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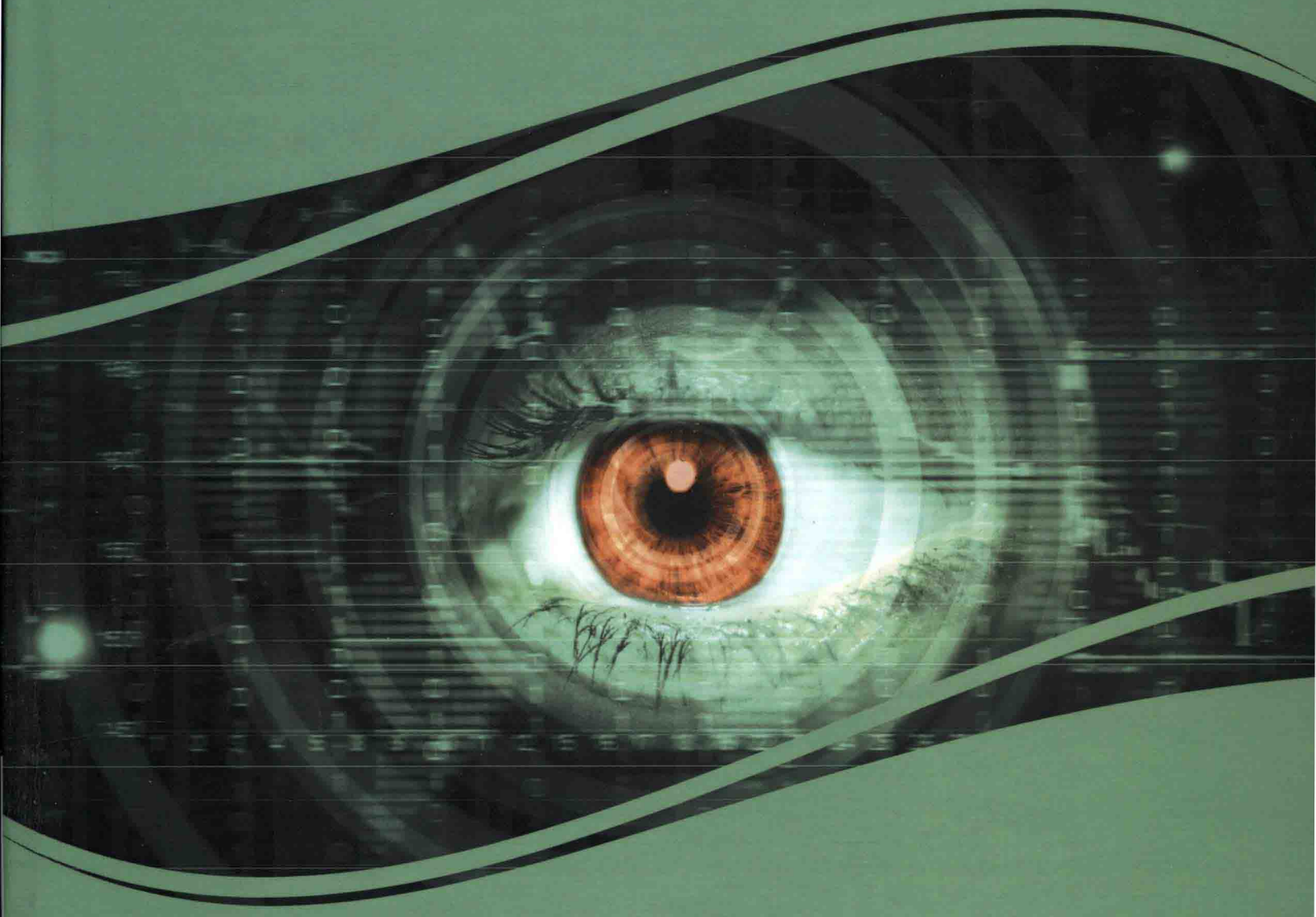

Rajarshi Pal

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Innovative Research in Attention Modeling and Computer Vision Applications

Rajarshi Pal
Institute for Development and Research in Banking Technology, India

A volume in the Advances in Computational Intelligence and Robotics (ACIR) Book Series

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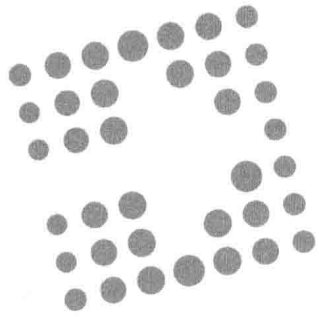

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Preface

Last few decades have witnessed a tremendous growth of image processing and computer vision. Improvement in sensor technologies coupled with efficient and effective algorithm development for image processing and computer vision has led to wide-spread usage of images and videos in several areas. It ranges from secret sharing through visual cryptography to surveillance and robotics. These later two require real-time intelligence to analyze surrounding images. Even image based technologies have been in use in sensitive domain like banking. For example, image based cheque clearing in banking system has emerged as a new phenomenon. So integrity of images has become a concern. In fact, it is not possible to codify all possible aspects of image processing and computer vision theories and their applications within a single book.

This edited book puts an effort to hold few of the application areas of image processing and computer vision. Many of these applications are benefited by theories from a psycho-visual phenomenon, called selective visual attention. Visual attention is a psycho-visual mechanism through which primates select only a few of the incoming sensory inputs for deeper analysis and recognition in brain. Though primate brains are very efficient, they cannot process the entire spectrum of sensory information in real-time. In order to carry out real-time interaction with external surrounding, primates pay attention to only selected stimuli, discarding myriads of other inputs. Which portions in a visual scene they focus has become a research problem. It has been observed that primate vision is guided by two kinds of attention mechanism – bottom-up and top-down. Bottom-up mechanism is purely stimulus driven. For example, a bright color tends to attract our vision. Top-down mechanism is a task-driven approach. This is guided by the task which an individual is performing.

Computer vision tasks also feel the burden of processing a bulk amount of image or video data. The capability of primates in efficiently dealing with dynamic surrounding through selective attention mechanism motivates computer vision researchers to develop efficient computer vision systems. They emulate this attention mechanism of primate vision to find out portions of importance in the visual scene. Processing based on only these selected portions in the scene increases speed as well as quality of outcome.

Beside these attention guided applications, many other interesting research areas in computer vision and image processing have also been presented in this book. Thus, this book is a compilation of research efforts in a wide spectrum of areas. Alongside highlighting usefulness of visual attention models in image processing and computer vision, this book sets up a platform of cross-disciplinary exchange of knowledge. Hopefully, these discussions will further open up new research directions.

This book contains few survey articles which give a good overview of the research that have been or still being carried out in some of these fields. Putting a good amount of existing research outcomes under one umbrella, these chapters are able to spot the lacunas which are still present there. Few new techniques have also been proposed in some of the chapters of this book to bring forward recent innovations.

This book has been divided into two sections. The first section, which consists of seven chapters (Chapter 1 to Chapter 7), speaks about visual attention models and how various applications in computer vision and image processing benefit from these visual attention models. The second section of this book (Chapter 8 to Chapter 16) discusses numerous other techniques in computer vision and image processing.

Chapter 1 discusses the conceptual theories related to visual attention mechanism. Then, it discusses various visual attention models. Both 2D and 3D models of visual attention have been presented. Chapter 2 highlights the usefulness of visual attention in image processing, computer vision and graphics through a thorough listing of applications which are benefited from theories of visual attention. Chapter 3 to Chapter 8, then, discusses few of these application areas in details. Chapter 3 sketches how attention is an important topic for robotic vision. A review on biologically-inspired models of attentive robot vision is presented in this chapter. Visual attention guided object detection and tracking has been discussed in Chapter 4. Chapter 5 is a compilation of phenomenal research efforts in the area of content-aware (based on identification of attentive regions) image retargeting. Image retargeting is useful in fitting an image of sufficiently high resolution in relatively small displays. Chapter 6 showcases the power of saliency for visual cryptography based watermarking. It proposes a novel visual cryptography based watermarking scheme using motion vector as a salient feature. Chapter 7 reports an electroencephalogram (EEG) based study of loss of alertness and fatigue of a driver using a visibility graph synchronization approach.

The second section (Chapter 8 to Chapter 16) of this book suggests that there are lot more in image processing and computer vision which do not intersect with visual attention theories. Chapter 8 describes a generic implementation for triangle-triangle intersection and its applications. Chapter 9 explains how some of the important problems in multi-object tracking can be tackled using scale-space representation of the objects, the method of linear assignment and Kalman filter. Chapter 10 discusses state-of-the-art research in digital image forensics and highlights few of the research challenges which must draw importance from research community. Chapter 11 discusses how noise feature can be used for video tampering detection. Chapter 12 provides an overview of existing palmprint based biometric recognition systems. Chapter 13 discusses techniques of emotion recognition from facial expressions. A novel technique of recognizing expression faces is proposed in Chapter 14 using 3D range images. Chapter 15 provides a survey of research in the area of scalable video watermarking. Chapter 16 proposes a technique of image watermarking based on fractal image coding.

Section 1

Visual Attention Modeling and Applications

Table of Contents

Preface xv

Section 1
Visual Attention Modeling and Applications

Chapter 1
2D and 3D Visual Attention for Computer Vision: Concepts, Measurement, and Modeling 1
Vincent Ricordel, University of Nantes, France
Junle Wang, University of Nantes, France
Matthieu Perreira Da Silva, University of Nantes, France
Patrick Le Callet, University of Nantes, France

Chapter 2
Applications of Visual Attention in Image Processing, Computer Vision, and Graphics 45
Rajarshi Pal, Institute for Development and Research in Banking Technology (IDRBT) Hyderabad, India

Chapter 3
Biologically-Inspired Models for Attentive Robot Vision: A Review 69
Amirhossein Jamalian, Technical University of Chemnitz, Germany
Fred H. Hamker, Technical University of Chemnitz, Germany

Chapter 4
Visual Attention Guided Object Detection and Tracking 99
Debi Prosad Dogra, Indian Institute of Technology Bhubaneswar, India

Chapter 5
Content-Aware Image Retargeting: A Survey 115
Rajarshi Pal, Institute for Development and Research in Banking Technology, India
Prasun Chandra Tripathi, Institute for Development and Research in Banking Technology, India & University of Hyderabad, India

Chapter 6
Video Saliency Detection for Visual Cryptography-Based Watermarking 132
Adrita Barari, Defence Institute of Advanced Technology, India
Sunita V. Dhavale, Defence Institute of Advanced Technology, India

Chapter 7
Study of Loss of Alertness and Driver Fatigue Using Visibility Graph Synchronization 171
Anwesha Sengupta, Indian Institute of Technology Kharagpur, India
Sibsambhu Kar, Samsung India Software Operations, India
Aurobinda Routray, Indian Institute of Technology Kharagpur, India

Section 2
Other Computer Vision Applications

Chapter 8
A Generic Design for Implementing Intersection between Triangles in Computer Vision and Spatial Reasoning 195
Chaman L. Sabharwal, Missouri University of Science and Technology, USA
Jennifer L. Leopold, Missouri University of Science and Technology, USA

Chapter 9
Multiple Object Tracking by Scale Space Representation of Objects, Method of Linear Assignment, and Kalman Filter 236
Kumar S. Ray, Indian Statistical Institute, India
Soma Ghosh, Indian Statistical Institute, India
Kingshuk Chatterjee, Indian Statistical Institute, India
Debayan Ganguly, Indian Statistical Institute, India

Chapter 10
Digital Forensics: State-of-the-Art and Open Problems 260
Ruchira Naskar, National Institute of Technology Rourkela, India
Pankaj Malviya, National Institute of Technology Rourkela, India
Rajat Subhra Chakraborty, Indian Institute of Technology Kharagpur, India

Chapter 11
Passive Video Tampering Detection Using Noise Features 279
Ramesh Chand Pandey, Indian Institute of Technology (BHU), Varanasi, India
Sanjay Kumar Singh, Indian Institute of Technology (BHU), Varanasi, India
K. K. Shukla, Indian Institute of Technology (BHU), Varanasi, India

Chapter 12
A Survey on Palmprint-Based Biometric Recognition System 304
Y. L. Malathi Latha, Swami Vivekananda Institute of Technology (SVIT), India
Munaga V. N. K. Prasad, Institute for Development and Research in Banking Technology, India

Chapter 13
Emotion Recognition Using Facial Expression 327
Santosh Kumar, Indian Institute of Technology (BHU), Varanasi, India
Shubam Jaiswal, Indian Institute of Technology (BHU), Varanasi, India
Rahul Kumar, Indian Institute of Technology (BHU), Varanasi, India
Sanjay Kumar Singh, Indian Institute of Technology (BHU), Varanasi, India

Chapter 14
Facial Expression Analysis Using 3D Range Images 346
Parama Bagchi, RCC Institute of Information Technology, India
Debotosh Bhattacharjee, Jadavpur University, India
Mita Nasipuri, Jadavpur University, India

Chapter 15
Scalable Video Watermarking: A Survey 365
Nilkanta Sahu, Indian Institute of Technology Guwahati, India
Arijit Sur, Indian Institute of Technology Guwahati, India

Chapter 16
Digital Image Watermarking Based on Fractal Image Coding 388
Channapragada R. S. G. Rao, CMR Institute of Technology, India
Munaga V. N. K. Prasad, Institute for Development and Research in Banking Technology, India

Compilation of References 400

About the Contributors 446

Index 454

Detailed Table of Contents

Preface xv

Section 1
Visual Attention Modeling and Applications

Chapter 1
2D and 3D Visual Attention for Computer Vision: Concepts, Measurement, and Modeling 1
Vincent Ricordel, University of Nantes, France
Junle Wang, University of Nantes, France
Matthieu Perreira Da Silva, University of Nantes, France
Patrick Le Callet, University of Nantes, France

Visual attention is one of the most important mechanisms deployed in the human visual system (HVS) to reduce the amount of information that our brain needs to process. An increasing amount of efforts has been dedicated to the study of visual attention, and this chapter proposes to clarify the advances achieved in computational modeling of visual attention. First the concepts of visual attention, including the links between visual salience and visual importance, are detailed. The main characteristics of the HVS involved in the process of visual perception are also explained. Next we focus on eye-tracking, because of its role in the evaluation of the performance of the models. A complete state of the art in computational modeling of visual attention is then presented. The research works that extend some visual attention models to 3D by taking into account of the impact of depth perception are finally explained and compared.

Chapter 2
Applications of Visual Attention in Image Processing, Computer Vision, and Graphics 45
Rajarshi Pal, Institute for Development and Research in Banking Technology (IDRBT) Hyderabad, India

Selective visual attention is an amazing capability of primate visual system to restrict the focus to few interesting objects (or portions) in a scene. Thus, primates are able to pay attention to the required visual content amidst myriads of other visual information. It enables them to interact with the external environment in real time through reduction of computational load in their brain. This inspires image and computer vision scientists to derive computational models of visual attention and to use them in varieties of applications in real-life, mainly to speed up the processing through reduction of computational burden which often characterizes image processing and vision tasks. This chapter discusses a wide variety of such applications of visual attention models in image processing, computer vision and graphics.

Chapter 3
Biologically-Inspired Models for Attentive Robot Vision: A Review 69
Amirhossein Jamalian, Technical University of Chemnitz, Germany
Fred H. Hamker, Technical University of Chemnitz, Germany

A rich stream of visual data enters the cameras of a typical artificial vision system (e.g., a robot) and considering the fact that processing this volume of data in real-rime is almost impossible, a clever mechanism is required to reduce the amount of trivial visual data. Visual Attention might be the solution. The idea is to control the information flow and thus to improve vision by focusing the resources merely on some special aspects instead of the whole visual scene. However, does attention only speed-up processing or can the understanding of human visual attention provide additional guidance for robot vision research? In this chapter, first, some basic concepts of the primate visual system and visual attention are introduced. Afterward, a new taxonomy of biologically-inspired models of attention, particularly those that are used in robotics applications (e.g., in object detection and recognition) is given and finally, future research trends in modelling of visual attention and its applications are highlighted.

Chapter 4
Visual Attention Guided Object Detection and Tracking 99
Debi Prosad Dogra, Indian Institute of Technology Bhubaneswar, India

Scene understanding and object recognition heavily depend on the success of visual attention guided salient region detection in images and videos. Therefore, summarizing computer vision techniques that take the help of visual attention models to accomplish video object recognition and tracking, can be helpful to the researchers of computer vision community. In this chapter, it is aimed to present a philosophical overview of the possible applications of visual attention models in the context of object recognition and tracking. At the beginning of this chapter, a brief introduction to various visual saliency models suitable for object recognition is presented, that is followed by discussions on possible applications of attention models on video object tracking. The chapter also provides a commentary on the existing techniques available on this domain and discusses some of their possible extensions. It is believed that, prospective readers will benefit since the chapter comprehensively guides a reader to understand the pros and cons of this particular topic.

Chapter 5
Content-Aware Image Retargeting: A Survey 115
Rajarshi Pal, Institute for Development and Research in Banking Technology, India
Prasun Chandra Tripathi, Institute for Development and Research in Banking Technology, India & University of Hyderabad, India

Displaying a large image in a small screen of a handheld gadget is a challenging task. Simple down-scaling of the image may reduce some objects too small to be perceptible. This gives rise to content-aware retargeting of the image. Important contents are allotted more screen space as compared to relatively less important contents of the image. Various types of content-aware image retargeting approaches have been proposed in a span of just over a decade. Another challenging area is to estimate importance of importance of the contents. Lot of researches has been carried out in this direction too to identify the important contents in the context of image retargeting. Equally important aspect is evaluation of these retargeting methods. This article contains a brief survey of related research in all of these aspects.

Chapter 6
Video Saliency Detection for Visual Cryptography-Based Watermarking 132
Adrita Barari, Defence Institute of Advanced Technology, India
Sunita V. Dhavale, Defence Institute of Advanced Technology, India

The aim of this chapter is to review the application of the technique of Visual cryptography in non-intrusive video watermarking. The power of saliency feature extraction is also highlighted in the context of Visual Cryptography based watermarking systems for videos. All schemes in literature related to Visual cryptography based video watermarking, have been brought together with special attention on the role of saliency feature extraction in each of these schemes. Further a novel approach for VC based video watermarking using motion vectors (MVP Algorithm) as a salient feature is suggested. Experimental results show the robustness of proposed MVP Algorithm against various video processing attacks. Also, compression scale invariance is achieved.

Chapter 7
Study of Loss of Alertness and Driver Fatigue Using Visibility Graph Synchronization 171
Anwesha Sengupta, Indian Institute of Technology Kharagpur, India
Sibsambhu Kar, Samsung India Software Operations, India
Aurobinda Routray, Indian Institute of Technology Kharagpur, India

Electroencephalogram (EEG) is widely used to predict performance degradation of human subjects due to mental or physical fatigue. Lack of sleep or insufficient quality or quantity of sleep is one of the major reasons of fatigue. Analysis of fatigue due to sleep deprivation using EEG synchronization is a promising field of research. The present chapter analyses advancing levels of fatigue in human drivers in a sleep-deprivation experiment by studying the synchronization between EEG data. A Visibility Graph Similarity-based method has been employed to quantify the synchronization, which has been formulated in terms of a complex network. The change in the parameters of the network has been analyzed to find the variation of connectivity between brain areas and hence to trace the increase in fatigue levels of the subjects. The parameters of the brain network have been compared with those of a complex network with a random degree of connectivity to establish the small-world nature of the brain network.

Section 2
Other Computer Vision Applications

Chapter 8
A Generic Design for Implementing Intersection between Triangles in Computer Vision and Spatial Reasoning 195
Chaman L. Sabharwal, Missouri University of Science and Technology, USA
Jennifer L. Leopold, Missouri University of Science and Technology, USA

The intersection between 3D objects plays a prominent role in spatial reasoning, and computer vision. Detection of intersection between objects can be based on the triangulated boundaries of the objects, leading to computing triangle-triangle intersection. Traditionally there are separate algorithms for cross and coplanar intersection. For qualitative reasoning, intersection detection is sufficient, actual intersection is not necessary; in contrast, the precise intersection is required for geometric modeling. Herein we present a complete design and implementation of a single integrated algorithm independent of the type of intersection. Additionally, this algorithm first detects, then intersects and classifies the intersections

using barycentric coordinates. This work is directly applicable to: (1) VRCC-3D+, which uses intersection detection between 3D objects as well as their 2D projections essential for occlusion detection; and (2) CAD/CAM geometric modeling where curves of intersection between a pair of surfaces are required for numerical control machines. Experimental results are provided.

Chapter 9

Multiple Object Tracking by Scale Space Representation of Objects, Method of Linear Assignment, and Kalman Filter 236
Kumar S. Ray, Indian Statistical Institute, India
Soma Ghosh, Indian Statistical Institute, India
Kingshuk Chatterjee, Indian Statistical Institute, India
Debayan Ganguly, Indian Statistical Institute, India

This chapter presents a multi-object tracking system using scale space representation of objects, the method of linear assignment and Kalman filter. In this chapter basically two very prominent problems of multi object tracking have been resolved; the two prominent problems are (i) irrespective of the size of the objects, tracking all the moving objects simultaneously and (ii) tracking of objects under partial and/or complete occlusion. The primary task of tracking multiple objects is performed by the method of linear assignment for which few cost parameters are computed depending upon the extracted features of moving objects in video scene. In the feature extraction phase scale space representation of objects have been used. Tracking of occluded objects is performed by Kalman filter.

Chapter 10

Digital Forensics: State-of-the-Art and Open Problems 260
Ruchira Naskar, National Institute of Technology Rourkela, India
Pankaj Malviya, National Institute of Technology Rourkela, India
Rajat Subhra Chakraborty, Indian Institute of Technology Kharagpur, India

Digital forensics deal with cyber crime detection from digital multimedia data. In the present day, multimedia data such as images and videos are major sources of evidence in the courts of law worldwide. However, the immense proliferation and easy availability of low-cost or free, user-friendly and powerful image and video processing software, poses as the largest threat to today's digital world as well as the legal industry. This is due to the fact that such software allow efficient image and video editing, manipulation and synthesis, with a few mouse clicks even by a novice user. Such software also enable formation realistic of computer-generated images. In this chapter, we discuss different types of digital image forgeries and state-of-the-art digital forensic techniques to detect them. Through these discussions, we also give an idea of the challenges and open problems in the field of digital forensics.

Chapter 11

Passive Video Tampering Detection Using Noise Features 279
Ramesh Chand Pandey, Indian Institute of Technology (BHU), Varanasi, India
Sanjay Kumar Singh, Indian Institute of Technology (BHU), Varanasi, India
K. K. Shukla, Indian Institute of Technology (BHU), Varanasi, India

With increasing availability of low-cost video editing softwares and tools, the authenticity of digital video can no longer be trusted. Active video tampering detection technique utilize digital signature or digital watermark for the video tampering detection, but when the videos do not include such signature then it

is very challenging to detect tampering in such video. To detect tampering in such video, passive video tampering detection techniques are required. In this chapter we have explained passive video tampering detection by using noise features. When video is captured with camera it passes through a Camera processing pipeline and this introduces noise in the video. Noise changes abruptly from authentic to forged frame blocks and provides a clue for video tampering detection. For extracting the noise we have considered different techniques like denoising algorithms, wavelet based denoising filter, and neighbor prediction.

Chapter 12

A Survey on Palmprint-Based Biometric Recognition System 304
Y. L. Malathi Latha, Swami Vivekananda Institute of Technology (SVIT), India
Munaga V. N. K. Prasad, Institute for Development and Research in Banking Technology, India

The automatic use of physiological or behavioral characteristics to determine or verify identity of individual's is regarded as biometrics. Fingerprints, Iris, Voice, Face, and palmprints are considered as physiological biometrics whereas voice and signature are behavioral biometrics. Palmprint recognition is one of the popular methods which have been investigated over last fifteen years. Palmprint have very large internal surface and contain several unique stable characteristic features used to identify individuals. Several palmprint recognition methods have been extensively studied. This chapter is an attempt to review current palmprint research, describing image acquisition, preprocessing palmprint feature extraction and matching, palmprint related fusion and techniques used for real time palmprint identification in large databases. Various palmprint recognition methods are compared.

Chapter 13

Emotion Recognition Using Facial Expression 327
Santosh Kumar, Indian Institute of Technology (BHU), Varanasi, India
Shubam Jaiswal, Indian Institute of Technology (BHU), Varanasi, India
Rahul Kumar, Indian Institute of Technology (BHU), Varanasi, India
Sanjay Kumar Singh, Indian Institute of Technology (BHU), Varanasi, India

Recognition of facial expression is a challenging problem for machine in comparison to human and it has encouraged numerous advanced machine learning algorithms. It is one of the methods for emotion recognition as the emotion of a particular person can be found out by studying his or her facial expressions. In this paper, we proposes a generic algorithms for recognition of emotions and illustrates a fundamental steps of the four algorithms such as Eigenfaces (Principal Component Analysis [PCA]), Fisherfaces, Local Binary Pattern Histogram (LBP) and SURF with FLANN over two databases Cohn-kanade database and IIT BHU student face images as benchmark database.The objective of this book chapter is to recognize the emotions from facial images of individuals and compare the performances of holistic algorithms like Eigenfaces, Fisherfaces, and texture based recognition algorithms LBPH, hybrid algorithm SURF and FLANN. Matching efficiency of individual emotions from facial expression databases are labeled for training and testing phases. The set of features is extracted from labeled dataset for training purpose and test images are matched with discriminative set of feature points. Based on that comparison, we conclude that Eigenfaces and Fisherfaces yields good recognition accuracy on the benchmark database than others and the efficiency of SURF with FLANN algorithm can be enhanced significantly by changing the parameters.