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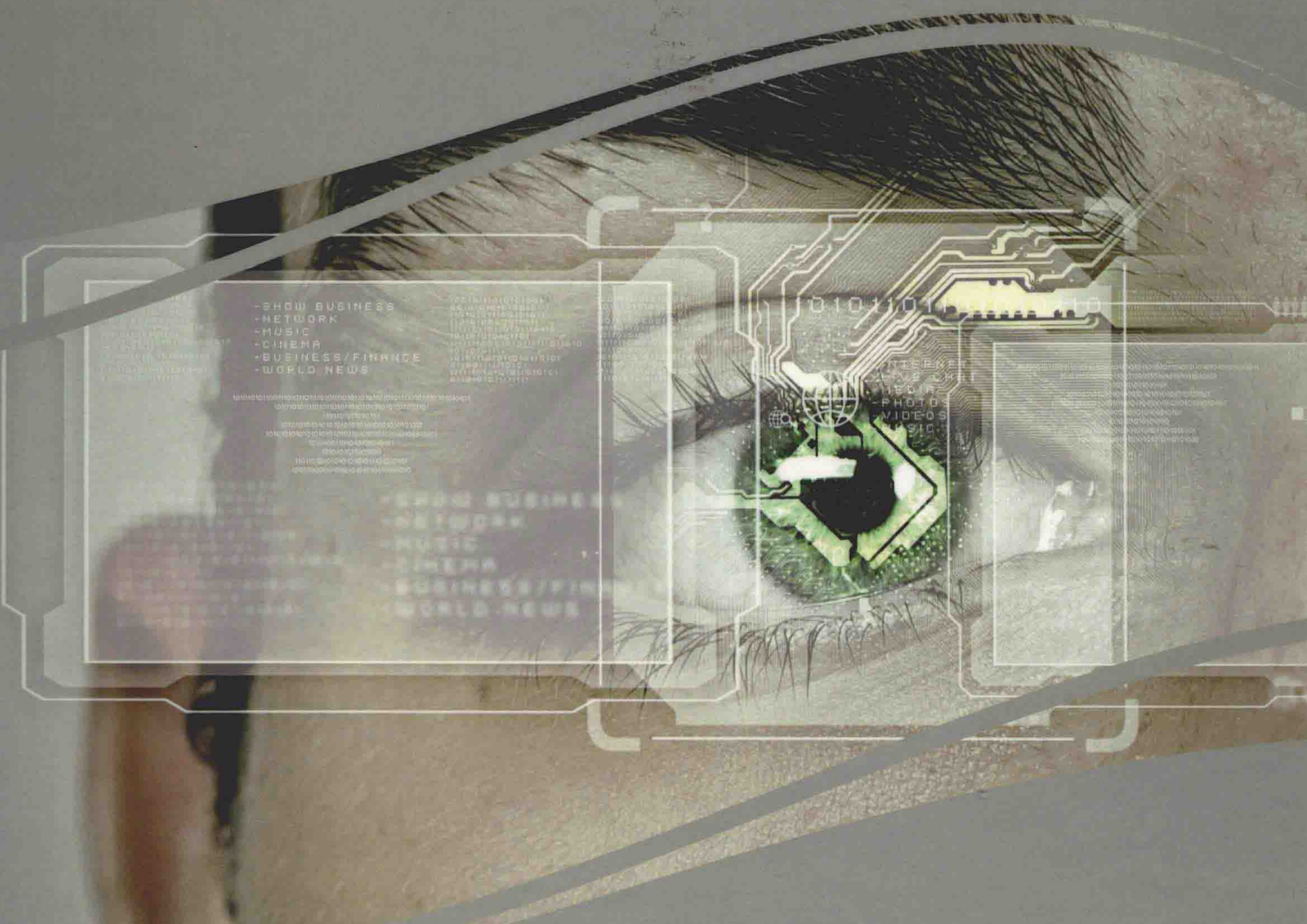

Muhammad Sarfraz

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Computer Vision and Image Processing in Intelligent Systems and Multimedia Technologies

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

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Preface

INTRODUCTION

Computer Vision (CV) and Image Processing (IP) are, although distinct, closely related fields. These are being treated as independent fields of study among the community worldwide. Due to their vital importance, effectiveness, and usefulness, extensive advances and discoveries are taking place everywhere. One can find a huge community worldwide contributing to these fields. In particular, CV and IP play significant roles in the development of Intelligent Systems (IS) and Multimedia Technologies (MT) in real life applications. Such real life applications are continuously needed to improve past and current practices. There is also a severe need to discover new state-of-the-art methodologies and systems for everyday life. There is plenty of literature available in the form of books, journals, conference proceedings, Websites, etc. One can find lot of events being held worldwide, numerous laboratories in function, and plenty of workgroups working in these fields. This book is specifically dedicated to the advances in CV and IP while working towards IS and MT applications.

COMPUTER VISION

Computer Vision (2012; Shapiro & Stockman, 2001; Morris, 2004; Jähne & Haußecker, 2000; Sonka, Hlavac, & Boyle, 2008; Forsyth & Ponce, 2003; Ballard & Brown, 1982; Turek, 2011; Carsten, Ulrich, & Wiedemann, 2007; Davies, 2005; Azad, Gockel, & Dillmann, 2008; Burger & Burge, 2007; Paragios, Chen, & Faugeras, 2005; Fisher, Dawson-Howe, Fitzgibbon, Robertson, & Trucco, 2005; Medioni & Kang, 2004; Hartley & Zisserman, 2003; Trucco & Verri, 1998; Klette, Schluens, & Koschan, 1998; Granlund & Knutsson, 1995; Crowley & Christensen, 1995) is a field that includes methods for acquiring, processing, analyzing, and understanding images and in general, high-dimensional data (Medioni & Kang, 2004; Hartley & Zisserman, 2003; Trucco & Verri, 1998) from the real world in order to produce numerical or symbolic information (Computer Vision, 2012; Shapiro & Stockman, 2001; Morris, 2004). A theme in the development of this field has been to duplicate the abilities of human vision by electronically perceiving and understanding an image (Jähne & Haußecker, 2000). Computer vision is a scientific as well as technological field (Computer Vision, 2012; Shapiro & Stockman, 2001; Morris, 2004; Jähne & Haußecker, 2000; Sonka, Hlavac, & Boyle, 2008). As a scientific field, it is concerned with the theory behind artificial systems that extract information from images. The image data can take many forms, such as video sequences, views from multiple cameras, or multi-dimensional data from a medical scanner. As a technological discipline, computer vision seeks to apply its theories and models to the construction of computer vision systems. Examples of applications of computer vision include detecting events for visual surveillance, navigation of a robot, and automatic inspection in manufacturing applications.

IMAGE PROCESSING

Digital Image Processing (2012; Gonzalez, Woods, & Eddins, 2009; Burger & Burge, 2007; Sarfraz, 2014; Jähne, 2002; Morris, 2004; Sonka, Hlavac, & Boyle, 1999; Stanciu, 2012; Koprowski & Wrobel, 2011; Zheng, 2011; Zhou, Wu, & Zhang, 2010; Young, Gerbrands, & Vliet, 2009; Starck & Murtagh, 2006; Blake & Isard, 2000; Starck, Murtagh, & Bijaoui, 1998; Philipps, 1997; Management Association, 2013; Sarfraz, 2013; Banissi & Sarfraz, 2012; Sargano, Sarfraz, & Haq, 2014) is the use of computer algorithms to perform image processing on digital images. As a subcategory or field of digital signal processing, digital image processing has many advantages over analog image processing. It allows a much wider range of algorithms to be applied to the input data and can avoid problems such as the build-up of noise and signal distortion during processing. Since images are defined over two dimensions (perhaps more), digital image processing may be modeled in the form of multidimensional systems.

Digital image processing allows the use of much more complex algorithms and can offer both more sophisticated performance of simple tasks and the implementation of methods that would be impossible by analog means. In particular, digital image processing is the only practical technology for classification, feature extraction, pattern recognition, projection, and multi-scale signal analysis. Some techniques that are used in digital image processing include pixelation, linear filtering, principal components analysis, independent component analysis, hidden Markov models, anisotropic diffusion, partial differential equations, self-organizing maps, neural networks, and wavelets.

LATEST ADVANCES

The chapters in this comprehensive reference explore the latest developments, methods, and approaches to computer vision and image processing in a wide variety of fields and endeavors, providing researchers, academicians, and readers of backgrounds and methods with an in-depth discussion of the latest advances in IP tools, IS, and MT technologies.

Abder-Rahman Ali et al. begin the book with a discussion of "Evaluating an Evolutionary Particle Swarm Optimization for Fast Fuzzy C-Means Clustering on Liver CT Images." This chapter aims at enhancing the performance of Fast Fuzzy C-Means, both in terms of the overall solution and speed. To that end, the concept of fractional calculus is used to control the convergence rate of particles, wherein each one of them represents a set of cluster centers. The proposed solution, denoted as FODPSO-FFCM, is applied on liver CT images, and compared with Fast Fuzzy C-Means and PSOFFCM, using Jaccard Index and Dice Coefficient. The computational efficiency is achieved by using the histogram of the image intensities during the clustering process instead of the raw image data. The experimental results based on the Analysis of Variance (ANOVA) technique and multiple pair-wise comparison show that the proposed algorithm is fast, accurate, and less time consuming.

This is followed by "Automatic Mammographic Parenchyma Classification According to BIRADS Dictionary" by Ahmed Anter et al. Breast Imaging Reporting and Data System (BIRADS) is becoming a standard for the assessment of mammographic images (American College of Radiology, 1998). Internal density of the breast is a parameter that clearly affects the performance of segmentation and classification algorithms to define abnormality regions. Recent studies have shown that their sensitivity is significantly decreased as the density of the breast is increased. In this chapter, enhancement and segmentation process is applied to increase the computation and focus on mammographic parenchyma. This parenchyma is analyzed to discriminate tissue density according to BIRADS using Local Binary Pattern (LBP), Gray Level Co-Occurrence Matrix (GLCM), Fractal Dimension (FD), and feature fusion technique is applied to maximize and enhance the performance of the classifier rate. The different methods for computing tissue density parameter are reviewed, and the authors also present and exhaustively evaluate algorithms using computer vision techniques. The experimental results based on confusion matrix and kappa coefficient show a higher accuracy is obtained by automatic agreement classification.

Motivated by recent results in diagnosis of Alzheimer's Disease, chapter 3, "Statistical Features-Based Diagnosis of Alzheimer's Disease Using MRI" by Namita Aggarwal et al., addresses the issue of early detection. It may help in development of appropriate treatment to slow down the disease's progression. In this chapter, a method is proposed that may assist in diagnosis of AD using T1 weighted MRI brain images. In the proposed method, first-and-second-order-statistical features were extracted from multiple trans-axial brain slices covering hippocampus and amygdala regions, which play a significant role in AD diagnosis. Performance of the proposed approach is compared with the state-of-the-art feature extraction techniques in terms of sensitivity, specificity, and accuracy. The experiment was carried out on two datasets built from publicly available OASIS data, with four well-known classifiers. Experimental results show that the proposed method outperforms all the other existing feature extraction techniques irrespective of the choice of classifier and dataset. In addition, the statistical test demonstrates that the proposed method is significantly better in comparison to the existing methods. The authors believe that this study will assist clinicians/researchers in classification of AD patients from controls based on T1-weighted MRI.

Machine vision system for citrus fruit harvesting manipulator is one of special applications of pattern recognition by visual perception. Chapter 4, "Use of Bi-Camera and Fusion of Pairwise Real Time Citrus Fruit Images for Classification Application" by PeiLin Li et al. constructs a typical machine vision system by the geometry of image formation, measurement, and interpretation. In this chapter, an application of visual recognition by a bi-camera imaging system is detailed as associated with citrus fruit identification for the citrus fruit harvesting manipulator. The use of bi-camera is enriched by using the measurement and the interpretation method based on the proposal of the use of multisensor from the horticultural industry literature. The application covers the real time citrus fruit image formation by two aligned CCD cameras, the measurement on the citrus fruit tree, and the image data filtering method with fusion approach. The research focuses on the pairwise image filtering method to address the real time citrus fruit image quality issues. One issue is the detail noise from the background of leave or the other, which has similar spectra as citrus fruit. The second issue is the maintenance or enhancement of the fundamental envelopment spectra using two source images. In the filtering method, two issues are addressed by assuming that the real time citrus fruit image is formed by the fundamental envelopment spectra mixed with the local detail noise with spatial variance property. The basis for the bi-camera image-filtering scheme is an approach of Multiscale Decomposition (MSD) by Discrete Wavelet Transform (DWT) using Daubechies wavelets. To a certain level of decomposition and with high-pass filtered coefficients zeroed, the fundamental envelopment spectra from two source images are maintained or enhanced by an arithmetic fusion rule. The pixel level fusion rule index is found by combining the low pass coefficient of the visible image and the low pass coefficient of the near-infrared image convoluted by the complement of local entropy filter from the visible low-pass coefficient. To achieve the function of pairwise images filtering, the prerequisite of the alignment of two cameras is addressed technically from the image formation to the measurement. The citrus fruit tree has been photographed by using a portable bi-camera cold mirror acquisition system. The prototype of the customized fixture has been manufactured to position and align a classical cold mirror with two CCD cameras in relative kinematic position. The algorithmic registration on the pairwise images can be bypassed by both of the alignment of two cameras in spatial coordinate and the triggering synchronization in temporal coordinate during the photographing. After the fused image is transformed reversely into the original resolution image, some clustering or classification methods are applied to segment the fused citrus fruit image. The results have been compared between the fused and the non-fused original color citrus fruit images to evaluate the improvement of the image quality issues. It is found that the citrus identification on the fused artifact image can be improved by comparing the original and the attenuated color image by both the visual perception and the misclassification error estimation. The misclassification error is measured by the empirical weak type error using the weak manual segmentation standard, respectively. The experimental fusion index on low-pass coefficients with high-pass detail coefficients zeroed primarily improves the issue of the similar detail spectra from the non-fruit area and some saturated background noise under the natural illumination condition.

Diseases in fruit cause devastating problem in economic losses and production in agricultural industry worldwide. The next chapter, “Automatic Fruit Disease Classification Using Images” by Shiv Ram Dubey and Anand Singh Jalal, introduces a method to detect and classify fruit diseases automatically. This method to detect and classify fruit diseases automatically is proposed and experimentally validated. The image processing-based proposed approach is composed of the following main steps: in the first step K-Means clustering technique is used for the defect segmentation, in the second step some color and texture features are extracted from the segmented defected part, and finally diseases are classified into one of the classes by using a multi-class Support Vector Machine. The authors have considered diseases of apple as a test case and evaluated the approach for three types of apple diseases, namely apple scab, apple blotch, and apple rot, along with normal apples. The experimental results express that the proposed solution can significantly support accurate detection and automatic classification of fruit diseases. The classification accuracy for the proposed approach is achieved up to 93% using textural information and multi-class support vector machine.

One of the prime factors in ensuring a consistent marketing of crops is product quality, and the process of determining ripeness stages is a very important issue in the industry of (fruits and vegetables) production, since ripeness is the main quality indicator from the customers’ perspective. To ensure optimum yield of high quality products, an objective and accurate ripeness assessment of agricultural crops is important. In the next chapter, Esraa El Hariri et al. describe an “Automated Ripeness Assessment System of Tomatoes Using PCA (Principal Components Analysis) and SVM (Support Vector Machine) Techniques.” This chapter presents a content-based image classification approach to automate the ripeness assessment process of tomatoes via examining and classifying the different ripeness stages. The proposed system consists of three phases, namely pre-processing, feature extraction, and classification. The classification process depends totally on color features (colored histogram and color moments), since the surface color of tomato is the most important characteristic to observe ripeness. This system uses PCA and SVM algorithms for feature extraction and classification, respectively. The dataset used for experiments was constructed based on real sample images for tomatoes at different stages, which were collected from different farms in Minya city, Upper Egypt. Dataset of total 250 images was used for both training and testing with 10-fold cross-validation. Training dataset is divided into 5 classes representing the different stages of tomato ripeness. Experimental results show that the proposed classification approach has obtained ripeness classification accuracy of 91.20%, using One-Against-One (OAO) multi-class SVM algorithm with linear kernel function and accuracy of 85.60% using One-Against-All (OAA) multi-class SVM algorithm with linear kernel function.

It is well known that the careful selection of a set of features, with higher discrimination competence, may increase the recognition performance. For example, the magnitude coefficients of some selected orders of Zernike Moments (ZMs) and Pseudo-Zernike Moments (PZMs) have been used as invariant image features in the current literature (Nor'aini, Raveendran, & Selvanathan, 2007; Singh, Walia, & Mittal, 2011a, 2011b, 2011c). Neerja Mittal et al., in Chapter 7, "Magnitude and Phase of Discriminative Orthogonal Radial Moments for Face Recognition," proposed a statistical method to estimate the discrimination strength of all the coefficients of ZMs and PZMs. For classification, only the coefficients with estimated higher discrimination strength are selected and are used in the feature vector. The performance of these selected Discriminative ZMs (DZMs) and Discriminative PZMs (DPZMs) features has been compared to that of their corresponding conventional approaches on YALE (Georghiades, 1997), ORL (AT&T Laboratories Cambridge, 2002), and FERET (Phillips, Moon, Rauss, & Rizvi, 2000) databases against illumination, expression, scale, and pose variations. In this chapter, an extension to these DZMs and DPZMs has been presented by exploring the use of phase information along with the magnitude coefficients of these approaches. The phase coefficients are computed in parallel to the magnitude so no additional time is spent on their computation. Further, DZMs and DPZMs are also combined with PCA and Fisher Linear Discriminant (FLD) (Belhumeur, Hespanha, & Kriegman, 1997). It has been observed from the exhaustive experimentation that with the inclusion of phase features the recognition rate is improved by 2-8%, at reduced dimensions and with less computational complexity, than that of using the successive ZMs and PZMs features.

The Internet is a powerful source of information. However, some of the information that is available on the Internet cannot be shown to every type of public. For instance, pornography is not desirable to be shown to children; pornography is the most harmful content affecting child safety and causing many destructive side effects. A content filter is one of more pieces of software that work together to prevent users from viewing material found on the Internet. Chapter 8, "An Efficient System for Blocking Pornography Websites," by Tarek Mahmoud et al., proposes an efficient content-based software system for detecting and filtering pornography images in Web pages. The proposed system runs online in the background of Internet Explorer (IE) for the purpose of restricting access to pornography Web pages. Skin and face detection techniques are the main components of the proposed system. Because the proposed filter works online, the authors propose two fasting techniques that can be used to speed up the filtering system. The results obtained using the proposed system are compared with four commercial filtering programs. The success rate of the proposed filtering system is better than the considered filtering programs.

During the Internet era, millions of users are using Web-based Social Networking Sites (SNSs) such as MySpace, Facebook, and Twitter for communication needs. Social networking platforms are now considered a source of big data because of real-time activities of a large number of users. In addition to idiosyncratic personal characteristics, Web-based social data may include person-to-person communication, profiles, patterns, and spatio-temporal information. However, analysis of social interaction-based data has not been studied from the perspective of person identification. In chapter 9, "Online User Interaction Traits in Web-Based Social Biometrics," Madeena Sultana et al. introduce for the first time the concept of using interaction-based features from online social networking platforms as a novel biometric. They introduce the concept of social behavioral biometric from SNSs to aid the identification process. Analysis of these novel biometric features and their potential use in various security and authentication applications are also presented. Such applications would pave the way for new directions in biometric research.

In the current age, use of natural communication in human-computer interaction is a known and well-installed thought. Hand gesture recognition and gesture-based applications have gained a significant amount of popularity amongst people all over the world. They have a number of applications ranging from security to entertainment. These applications generally are real time applications and need fast, accurate communication with machines. On the other end, gesture-based communications have few limitations, but bent finger information is not provided in vision-based techniques. The next chapter, "Fingers' Angle Calculation Using Level-Set Method" by Ankit Chaudhary et al., proposes and contributes towards a novel method for fingertip detection and for angle calculation of both hands' bent fingers. Angle calculation has been done before with sensor-based gloves/devices. This study has been conducted in the context of natural computing for calculating angles without using any wired equipment, colors, marker, or any device. The pre-processing and segmentation of the region of interest is performed in a HSV color space and a binary format, respectively. Fingertips are detected using level-set method and angles are calculated using geometrical analysis. This technique requires no training for the system to perform the task.

The recent advances in multimedia technology demand protection of digital images from unintentional manipulation for content integrity, copyright, and ownership. Digital watermarking technique has wide acceptance in the industry for anti-piracy, ownership verification, and digital image authentication. There have been a large number of schemes in the literature proposed for digital watermarking using non-cryptographic and cryptographic primitives. Use of Least Significant Bits (LSB) is one of the oldest but classical approaches for digital image authentication. Although LSB approach is efficient, it does not provide adequate security. Cryptographic primitives such as hash function, digital signature, and message authentication codes have been used in several applications including multimedia for data authentication. Digital signature-based image authentication provides strong security, but the approach requires managing public key infrastructure, which is a costly operation. Partial data protection is also an optimal approach for protecting important data while leaving unimportant data unprotected. Considering security weakness of the LSB-based approach and cost overhead of the public key-based approach, Siva Charan Muraharirao and Manik Lal Das present, in chapter 11, a digital image authentication scheme using LSB, keyed hash, and partial encryption. They show that the proposed watermarking scheme is secure and efficient in comparison to other related schemes.

Next, Noura Semary explores "An Efficient Color Image Encoding Scheme Based on Colorization." Image colorization is a new image processing topic to recolor gray images to look as like the original color images as possible. Different methods have appeared in the literature to solve this problem, the way that leads to thinking about decolorization, eliminating the colors of color images to just small color keys, aid in the colorization process. Due to this idea, decolorization is considered as a color image encoding mechanism. In this chapter, the authors propose that a new decolorization system depends on extracting the color seeds (Representative Pixels [RP]) using morphology operations. Different decolorization methods are studied and compared to the system results using different quality metrics.

Saif al Zahir then presents "A Fast New Rotation Insensitive WP-Based Method for Image Indexing and Retrieval." In this chapter, the author presents a novel Wavelet Packet (WP)-based method for image identification and retrieval that enables the recovery of the original image from a database even if the image has been subjected to geometric transformations such as size-conserving rotation or flipping operations. The proposed method uses the correlation of wavelet packet coefficients to create an image signature. This signature is comprised of two parts. The first part is a short signature, SS, that represents the location of specific values of the WP coefficient correlations in each frequency band. The second portion is the basis signature of the image, which is a long signature, LS, of 1296 correlation points produced by summing up the correlation values along all frequency bands. Computer simulation results show that the method is extremely fast, has a perfect image retrieval rates (100%), and perfect geometric transformations recognition, if any. In addition, the simulation results show that target images are perfectly identified from an image database of 7500 image signatures within a short period of time (nearly 8 seconds on the average). This method is robust against geometric transformation and requires minimal data transfer and can be used for online image retrieval.

Intelligent process control technology in various manufacturing industries is important. Vision-based non-magnetic object detection on moving conveyor in the steel industry will play a vital role for intelligent processes and raw material handling. In chapter 14, K. C. Manjunatha et al. present an approach for a vision-based system that performs the detection of non-magnetic objects on raw material moving conveyor in a secondary steel-making industry. At single camera level, a vision-based differential algorithm is applied to recognize an object. Image pixels-based differential techniques, optical flow, and motion-based segmentations are used for traffic parameters extraction; the proposed approach extends those futures into industrial applications. The authors implement a smart control system, since they can save the energy and control unnecessary breakdowns in a robust manner. The technique developed for non-magnetic object detection has a single static background. Establishing background and background subtraction from continuous video input frames forms the basis. Detection of non-magnetic materials, which are moving with raw materials, and taking immediate action at the same stage as the material handling system will avoid the breakdowns or power wastage. The authors achieve accuracy up to 95% with the computational time of not more than 1.5 seconds for complete system execution.

Next, a review of novel techniques for detecting corner features of planar objects is presented by Muhammad Sarfraz in chapter 15, "Detecting Corner Features of Planar Objects." Corner points or features determine significant geometrical locations of the digital images. They provide important clues for shape representation and analysis. Corner points represent important features of an object that may be useful at subsequent levels of processing. If the corner points are identified properly, a shape can be represented in an efficient and compact way with sufficient accuracy in many shape analysis problem. This chapter reviews some well referred algorithms in the literature together with empirical study. Users can easily pick one that may prove to be superior from all aspects for their applications and requirements.

Finally, in "Outline Capture of Planar Objects by Detecting Corner Features," Misbah Irshad et al. propose a scheme that helps digitizing hand printed and electronic planar objects or vectorizing the generic shapes. An evolutionary optimization technique, namely Genetic Algorithm (GA), is used to solve the problem of curve fitting with cubic and rational cubic spline functions. The underlying scheme is comprised of various phases including data of the image outlines, detection of corner points, using GA for optimal values of shape parameters in the description of spline functions, and fitting curve using spline functions to the detected corner points.

CONCLUSION

In all, the chapters in this book present readers with a full view of some of the most up-to-date discoveries in the fields of computer vision and image processing. The mix of practical applications and theoretical research included in this reference volume effectively illustrate best practices alongside novel techniques, encouraging practitioners and educators to join in creating the next generation of IS and MT technologies and applications.

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