artificial vision is a rapidly growing discipline, aiming to build computational models of the visual functionalities in humans, as well as machines that emulate them. Although the ultimate goals are ambitious, successful theories and applications have appeared so far in the literature, thanks to the converging contributions from image processing, computational geometry, optics, pattern recognition and basic computer science.

The on-going research work suggests that vision is to be studied in the context of other – seemingly distinct – functionalities. In particular, active vision focuses on the dynamics of sensing, so that moving, modifying sensor parameters, and acquiring information concur to perform visual tasks in a purposive way. Moreover, quite often visual modules are to be included into more complex 'intelligent' systems devoted to real-world applications – e.g., automated control, inspection and diagnosis. Models of the objects are to be acquired and stored; plausible hypotheses are to be maintained about the scene content. In this way, profound links emerge between visual and cognitive capabilities, like learning, reasoning and communicating. Visual communication, in itself, involves a number of challenging topics, with a dramatic impact on the contemporary culture, where human–computer interaction and human dialogue via computers play a more and more significant role.

The present volume contains a number of selected review articles concerning the research trends mentioned above. In particular, Part I groups contributions in active vision, Part II deals with the integration of visual with cognitive capabilities, while Part III concerns visual communication.

We hope that the topics reported in this volume will encourage further research work along the emerging directions, and towards an integrated, comprehensive study of vision and intelligence in humans and machines.

Part of the material has been presented at the fourth School on Machine Vision, organized by the Italian Chapter of the International Association for Pattern Recognition (IAPR), and held in Udine, Italy, 24–28 October 1994.

We wish to thank all the researchers who contributed to the success of the school and the preparation of this volume. In particular, we thank all the members of the scientific committee: L. Cordella (Napoli), S. Gaglio (Palermo),

S. Impedovo (Bari), G. Pieroni (Udine) and R. Stefanelli (Politecnico di Milano). The International Centre for Mechanical Sciences (CISM) is gratefully acknowledged for hosting the school. We are also grateful to Forum (Udine) for the help in typesetting and preparing the manuscripts.

Pavia, Rome and Udine, December 1995

Virginio Cantoni
Stefano Levialdi
Vito Roberto

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PART I

ACTIVE VISION

Real-time vision applications can achieve their required performances only by applying the appropriate computations on the relevant data, and at the right time. A 'smart' selection of data, located almost anywhere in the wide field of view, is generally performed at the early stages of the analysis, to broadly detect what is present in the scene, and where it is. The human camera-eye maneuvers for position and 'localizes' the regions of interest thanks to a sophisticated control. The highest concentration of sensing transducers occurs in the fovea, which occupies just a small portion of the field of view: about 120 minutes of arc around the visual axis; meanwhile, the sensing field is extended broadly, over 180 degrees. A complex 'alerting mechanism' allows one to effectively exploit the limited, but wealthy sensing resources of the fovea: as the scene changes, it rapidly guides the selection of the regions of interest to be focussed through the fovea. The selection itself requires eye vergence and head-and-eye movements, to scan the surrounding environment.

The following sections address the main aspects of the mentioned strategy.

The processes towards the area of scrutiny of an image, the general mechanisms that control the approaches, and the sequence of activities involved, are discussed in Chapter 1 from the point of view of biological systems; meanwhile, Chapter 2 considers the main features of attention mechanisms – and possible ways to model them – from the perspective of artificial systems. Chapter 3 emphasizes the purposeful modification of the parameters of the sensory apparatus, in order to simplify the visual tasks. Details are illustrated in Chapter 4 on the scan-path selection for model acquisition of unknown objects, and the solutions proposed in order to use the same models for planning sensor configurations in active vision. Finally, Chapter 5 deals with the basic regularization processes in early vision that drive the image analysis towards robust, goal-directed solutions.