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New Techniques Used for Image Enhancement

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Abstract: *Principle objective of Image enhancement is to process an image so that result is more suitable than original image for specific application. Digital image enhancement techniques provide a multitude of choices for improving the visual quality of images. Appropriate choice of such techniques is greatly influenced by the imaging modality, task at hand and viewing conditions. The paper focuses on techniques for image enhancement.*

Keywords: *Digital, Image Processing, Image Enhancement*

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I. Introduction

Digital Image Processing (DIP) involves the modification of digital data for improving the image qualities with the aid of computer. The processing helps in maximizing clarity, sharpness and details of features of interest towards information extraction and further analysis. This form of remote sensing actually began in 1960s with a limited number of researchers analyzing airborne multispectral scanner data and digitized aerial photographs. However, it was not until the launch of Landsat-1, in 1972, that digital image data became widely available for land remote sensing applications. At that time not only the theory and practice of digital image processing was in its infancy but also the cost of digital computers was very high and their computational efficiency was far below by present standards. Today, access to low cost and efficient computer hardware and software is commonplace and the source of digital image data are many and varied. The digital image sources range from commercial earth resources satellites, airborne scanner, airborne solid-state camera, scanning micro-densitometer to high-resolution video camera.

Digital image processing is a broad subject and often involves procedures which can be mathematically complex, but central idea behind digital image processing is quite simple. The digital image is fed into a computer and computer is programmed to manipulate these data using an equation, or series of equations and then store the results of the computation for each pixel (picture element).

These results form a new digital image that may be displayed or recorded in pictorial format or may itself be further manipulated by additional computer programs. The possible forms of the digital image manipulation are literally infinite. The raw digital data when viewed on the display will make it difficult to distinguish fine features. To selectively enhance certain fine features in the data and to remove certain noise, the digital data is subjected to various image processing operations. Image enhancement is basically improving the interpretability or perception of information in images for human viewers and providing `better' input for other automated image processing techniques. The principal objective of image enhancement is to modify attributes of an image to make it more suitable for a given task and a specific observer. During this process, one or more attributes of the image are modified. The choice of attributes and the way they are modified are specific to a given task. Moreover, observer-specific factors, such as the human visual system and the observer's experience, will introduce a great deal of subjectivity into the choice of image enhancement methods.

Many different, often elementary and heuristic methods are used to improve images in some sense. The problem is, of course, not well defined, as there is no objective measure for image quality. Here, we discuss a few recipes that have shown to be useful both for the human observer and/or for machine recognition. These methods are very problem-oriented: a method that works fine in one case may be completely inadequate for another problem. In this paper basic image enhancement techniques have been discussed with their mathematical understanding.

II. Image Enhancement

Enhancement is the modification of an image to alter impact on the viewer. Generally enhancement distorts the original digital values; therefore enhancement is not done until the restoration processes are completed.

Contrast Enhancement

There is a strong influence of contrast ratio on resolving power and detection capability of images. Techniques for improving image contrast are among the most widely used enhancement processes. The sensitivity range of any remote sensing detector is designed to record a wide range of terrain brightness from black basalt plateaus to white sea beds under a wide range of lighting conditions. Few individual scenes have a brightness range that utilizes the full sensitivity range of these detectors. To produce an image with the optimum contrast ratio, it is important to utilize the entire brightness range of the display medium, which is generally film.

Intensity, Hue And Saturation Transformations

The additive system of primary colors (red, green, and blue, or RGB s y stem) is well established. An alternate approach to color is the intensity, hue and saturation system (IHS), which is useful because it presents colors more nearly as the human observer perceives them. The IHS system is based on the color sphere in which the vertical axis represents intensity, the radius is saturation, and the circumference is hue. The intensity (I) axis represents brightness variations and ranges from black (0) to white (255): no color is associated with this axis. Hue (H) represents the dominant wavelength o f co l o u r. Hue values commence with 0 at the midpoint of red tones an d i n crease counterclockwise around the circumference of the sphere to conclude with 255 adjacent to 0. Saturation (S) represents the purity of color and ranges from 0 at the centre of the color sphere to 255 at t h e circumference. A saturation of 0 represents a completely impure color, in which all wavelengths are equally represented and which the eye will perceive a shade of grey that ranges from white to black depending on intensity.

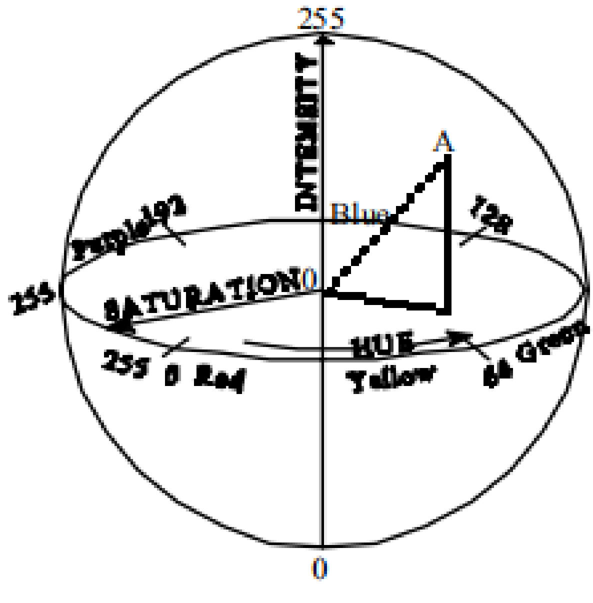

Figure 1: Intensity, Hue and Saturation color coordinate system. Color at point A has the values: I=195, H=75 and S=135.

Edge Enhancement

Most interpreters are concerned with recognizing linear features in images such as joints and lineaments. Geographers map manmade linear features such as highways and canals. Some linear features occur as narrow lines against a background of contrasting brightness; others are the linear contact between adjacent areas of different brightness. In all cases, linear features are formed by edges. Some edges are marked by pronounced differences that may be difficult to recognize. Contrast enhancement may emphasize brightness differences associated with some linear features. This procedure, however, is not specific for linear features because all elements of the scene are enhanced equally, not just the linear elements.

Spatial Domain Techniques

Spatial domain techniques are operated on pixels. The values of pixels or pels are modified to get the intended improvement. It involves the techniques such as log transformations, power-law(gamma) transformations, histogram equalization and Matching(Specification) that are dependent on the direct operation on the pixels in the image. These are basically used for the direct alteration of the gray values of the pixels individually and also for the sharpness of the image. However the problem in it is sometimes it also generates the unacceptable results because it works in the uniform way in the whole picture that was taken. So this method is not suitable for the images that need to improve the selected region or the intended information.

Point Operation

In this type of operation, the individual pixels are operated by image processing operation or the point operations that is

g(m, n)= T[f(m, n)]

in which f(m ,n) is the input or original picture, g(m, n) is the processed or resultant picture, and T is used for modification process that is operated on a single pel or pixel.

Mask Operation

Every pel or pixel is changed as per their values in a close or small neighborhood in this operation.

Global Operation

All the pixel values are taken into account of the image to perform the global operation.

Frequency Domain Techniques

Frequency domain techniques are suitable for the images that are based on frequency components and works on the orthogonal transformation of the image rather than the image itself. The principle of these techniques is composed of 2D discrete unitary transformation, for illustration the 2-D discrete fourier transform that replaces the coefficients by the operator and then perform the inverse process. It has two components namely magnitude and phase. Magnitude is composed of frequency component and phase is for restoring the image back to the spatial domain. These are straightforward techniques. Firstly, the fourier transform of the image is computed which is to be computed and result is multiplied by a filter and inverse transform is taken to generate the output image. In low pass filtering , high frequency components of image are eliminated and as a result, image would be blurred associated with noise. An ideal filter also has two issues: blurring of image and ringing of image.

Histogram Processing

Histogram processing is used in image enhancement the information inherent in histogram can also used in other image processing application such as image segmentation and image compression. A histogram simply plots the frequency at which each grey-level occurs from 0 (black) to 255 (white). Histogram processing should be the initial step in preprocessing. To produce a much better image histogram equalization and histogram specification (matching) are two methods widely used to modify the histogram of an image.

Histogram represents the frequency of occurrence of all gray-level in the image, that means it tell us how the values of individual pixel in an image are distributed.

Histogram is given as

h (rk) = nk/N

Where and are intensity level and number of pixels in image with intensity respectively.

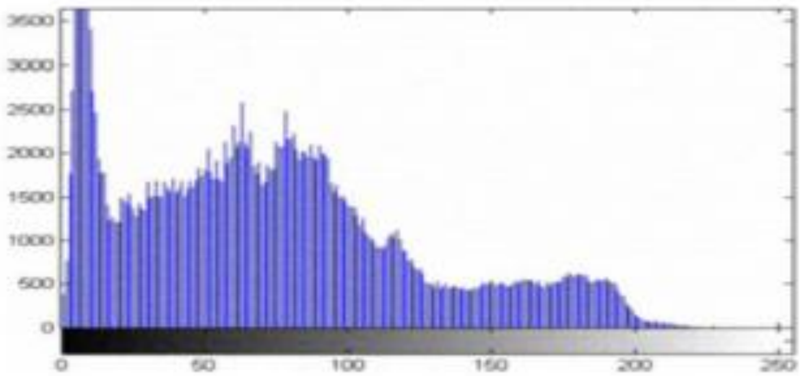

Figure 2: Histogram

Histogram Equalization

Histogram equalization is a common technique for enhancing the appearance of images. Suppose we have an image which is predominantly dark. Then its histogram would be skewed towards the lower end of the grey scale and all the image detail is compressed into the dark end of the histogram. If we could `stretch out' the grey levels at the dark end to produce a more uniformly distributed histogram then the image would become much clearer. Histogram equalization stretches the histogram across the entire spectrum of pixels (0 – 255). It increases the contrast of images for the finality of human inspection and can be applied to normalize illumination variations in image understanding problems. Histogram equalization is one of the operations that can be applied to obtain new images based on histogram specification or modification.

Thresholding Transformations

Thresholding transformations are particularly useful for segmentation in which we want to isolate an object of interest from a background. Image threshold is the process of separating the information (objects) of an image from its background, hence, thresholding is usually applied to grey-level or color document scanned images. Thresholding can be categorized into two main categories: global and local. Global thresholding methods choose one threshold value for the entire document image, which is often based on the estimation of the background level from the intensity histogram of the image; hence, it is considered a point processing operation. Global thresholding methods are used to automatically reduce a grey-level image to a binary image. The images applied to such methods are assumed to have two classes of pixels (foreground and background). The purpose of a global thresholding method is to automatically specify a threshold value T, where the pixel values below it are considered foreground and the values above are background. A simple method would be to choose the mean or median value of all the pixels in the input image, the mean or median will work well as the threshold, however, this will generally not be the case especially if the pixels are not uniformly distributed in an image.

Local adaptive thresholding uses different values for each pixel according to the local area information. Local thresholding techniques are used with document images having non-uniform background illumination or complex backgrounds, such as watermarks found in security documents if the global thresholding methods fail to separate the foreground from the background. This is due to the fact that the histogram of such images provides more than two peaks making it difficult for a global thresholding technique to separate the objects from the background, thus; local thresholding methods are the solution.

Change-Detection Images

Change detection images provide information about seasonal or other changes. The information is extracted by comparing two or more images of an area that were acquired at different times. The first step is to register the images using corresponding ground-control points. Following registration, the digital numbers of one image are subtracted from those of an image acquired earlier or later. The resulting values for each pixel will be positive, negative, or zero; the latter indicates no change. The next step is to plot these values as an image in which neutral grey tone represents zero. Black and white tones represent the maximum negative and positive differences respectively. Contrast stretching is employed to emphasize the differences. The agricultural practice of seasonally alternating between cultivated and fallow fields can be clearly shown by the light and dark tones in the difference image. Change-detection processing is also useful for producing difference images for other remote sensing data, such as between nighttime and daytime thermal IR images.

Applications

Image enhancement has applications in many fields like aerial imaging, satellite images, digital camera pictures, remote sensing applications , forensic labs, astrophotography, fingerprint or face recognition etc. Image Enhancement is a important tool for highlighting areas to improve the visual representation of the picture. It has a considerable application in medical imaging like in MRI, Ultrasound and X- Rays.

III. Conclusion

Image enhancement algorithms offer a wide variety of approaches for modifying images to achieve visually acceptable images. The choice of such techniques is a function of the specific task, image content, observer characteristics, and viewing conditions. The point processing methods are most primitive, yet essential image processing operations and are used primarily for contrast enhancement. Image Negative is suited for enhancing white detail embedded in dark regions and has applications in medical imaging. Power-law transformations are useful for general purpose contrast manipulation. For a dark image, an expansion of gray levels is accomplished using a power-law transformation with a fractional exponent. Log Transformation is Useful for enhancing details in the darker regions of the image at the expense of detail in the brighter regions the higher-level values. For an image having a washed-out appearance, a compression of gray levels is obtained using a power-law transformation with γ greater than 1. The histogram of an image (i.e., a plot of the gray level frequencies) provides important information regarding the contrast of an image. Histogram equalization is a transformation that stretches the contrast by redistributing the gray-level values uniformly. Only the global histogram equalization can be done completely automatically.

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