Digital Image Processing

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ABSTRACT

Image processing is a method to convert an image into digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it.

It is a type of signal dispensation in which input is an image, like video frame or photograph and output may be image or characteristics associated with that image.

Usually Image Processing system includes treating images as two dimensional signals while applying already set signal processing methods to them.

INTRODUCTION

The purpose of image processing is divided into 5 groups. They are:

Visualization - Observe the objects that are not visible.

Image sharpening and restoration - To create a better image.

Image retrieval - Seek for the image of interest.

Measurement of pattern – Measures various objects in an image.

Image Recognition – Distinguish the objects inan image.

Fundamental steps in Digital Image Processing:

Image Acquisition

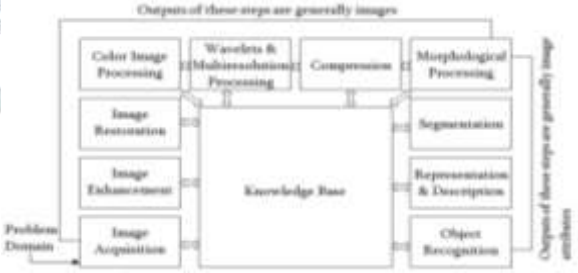
This is the first step or process of the fundamental steps of digital image processing. Image acquisition could be as simple as being given an image that is already in digital form. Generally, the image acquisition stage involves preprocessing, such as scaling etc.

Image Enhancement

Image enhancement is among the simplest and most appealing areas of digital image processing. Basically, the idea behind enhancement techniques is to bring out detail that is obscured, or simply to highlight certain features of interest in an image. Such as, changing brightness & contrast etc.

Image Restoration

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.



Color Image Processing

Color image processing is an area that has been gaining its importance because of the significant increase in the use of digital images over the Internet. This may include color modeling and processing in a digital domain etc.

Wavelets and Multiresolution Processing

Wavelets are the foundation for representing images in various degrees of resolution. Images subdivision

successively into smaller regions for data compression and for pyramidal representation.

Compression

Compression deals with techniques for reducing the storage required to save an image or the bandwidth to transmit it. Particularly in the uses of internet it is very much necessary to compress data.

Morphological Processing

Morphological processing deals with tools for extracting image components that are useful in the representation and description of shape.

Segmentation

Segmentation procedures partition an image into its constituent parts or objects. In general, autonomous segmentation is one of the most difficult tasks in digital image processing. A rugged segmentation procedure brings the process a long way toward successful solution of imaging problems that require objects to be identified individually.

Representation and Description

Representation and description almost always follow the output of a segmentation stage, which usually is raw pixel data, constituting either the boundary of a region or all the points in the region itself. Choosing a representation is only part of the solution for transforming raw data into a form suitable for subsequent computer processing. Description deals with extracting attributes that result in some quantitative information of interest or are basic for differentiating one class of objects from another.

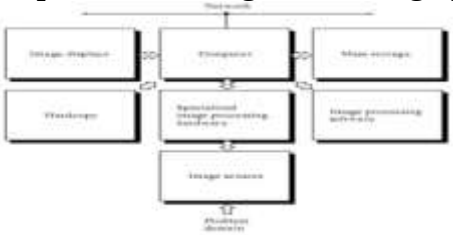
Object recognition

Recognition is the process that assigns a label, such as, “vehicle” to an object based on its descriptors.

Knowledge Base:

Knowledge may be as simple as detailing regions of an image where the information of interest is known to be located, thus limiting the search that has to be conducted in seeking that information. The knowledge base also can be quite complex, such as an interrelated list of all major possible defects in a materials inspection problem or an image database containing high-resolution satellite images of a region in connection with change-detection applications.

Components of Image Processing System



In sensing, two elements are required to acquire digital images.

The first is physical device that is sensitive to the energy radiated by the object we wish to image.

The second called a digitizer, is a device for converting the output of the physical sensing device into digital form.

Specialized image processing hardware usually consists of the digitizer plus hardware that performs other primitive operations such as arithmetic and logical operations (ALU).

Eg. Noise reduction. This type of hardware sometimes is called a front end subsystem.

The computer is an image processing system is a general purpose to supercomputer

Software which include image processing specialized modules that performs specific tasks

Mass storage capability is a must in image processing applications.

Image displays in use today are mainly color TV monitors.

Hardcopy devices for recording images include laser printers, film cameras, inkjet units and CD-ROM.

Networking for communication.

Different types of Images.

Images can be classified as follows:

- Monochrome image (Binary images).
- Grey scale images.
- Color (24-bit) images.
- Half-toned images.

Monochrome Image

In this, each pixel is stored as a single bit (0 or 1.) Here, 0 represents black while 1 represents while. It is a black and white image in the strictest sense. These images are also called bit mapped images; we have only black and white pixels and no other shades of grey.

Grey scale Image

Here each pixel is usually stored as a byte (8-bits). Due to this, each pixel can have values ranging from 0(black) to 255(white). Grey scale images, as the name suggests have black, white and various shades of grey present in the image.

Color Image (24-bit)

Color images are based on the fact that a variety of colors can be generated by mixing the three primary colors viz, Red, Green and Blue, in proper proportions. In color images, each pixel is composed of RGB values each of these colors require 8-bits (one byte) for it's represented by 24-bits [R (8-bits,), G (8-bits), B (8-bits)].

A 24-bit color image supports 16, 777,216 different combinations of colors.

Color images can be easily converted to grey scale images using the equation

$$X = 0.30R + 0.59G + 0.11B$$

An easier formula that could achieve similar results is

$$X = \frac{R + G + B}{3}$$

Half Toning

It is obvious that a grey scale image definitely looks than the monochrome image as it utilizes more grey levels. But there is a problem in hand. Most of the printers, that we use (inkjet, lasers, dot matrix) are all bi-level devices. i.e., they have only a black cartridge and can only produce two levels (black on a white back-ground). In fact, most of the printing jobs are done using bi-level devices.

Different types of Image file Format.

JPEG

JPEG stands for Joint Photographic Experts Group.

It uses lossy compression technique i.e. information is lost from the original image when saved as JPEG file.

Since JPEG discards most of the information, the size of JPEG file is usually small.

JPEG files are generally used for photographs on the web, because they create a small file that is easily loaded on webpage and also looks good.

JPEG is used when small file size is more important than maximum quality.

Pros

- 24-bit color, with up to 16 million colors.
- Rich colors, great for photographs that needs fine attention to color details.
- Compatible in most OS.
- Most used and most widely accepted.

Cons:

- They tend to discard a lot of data.
- JPEG does not support transparency.

TIFF

TIFF stands for Tagged Image File Format.

TIFF images create very large file sizes.

Images are uncompressed and therefore contain a lot of detailed information.

It is extremely flexible in terms of color, it can be grayscale or CYMK for print or RGB for web.

It is most common file type used in photo software (Photoshop) as well as page layout software (Quark & InDesign).

Pros:

- Very flexible file format.
- Supports several types of compression like JPEG, LZW, ZIP or compression at all.
- High Quality image format, all color and data information is stored.
- TIFF format can be saved with layers.

Cons:

- Very large file size.

BMP

BMP stands for Bitmap files.

The windows bitmap or BMP files are image files within the Microsoft windows OS.

They are large and uncompressed.

They are rich in color, high in quality, simple and compatible in al windows OS.

They are also called as raster or paint images.

They are made of pixels with different colors and arrangement to come up with an image and pattern.
It can be 8-bit, 16-bit or 24-bit image.

Pros:

- It works well with most windows programs and OS.
- It can be used as windows wallpaper.

Cons:

- It is not web-friendly, not compatible with all platforms.
- It does not scale or compress well.

Different types of Image color models.

RGB Model

In the RGB model, an image consists of three independent image planes, one in each of the primary colors: red, green and blue.

Specifying a particular color is by specifying the amount of each of the primary components present.

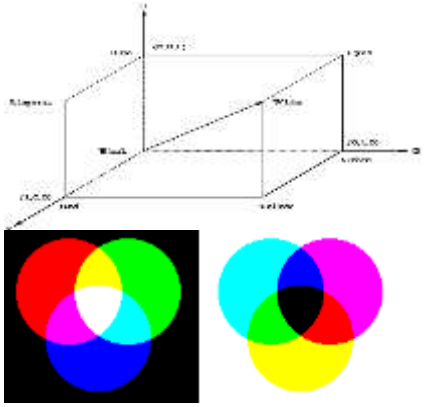
Figure shows the geometry of the RGB color model for specifying colors using a Cartesian coordinate system.

The greyscale spectrum, i.e. those colors made from equal amounts of each primary, lies on the line joining the black and white vertices.

This is an additive model, i.e. the colours present in the light add to form new colours, and is appropriate for the mixing of coloured light for example.

The image on the left of figure:4 shows the additive mixing of red, green and blue primaries to form the three secondary colours yellow (red + green), cyan (blue + green) and magenta (red + blue), and white ((red + green + blue).

The RGB model is used for colour monitors and most video cameras**.**

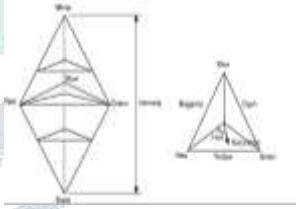


HSI Model

Color may be specified by the three quantities hue, saturation and intensity. This is the HSI model, and the entire space of colors that may be specified in this way is shown in figure

The HSI model, showing the HSI solid on the left, and the HSI triangle on the right, formed by taking a horizontal slice through the HSI solid at a particular intensity.

Hue is measured from red, and saturation is given by distance from the axis. Colours on the surface of the solid are fully saturated, i.e. pure colours, and the greyscale spectrum is on the axis of the solid. For these colours,hue is undefined.



Conversion between the RGB model and the HSI model is quite complicated. The intensity is given by

$$I = \frac{(R + G + B)}{3}$$

Where the quantities R, G and B are the amounts of the red, green and blue components, normalized to the range [0,1].

The intensity is therefore just the average of the red, green and blue components. The saturation is given by:

$$S = 1 - \frac{\min(R,G,B)}{I}$$
$$= 1 - \frac{3}{R+G+B}\min(R+G+B)$$

where the min(R,G,B) term is really just indicating the amount of white present. If any of R, G or B are zero, there is no white and we have a pure color.

Image Enhancement

Image enhancement is one of the first steps in image processing.

As the name suggests, in this technique, the original image is processed so that the resultant image is more suitable than the original for specific applications i.e. the image is enhanced. Image enhancement is a purely subjective processing technique.

By subjective we mean that the desired result varies fromperson to person.

An image enhancement technique used to process images might be excellent for a person, but the same result might not be good enough for another.

It is also importantto know at the outset that image enhancement is a cosmetic procedure i.e. it does not add any extra information to the original image.

It merely improves the subjective quality of the images by working with the existing data. Image enhancement can be done in two domains:

(1) The spatial domain

(2) The frequency domain

–1	–1	–1
–1	8	–1
–1	–1	–1

Image segmentation

Segmentation is the underlying concept for creating objects from pixels. The segmentation process involves dividing the image into regions or objects have common properties. Typical image segmentation techniques involve one of the two process:

- Region merging according to some measure of homogeneity
- Separation of objects by finding edges using the gradient of digital numbers (DNs) between neighboring pixels.

Region- margining approaches can be divided into two approaches:

- Region Growing
- Region split and merging

Detection of Discontinuities in Digital Image– Point Detection, Line Detection and Edge Detection

Point detection in an image?

Detecting points is fairly simple with the help of standard high pass mask.

By setting a threshold value, this mask detects only points and not lines. Hence point has been detected at the location on which the mask is centered only if

$$|R| \geq T$$

where R is derived from the standard convolution formula

$$R = w_1 z_1 + w_2 z_2 + \cdots + w_9 z_9$$
$$R = \sum_{i=1}^{9} w_i z_i$$

T is a non-negative threshold which is defined by the user.

We take |R| because we want to detect both the kinds of points i.e. white points on a black background as well as black points on a white background.

Line detected in an image?

Detection of lines can be done using the masks shown below.

In an image, lines can be in any direction and detecting these lines would need different masks.

–1	–1	–1
2	2	2
–1	–1	–1

Horizontal

–1	–1	2
–1	2	–1
2	–1	–1

+45°

–1	2	–1
–1	2	–1
–1	2	–1

Vertical

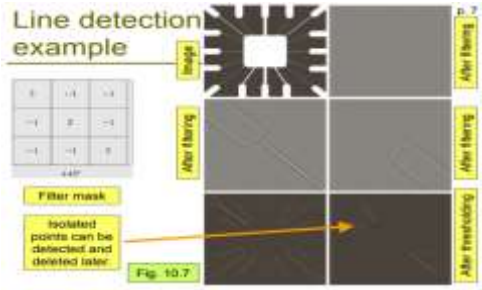
2	–1	–1
–1	2	–1
–1	–1	2

–45°

All these masks have a sum equal to zero, and hence all of them are high pass masks.

The first mask would respond strongly to lines that are oriented horizontally.

The second mask would respond to lines at an angle of +45°, the third mask would respond strongly to vertical lines and the last mask would respond strongly to lines at an angle of –45°.

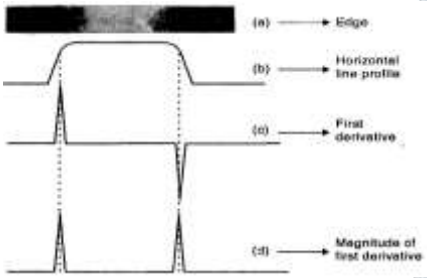


Edge detected in an image?

Variation of scene features, usually brightness, give rise to edges. In other words, edges are representations of the discontinuities of the scene intensity function.

To detect these discontinuities as edges. The process of edge detection is carried out by the derivative approach.

Consider the image shown in figure.



Above figure shows that the first derivative of the grey line profile is positive at the leading edge of a transition, negative at the trailing edge and zero in areas of constant grey levels.

We can thus conclude that computing the derivative helps us in detecting the edges.

The first derivative at any point in an image is obtained by using the magnitude of the gradient at that point.

Finding Gradients using Masks:

$$|\nabla F| = |Z_5 - Z_8| + |Z_5 - Z_6|$$

This is the first order difference gradient. This can be implemented using two masks.

Reference-

- Handbook on Digital Image Processing
- MATLAB and Simulink Handbook.