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Article

Digital Image Fundamentals: An Image Created Through the Process of Digitization

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A B S T R A C T

Digitization is the process through which we transform the formats or objects that one can see or hear like: text, image or sound from analog media, into electronic data that we can save, organize, retrieve, and restore through electronic devices into perceptible surrogates of the original works. Of the vast number of digital assets that are being created, still images, texts, motion pictures, and sound recordings predominate. A digital image, then, is one that has been created through the process of digitization.

Keywords: Digitization, Digital image, Digital Image Processing (DIP), Pixels, Different formats of image.

Introduction to Image

An image may be defined as a two-dimensional function f(x, y), where x and y are plane coordinates, and the amplitude of f at any pair of coordinates (x, y) is called the intensity or gray level of the image at that point.

The x and y coordinates represents the ROWS and COLUMNS of an image. When x, y and the amplitude values are all finite then the image is called a digital image.

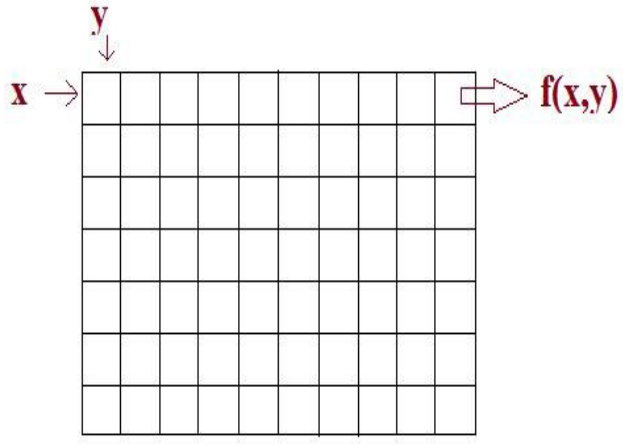

Figure 1.Image Representation

Image Formation in the Eyes

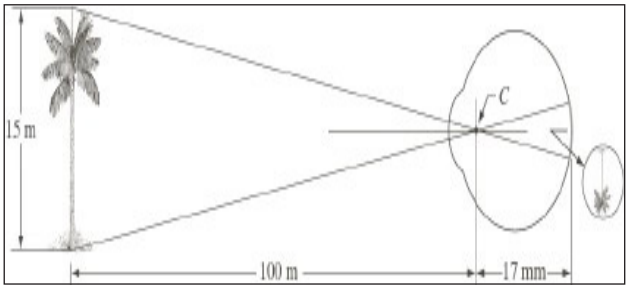

Figure 2.Graphical representation of eyes looking at the palm tree. Point C is the optical centre of the lens

Photo camera: lens has fixed focal length. Focus ingat various distances varying distance between lens and imaging plane (location of film or chip).

Human eye: converse. Distance lens-imaging region (retina) is fixed. Focal length for proper focus is obtained by varying the shape of the lens.

Brightness Adaptation and Discrimination

Eye's ability to discriminate between different intensity levels. Range of light intensity levels to which the human visual system can adapt: on the order of 10^{10}.

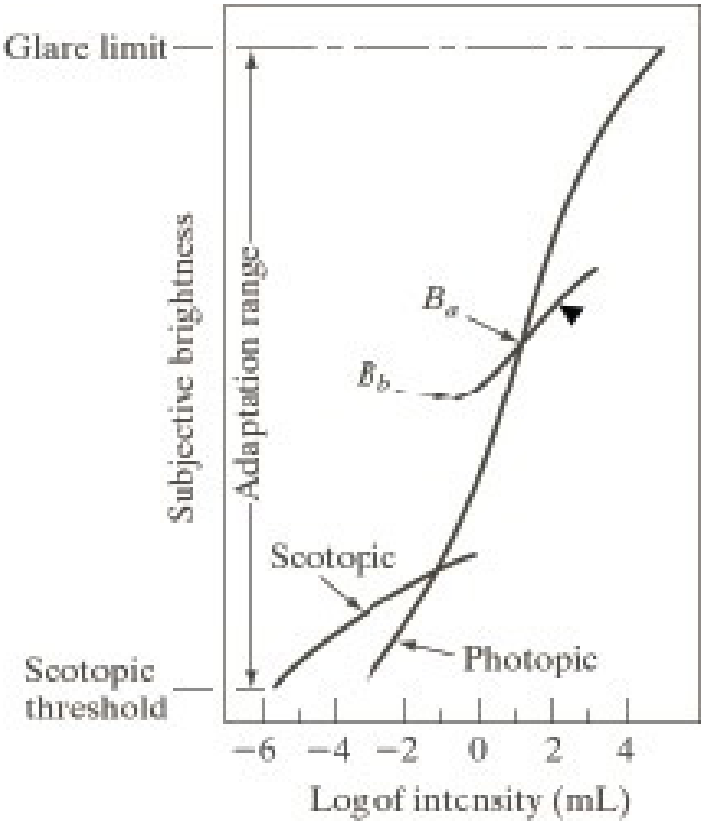

Figure 3.Range of subjective brightness the eye can perceive when adapted to this level Ba

Light and the Electromagnetic Spectrum

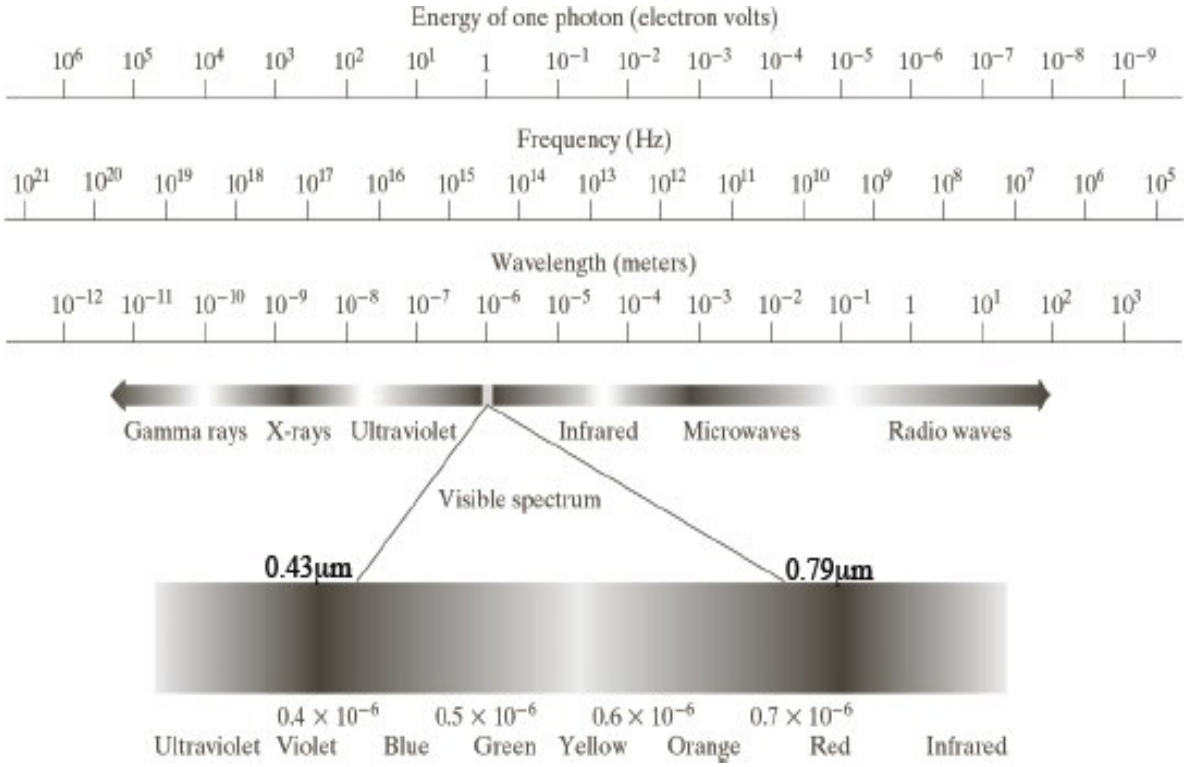

Figure 4.Light and the Electromagnetic Spectrum

Figure 5.Grayscale Image and Gray Shades

Gray-Scale Image

Gray-scale images are the images which only contains the intensity (amount of color) information. It composed of gray shades varying from black as the weakest intensity and white as the strongest intensity. For an 8-bit image it varies from 0 to 255 i.e. it has 256 possible gray shades.

Binary Image

Binary images are the images that have only two values for each pixel either 0 (black) or 1 (white), which means each pixel has a single bit. These are also known as bi-level or two-level. 1 bit in each pixel, 2^1= 2 colors either 0 or 1.

Figure 6.Binary Image

Pixel

A digital image is composed of a finite number of elements, each of which has a particular location (i.e. the x and y coordinates defined the location) and value (intensity). These elements are referred to as picture elements, image elements, pels and pixels. In Fig. 7 each cell in the rectangular grid represents the pixel of an image. These cells have specific locations and values.

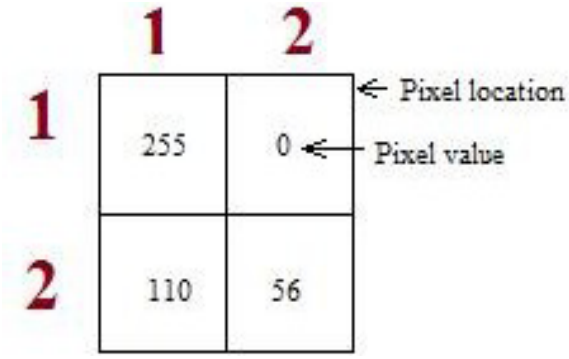

Figure 7.Pixel Representation

The rectangular grid represents the image with 4 pixels. Pixel 1 location is (1, 1) and value is 255, Pixel 2 location is (1, 2) and value is 0, Pixel 3 location is (2, 1) and value is 110, Pixel 4 location is (2, 2) and value is 56.

Neighbors of a Pixel

A pixel p at coordinates {x, y) has four horizontal and vertical neighbors whose coordinates are given by

(x + 1, y), (x - 1, y), (x, y + l), (x, y - 1)

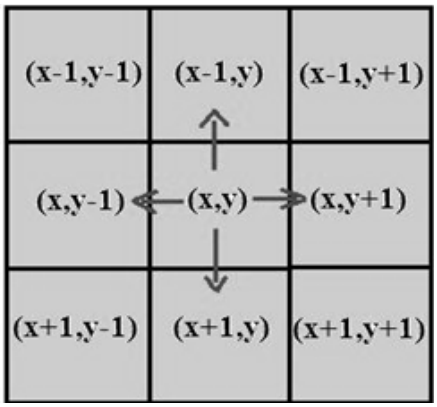

Figure 8. 4-Neighbours of a Pixel

This set of pixels, called the 4-neighbours of p, is denoted by N4(p). Each pixel is a unit distance from (x, y), and some of the neighbors of p lie outside the digital image if {x, y) is on the border of the image. The four diagonal neighbors of p have coordinates.

(x + l, y + 1), (x+1, y - 1), (x - 1, y + 1), (x - l, y- 1)

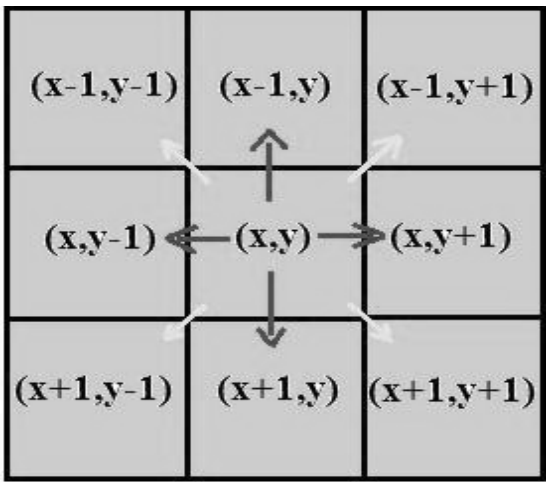

Figure 9. 8-Neighbours of a Pixel

And are denoted by ND(p). These points, together with the 4-neighbours, are called the 8- neighbours of p, denoted by N8(p). As before, some of the points in ND(p) and N8(p) fall outside the image if (x, y) is on the border of the image.

Connectivity between Pixels

Connectivity between pixels is a fundamental concept that simplifies the definition of numerous digital image concepts, such as regions and boundaries.

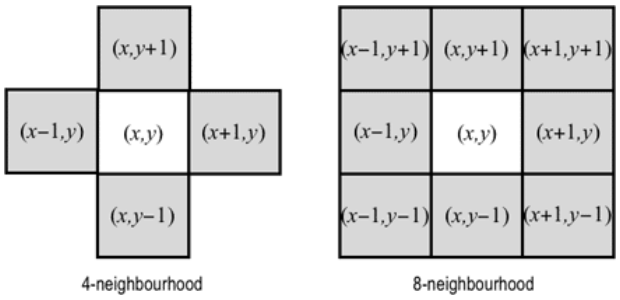

Figure 10.Connectivity between Pixels

To establish if two pixels are connected, it must be determined if they are neighbors and if their gray levels satisfy a specified criterion of similarity (say, if their gray levels are equal). For instance, in a binary image with values 0 and 1, two pixels may be 4-neighbours, but they are said to be connected only if they have the samevalue.

Adjacency between Pixels

Let V be the set of gray-level values used to define adjacency. In a binary image, V = {1} if we are referring to adjacency of pixels with value 1. In a gray-scale image, the idea is the same, but set V typically contains more elements. For example, in the adjacency of pixels with a range of possible gray-level values 0 to 255, set V could be any subset of these 256values.

- 4-adjacency- Two pixels p and q withvalues from V are 4-adjacent if q is in the Set N4(p).
- 8-adjacency- Two pixels p and q with values from V are 8-adjacent if q is in the SetN8(p).

A (digital) path (or curve) from pixel p with coordinates (x, y) to pixel q with coordinates (s, t) is a sequence of distinct pixels with coordinates

(x0, y0), (x1, y1)… (xn, yn)

Where, (x0, y0) = (x, y), (xn, yn) = (s, t), and pixels (xi, yi) and (x (i-1), y (i-1)) are adjacent for 1 <= i<=

n. In this case, n is the length of the path. If (x0, y0) = (xn, yn), the path is a closed path.

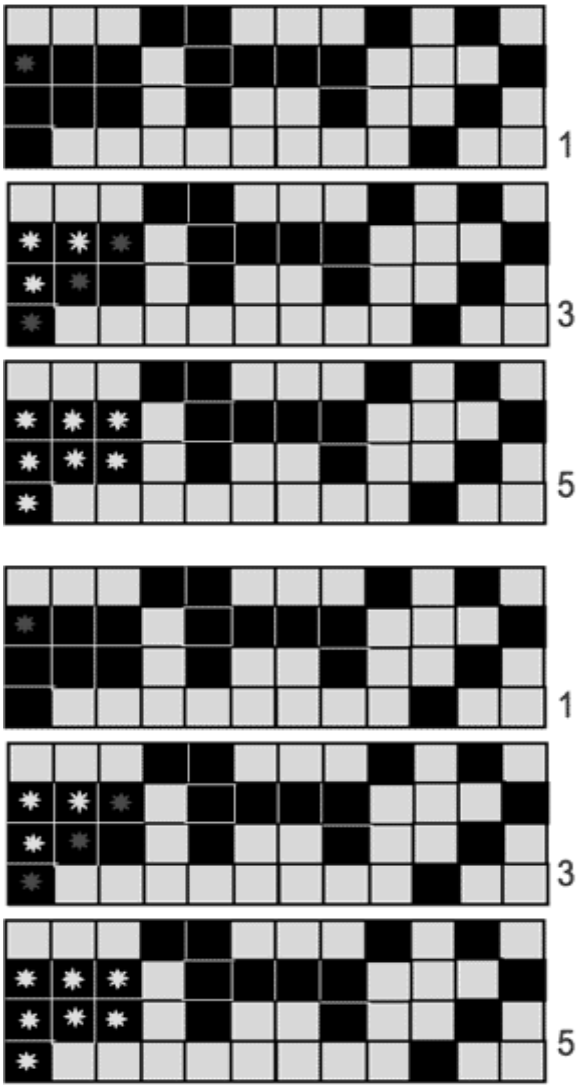

Figure 11.An Example of Region of Pixels

Region

Let S represent a subset of pixels in an image. Two pixels p and q are said to be connected in S if there exists a path between them consisting entirely of pixels in S.

For any pixel p in S, the set of pixels that are connected to it in S is called a connected component of S. If it only has one connected component, then set S is called a connected set.

Let R be a subset of pixels in an image. We call R a region of the image if R is a connected set. The boundary (also called border or contour) of a region R is the set of pixels in the region that have one or more neighbors that are not in R.

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