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Pattern Recognition in Image Processing – A Study

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ABSTRACT: Pattern recognition is the study of how machines can observe the environment, learn to distinguish patterns of interest, make sound and reasonable decisions about the categoriesof the patterns. Image processing has been proved to be aeffective tool for analysis in various fields and applications. Many times expert advice may not be affordable, majority times the availability of expert and their services may consume time. Image processing along with availability of communication network can change the situation of getting the expert advice well within time and at affordable cost since image processing was the effective tool for analysis of parameters.. In this paper, a practical implementation of image processing and isolated word recognition has been explained.

I. INTRODUCTION

The field of image processing grew from electrical engineering as an extension of the signal processing branch, whereas are the computer science discipline was largely responsible for developments in computer vision. Digital image processing analysis and computer visions have exhibited animpressive growth in the past decade in terms of both theoretical development and applications. They constitute a leading technology in a number of very important areas, for example in digital telecommunication, broadcasting medical imaging, multimedia systems, biology, material sciences, robotics and manufacturing, intelligent sensing systems, remote sensing, graphic arts andprinting.Image is avisual representation of the external form of a person or thing in art.Processing means performing a series of mechanical or chemical operations on (something) in order to change or preserve it. The combination of the above two i.e.Image processing is defined as improvement of pictorial information for human interpretation and analysis.The computational part of image processing is Digital Image processing and is usually explained as using computer algorithms to perform image processing on digital images. The basic term Pattern Recognition is detecting and extractingpatterns from data where patterns aresubsets of data that may be described by some well-defined set of rules. They constitute the smallest entity in the data that represent knowledge.Image processing along with availability of communication network can change the situation of getting the expert advice well within time and at affordable cost since image processing is considered as the effective tool for analysis of parameters. This field has been proved to be effective tool for analysis in various fields and applications.

This paper has been distributed as various sections based on the survey of the application of Image processing on various fields. In this work we have also covereddifferent classifier which is widely used in this area such as Bayesian and Gaussian classifiers, as well as artificial neural networks. The accompanying exercises will provide further details on the methods and procedures used in various papers for applying Image processing in the particular field.

II. APPLICATIONS OF IMAGE PROCESSING

In this section we have tried to cover various fields where Image Processing is applied.

2.1 Signal Processing:

HaqueandShorifUddinhave described in their paper how Fast Fourier Transform (FFT) method has been used for image processing using Graphics Processing unit[1]. The Fourier Transform (FT) is a mathematical operation used widely in many fields. Fast Fourier Transform (FFT) is being used for the processing of images in its frequency domain rather than spatial domain. It is an important image processing tool which is used to decompose an image into its sine and cosine components. The objective is to develop FFTbased image processing algorithm to run under Central Processing

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Unit (CPU) and also Graphics Processing Unit (GPU) for comparing performance. The experimental results show a significant speedup of the algorithm in GPU than that of CPU based implementation. It is expected that this will accelerate many compute intensive image processing.

Fourier Transform was a revolutionary concept which took mathematicians all over the world over a century to "adjust". Basically, the great contribution of Fourier Transformation states that any function can be expressed as the integral of sine's and/or cosines multiplied by a weighting function. It works for any sort of complex functions, as long as it meets some mild mathematical conditions. The function, expressed in a Fourier transform, can be reconstructed (recovered) completely via an inverse process [2]. This important property of Fourier transform allows working in the "frequency domain" and then returning to the spatial domain without losing any information [3]. Medical imaging is one of the main application areas of FFT.

Besides the performance advantage of using a GPU over a CPU for FFT based image processing, thereare other advantages as well. In some imaging device, the CPU can be preoccupied with time controlling the data acquisition hardware. In this case, it is beneficial to use the GPU for image processing, leavingthe CPU to do data acquisition. Moreover, because of the GPU is free of interrupts from results better performance than interrupt driven CPU. The rate of increase in performance of GPUs is expected tooutshine that of CPUs in the next few years, increasing the demand of the GPU as the processor of choice for image processing.

2.2 Agriculture:

In this paper Vibhuteand Bodhe have described the applications of Image Processing in Agriculture[4]**.** In this review the authors have reviewed the different techniques for crop inventory in Indian scenario*viz.* Optical and microwave data used to classify the crop. Chlorophyll and water were represented by optical data, crop geometry and dielectric properties were characterized by microwave. They also conducted a survey of application of image processing in agriculture field such as imaging techniques, weed detection and fruit grading. The analysis of the parameters has proved to be accurate and less time consuming as compared to traditional methods. In agriculture, Remote Sensing (RS) technique was widely used for various applications. Remote Sensing was the science of identification of earth surface features and estimation of geo-biophysical properties using electromagnetic radiation. Paper reviewed the RS techniques and its applications with optical and microwave sensors.

RS data and pattern recognition technique was used to estimate direct and independent crop area in the study region [5]. Applications of image processing in agriculture can be broadly classified in two categories: first one depends upon the imaging techniques and second one based on applications. This survey mainly focuses on application of image processing in various domains of agriculture.This approach helps to save the environment as well as the cost. In case of fruit grading systems the segmentation and classification can also be achieved with great accuracy as the case with weed detection. In this case also the classification accuracy was obtained up to 96% with correct imaging techniques and algorithms. Thus they concluded that image processing was the non-invasive and effective tool that can be applied for the agriculture domain with great accuracy for analysis of agronomic parameters.Thus they concluded that image processing was the noninvasive and effective tool that can be applied for the agriculture domain with great accuracy for analysis of agronomic parameters.

2.3 Bio-Technology:

In this reviewIsmail*et al.* has described the use of Image Processing Methods in Bio-Technology[6]. Theyhave identified the problem faced in Bio-technology field using different image processing technique theyhave also done a comparison between their methods and the other hardware laboratory experiments. The scanning electron microscope (SEM) remains a main tool for bio measurementsOtherwise, TEM -expand and AFM -expand are increasingly used forminimum size features, as in plant sample. This technique started by converting the prepared sample's images (gray scale or colored images) to data file (*.dat) in two dimensional and then converting the 2D data to 3D data file using FORTRAN programming. Spectral enhancement relies on changing the gray scale representation ofpixels to give an image with more contrast for interpretation.

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Authors have concluded in this paper that the approach depends how image analysis can be done from any part and without reanalyzing it. The sample can be taken of different size and this method increases the accuracy of the analysis as well as decreases the cost of hardware used.

2.4 Biometric:

Bharadwaj*et al*. have described a review of fingerprint, irisand face using Image Processing techniques [7].A survey was conducted in this paper of different concepts and interpretations of biometric quality so that a clear picture of the current state and futuredirections could be presented. Several factors that cause different types of degradations of biometric samples, includingimage features that attribute to the effects of these degradations, are discussed. Evaluation schemes are used totest the performance of qualitymetrics for various applications.

The analysis of the characteristic function of quality and match scores shows that a careful selection of complimentary set of quality metrics can provide more benefit to various applications of biometric quality. Biometric systems encounter variability in data that influence capture, treatment, and usage of a biometric sample. It is imperative to first analyze the data and incorporate this understanding within the recognition system, making assessment of biometric quality an important aspect of biometrics. Biometrics, as an integral component in identification science, is being utilized in large-scale biometrics deployments such as the US Visitor and Immigration Status Indicator Technology (VISIT), UK Iris Recognition Immigration System (IRIS) project, UAE iris-based airport security system, and India's Aadhaar project. Biometric systems, like other applications of pattern recognition and machine learning, are affected by the quality of input data [8].

Quality assessment (QA) of an imagemeasures itsdegradation during acquisition, compression, transmission,processing, and reproduction. Several QA algorithmsexist in image processing literature, which pursuedifferent philosophies, performance, and applications. Amajority of these methods are motivated towards accurateperceptualimage quality i.e., quality as perceivedby the sophisticated human visual system (HVS). Theseapproaches require an in depth understanding of theanatomy and psychophysical functioning of the humancognitive system.Authors have concluded in this paper that biometric standardization is much needed in the communityto ensure easy exchange of ideas and information, with the community still struggling with problemsof interpretability.

2.5 Image edge detection:

The study and comparison of various image edge detection techniques was conducted by Maini and Aggarwalin their paper[9]. In this approach author's analyzed and did the visual comparison of the most commonly used gradient andLaplacian based edge detection techniques for problems of inaccurate edge detection, missing true edges,producing thin or thick lines and problems due to noise etc. The software was developed using MATLAB 7.0.

Edge detection refers to the process of identifying and locating sharp discontinuities in an image. Thediscontinuities are abrupt changes in pixel intensity which characterize boundaries of objects in a scene.Classical methods of edge detection involve convolving the image with an operator (a 2-D filter), which isconstructed to be sensitive to large gradients in the image while returning values of zero in uniform regions. There are an extremely large number of edge detection operators available, each designed to be sensitive to certain types of edges. Image edge detection significantly reduces the amount of data and filters out useless information, while preserving the important structural properties in an image. There are many ways to perform edge detection. However, the majority of different methods may be grouped into two categories:Gradient based Edge Detection and Laplacian based Edge Detection.

According to the authors edge detection is the initial step in object recognition and hence it is important to know the differences between edgedetection techniques. In this paper they studied the most commonly used edge detection techniques of gradient-based and Laplacianbasededge detection.The performance of the canny algorithm depends heavily on the adjustable parameters σ which is thestandard deviation for the Gaussian filter, and the threshold values, 'T1' and 'T2'. σalso controls the size of theGaussian filter. The bigger the value for σ, the larger the size of the Gaussian filter becomes. This implies moreblurring necessary for noisy images, as well as detecting larger edges. As expected, however, the larger thescale of the Gaussian, the less accurate is the localization of the edge.

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2.6 Face recognition:

In this paper ChandanSingh*et al.* describe the complementary feature sets for optimal facerecognition[10].In recent times, face recognition has become one of the widely used biometric techniques having a number of real-world applications like human-computer interaction, surveillance, authentication, computer vision applications,computer user interfaces, etc. In order to improve the existing face recognition techniques, discriminative competence of the invariant features selected to represent the face images should be high because, thereafter, classification is performed on the basis of these invariant features only. According to authors in literature, the approaches used to represent the face images are classified broadly into two categories, namely, the globalfeature extraction approaches and the local feature extraction approaches.

In this techniques 2D Fourier transform is used toextract the global features and the Gabor wavelet is optedto extract local features. Subsequently, equal weights areassigned to both the global and local features for combiningthe outputs of two classifiers, although it is establishedby the authors that the contribution of both global andlocal features is different. Wong *et al*. have proposed dualoptimal multiband feature (DOMF) method for face recognition in where wavelet packet transform (WPT) decomposesthe image into frequency sub bands and the multiband feature fusion technique is incorporated to selectoptimal multiband feature sets that are invariant to illuminationand facial expression. The recognition results achieved by theproposed method are approximately 10 to 30% higher than those obtained with these descriptors separately.Recognition rates of the proposed method are also found to be significantly better (i.e., by 8 to 24%) in case ofsingle example image per person in the training.

2.7 Steganography :

Hemalatha*et al.*in their paper described the secure and high capacity image using steganography technique[11].Information security is essential for confidential data transfer. Steganography is one of the ways used for secure transmission of confidential information. It contains two main branches: digitalwatermarking and steganography. Steganography is the science of “invisible” communication. The purpose of steganography is to maintain secret communication between two parties. The secret information can be concealed in content such as image, audio, or video. This focus on a novel image steganography technique to hide multiple secret images and keys in color cover image using Integer Wavelet Transform (IWT). The main purpose of steganography is to convey the information secretly by concealing the very existence of information in some other medium such as image, audio or video. The content used to embed information is called as cover object.

According to the paper, the objective of the steganographyis to smooth and sharp the images by using various filtering techniques, where filtering techniques are one of the enhancement techniques in the digital image processing.. In this paper they have implemented few spatial domain filters and frequency domain filters to remove various types of noises. Authors observe that two secret images can be hidden in one color image and they can beregenerated without actually storing the image. This approach results in high quality of the imagehaving high [PSNR] (Peak Signal to Noise Ratio)values compared to other methods. However the disadvantage of this approach is that it is susceptible to noise if spatial domain techniques are used to hide the key. This can be improved if transform domain techniques are used to hide the key. The approach isvery simple and the security level can be increased by using standard encryption techniques toencrypt the keys.Emphases on various types of noises are not discussed in this paper and in future work that area will be explored.

2.8 Spectral image processing:

In the paper byManolakis*et al.*hyperspectralimage processingfor automatic target detection applications has beendescribed [12].Firstlythey described the fundamental structure of the hyper spectral data and explained howthese data influence the signal models used for the development and theoreticalanalysis of the detection algorithms. Next they discussed the approach used to derivedetection algorithms, the performance metrics necessary for the evaluation ofthese algorithms, and a taxonomy that presents the various algorithms in asystematic manner. The basic idea for hyper spectral imaging stems fromthe fact that, for any given material, the amount of radiation that is reflected, absorbed, or emitted i.e. Theradiance varies with wavelength. Hyper spectralimaging sensors measure the radiance of the materials within each pixel area at a very large number of contiguousspectral wavelength bands. A hyper spectral

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remote sensing system has four basicparts: the radiation (or illuminating) source, theatmospheric path, the imaged surface, and the sensor.

Hyper spectral imaging sensors measure the spectral radiance information in a scene to detect targetobjects, vehicles, and camouflage in open areas, shadows, and tree lines. Imaging sensors on satellites oraircraft gather this spectral information, which is a combination of sunlight (the most common form of illuminationin the visible and near infrared), atmospheric attenuation, and object spectral signature. The sensor detectsthe energy reflected by surface materials and measures the intensity of the energy in different parts of thespectrum. This information is then processed to form a hyper spectral data set. Each pixel in this data set contains high-resolution spectrum, which is used to identify the materials present in the pixel by an analysis ofreflectance or emissivity.

2.9 Facial Image Processing:

Garcia*et al.*,in their paper have discussed Facial Image Processing [13].Facial Image Processing is an area of research dedicated to the extraction and analysis of information about human faces; information which is known to play a central role in social interactions including recognition, emotion, and intention. With the introduction of new powerful machine learning techniques, statistical classification methods, and complex deformable models, recent progresses have made possible a large number of applications in areas such as imageretrieval, surveillance and biometrics, visual speech understanding, virtual characters for e-learning, online marketing or entertainment, intelligent human-computer interaction, and others.

Wang *et al.*in their paper have focused on the fusion of 2Dfacial images and 3D stereo depth maps for enhancing facerecognition[14]. They propose an original machine learningmethod, the bilateral two-dimensional linear discriminantanalysis (B2DLDA), able to extract discriminant facial featuresfrom the appearance and disparity images. They showthat the present-day passive stereoscopy does make a positivecontribution to face recognition.

Lee and Sohn tackle the problem of multiviewface recognition in their paper[15]. Many current face descriptors give satisfactoryresults with frontal views, but fail to accurately represent tall views of the human head. The authors propose anew paradigm to facilitate multiview face recognition, notthrough a multiviewer face recognizer, but through multiplesingle-view recognizers. The resulting face descriptor basedon multiple representative views, which is of compact sizeprovides reasonable face recognition performance on any facialview.

2.10 Lung Cancer Detection:

Mokhledhas described the lung cancer detection using Image Processing Techniques in his paper [16].Recently, image processing techniques are widely used in several medical areas for image improvement *viz.* in earlier detection and treatment stages, where the time factor is very important to discover the abnormality issues in target images, especially in various cancer tumors such as lung cancer, breast cancer, etc. Image quality and accuracy are the core factors of this research.

Image quality assessment as well as improvement is depending on the enhancement stage where low pre-processing techniques is used based on Gabor filter within Gaussian rules. Lung cancer is a disease of abnormal cells multiplying and growing into a tumor. The first stage starts with taking a collection of CT images (normal and abnormal) from the available database from IMBA Home (VIA-ELCAP Public Access). The second stage applies several techniques of image enhancement, to get best level of quality and clearness. The third stage applies image segmentation algorithms which play an effective rule in image processing stages, and the fourth stage obtains the general features from enhanced segmented image which gives indicators of normality or abnormality of images. Lung cancer is the most dangerous and widespread cancer in the world according to stage of discovery of the cancer cells in the lungs, so the process early detection of the disease images.

In this paper, an image improvement technique was developed for earlier disease detection andtreatment stages and the time factor was taken into account to discover the abnormality issues intarget images. Image quality and accuracy is the core factors of this research, image qualityassessment as well as enhancement stage were adopted on low pre-

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processingtechniques based on Gabor filter within Gaussian rules. The proposed technique gives very promising results compared with other usedtechniques. Relying on general features, a normality comparison is made.

2.11 Robot Navigation:

Robot Navigation Using Image Processing and Isolated Word Recognitionwas described in the paper by Shashank*et al.*[17]. A practical implementation of image processing and isolated word recognition has been explained. A modeled vehicle has been driven autonomously on the road and can navigate on a road on its own, stop at zebra-crossing, follow traffic lights and reach an end point or can be controlled through voice commands. The vehicle has been developed using an old scrap body of a kinetic sunny and its engine, servo motors, microphone, PCB and cameras. This paper explains about an automated guided vehicle (robot vehicle) which was developed for operating on the roads with real life like environment. The robot was designed as an outdoor robot which can detect and follow lanes, detect zebra crossing, traffic red light and stop at an end point. The specifications of robot, arena and rules are discussed in details in the third section of the paper. This also involves traffic light detection, lane following and zebra crossing detection which requires a significant amount of image processing. Isolated word recognition using HTK toolkit was also implemented later on for the purpose of practical study. The authors also have developed a speaker independent isolated word recognition application for commanding the vehicle manually. As speech is oneof the most efficient methods of interaction with a robot .The robot was controlled using both image processing and isolated word commands.

This robot was made as a prototype lane follower and can be used as a helper for drivers, people withdisabilities, load carrier in plants and mines by roadand the persons who cannot drive can use voice commandsto navigate the vehicle. Voice commands can also be used in uneven terrain, absence of proper marking on theroad etc. The authors says work can be improved further by using better computing machine with more accurate algorithms for trafficlight detection, lane following and isolated word recognition system which can be trained with very large number ofpeople for better accuracy.

III. CONCLUSION

In this paper we have made an attempt to familiarize the readers with the overall pipeline of a pattern recognition system. The various steps involved from data capture to pattern classification are presented in various papers. Analog to digital conversion is also briefly discussed with a focus on how it impacts further signal analysis. Commonly used preprocessing methods are also described. A key component of pattern recognition is feature extraction. In our future work, we will be studying several other techniques for feature computation whichincludesWalsh Transform, Haar Transform, Linear Predictive Coding, Wavelets, Moments, Principal Component Analysis and Linear Discriminant Analysis.

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