Chapter

Introductory Chapter: On Digital Image Processing

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1. Introduction

An image would be called as an analog image if its pictorial representation can be represented in analog wave formats, whereas an image would be called as a digital image if its pictorial representation can be represented or stored in the data in digital form. Similarly, field of image processing can be categorized into digital image processing and analog image processing. Digital image processing (or digital imaging), in the area of computer science today, is defined as processing digital images through some algorithms using digital computers, whereas, analog image processing is any image processing task that can be conducted on two-dimensional analog signals by analog means [1, 2].

After the invention of digital computers, digital image processing took various advantages over analog image processing. A broad range of techniques and methods, in the form of a variety of algorithms, came into existence. One can find a rich literature toady which can be applied to the input image data to solve various problems. These problems may include converting images into digital data, calibration, removing the build-up of noise and distortion during processing, etc. Since images are defined over two dimensions (and perhaps more) digital image processing may be modeled in the form of multidimensional systems. Digital image processing has evolved rapidly with the development of computers, mathematics, and the real-life demand for a variety of applications in wide range of areas [3–30].

In the current age and time, digital imaging is used widely in various real-life applications. There is a number of potential digital imaging applications that include different areas such as environment, industry, medical science, agriculture, military, film, television, photography, robotics, remote sensing, medical diagnosis, reconnaissance, architectural and engineering design, art, crime prevention, geographical information systems, communication, intellectual property, retail catalogs, nudity-detection, face finding, industrial applications, and others. The increasing trends, needs, and applications of imaging make it more difficult to process images for desired objectives. This leads to the idea of capturing, storing, finding, retrieving, analyzing, and using images in everyday life under the computing environment. Being a computer-based technology, digital imaging carries out automatic processing, manipulation, and interpretation of visual information. It plays a significant and important role in various aspects of real life. It is also highly useful in many areas, disciplines and fields of art, and science and technology. This chapter is specifically dedicated to digital imaging history, methodologies, tasks, software, and applications [31–57].

2. History

One of the earliest applications of digital image, in the early 1920s, can be seen in the newspaper industry. It was about the pictures that were sent by submarine cable between London and New York. The Bart lane cable picture transmission system reduced the amount of time tremendously weeks to hours across the Atlantic. As the field of digital image processing developed along with the development of the modern digital computers in 1950s, various techniques, methods, and technologies of digital image processing were developed in the 1960s at various places. Some of those places can be named as Bell Laboratories, the Jet Propulsion Laboratory, Massachusetts Institute of Technology, and University of Maryland. Together with them, there were also some other research facilities for satellite imagery, medical imaging, wire-photo standards conversion, photograph enhancement, videophone, and character recognition [3]. In the early days, image processing was mainly meant for improving the image quality in general. Very basic and commonly used techniques in image processing included enhancement, restoration, encoding, and compression of images.

American Jet Propulsion Laboratory (JPL) happened to be the first successful application in 1960s. Using this, in 1964, Space Detector Ranger 7 sent thousands of lunar photos. They mainly used image processing techniques like geometric correction, gradation transformation, and noise removal on the sent lunar photos. It was a big success story to have the successful computerized mapping of the moon's surface. The success kept progressing so much so that spacecraft sent nearly 100,000 photos that were processed with more complex imaging functionalities. It helped to obtain the topographic map, color map, and panoramic mosaic of the moon. This resulted in extraordinary achievements and happened to be landmark basis of history for human landing on the moon [4].

This is true that, due to computing machines of 1960s and earlier, the processing cost was fairly high. With the passage of time, in the 1970s, however, things changed relatively with faster digital image processing and cheaper computing equipment. Slowly and gradually afterwards, processing power kept increasing together with lower cost machines which resulted in images to be processed faster and faster. So much so, various complex problems like television standards conversion were managed in real time. In the years 2000s and after, the general-purpose computing equipment became much faster. Various developments in the technological world led to dedicated and special purpose hardware and equipment. Today, digital image processing has turned to a vital computing discipline which is playing a significant role to solve various real life problems in real time.

3. Methodology and tasks

Image processing is a very important area in today's science and engineering. The processing of digital images can be divided into various classes including image enhancement, image restoration, image analysis, and image compression. Imaging provides methodology to perform some kind of operations on input images. The output is obtained in terms of enhanced images, or some desired information, or some required features. For the sake of smooth workflow, it is important to first capture images and then to process them afterwards. Image processing techniques work on digital images with computing algorithms. Various steps and phases are needed to work on the images. For example, first, one can convert signals from an image sensor into digital images. After that, we can improve clarity and remove noise. Next, steps may be extracting the size, scaling, or desired objects in a scene. Then, images can be prepared for display. Lastly but not finally, compression of images is a very important phenomenon as it is needed for communication across busy networks.

There are various other phases and tasks which need attention depending on nature of applications. These include morphological processing, segmentation, enhancement, object recognition, and color image processing. Digital image processing involves much more sophisticated and useful computer algorithms. Most of the times, it is based on classification, feature extraction, multi-scale signal analysis, pattern recognition, and projection. Some of the popular techniques that can be used in digital image processing include anisotropic diffusion, Hidden Markov models, image editing, image restoration, independent component analysis, linear filtering, neural networks, partial differential equations, pixelization, point feature matching, principal components analysis, self-organizing maps, and wavelets.

4. Software and applications

There are a variety of software that can be used for image processing. For example, Matlab has many tools for image processing; it also facilitates to develop graphical user interfaces (GUI). ImageJ can be utilized for simple things, whereas Amira can be used for complex tasks. In case of medical applications, eFilm is one of the useful tools.

Applications of image processing range from medicine to entertainment and much more. Some of the important applications of image processing in the field of science, engineering, and technology include image sharpening and restoration, remote sensing, feature extraction, face detection, forecasting, optical character recognition, biometrics, medical imaging, optical sorting, augmented reality, virtual reality, video processing, microscope imaging, license plate recognition, lane departure caution, transportation, parking, transmission and encoding, machine vision, robotics, color processing, signature recognition, iris recognition, face recognition, forensics, automobile detection, fault detection, pattern recognition, military applications, and others. Following subsection has been dedicated to an application of license plate recognition (LPR) with systematic methodologies.

4.1 License plate recognition

Here is an example of different tasks and phases for a system to recognize license plates from the front and rear of the vehicle [58–60]. Input to the system is an image sequence acquired by a digital camera that consists of a license plate and its output is the recognition of characters on the license plate. The system consists of the standard four main modules in an LPR system which includes image acquisition, license plate extraction, license plate segmentation, and license plate recognition. The structure of the system is shown in **Figure 1**. The first task acquires the selected portion of the image (i.e., the portion which contains a license plate). The second task extracts the region that contains the license plate. The third task isolates the characters, consisting of letters and numerals, depending on the targeted License Plates. The last task identifies or recognizes the segmented characters.

Image acquisition: This is the first phase in an LPR system. This phase deals with acquiring an image by an acquisition method. In the LPR system, we need to use a high resolution digital camera to acquire the input image. The input image can be taken for example 640 × 480 pixels.

License plate extraction: License plate extraction is a key step in an LPR system, which influences the accuracy of the system significantly. This phase extracts the region of interest, i.e., the license plate, from the acquired image. The proposed

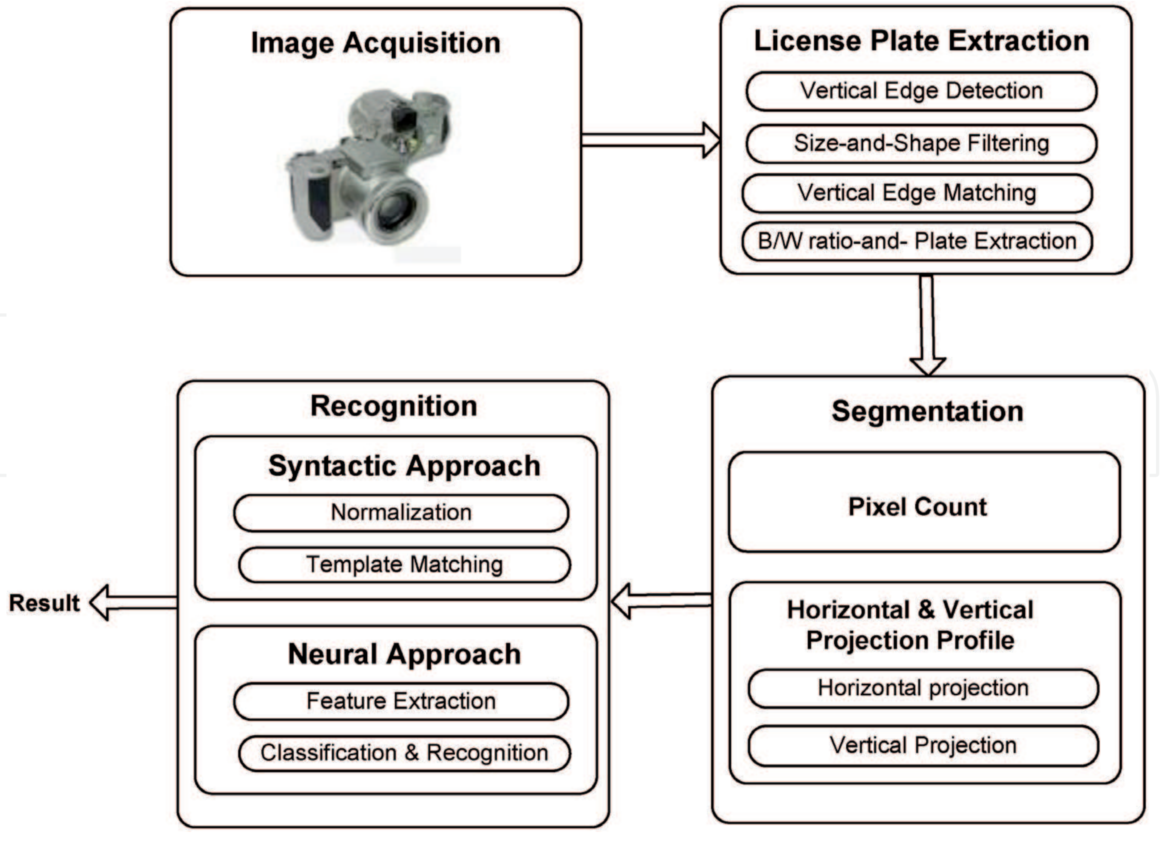

Figure 1.
Structure of the proposed system.

approach involves four steps including vertical edge detection, size-and-shape filtering, vertical edge matching, and finding B/W (Black/White) ratio.

License plate segmentation: License plate segmentation takes the region of interest and attempts to divide it into individual characters. To ease the process of detecting the characters, the extracted plate is divided into independent images, each containing one isolated character with letters and numerals depending on the structure of the license plate. It is proposed to have segmentation using two methods: Pixel Count and Horizontal and Vertical Projection.

License plate recognition: The last phase in LPR system is to recognize the isolated characters. After splitting the extracted license plate into six images, the character in each image can be identified. There are many methods to recognize isolated characters; we suggest using Syntactic approach and Neural network approach.

5. Conclusion

With the advent of fast and cheap machines, digital image processing has become a very highly demanded field of study and practice. It provides solutions to various real-life applications in an economical way. Various techniques have been developed to build intelligent systems; many of them are in progress at various facilities internationally. This chapter has provided some introductory notes on image processing, its brief history, methodologies, tasks, software, and applications. It will help to kick start the community interested to have some knowhow on the image processing subject. The future of digital image processing has a high probability to contribute toward the build of smart and intelligent world in terms of health, education, defense, traffic, homes, offices, cities, etc.

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