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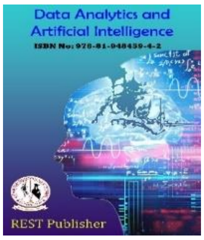

Image Processing: Research Opportunities and Challenges

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Abstract: *Computer digital image technology is a very important branch of the computer application discipline, and its application areas include measurement, computer-aided design, physics, three-dimensional simulation and other industries. Moreover, with the improvement of computer hardware performance, image processing algorithms have improved the application of digital image processing technology. This article focuses on the current digital image processing technology and its application status.*

1. INTRODUCTION

Digital image processing technology is the use of computer technology to remove the image noise, enhance, segmentation, recovery and so on. The development of computer network technology has led to the development of digital image processing technology, the increasinglevel of mathematics, and the constant demand for digital image processing technology from various industries in society, which has brought new opportunities for digital image technology and provided advancement. In the 1920s, human beings used digital image processing technology for the first time. They used cables to transfer photos between the United Kingdom and the United States. However, the quality of images transmitted was not very good. Therefore, image quality should be improved and optimized. It was not until the 1970s that digital image processing technology had been updated. The study of digital imagesat this stage also incorporated a pattern understanding system. As technology is continuously updated and applied to different fields, the requirements for digital image processing technology are getting higher and higher, which also accelerates the development of digital image processing technology.

2. OVERVIEW OF DIGITAL IMAGE PROCESSING TECHNOLOGY

Digital image processing, also known as computer image processing, refers to the process ofconverting an image signal into a digital signal and processing it with a computer. This process includes image enhancement, noise reduction, segmentation, restoration, encoding, compression, and extraction of features. The process of digital image processing is shown in figure 1. Image processing technology cannot be developed without the development of computers, the development of mathematics, and the growth of application requirements in various industries. In the 1960s, the image processing technology began to be applied more scientifically, and people used this technology to perform idealized processing of output images. After years of development, the current electronic image processing technology has the following characteristics: better reproducibility: Compared with traditional analog imageprocessing and digital image processing will not be due to storage, copying, or transmissionin image processing. Causes the change of image quality; The occupied frequency band is wider: this is relative to the language information, the image information is several orders ofmagnitude larger than the frequency band of the language information, so the image information is more difficult in the process of operation; Applicable width: data sources canbe obtained from various sources. Digital images can be processed from microscopes to astronomical telescopes. High flexibility: Electronic images can be used almost as long as they can be expressed usingmathematical formulas and mathematical logic.

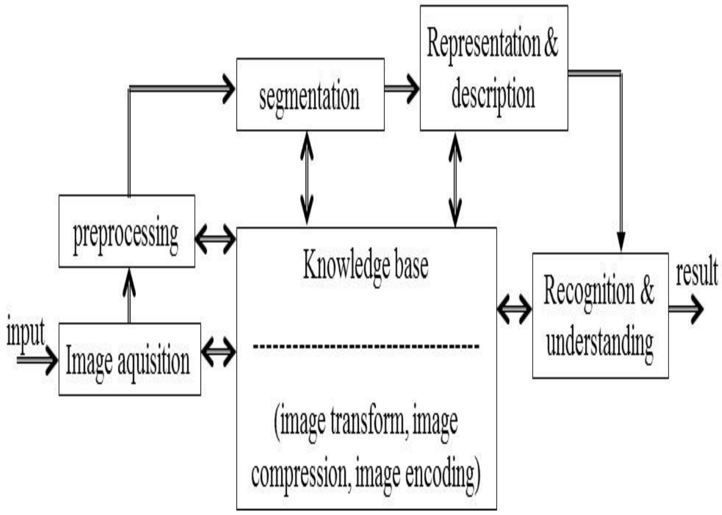

FIGURE 1. Image processing technology

3. FEATURES OF DIGITAL IMAGE PROCESSING

Reproducibility is good: Digital image processing technology records and saves image information in binary format. As long as the original information is accurate, the processing of copying the image will not have any influence on the original image, and thus it canguarantee the real information. High processing resolution: Digital image processing technology differs from analog technology in that it records information in the form of pixel lattices. Therefore, the storageaccuracy of an image largely depends on the number of quantization bits used in the conversion and the current digital image. It can have 8, 12, 16, or higher. Wide range of applications: Given the basic principles of digital image processing technology, it can be derived from a variety of sources, from microbes to space images, fromhuman skeletons to lakes and mountains. Without being limited to the target's environment, they can accurately reflect their objective appearance and size. These images can all be processed by the same processing method. Flexible processing: Traditional analog images are limited by the optical principles they generate, and thus cannot be processed in accordance with people's wishes, and can only beprocessed linearly; while digital images are different, it can be used for any operation including linearity. Operations and non-linear operations greatly increase the flexibility of processing and make processing easy. Large compression space: Since digital images record and preserve information in the form ofpixels, the pixel points of the brother-in-law image are not encouraged by each other, but there is some kind of connection. As long as this link is identified, a certain means of recording can be used, without having to record pixel by pixel, thereby compressing the storage space. Especially for image images, the contents of the two frames before and afterare often not very different, with more than 90% of the data being the same, and the compression ratio can be very large.

4. THE CONTENT OF DIGITAL IMAGE PROCESSING TECHNOLOGY ACQUISITION OF IMAGES

First of all, from the image acquisition, that is, the imaging point of view: to image processing, we must first obtain the image. From the perspective of the imaging sensor, there is a general TV camera that can obtain general visible light image signals; there is an infraredcamera that captures infrared specifically The image has a high practical value in the military;there are acoustic wave imaging, the use of material acoustic parameters on the impact of acoustic wave propagation, can obtain information and images of the internal structure of the opaque object; with x-ray imaging, the use of objects to the penetration of x-rays Differentsex, obtain information on the internal shape of the object; have γ-ray imaging, use the imaging of γ-particles in the isotope to obtain information on the function of human organs,detect normal or abnormal function of human organs, and use nuclear magnetic resonance imaging to take advantage of the curve changes of different substances NMR , Get information on changes in human organs and more. These imaging techniques are very easyto use 2D imaging information, using tomography and other technologies, into 2D and 3D images. The development of these technologies has an extremely important role in themedical, military, and industrial development.

5. IMAGE ENHANCEMENT AND RECOVERY

The acquired images often have various distortions and disturbances. For example,there are defects in the imaging device. For example, if the bandwidth limitation causes image blur, and the inevitable thermal noise in the imaging process and various interference noises from other interference sources, etc., in order to obtain good quality images required for people's observation processing, it is necessary to introduce image processing. This includes image enhancement and image restoration. The enhancement of the image is the use of enhanced contour edges for grayscale and color transformations, making the image more suitable for people's needs of observation and processing. The complex principle of the imageis to eliminate or reduce the damage and degradation of the image caused during image acquisition and transmission. This includes image blur, image interference, and noise, and theoriginal image is obtained as much as possible. Image restoration is often a difficult and complex inverse filtering process. Especially when the process of causing image degradation is more complicated and difficult to predict, image restoration is more difficult to perfect. Regardless of whether the image is enhanced or restored, all the pixels of the entire imagemust be calculated. The computational complexity of the image pixel is also enormous.

6. IMAGE COMPRESSION

Another crucial issue in image processing is the compression of image data. Especiallyafter acquiring a large number of static and dynamic images, the greatest difficulty encountered when transferring them to the user terminal or storing the images for future use is the huge amount of data of the images. For example, a frame of color image has a data amount of approximately 768 KB. If no image compression processing is performed, it is difficult to store a large amount of image data. At the same time, this problem also exists in the image transmission process, a large number of image data is difficult to quickly transfer, or the transmission of image quality requirements are very high (such as digital TV transmission rate to 100Mb / s), these are difficult transmission systems suffered. The compression of image information is a crucial issue in the storage and delivery of images, andeven in the multimedia technologies mentioned later. Research on image compression codinghas a long history. Up to now, new technologies and methods are still being explored. The image compression coding method mainly eliminates a large amount of data redundancy generated in the image storage process. For better results, high definition image compression coding methods such as predictive coding, transform coding, and entropy coding can be used.

7. DEVELOPMENT OF DIGITAL IMAGE PROCESSING TECHNOLOGY

Since the United States began to obtain a large number of moon pictures via satellite and processed it using digital technology since 1964, more and more corresponding technologies have begun to be applied to image processing. Digital image processing also occupies an independent position as a science. The status of disciplines has begun to be used in scientific research in various fields. Another leap-forward development of image technology appeared in 1972. The sign was the birth of CT medical technology. Under the guidance of this technology, an X-ray computed tomography device was used. According to the projection of the human head, the computer processed the data. Reconstructing cross- sectional images, this image reconstruction technique was later extended to a whole-body CT device and made contributions to human development across the times. Subsequently, digitalimage processing technology was used in more fields and developed into a new discipline of unlimited prospects. Ten years later, digital image processing technology also developed in the deeper direction. People began to build digital human vision systems through computers. This technology is called image understanding or computer vision. Many countries have invested a lot of research energy in this area and have made profound research results. Among them, the visual computing theory proposed at the end of the 1970s provided theguiding ideology for the later theoretical development of computer digital image technology, but theoretically Assuch, there are still many difficulties in practical operation. China began research on computer technology since the founding of the People's Republic ofChina. Since the reform and opening up, China's development in computer digital image processing technology has been very large. Even in some theoretical studies, it has caught upwith the world's advanced level. With respect to the ability to collect imaging data, China successfully obtained a series of sensors and launches of Earth observation satellites to obtaintimely and effective data on wind, sea, resources, and environmental disaster reduction, and achieved effective data. In addition, representatives of digital image processing technology ina wider range of fields are construction, traffic engineering and biomedical engineering. The application of digital image processing technology in these aspects can best reflect the current development of the technology. In the construction industry, digital image processing technology can convert the height, density, and other information that may affect building quality and the built environment into the image of the building or group of buildings to be constructed, so as to enable designers to plan more rationally; In the field of engineering, digital image technology and voice, text and other factors constitute the basic content of modern multimedia. In the process of transferring images, encoding technology is used to compress the bit amount of information. The current development content of this technology includes transform coding, etc. What may also play a role is wavelet transform image compression coding, branch coding and so on. In biomedical engineering, book image technology can objectively present the mechanism of human activities to researchers in the form of images, which has an irreplaceable role in the future development of medicine.

8. 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 arc 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 withlower basal velocity.

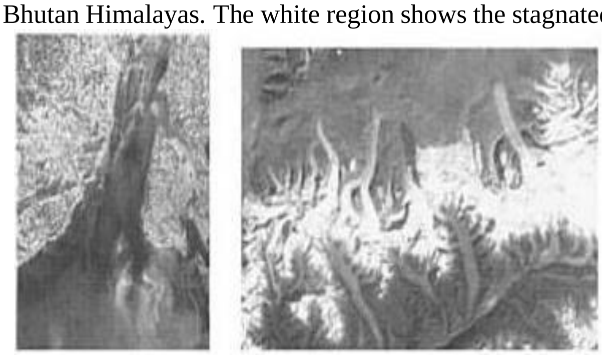

FIGURE 1. Example of a remotely sensed image of (a) delta of river Ganges, (b) Glacier flow inBhutan Himalayas

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

9. 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 medicaldiagnos is [5]-[7]. Examples ofbiomedical images captured by different image formation modalities such as CT-scan, X-ray, and MRI are shownin Figure 2

(a) (b) (c)

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

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. Theanatomical 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 ab-dominal cavity. These regions in the chest radiographs are examined for abnormality by analyzing the corresponding segments. Heart disease identification: Quantitative measurements such as heart size and shape are important diagnostic features to classify heart diseases. Image analysis techniques may beemployed to radiographic images for improved diagnosis of heart diseases. Digital mammograms: Digital mammograms are very useful in detect-ing 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 toanalyze mammograms. The regularity of the shape of the tumor determines whether the tumoris benign or malignant.

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 surveillancetechniques. 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. Todescribe all possible formations of the vessels, it is required that we should be able to identifythe distribution of these objects in the eight possible directions, namely,

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 recoguized in successive image-frames and tracking is carried-out using its positional information. Neural Aspects of the Visual Sense The optic nerve in our visual system enters the eyeball and connects with rods and coneslocated 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 arc either stimulated or inhibited by these chemicals, diffusing across the interface. The opticnerves begin as bun-dles 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, andthere 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 nonuniform illumination, a difference in illumination at the center and the periphery creates stimulations. Some receptivefields use color differences, such as red-green of yellow-blue, so the differencing of stimuli applies to color as well as to brightness. There is further grouping of receptive field responsesin the lateral geniculate bodies and the visual cortex for directional edge defection 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 theoptic nerves. The optic nerves cross at the optic chiasma, where all signals from the right sides of the two retinas arc 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 aneye 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.

10. CONCLUSION

Image processing has wide verity 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 inthe 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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