



AN ANALYSIS-BASED STUDY ON OPPORTUNITIES AND OBSTACLES FOR IMAGE PROCESSING RESEARCH

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Abstract— The improvement of pictorial information for human interpretation and the processing of image data for storage, transmission, and representation for autonomous machine perception are the two main application areas that have sparked interest in digital image processing techniques. The goals of this article are to define the terms "image processing" and "image processing scope," "typical image processing stages and methodologies," and "applications of image processing tools and processes in the frontier areas of study."

Keywords—*Image Processing, Image analysis, Applications, Research.*

1. INTRODUCTION

An image can be thought of as a two-dimensional function, $f(x, y)$, with x and y being spatial (plane) coordinates, and the amplitude of f at any given pair of coordinates (x, y) is referred to as the intensity or grey level of the image at that location. We refer to the image as a digital image when x , y , and the amplitude values of f are all finite, discrete quantities. Processing digital photos using a digital computer is referred to as the field of digital image processing. You should be aware that a digital image is made up of a finite number of elements, each of which has a unique position and value. These components are also known as pixels, pels, and picture elements. The most frequently used term to refer to indicate what makes up a digital image. Images play the single most significant function in human perception, which is not surprising given that vision is the most developed of our senses. Imaging devices, on the other hand, almost completely cover the electromagnetic (EM) spectrum, from gamma to radio waves, unlike humans, who are restricted to the visual range. They can work with visuals produced by sources that people aren't used to connecting with images.. These include ultrasound, electron microscopy, and computer-generated images. Thus, digital image processing encompasses a wide and varied field of applications [1].

2. FUNDAMENTAL STEPS IN DIGITAL IMAGE PROCESSING

The processes used in digital image processing can be divided into two categories: those whose input and output are images, and those whose inputs may be images but whose outputs are properties retrieved from those images. The initial step in the processing of digital images is picture acquisition. Keep in mind that receiving an image that has already been converted to digital form could suffice as an acquisition. Typically, preprocessing, such as scaling, is done at the image acquisition step. The next phase of digital image processing is image enhancement, which is also one of the most straightforward and appealing. The basic idea behind enhancement techniques is to either emphasise specific features of interest in an image or reveal obscured detail. An everyday illustration of enhancement is when we boost an image's contrast because it looks better. It is important to keep in mind that enhancement is a very subjective area of image processing. Image restoration is an area that also deals with improving the appearance of an image. However, unlike enhancement, which is subjective, image restoration is objective, in the sense that restoration techniques tend to be based on mathematical or probabilistic models of image degradation. Enhancement, on the other hand, is based on human subjective preferences regarding what constitutes a "good" enhancement result. Color image processing is an area that has been gaining in importance because of the significant

increase in the use of digital images over the Internet. Color image processing involves the study of fundamental concepts in color models and basic color processing in a digital domain. Image color can be used as the basis for extracting features of interest in an image. Wavelets are the foundation for representing images in various degrees of resolution. In particular, wavelets can be used for image data compression and for pyramidal representation, in which images are subdivided successively into smaller regions.

3. APPLICATIONS OF IMAGE PROCESSING

The use of image processing is widespread across a wide range of human endeavours, from the interpretation of biomedical images to remotely sensed scene interpretation. We just give a quick overview of some of these applications in this section.

(i) Automatic Visual Inspection System- Automated visual inspection systems are essential to improve the productivity and the quality of the product in manufacturing and allied industries [2]. We briefly present few visual inspection systems here. Automatic inspection of incandescent lamp filaments: An interesting application of automatic visual inspection involves inspection of the bulb manufacturing process. Often the filament of the bulbs get fused after short duration due to erroneous geometry of the filament, e.g., nonuniformity in the pitch of the wiring in the lamp. Manual inspection is not efficient to detect such aberrations. In an automated vision-based inspection system, a binary image slice of the filament is generated, from which the silhouette of the filament is produced. This silhouette is analyzed to identify the non-uniformities in the pitch of the filament geometry inside the bulb. Such a system has been designed and installed by the General Electric Corporation. **(ii) Remotely Sensed Scene Interpretation-** Information regarding the natural resources, such as

agricultural, hydrological, mineral, forest, geological resources, etc., can be extracted based on remotely sensed image analysis. For remotely sensed scene analysis, images of the earth's surface are captured by sensors in remote sensing satellites or by a multi-Spectra scanner housed in an aircraft and then transmitted to the Earth Station for further processing [3, 4]. We show examples of two remotely sensed images in Figure 1 whose color version has been presented in the color figure pages. Figure 1(a) shows the delta of river Ganges in India. The light blue segment represents the sediments in the delta region of the river, the deep blue segment represents the water body, and the deep red regions are mangrove swamps of the adjacent islands. Figure 1.1(b) is the glacier flow in Bhutan Himalayas. The white region shows the stagnated ice with lower basal velocity.

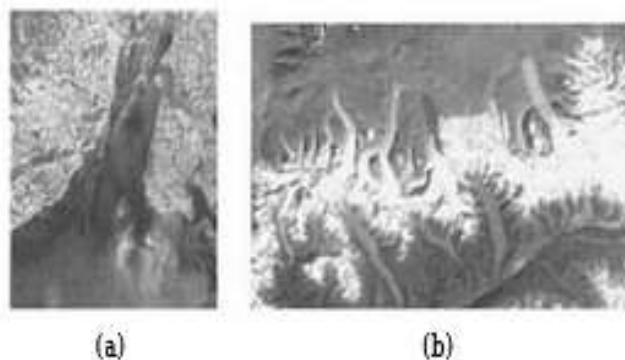


Fig. 1: Example of a remotely sensed image of (a) delta of river Ganges, (b) Glacier flow in Bhutan Himalayas

Techniques of interpreting the regions and objects in satellite images are used in city planning, resource mobilization, flood control, agricultural production monitoring, etc.

(iii) Biomedical Imaging Techniques- Various types of imaging devices like X-ray, computer aided tomographic (CT) images, ultrasound, etc., are used extensively for the purpose of medical diagnosis

[5]-[7]. Examples of biomedical images captured by different image formation modalities such as CT-scan, X-ray, and MRI are shown in Figure 2.

(i) localizing the objects of interest, i.e. different organs

(ii) taking the measurements of the extracted objects, e.g. tumors in the image

(iii) interpreting the objects for diagnosis. Some of the biomedical imaging applications are presented below.

(A) Lung disease identification: In chest X-rays, the structures containing air appear as dark, while the solid tissues appear lighter. Bones are more radio opaque than soft, tissue. The anatomical structures clearly visible on a normal chest X-ray film are the ribs, the thoracic spine, the heart, and the diaphragm separating the chest cavity from the abdominal cavity. These regions in the chest radiographs are examined for abnormality by analyzing the corresponding segments.

(B) Heart disease identification: Quantitative measurements such as heart size and shape are important diagnostic features to classify heart diseases. Image analysis techniques may be employed to radiographic images for improved diagnosis of heart diseases.



Fig. 2: Examples of (a) CT Scan image of brain, (b) X-ray image of wrist and (c) MRI image of brain

(C) Digital mammograms: Digital mammograms are very useful in detecting features (such as microcalcification) in order to diagnose breast tumor. Image processing techniques such as contrast enhancement, segmentation, feature extraction, shape analysis, etc. are used to analyze mammograms. The regularity of the shape of the tumor determines whether the tumor is benign or malignant.

(iv) Defense surveillance- Application of image processing techniques in defense surveillance is an important area of study. There is a continuous need for monitoring the land and oceans using aerial surveillance techniques. Suppose we are interested in locating the types and formation of naval vessels in an aerial image of ocean surface. The primary task here is to segment different objects in the water body part of the image. After extracting the segments, the parameters like area, location, perimeter, compactness, shape, length, breadth, and aspect ratio are found, to classify each of the segmented objects. These objects may range from small boats to massive naval ships. Using the above features it is possible to recognize and localize these objects. To describe all possible formations of the vessels, it is required that we should be able to identify the distribution of these objects in the eight possible directions, namely, north, south, east, west, northeast, northwest, southeast and southwest. From the spatial distribution of these objects it is possible to interpret the entire oceanic scene, which is important for ocean surveillance.

(v) Content-Based Image Retrieval- Retrieval of a query image from a large image archive is an important application in image processing. The advent of large multimedia collection and digital libraries has led to an important requirement for development of search tools for indexing and retrieving information from them. A number of good search engines are available today for



retrieving the text in machine readable form, but there are not many fast tools to retrieve intensity and color images. The traditional approaches to searching and indexing images are slow and expensive. Thus there is urgent need for development of algorithms for retrieving the image using the embedded content in them. The features of a digital image (such as shape, texture, color, topology of the objects, etc.) can be used as index keys for search and retrieval of pictorial information from large image database. Retrieval of images based on such image contents is popularly called the content-based image retrieval [8, 9].

(vi) Moving-Object Tracking- Tracking of moving objects, for measuring motion parameters and obtaining a visual record of the moving object, is an important area of application in image processing (13, 14). In general there are two different approaches to object tracking: (i) Recognition-based tracking (ii) Motion-based tracking. A system for tracking fast targets (e.g., a military aircraft, missile, etc.) is developed based on motion-based predictive techniques such as Kalman filtering, extended Kalman filtering, particle filtering, etc. In automated image processing based object tracking systems, the target objects entering the sensor field of view are acquired automatically without human intervention. In recognition-based tracking, the object pattern is recognized in successive image-frames and tracking is carried-out using its positional information.

(vii) Neural Aspects of the Visual Sense- The optic nerve in our visual system enters the eyeball and connects with rods and cones located at the back of the eye. The neurons contain dendrites (inputs), and a long axon with an arborization at the end (outputs). The neurons communicate through synapses. The transmission of signals is associated with the diffusion of the chemicals across the interface and the receiving neurons are either stimulated or inhibited by these chemicals, diffusing

across the interface. The optic nerves begin as bundles of axons from the ganglion cells on one side of the retina. The rods and cones, on the other side, are connected to the ganglion cells by bipolar cells, and there are also horizontal nerve cells making lateral connections. The signals from neighboring receptors in the retina are grouped by the horizontal cells to form a receptive field of opposing responses in the center and the periphery, so that a uniform illumination of the field results in no net stimulus. In case of non uniform illumination, a difference in illumination at the center and the periphery creates stimulations. Some receptive fields use color differences, such as red-green or yellow-blue, so the differencing of stimuli applies to color as well as to brightness. There is further grouping of receptive field responses in the lateral geniculate bodies and the visual cortex for directional edge detection and eye dominance. This is low-level processing preceding the high-level interpretation whose mechanisms are unclear. Nevertheless, it demonstrates the important role of differencing in the senses, which lies at the root of contrast phenomena. If the retina is illuminated evenly in brightness and color, very little nerve activity occurs. There are 6 to 7 million cones, and 110 to 130 million rods in a normal human retina. Transmission of the optical signals from rods and cones takes place through the fibers in the optic nerves. The optic nerves cross at the optic chiasma, where all signals from the right sides of the two retinas are sent to the right half of the brain, and all signals from the left, to the left half of the brain. Each half of the brain gets half a picture. This ensures that loss of an eye does not disable the visual system. The optical nerves end at the lateral geniculate bodies, halfway back through the brain, and the signals are distributed to the visual cortex from there. The visual cortex still has the topology of the retina, and is merely the first stage in perception, where information is made available. Visual regions in two cerebral hemispheres are connected in the corpus callosum, which unites the halves of the visual field.

CONCLUSION

Image processing has wide variety of applications leaving option to the researcher to choose one of the areas of his interest. Lots of research findings are published but lots of research areas are still untouched. Moreover, with the fast computers and signal processors available in the 2000s, digital



image processing has become the most common form of image processing and generally, is used because it is not only the most versatile method, but also the cheapest.

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