Image Processing Principles and Applications

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***Abstract* - Digital image processing involves the manipulating images with digital computer. Its application has grown rapidly in the recent years. Digital image processing can also be defined as, the numerical representation of an image being subjected to a series of operations to get a specific result. It involves converting a physical image into a digital image and then extracting useful knowledge from the converted digital image by using different algorithms. Popular fields of applications of digital image processing are medicine, multimedia, leisure, remote sensing, and so on.**

Keywords-digital image, numerical representation, knowledge

I. INTRODUCTION

Digital image processing involves manipulating images with digital computers. Its use has only increased along with the development of technologies. It is used in a wide range of applications such as entertainment, medicine, military, smart home, environment monitoring, remote sensing and much more. A digital image is represented as a function f (x, y) of two variables x and y which are continuous. For it to be processed digitally, the image must be scanned and converted into a number matrix. As computers displays numbers with a certain precision, these variables must be quantized for it to be displayed digitally [3]. The processing of images can be done in several ways such as image enhancement, image restoration, image analysis and image compression. Image enhancement uses heuristic techniques so that significant data can be extracted from it. Image recovery techniques aims to deal with damaged images, and reversing the effect of damage in order to recover the original image [6]. Image analysis technique is the process of extracting some useful information from the image. A significant aspect of images is the amounts of information required to represent them. Therefore, in order to store and transfer digital images practically, compression on images is done using the redundancy of the images so that the number of bits required for their representation is reduced [5].

II. ARCHITECTURE

The architecture of any image processing system, as seen in Fig. 1, consists of several basic components such as digitizer, storage, processor, program library and recorder.

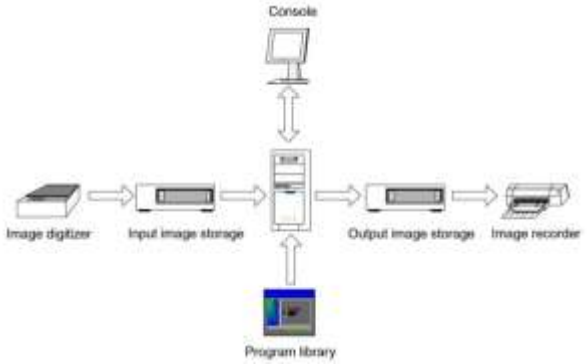

Fig. 1. Architecture of an Image Processing system

A. Image Digitizer

Image Digitizers are generally camera sensors that convert the physical images into digital images because computer systems are only capable of processing digits or rather digital images [4]. This process of converting physical image into digital image is called digitalization. It is represented in Fig. 2.

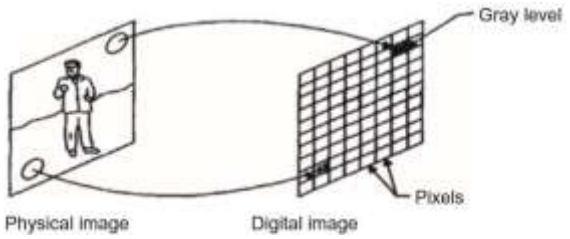

Fig. 2. Conversion of a physical image into a digital image

Brightness of a particular position in an image is the represented as an integer value by sampling and quantizing the pixel position brightness. The image is displayed as an integer matrix after each pixel conversion is complete. Each pixel has two aspects : position and grayscale. The position is the two coordinates of the sampling point in the scan line or simply, row and the column. Gray scale is the integer representing the brightness of a pixel position [4].

B. Program Library

The digital image is processed by the image processing system through a single or a collection of algorithms on top of different individual techniques [1, 4]. Several techniques of image processing are,

- Image Representation
- Image Preprocessing
- Image Enhancement
- Image Restoration
- Image Analysis
- Image Reconstruction
- Image Data Compression

III. PRINCIPLE OF IMAGE PROCESSING

Image processing is the alteration of image information in order to evaluate and enhance the quality of the image as much as possible. In digital image processing, images are processed on a digital computer [5, 6]. Another way of defining digital image processing is, performing a set of actions on the numerical form of an object. It is not necessary that all image processing systems has to consist a console or output image storage or an image recorder as depicted in the architecture diagram above. The components of an image processing system, depends upon the application needs [2].

Image Processing is of two methods.

Analog Image Processing

Analog Image Processing is the process of altering images on two dimensional signals through electric means. Analog signals can be either periodic or non-periodic. Analog signal is a time varying signal so the images formed under an analog image processing gets varied. The best example of analog image processing is television sets during older days where signal is received through an antenna and the amplitude of the signal determines the brightness of the picture produced. Altering this value, results in brightening or darkening of the brightness range of the picture [2].

Digital Image Processing

Digital Image Processing as we know is where a physical image is captured and represented as a function of f(x, y) where x and y are the coordinate value is the image matrix and the value of the function is the intensity of the image at that point. The intensity of a pixel ranges from 0 to 255 where 0 are white and 255 are black [2]. It is represented in Fig. 3.

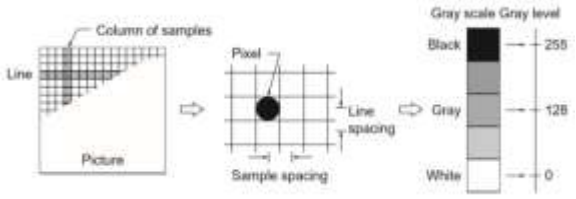

Fig. 3. Intenstiy range of each pixel

A. Overlapping fields of image processing

There are several fields that are similar to Image Processing. Fig. 4 maps the differences between each field as they majorly differ in input they take or output they produce or both.

1) Computer Vision

It is an area in image processing that associates with presenting useful information from digital images and videos. From a technical point of view, it is the method of making systems to obtain an intelligent sense of understanding from images and videos that humans could not easily get. Computer vision involves extracting, analyzing and understanding information from an image frame or video frames. It involves a set of theoretical and algorithmic basis to achieve a visual understanding of the image [6].

2) Computer Graphics

The area that deals with the generation of images with the help of computers is called as computer graphics. Today computer graphics is an essential aspect in entertainment, engineering, medicine and much more fields [6].

3) Artificial Intelligence

AI in image processing allows one to implement face recognizing patterns, detect and recognize object on still images and moving video frames. AI is automating man's work in major areas of engineering such as machinery. It is also used in smart home automation and much more [6].

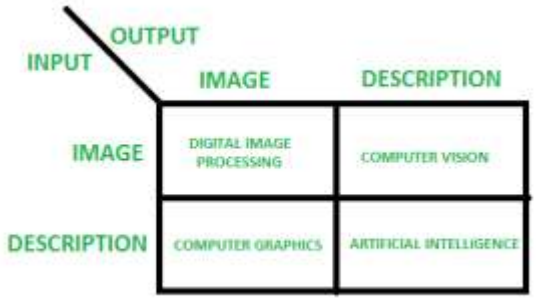

Fig. 4. Overlapping fields of image processing

IV. Techniques in Image Processing

A. Image Preprocessing

1) Scaling

a) Magnification

It is the process of increasing the size of an image for better interpretation [1]. In order to enlarge an image by any factor, say of n, every pixel of the actual image must be substituted by a block of n x n pixels, with having the same brightness value as the original pixel [2].

b) Reduction

It is the process of reducing a digital image to the original data by selecting and displaying every m^{th} row and m^{th} column of the original image. An alternate way of achieving this is to take and display the rounded average in the "m x m" block [1, 2].

2) Rotation

Used in image mosaic. The process of changing the orientation of an image is called rotation. It is achieved using a rotation matrix which can be decomposed into three separable matrices. This process is called 3 pass shear rotation [2].

B. Image Enhancement

Specific features in images are emphasized and other features are reduced, thus, the enhanced images do not necessarily approach the original image [1]. For example, a specific contour is highlighted by removing noises [2].

C. Image Restoration

Sometimes the images taken by satellites, some limited digital cameras, might not contain enough contrast or brightness due to the restricted lighting conditions and imaging systems. Different types of noises creep into the images. These noises are filtered using image restoration techniques [1, 2].

D. Image Analysis

Image analysis is the process of obtaining some useful description or information from an image by performing some quantitative measurements. It could be as simple as reading the description of a grocery or it could be as complex as measuring quantitative information to control a robotic arm [2].

V. Applications

DIP has wide range of applications; right from a simple bar code or QR code scanner to vision for robots in robotics. It is used in almost every field of engineering and science. Several important applications of image processing are,

A. General purpose Applications

1) Mobile Applications

Several mobile applications such as GooglePay and ShareIt use camera to scan the other user's QR codes and fetches data from it [7, 8].

2) Barcode scanner and Bio Metrics

Barcode scanners are used for attendance and biometrics such as iris scanner scanners are used for security purposes [7, 8].

3) Photo and video editing applications

Applications such as Photoshop or premiere are used to edit and enhance pictures or video frames. Heavily used in entertainment fields [7, 8].

B. Engineering Applications

1) Vehicular Applications

Vehicle parking systems are engineered to use image processing and other sensors such as proximity sensors to detect nearby objects and park cars safely. Auto pilot in cars use image processing to sense nearby vehicles [7, 8].

2) Quality Control of final products

Quality check of final products in manufacturing factories is automated using image processing. The system detects any faults in products and reports it [7, 8].

3) Machine Vision

Machine Vision is the practical input to robots and computer systems through vision. For instance, measurement of a product has to be calculated by a robotic arm in order to pick it correctly [7, 8].

4) Remote Sensing

In remote sensing, the terrestrial area is scanned from a satellite or from very high soils and then analyzed to obtain information. This data is used to detect damage to the infrastructure caused by an earthquake [7, 8].

C. Medical Applications

Imaging and scans

Various scans such as X-Ray, MRI and CT capture images of a person's internal organs and processes it as per medical needs and provides a processed visual representation of the organs [7, 8].

VI. Conclusion

Digital image processing is a vast and versatile field in signal processing. It is used in almost every field of science and is ever growing and will continue to influence upcoming technologies and inspire new embedded technologies.

VII. References

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