Valentina Zharkova, Lakhmi C. Jain (Eds.)

Artificial Intelligence in Recognition and Classification
of Astrophysical and Medical Images

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Preface

During the past decade digital imaging has significantly progressed in all imaging areas ranging from medicine, pharmacy, chemistry, biology to astrophysics, meteorology and geophysics. The avalanche of digitized images produced a need for special techniques of processing and knowledge extraction from many digital images with minimal or even without human interaction. This has resulted in a new area in the digital processing called pattern recognition that becomes increasingly necessary owing to a growing number of images to be processed. The first applications of pattern recognition techniques were for the analysis of medical X-rays and MMR images that enabled the extraction of quantified information in terms of texture, intensity and shape and allowed to significantly improve a diagnosis of human organs. These techniques were significantly developed over the last few years and combined feature detection and classification by using region based and artificial intelligence methods. By using growing databases of medical images processed with pattern recognition and classification techniques, one can produce fast and consistent diagnosis of diseases based on the accumulated knowledge obtained from many other similar cases from the stored databases.

The use of CCD cameras for astrophysical instruments on the ground and space produce digitized images in various fields of astrophysics. In the past decade, many space and ground-based instruments provide large numbers of digitized images of the night skies and of the Sun, our closest star. These images provide more and more valuable knowledge about the evolution of celestial bodies and the physical processes occurring in them. This ample information can be processed with relatively new methods of feature recognition and classification developed in other imaging fields. With every new instrument and space mission, the archives of digital images are growing enormously in size. This imposes increasing requirements for the development of automated pattern recognition methods in applications to these archives.

The progress in digital imaging led to the application of pattern recognition techniques developed for medical and biomedical image to astrophysical images. They have proven to be the revolutionary way for the data processing in astrophysics and solar physics. In spite of difference

between the images in medicine, astrophysics and solar physics, there are many common approaches and techniques that are applicable to them all while some alterations are required to accommodate differences in the specific data.

Unlike features in medical images that are, in a general way, understood by wider range of readers as related to a human body, astrophysical and solar images contain the information about physical processes in the stars and the Sun that often affect the Earth and many aspects of human lives. These processes can be also uncovered with the pattern recognition techniques similar to those applicable to medical images but modified to accommodate the differences in recognized patterns. This book makes use of domain knowledge in astrophysical and medical image processing areas by employing the techniques used for general object recognition for an automated recognition of the features on astrophysical and medical images.

The book is intended for astrophysicists, medical researches, engineers, research students and technically aware managers in the Universities, Astrophysical Observatories, Medical Research Centres working on the processing of large archives of astrophysical or medical digital images. This book can be used as a text book for students of Computing, Cybernetics, Applied Mathematics and Astrophysics.

We are indebted to the authors and the reviewers for their wonderful contribution. Special thanks go to Berend Jan van der Zwaag, Rajesh Kannah, and Nandini Loganathan for their excellent help in the preparation of the camera ready copy. The editorial assistance provided by Springer is acknowledged.

Editors

Foreword

The interest in classification of objects into categories is as old as civilisation itself. It doesn't matter whether we are classifying types of animal species, rocks, weather patterns, or more modern applications such as automated character recognition, segmentation of retail customers, or identifying which stocks are likely to increase in value over a certain period of time - the task is still the same: classification is the search for common features in the data to enable us to group the data into distinct categories or classes. Once these similar features have been found the class of similar data can be labelled with a common label.

The techniques used in this book fall into two classes themselves. The first are the set of artificial intelligence methods used for pattern recognition and classification across a broad set of application domains. These include neural networks, decision trees, and more sophisticated spectral methods such as wavelet transforms and fractal analysis. The second class of techniques used relate to the specific application domain that is the focus of this book: images arising in medical and astrophysical applications. As soon as we start to apply classification techniques to images, we require a whole suite of specific techniques to assist with the unique data preparation and processing issues that images present. Thus, this book also discusses techniques for image standardization, enhancement and segmentation, as well as source separation. The role of all of these techniques in computer-aided recognition and diagnosis (in the case of the medical images) is explored. The collection of questions and solutions is a useful addition that makes this book ideal as a textbook.

Of all the application domains that these techniques are applicable to, none have more significance for the human race than recognising and classifying images belonging to our bodies and our universe. While there are plenty of volumes tackling pattern recognition problems in finance, marketing, and the like, I commend the editors and the authors for their efforts to tackle the big questions in life, and their excellent contributions to this book.

Professor Kate Smith-Miles
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