DIGITAL IMAGE PROCESSING

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Abstract: Digital Image Processing is a rapidly evolving field with growing applications in Science and Engineering. Modern digital technology has made it possible to manipulate multi-dimensional signals. Digital Image Processing has a broad spectrum of applications. They include remote sensing data via satellite, medical image processing, radar, sonar and acoustic image processing and robotics [1].

Keywords: Digital Image, colour image processing

Introduction: Digital image processing is a subset of the electronic domain wherein the image is converted to an array of small integers, called pixels, representing a physical quantity such as scene radiance, stored in a digital memory, and processed by computer or other digital hardware. Digital image processing, either as enhancement for human observers or performing autonomous analysis, offers advantages in cost, speed, and flexibility, and with the rapidly falling price and rising performance of personal computers it has become the dominant method in use [2]. Image processing is the application of computer processing techniques on the images or stream of images (i.e. video) made available to it through relevant Input mechanisms. After processing the Image, various kinds of outputs can be generated which range widely depending upon the use which the user wants [3].

Basic Image Parameters

Image: An Image can be thought of a two dimensional light intensity function f(x,y) , where x and y represent the Cartesian coordinates and the value of the function f at any point (x,y) depends on the brightness and gray level (in black and white image) or RGB value(in

coloured image) at that point. In common scenarios now a days we encounter digital images and videos in which everything is essentially discrete, so this means that the function f(x,y) has been made discrete both in terms of the coordinates and the value of f at any point. Keeping this in mind, an image can essentially be treated as 2-Dimensional array of Pixels or the picture elements which have been arranged in rows and columns, and their combination is what we see on the screen as an image.

Pixel: A pixel, short form of Picture Element, is the smallest Independent Unit of an Image. Any image is defined by the placement of pixels in it in any particular fashion. Any Image pixel has two important characters, and these are position of the pixel and the value of the pixel. Now, if the pixel belongs to that of a black and white image, then its value will be either 0 or 255, where 0 means black and 255 means white. If the image is Grayscale Image then the value of pixel can range from 0 to 255, with brightness level increasing from 0 to 255. For a coloured image pixel, the pixel value is somewhat treated differently.

Image Resolution: Image Resolution is a very common term. The resolution refers to the number of pixels comprising the image. For example, if an image has a resolution [n * m], then that means there are n pixels in the horizontal direction and m in the vertical direction and the size of the image is n * m pixels or (n * m) * 10^-6 MP [Mega Pixels]. Now, each Pixel corresponds to piece of information, so more is the number of pixels, more will be the information stored in the image and more is going to be its clarity when scaled to the same width and height.

Channels: A typical pixel does not contain only single value, i.e. value of a pixel at given coordinates might not be a single number, but a collection of numbers as well. Thus, the number of values a pixel has for a given (x,y) is called the channel of the pixel [3].

Fundamental steps in image processing:
1. Image acquisition: to acquire a digital image
2. Image preprocessing: to improve the image in ways that increase the chances for success of the other processes.
3. Image segmentation: to partitions an input image into its constituent parts or objects.
4. Image representation: to convert the input data to a form suitable for computer processing.
5. Image description: to extract features that result in some quantitative information of interest or features that are basic for differentiating one class of objects from another.
6. Image recognition: to assign a label to an object based on the information provided by its descriptors.
7. Image interpretation: to assign meaning to an ensemble of recognized objects [4].

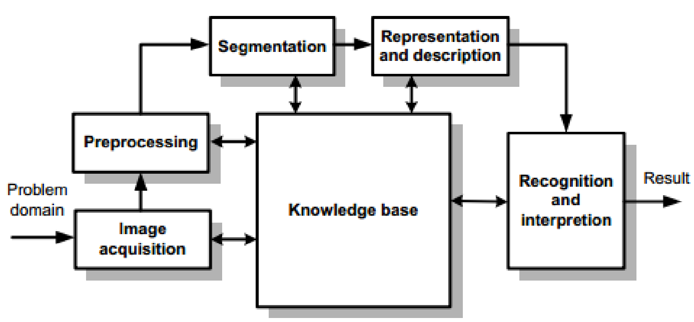

Fig 1: Fundamental steps in digital image processing

Applications of Digital Image Processing
• Medical applications
• Restorations and enhancements
• Digital cinema
• Image transmission and coding
• Colour processing
• Remote sensing
• Robot vision
• Hybrid techniques
• Facsimile
• Pattern recognition
• Registration techniques
• Multidimensional image processing
• Image processing architectures and workstations
• Video processing
• Programmable DSPs for video coding
• High-resolution display
• High-quality colour representation
• Super-high-definition image processing
• Impact of standardization on image processing [5]

Colour Processing
Colour Fundamentals

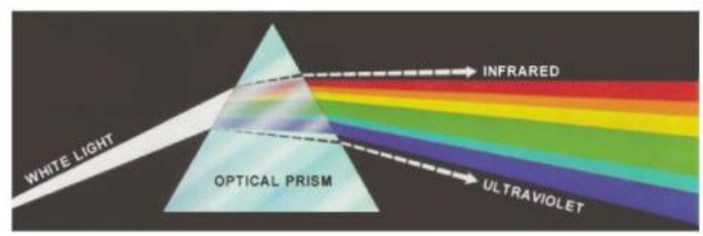

Fig 2: Colour spectrum seen by passing white light through a prism

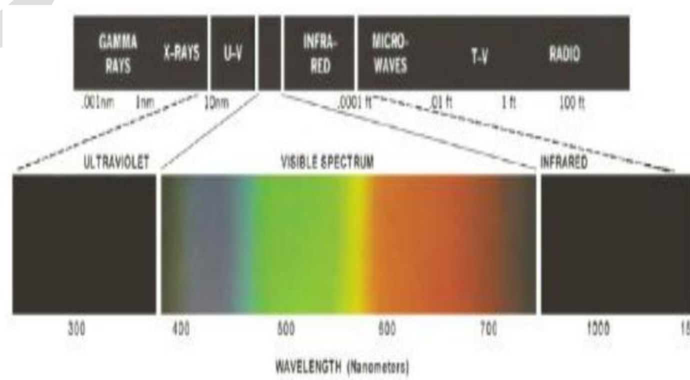

Fig 3: Wavelengths comprising the visible range of the electromagnetic spectrum

Perception of colours by the human eye
Cones can be divided into 3 principal sensing categories: (roughly) red, green and blue ~65% are sensitive to red light, ~33% to green light and ~2% to

blue (but most sensitive) Colours are seen as variable combinations of the primary colours: Red, Green, Blue From CIE* (1931), wavelengths: blue = 435.8nm, green = 546.1nm, red = 700nm

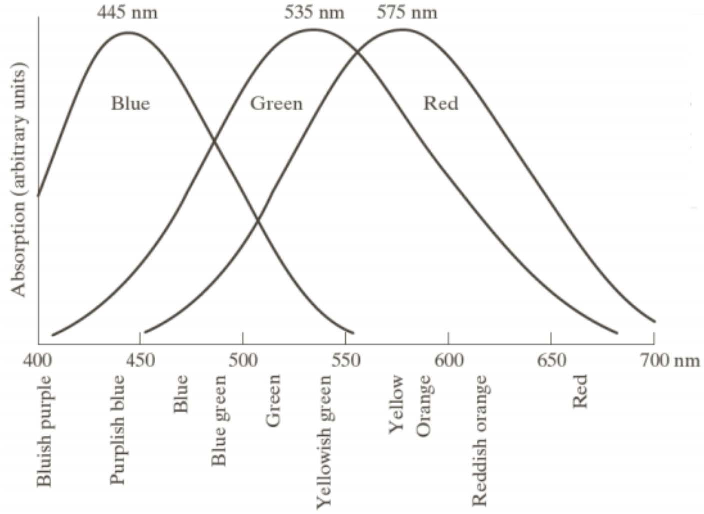

Fig 4: Absorption of light by the red, green and blue cones in the human eye as a function of wavelength

Primary colours can be added to produce the secondary colours of light:

• Magenta (red plus blue)

• Cyan (green plus blue)

• Yellow (red plus green)

Mixing the three primaries in the right intensities produce white light Primary colours of pigment: absorb a primary colour of light and reflects or transmits the other two magenta, cyan and yellow

Characteristics of a colour:

• **Brightness:** embodies the achromatic notion of intensity

• **Hue:** attribute associated with the dominant wavelength in a mixture of light waves

• **Saturation:** refers to the relative purity or the amount of white light mixed with a hue (The pure spectrum colours are fully saturated; e.g. Pink (red and white) is less saturated, degree of saturation being inversely proportional to the amount of white light added).

Hue and Saturation together = chromaticity

Colour may be characterized by its brightness and chromaticity.

Tristimulus values = amounts of red (X), green (Y) and blue (Z) needed to form a particular colour. A colour can be specified by its trichromatic coefficients:

$$x = \frac{X}{X+Y+Z}$$

$$y = \frac{Y}{X+Y+Z}$$

$$z = \frac{Z}{X+Y+Z}$$

Note: X+Y+Z=1

Colour Models

• Also called: colour spaces or colour systems

• Purpose: facilitate the specification of colours in some "standard" way

• Colour model = specification of a coordinate system and a subspace within it where each colour is represented by a single point

Most commonly used hardware-oriented models:

• RGB (Red, Green, Blue), for colour monitors and video cameras

• CMY (Cyan, Magenta, Yellow) and CMYK (CMY+Black) for colour printing

• HSI (Hue, Saturation, Intensity)[6]

Colour Feature Detection: Classification of Colour Structures

The detection and classification of local structures (i.e., edges, corners, and T-junctions) in colour images is important for many applications, such as image segmentation, image matching, object recognition, and visual tracking in the fields of image processing and

Computer vision.

[1] Combining Shape and Colour: By combining geometrical and photometrical information, we are able to specify the physical nature of salient points. For example, to detect high lights, we need to use both a highlight invariant colour space, and one or more highlight variant spaces.

The detection of shadow–geometry/highlight/material edges, corners, and T-junctions. The features used to detect shadow–geometry edges are first-order derivate applied on both the RGB and the c1c2c3 colour channels. Further, the second-order derivative is only applied on the RGB colour image. To be precise we use the curvature gauge to characterize local structures that are only characterized by their second-order structure. It is a coordinate system on which the Hessian becomes diagonal, yielding the (p, q)-coordinate system. The two eigenvectors of the Hessian are κ1 and κ2 and are defined by κ1

$$k1 = f_{xx} + f_{yy} - \sqrt{(f_{xx} + f_{yy})^2 + 4 f_{xy}^2}$$

$$k2 = f_{xx} + f_{yy} + \sqrt{(f_{xx} + f_{yy})^2 + 4 f_{xy}^2}$$

[2] Detection of Highlights:
The features used for highlight detection are *κ*1 and *κ*2 applied on the *HSB* colour channels yielding a five-dimensional space for each image point:

• **Gaussian:** The Gaussian method performs well to detect highlights, Most of the highlights are detected. However, only a few false positives are found (e.g., bar-shaped structures). This is because the reflectances at these structures are composed of a portion of specular reflection.

• **Mixture of Gaussians:** The MoG method gives slightly better results than the Gaussian method. For this method, the highlighted bars, found by the Gaussian method, are discarded.

• ***k*-Nearest neighbor:** This method performs slightly worse as opposed to the detection method based on a single Gaussian (see Figure 9.10d). The problem with the highlighted bars is still present.

• **Summary:** The detection methods based on a single Gaussian as well as on the MoG are well suited for highlight detection. Efficiency and accuracy of the results, the Gaussian or MoG are most appropriate for highlight detection

[3] Detection of Geometry/Shadow Edges
The features that are used to detect geometry/shadow edges are the first-order derivatives applied on both the RGB and the c1c2c3

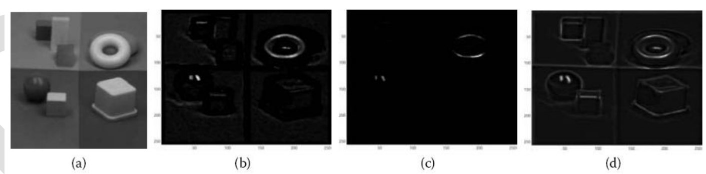

Fig 5: (a) Test image, (b) Gaussian classifier, (c) mixture of Gaussians, and (d) k-nearest neighbor. Based on the (training)

[4] Detection of Corners
The first-order derivative (fw) and second-order derivative (fvv) of the RGB colour space are used for corner learning and classification. To determine the thresholds for corner detection [7].

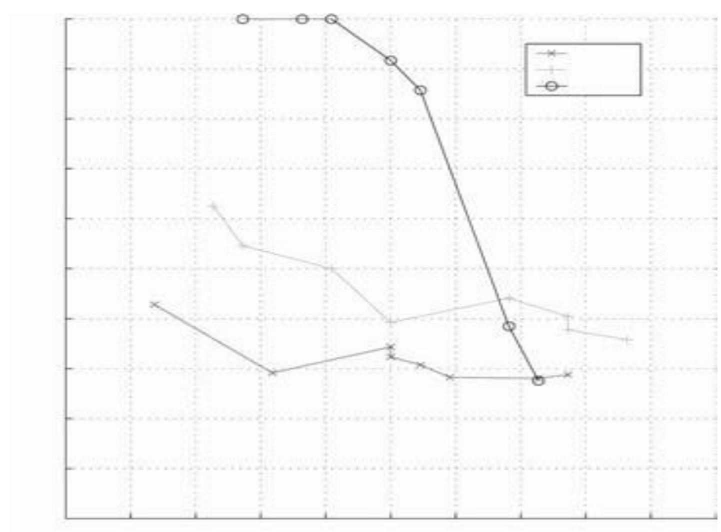

Fig 6**:** Precision/recall graph for the classifiers of corners.

Conclusion: This paper focused on presenting methods of colour image processing. The processing of images is faster and more cost-effective. One needs less time for processing, as well as less film and other photographing equipment. It is more ecological to process images. No processing and fixing chemicals are needed to take and process digital images.

Reference:

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