A Comprehensive Study on Digital Image Processing and its Real-World Applications

Ms.M.Dhivyaa[1]
Assistance Professor, Department of Electronics and Communication Engineering, Sri Shanmugha College of Engineering and Technology, Pullipalayam, Morur (Post), Sankari (Tk), Salem, dhivyaa.ece@shanmugha.edu.in
Dr.Sunil Kumar[2]
Professor, Department of Electronics and Communication Engineering, Sri Shanmugha College of Engineering and Technology, Pullipalayam, Morur (Post), Sankari (Tk), Salem, vp.accreditation@shanmugha.edu.in
Dr.J.Amutha[3]
Professor,Department of Electronics and Communication Engineering, Sri Shanmugha College of Engineering and Technology, Pullipalayam, Morur (Post), Sankari (Tk), Salem, hod.ece@shanmugha.edu.in
Mr.R.V.Ashokprathap[4]
Assistance Professor, Department of Electronics and Communication Engineering, Sri Shanmugha College of Engineering and Technology, Pullipalayam, Morur (Post), Sankari (Tk), Salem, Ashokprathap@shanmugha.edu.in

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.

Keywords – Digital Image Processing, Technology, Development Course, Application, improvement of computer hardware performance, image processing algorithms.

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 increasing level 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[1]. The study of digital images at 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. Digital image processing, also known as computer image processing, refers to the process of converting 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[2]: Compared with traditional analog image processing and digital image processing will not be due to storage, copying, or transmission in 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 of magnitude 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 can be obtained from various sources.

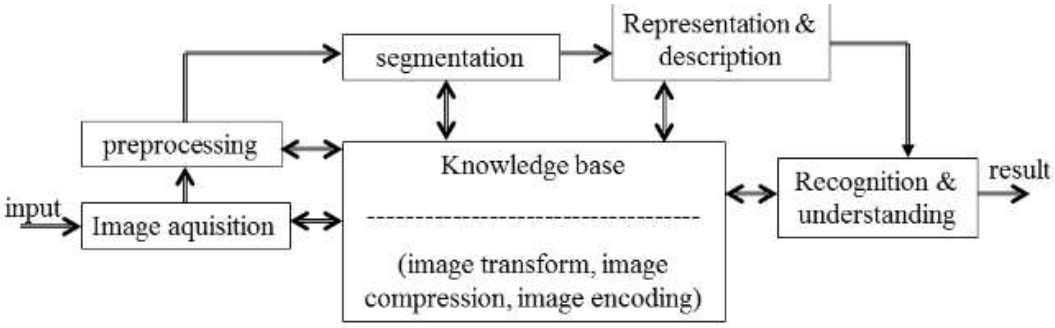

Figure 1- A schematic diagram of the process of digital image processing[1]

DIGITAL IMAGE PROCESSING TECHNOLOGY

(i) 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 infrared camera 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 Different sex, 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[3], 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 easy to 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 the medical, military, and industrial development.
(ii) 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 image is to eliminate or reduce the damage and degradation of the image caused during image acquisition and transmission[4]. This includes image blur, image interference, and noise, and the original 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 image must be calculated. The computational complexity of the image pixel is also enormous.

(iii) Image Compression- Another crucial issue in image processing is the compression of image data. Especially after 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, and even in the multimedia technologies mentioned later. Research on image compression coding has 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.

DIGITAL IMAGE PROCESSING TECHNOLOGY

Digital image processing technology has made great progress in all walks of life. The application fields of digital image processing are shown in table 1.

Field	Application
Physics and Chemistry	Spectrum Analysis
Biology and Medicine	Cell analysis; CT; X-ray analysis
Environment Protection	Research of atmosphere
Agriculture	Estimation of plants
Irrigation works	Lake, river and dam
Weather	Cloud and weather report
Communication	Fax; TV; phone
Traffic	Robot; products
Economics	IC-card
Military	Missile guidance; training

Table 1- Application analysis table of digital image processing[2]

In remote sensing and aerospace, many countries have dispatched reconnaissance aircraft to take aerial photographs of target areas, and then used image processing techniques to analyze

photographs. This saved manpower and physics, and could also obtain other useful information from pictures. Since the 1960s, the United States and other countries have launched resource remote sensing satellites. Due to the very poor imaging conditions, the quality of the image itself is not high, and digital image processing technology is required, such as scanning with a multi-band scanner. Imaging, image resolution is 30m and these images are converted to digital signals and processed. Digital image processing technology has been widely used in various countries, such as forest surveys, disaster monitoring, resource exploration, and urban planning. The application of digital image processing technology to the aviation field can use JPL to better process the images returned by the Moon and Mars[5]. It is used in aircraft remote sensing and satellite remote sensing technologies, mainly through reconnaissance aircraft to a certain area of the Earth. In aerial shooting, after the required photos are processed by the image, the digital code can be stored in the air, and then the satellite can pass through the processing center when the satellite passes over the area with the receiving station. The image is analyzed in real time, and judgment reading can be processed in this process using multiple digital image processing techniques.

IMAGE RECTIFICATION AND REGISTRATION

Geometric distortions manifest themselves as errors in the position of a pixel relative to other pixels in the scene and with respect to their absolute position within some defined map projection. If left uncorrected, these geometric distortions render any data extracted from the image useless.

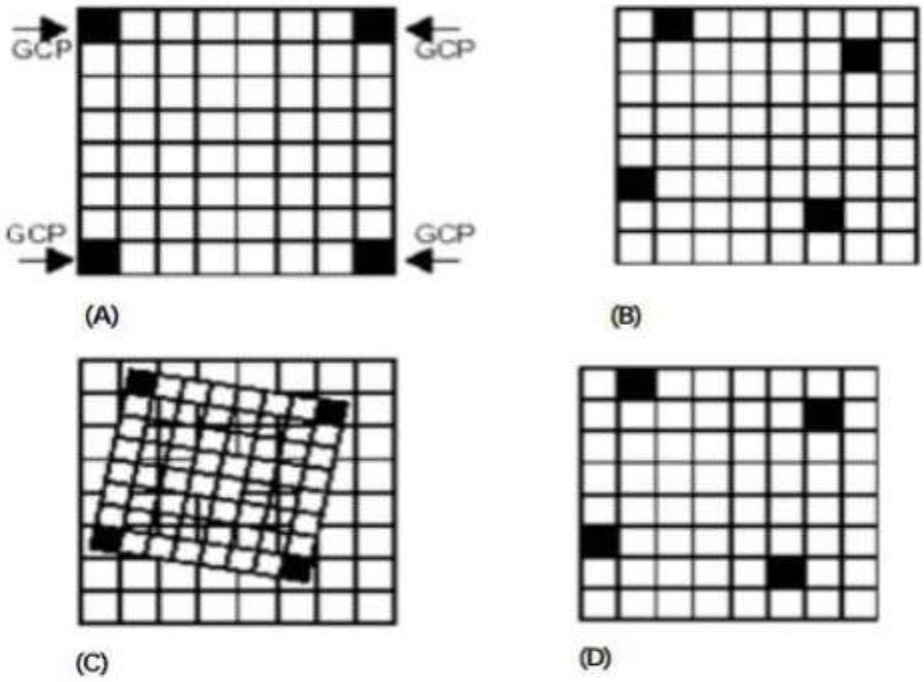

Figure 2- Image Rectification (a & b) Input and reference image with GCP locations, (c) using polynomial equations the grids are fitted together, (d) using resampling method the output grid pixel values are assigned (source modified from ERDAS Field guide[3]

This is particularly so if the information is to be compared to other data sets, be it from another image or a GIS data set. Distortions occur for many reasons. For instance distortions occur due to changes in platform attitude (roll, pitch and yaw), altitude, earth rotation, earth curvature, panoramic distortion and detector delay. Most of these distortions can be modelled mathematically

and are removed before you buy an image. Changes in attitude however can be difficult to account for mathematically and so a procedure called image rectification is performed[6]. Satellite systems are however geometrically quite stable and geometric rectification is a simple procedure based on a mapping transformation relating real ground coordinates, say in easting and northing, to image line and pixel coordinates. Rectification is a process of geometrically correcting an image so that it can be represented on a planar surface , conform to other images or conform to a map (Figure 2). That is, it is the process by which geometry of an image is made planimetric. It is necessary when accurate area, distance and direction measurements are required to be made from the imagery. It is achieved by transforming the data from one grid system into another grid system using a geometric transformation.

DIGITAL IMAGE PROCESSING & STEGANOGRAPHY APPLICATIONS

Steganography is employed in various useful applications, e.g., copyright control of materials, enhancing robustness of image search engines and smart IDs (identity cards) where individuals‟ details are embedded in their photographs. Other applications are video-audio synchronization, companies‟ safe circulation of secret data, TV broadcasting, TCP/IP packets (for instance a unique ID can be embedded into an image to analyze the network traffic of particular users), and also checksum embedding. Petitcolas demonstrated some contemporary applications, one of which was in Medical Imaging Systems where a separation is considered necessary for confidentiality between patients‟ image data or DNA sequences and their captions, e.g., physician, patient‟s name, address and other particulars. A link however, must be maintained between the two [7-10]. Thus, embedding the patient‟s information in the image could be a useful safety measure and helps in solving such problems. Steganography would provide an ultimate guarantee of authentication that no other security tool may ensure. Miaou et al. present an LSB embedding technique for electronic patient records based on bipolar multiple-base data hiding. A pixel value difference between an original image and its JPEG version is taken to be a number conversion base. Nirinjan and Anand and Li et al. also discuss patient data concealment in digital images. Inspired by the notion that steganography can be embedded as part of the normal printing process, the Japanese firm Fujitsu is developing technology to encode data into a printed picture that is invisible to the human eye (data), but can be decoded by a mobile phone with a camera as exemplified in Fig. 3a and shown in action in Fig. 3b. The process takes less than one second as the embedded data is merely 12 bytes. Hence, users will be able to use their cellular phones to capture encoded data. They charge a small fee for the use of their decoding software which sits on the firm's own servers [8]. The basic idea is to transform the image colour scheme prior to printing to its Hue, Saturation and Value components (HSV), then embed into the Hue domain to which human eyes are not sensitive. Mobile cameras can see the coded data and retrieve it. This application can be used for “doctor‟s prescriptions, food wrappers, billboards, business cards and printed media such as magazines and pamphlets”, or to replace barcodes [12-14]

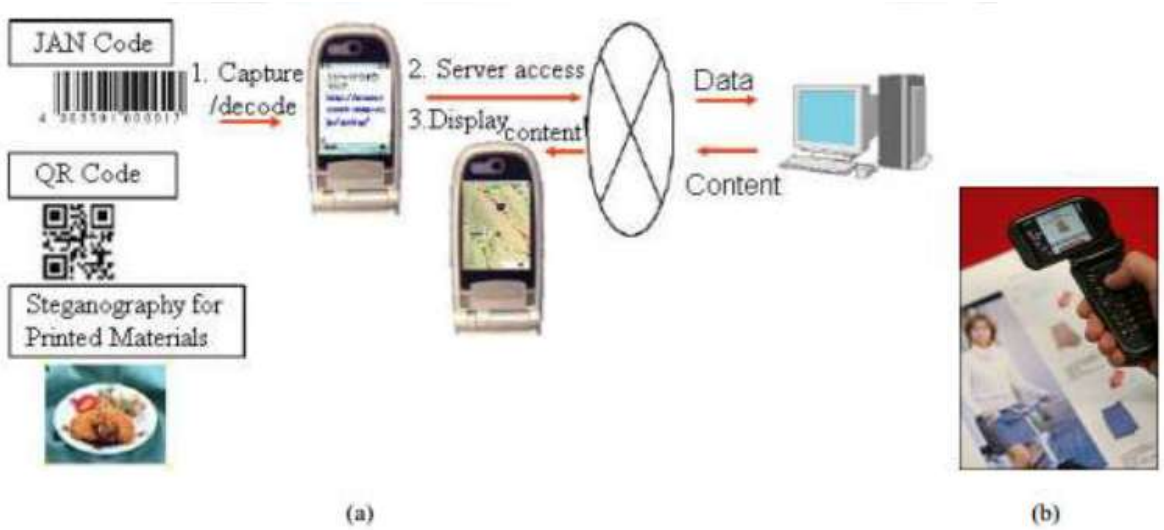

Figure 3- Fujitsu exploitation of steganography: (a) a sketch representing the concept and (b) the idea deployed into a mobile phone shown at an exhibition recently[4]

CONCLUSION

To sum up, this paper first analyzes the research status and major application fields of digital image processing technology, and then studies the development trend of digital image technology. At present, digital image processing technology has been widely used in life. For example, applications in networks, mobile phones, etc., the development of digital image processing technology is closely related to people's lives. With the continuous development of technology, digital image processing technology will continue to be obtained. Progress, these also need more people to study.

REFERENCES

[1]. Kong Dali, Cui Yang. Research Status and Development Direction of Digital Image Processing Technology. Shandong Institute of Water Conservancy, 2023(04):11-14.
[2]. CHEN Bingquan, LIU Hongli, MENG Fanbin. Current Status and Development Direction of Digital Image Processing Technology. Journal of Jishou University(Natural Science Edition), 2024(01):63-70.
[3]. Lu Gejing.Discussion on the status quo and development of digital image processing technology.Computer Knowledge and Technology,2023(33):8035-8036.
[4]. Ding Ke. Research and Development Direction of Digital Image Processing Technology. Economic Research Guide, 2024(18): 246-270.
[5]. Rafael C.Gonzalez,Richard E.Woods and Qiuqi Ruan(Translator): Digital Image Processing (Third Edition) ,Electronic Industry Press,China,2024
[6]. Elham Yousef Kalafi,Wooi Boon Tan and Christopher Town,etc. Automated identification of Monogeneans using digital image processing and K-nearest neighbour approaches. BMC Bioinformatics, 2023, Vol.17 (19)
[7]. Abdelgawad Mohamed, Watson Michael W L, Wheeler Aaron R. Hybrid microfluidics: a digital-to-channel interface for in-line sample processing and chemical separations. Lab On a Chip, 2023, 9(8).
[8]. Watson Michael W L, Jebrail Mais J, Wheeler Aaron R. Multilayer hybrid microfluidics: a digital-to-channel interface for sample processing and separations.Analytical Chemistry, 2023, 82(15).

[9]. **Sanjay Kumar Suman**, Dhananjay Kumar and L. Bhagyalakshmi, "Non Cooperative Power Control Game with New Pricing for Wireless Ad hoc Networks", International Review on Computers and Software, vol. 9, no. 1, pp. 18-28, 2014. ISSN: 1828-6003,

[10]. S. Porselvi, **Sanjay Kumar Suman** and L. Bhagyalakshmi, "Harvesting RF energy for mobile charging", Australian Journal of Basic and Applied Science, vol. 9, no. 20, pp. 454-465, June 2015.

[11]. K. Swapna, P. Rajalakshmi and **Sanjay Kumar Suman**, "Security Enhancement in MANET using Game Theory", Middle East Journal of Scientific Research, vol. 23, pp. 190-195, 2015.

[12]. Sujeetha Devi, Bhagyalakshmi L and **Sanjay Kumar Suman**, "Cluster based energy efficient joint routing algorithm for delay minimization in wireless sensor networks", International Journal of Pure and Applied Mathematics, vol. 119, no. 15, 307-313, 2018

[13]. Sujeetha Devi, Bhagyalakshmi L and **Sanjay Kumar Suman**, "Enhancing the Performance of Wireless Sensor Networks through Clustering and Joint Routing with Mobile Sink", International Journal of Engineering and Advanced Technology, vol. 8, issue 6, pp. 323-327, 2019. https://doi.org/10.35940/ijeat.E7664.088619

[14]. L. Bhagyalakshmi, **Sanjay Kumar Suman**, S. Mohanalakshmi, and Satyanand Singh, "Improving Spectral Efficiency and Coverage Capacity of 5G Networks: A Review", Advances in mathematics: scientific journal, vol.9, no. 6, pp. 3387-3397, 2020. https://doi.org/10.37418/amsj.9.6.19