Emerging Topics in Computer Vision and its Applications

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Series in Computer Vision - Vol. 1

Emerging Topics in Computer Vision and its Applications

Editor

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PREFACE

From my recollection, computer vision was in early stage of development in the 60's and 70's and there was very limited textbook choice when I first taught computer vision in the mid-70s. Image processing was included as part of computer vision course at that time. The late Prof. A. Rosenfeld was instrumental to the early progress in computer vision and image processing. The influential work on human representation and processing of visual information by David Marr and others have had profound impact later on computer vision. For example texture was found to be very useful for both human and computer vision. There have been rapid progress in both computer vision and image processing in the last forty years. Computer vision and image processing are now two separate courses in most university curriculums. Similar advances were seen in the industry at the same time and computer vision especially is responsible for the advanced automation in the recent years. During the 80's there was much interest in using computer vision in manufacturing and during the 90's the need for robotic vision was greatly increased. The progress in the computer vision applications in fact far exceeds the theoretical advances.

Though currently there are many nice books on computer vision, there is always a need for another one as no single book can capture the major advances in computer vision. The book is much influenced by the well prepared book, *Emerging Topics in Computer Vision*, edited by Gerard Medioni and Sing Bing, published by Prentice-Hall 2005. The book in particular seeks to provide a balanced coverage of both theory and applications of computer vision, with greater emphasis on modern applications.

The book has three parts: Part 1 is emerging theory and methodology (algorithms) with 8 chapters. Part 2 is emerging applications of computer vision and image processing with 8 chapters, and Part 3 is on modern vision systems and technology with 7 chapters. Some chapters may partially belong to other parts. On the theoretical side, much emphasis is placed on 3-D modeling and analysis and on the application side, the book covers areas like biomedicine, surveillance, human recognition, fish identification, defect inspection, driver assistance, etc. The book's objective is to capture the emerging advances and

major results on computer vision so that readers will be able to read in a single and comprehensive volume the modern development, and progress in computer vision.

The first chapter of Part I deals with human post estimation and tracking from video sequence, which has continued to be a challenging problem in computer vision. The second chapter deals with a new approach which reconstructs the high resolution image from its low resolution ones with special reference for face images. The use of graphs and graphical models has been increasingly important in recent years for clustering and recognition. Chapters 3 and 4 present two emerging and powerful approaches with use of the graphs, one being based on a vectorial description of the graph and the other using the time-sliced probabilistic graphical models. Chapter 5 presents a new algorithm to estimate the background for images that are taken by freely moving camera, or images taken from different viewpoints of the same scene. Chapter 6 investigates the relationship between image deformation and their effects on image moments, based on which a registration algorithm is presented that is both computationally efficient and fairly robust to noise. Taking a radical departure from existing approaches, the non-parametric sample-based framework presented in Chapter 7 aims to model image data as a lattice of nonparametric conditional probability distributions estimated via random sampling. The main advantage of the approach is that significantly improved structural preservation at different scales can be achieved for computer vision tasks such as edge detection and image segmentation. Chapter 8 addresses another basic problem which is to determine correspondence of feature-points in a sequence of images. Based on the probabilistic framework, the chapter proposes an algorithm for feature-point correspondence that works under relaxed statistical assumptions and demonstrates the effectiveness of the approach by applying it to local flow estimation and tracking.

Chapter 1 of Part II presents a powerful Fourier shape modeling method, called spherical harmonic (SPHARM) method, for processing arbitrarily shaped but simply connected 3D surface data. Among applications of the approach presented is combining shape analysis of brain's substructure with genetic analysis to identify a neurodegeneration biomarker for Alzheimer's disease. While much of face recognition effort is on faces in visible light, Chapter 2 discusses specifically the eye glass problem in near infrared face recognition. Chapter 3 demonstrates the significant advantage of using phase-only information to detect defect in vision based surface inspection, without prior knowledge of defects. By exploiting some unique advantages of cellular automata (CA), Chapter 4 examines the use of CA in binary and gray scaled image denoising and edge detection. Chapters 5 and 6 present respectively results

on computer vision based marine fishery identification and vehicle detection from satellite imagery. One important difficulty in fingerprint classification, as well as other image classification problems, involves extracting representative features that are invariant to translation and rotation. Chapter 7 shows how the Polar Harmonic Transforms has such a desirable property and offers comparable classification performance with the state-of-the art methods using the NIST special fingerprint data base. The final chapter, Chapter 8, of Part II deals with a unique problem in computer vision, which is to detect many-to-many object correspondences across the original multiple images in an unsupervised manner. The method presented can detect and segment identical objects directly from a single image or a handful of images, with the use of object correspondence networks that connect matching objects.

Going back to the 3D world, Chapter 1 of Part III investigates the use of constraints that can help retrieve the 3D metric structure of a scene from two images. In video surveillance, multiple cameras are often used. The problem of how these cameras cooperate with one another such that all existing persons can be followed with an optimal group of cameras is addressed in Chapter 2 by using auction mechanism for camera network. Chapter 3 presents a novel photogeometric framework consisting of a family of methods using off-the-shelf projectors and cameras. The photometric and geometric information is concurrently captured in order to produce a photogeometric modeling system. In Chapter 4, the authors concentrate on image matching which is an essential part of any generic multi-view reconstruction system, with special focus on a particular correspondence growing method called quasi-dense wide baseline matching. The quasi-dense approach can be used to match parts of views of arbitrary and possibly deforming scenes. Chapter 5 investigates a single view traffic sign detection and recognition system with a multi-object, model-based 3D tracker for driver assistance. Chapter 6 examines the problem of extrinsic self-calibration of a multi-camera system. During such a self-calibration the cameras estimate their position and orientation in a common global coordinate system only from the images they record. Robots should be able to localize themselves in order to navigate in the environment, compute a path to a target destination, and recognize that the target destination has been reached. Chapter 7 deals with such robot localization problem by examining issues such as data association, and motion estimation with experimental results using publically available data base.

The very short description of chapters given above is highly incomplete. It is best to let each chapter speaks for itself. The readers can then get a good understanding of the scope, progress and complexity of computer vision problems.

I am grateful to all authors for their important contributions to this book. It is my honor to work with them on this book project. The book is the first of the Series in Computer Vision launched by World Scientific Publishing. The readers may also find some useful chapters in computer vision in the Handbook of Pattern Recognition and Computer Vision, vol. 4, 2010 also published by World Scientific Publishing. We certainly welcome feedbacks from the readers.

May, 2011

C.H. Chen

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