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RESEARCH PROSPECTS IN DIGITAL IMAGE PROCESSING

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Abstract:
Digital image processing is the use of computer algorithms to perform image processing on digital images. It allows a much wider range of algorithms to be applied to the input data and can avoid problems such as the build-up of noise and signal distortion during processing. As raw data from imaging sensors contains deficiencies, to get over such flaws and to get originality of information, it has to undergo various phases of processing. The three general phases that all types of data have to undergo while using digital technique are pre-processing, enhancement and information extraction. Since images are defined over two dimensions, digital image processing may be modeled in the form of Multidimensional Systems. It has got its application in computerized photography, Space image processing, Medical/Biological image processing, Automatic character recognition, finger print/face/iris recognition, Remote sensing, Reconnaissance and industrial Applications. There are more research prospects in these areas to make the process efficient, reliable and faster and that is the core idea of this paper.

Key Words: Enhancement, Segmentation, Feature & Filter

1. Introduction:

Pictures are the most common and suitable means of conveying information. A picture is worth a thousand words. Pictures succinctly express information about positions, sizes and inter-relationships between objects. They portray spatial information that we can recognize as objects. Human beings are good at deriving information from such images, because of the innate visual and mental abilities. About 75% of the information received by human is in pictorial form. Image processing is a means to perform some operations on an image, in order to get an enhanced image or to extract some useful information from it. It is a type of signal processing in which input is an image and output may be image or characteristics/features associated with that image [1]. Nowadays, image processing is among rapidly growing technologies. It forms core research area within engineering and computer science disciplines too. Digital image processing techniques help in manipulation of the digital images by using computers. The three general phases that all types of data have to undergo while using digital technique are pre-processing, enhancement, information extraction. This paper has been organized as follows: Section 2 describes the image pre-processing, section 3 explains image segmentation, section 4 says about feature extraction, a comparative study is made in section 5, image processing applications are conveyed in section 6 and section 7 concludes this paper with direction to future research.

2. Image Pre-Processing:

A number of image processing techniques can be applied to extract useful data from the images. Techniques that can be applied for such purpose are enhancement, convolution edge detection, mathematical processing, filters, trend removal, and image analysis. Image pre-processing is the term for operations on images at the lowest level of abstraction. These operations do not increase image information content but they decrease it if entropy is an information measure [2, 3]. The main aim of pre-processing is an improvement of the image data that suppresses undesired distortions or enhances some image features relevant for further processing and analysis task. Image pre-processing uses the redundancy in images. Neighboring pixels corresponding to one real object have the same or similar brightness value. If a distorted pixel can be picked out from the image, it can be restored as an average value of neighboring pixels. Image pre-processing methods can be classified into categories according to the size of the pixel neighborhood that is used for the calculation of new pixel brightness.

Image enhancement: Image enhancement is the process of making the information more visible. The enhancement technique differs from field to field according to its objective. The main objective is to process an image so that the result is more suitable than the original image for a specific application. This can be classified into two categories: Spatial Domain and Frequency domain enhancement [4].

Spatial Domain: Spatial domain methods are procedures that operate directly on the pixels. Spatial domain processes will be denoted by the expression,

$$g(x,y) = T[f(x,y)]$$

Where f (x, y) is the input image, g (x, y) is the processed image and T is some operator defined over some neighbourhood of (x, y).

Point Processing: The simplest spatial domain operations occur when the neighbourhood is simply the pixel itself. In this case T is referred to as a grey level transformation function or a point processing operation Point processing operations take the form

$$\mathbf{S = T\,(r)}$$

Where s refers to the processed image pixel value and r refers to the original image pixel value. Negative images are useful for enhancing white or grey detail embedded in dark regions of an image. Thresholding transformations are particularly useful for segmentation in which we want to isolate an object of interest from a background

$$S = \begin{cases} 1.0 & r > threshold \\ 0.0 & r \leq threshold \end{cases}$$

Basic Grey Level Transformations:

- ✓ There are many different kinds of grey level transformations

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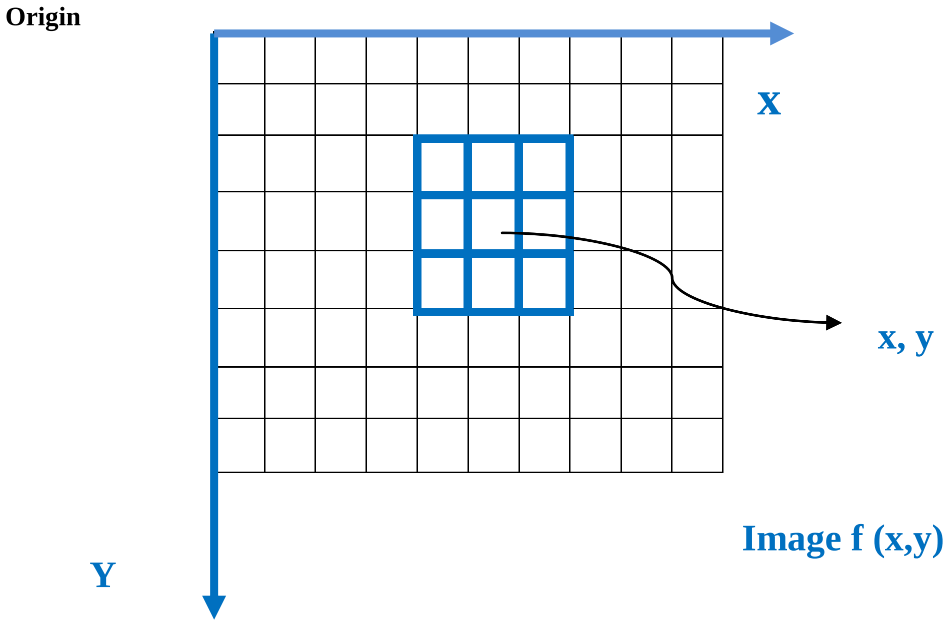
- ✓ Three of the most commonly used transformations are:



- **Linear:** Negative/Identity
- **Logarithmic:** Log/Inverse log
- **Power Law:** n^{th} power/n^{th} root

Logarithmic Transformations: The general form of the log transformation is

- ✓ s = c * log(1 + r)
- ✓ The log transformation maps a narrow range of low input grey level values into a wider range of output values
- ✓ The inverse log transformation performs the opposite transformation

Log functions are particularly useful when the input grey level values may have an extremely large range of values

Power Law Transformations: Power law transformations have the following form

$$s = c * r^{y}$$

Map a narrow range of dark input values into a wider range of output values or vice versa Varying γ gives a whole family of curves.

Frequency Transformation: In frequency transformation, fourier transformation of the image is computed first. Then the enhancement is performed and finally inverse fourier transformation is computed to get the resultant image.

G(u,v) = H(u,v) F(u,v)
G – Enhanced Image
H – Transfer function
F - Original Image

The concept of filtering is easier to visualize in frequency domain. This can be used for image enhancement. Filtering can be divided into two categories namely:

- ✓ Low pass filtering
- ✓ High pass Filtering

Edges and sharp transitions in gray values in images contribute significantly to the high frequency content of the fourier transformation. Regions of relatively uniform gray values in an image contribute to low frequency content of the fourier transformation.

Low Pass Filtering: Image can be smoothed in the frequency domain by attenuating the high frequency content of the fourier transform. This would be the low pass filter.

An ideal low pass filter of with cutoff frequency r_0 is given by

$$H(u,v) = \begin{cases} 1 \ if \ \sqrt{u^2+v^2} \leq r_0 \\ 0 \ if \ \sqrt{u^2+v^2} > r_0 \end{cases}$$

The cutoff frequency of the LPF determines the amount of frequency components passed by the filter.

Butterworth Lass Pass Filtering: The two-dimensional butter worth low pass filter has the transformation function.

$$H(u,v) = \frac{1}{1+\left[\frac{\sqrt{u^2+v^2}}{r_0}\right]}2n$$

r_0 cuttoff frequency & n filter order

Gaussian Low Pass Filtering: The form of the Gaussian low pass filter in two dimension is given by:

$$H(u,v) = e^{D^{2(u,v)/2\sigma^2}}$$

$$D(u, v) = \sqrt{u^2 + v^2}$$

Where D is the distance from the original frequency domain.

High Pass Filtering: An image can be smoothed in the frequency domain by attenuating the low f. An ideal high pass filter of with cutoff frequency r_0 is given by

$$H(u, v) = \begin{cases} 1 \; if \; \sqrt{u^2 + v^2} \leq r_0 \\ 0 \; if \; \sqrt{u^2 + v^2} > r_0 \end{cases}$$

Butterworth High Pass Filtering: The two-dimensional butter worth high pass filter has the transformation function.

$$H(u, v) = \frac{1}{1 + \left[\frac{\sqrt{u^2 + v^2}}{r_0}\right]} 2n$$

r_0 cuttoff frequency & n filter order

3. Image Segmentation:

Image segmentation is one of the most critical tasks in automatic image analysis. Segmentation consists of subdividing an image into its constituent part and extracting those of interest. Many techniques for global thresholding have been developed over the years to segment images and recognize patterns but the error on the segmentation leads to misclassification. The outcome of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image. Each of the pixels in a segment are similar with respect to some characteristic or computed property, such as color, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristic(s).

Basic Methods:

- ✓ Point, Line, Edge Detection
- ✓ Thresholding
- ✓ Region Growing
- ✓ Morphological Watersheds

Advanced Methods:

- ✓ Clustering
- ✓ Model Fitting.
- ✓ Probabilistic Methods

4. Image Feature Extraction:

In image processing feature extraction starts from an initial pixels and builds features intended to be informative and non-redundant, facilitating learning process. Feature extraction is related to dimensionality reduction. A lot of features can be extracted from an image. From the extracted features, the subset of efficient features can be selected which are the representations of the image. The selected features are expected to contain the relevant information from the input image data. This process is called feature selection. Low-level features are those basic features that can be extracted automatically from an image without any spatial relationships. As such, thresholding is a form of low-level feature extraction performed as a point operation. There are two main areas of feature extraction. The traditional approaches aim to derive local features by measuring specific image properties. The main target has been to estimate curvature: peaks of local curvature are corners, and analysing an image by its corners is especially suited to images of artificial objects. The second area includes more modern approaches that improve performance by using region or patch-based analysis. The scale invariant feature transform (SIFT) [5, 6] aims to resolve many of the problems in low-level feature extraction and their use in matching images. The new saliency operator [7] was also motivated by the need to extract robust and relevant features. High-level feature extraction concerns finding shapes in computer images. To be able to recognize faces automatically, for example, one approach is to extract the component features. This requires extraction of, say, the eyes, the ears and the nose, which are the major facial features. To find them, one can use their shape: the white part of the eyes is ellipsoidal; the mouth can appear as two lines, as do the eyebrows. Shape extraction implies finding their position, their orientation and their size. This feature extraction process can be viewed as similar to the way in which one perceives the world: many books for babies describe basic geometric shapes such as triangles, circles and squares. More complex pictures can be decomposed into a structure of simple shapes. In many applications, analysis can be guided by the way in which the shapes are arranged. For the example of face image analysis, eyes above (and either side of) the nose, and the mouth below the nose. In feature extraction, seek invariance properties so that the extraction process does not vary according to chosen (or specified) conditions. That is, techniques should find shapes reliably and robustly whatever the value of any parameter that can control the appearance of a shape.

5. Comparative Study:

This section briefly describes the purpose of the above mentioned methods:

Phase in Image Processing	Techniques	Purpose
Image Preprocessing	Image enhancement using Filters	To remove noise and make the image more suitable than the original image for a specific application.
Image Segmentation	Point, line, edge detection Thresholding Region growing Morphological watersheds Clustering Model fitting. Probabilistic methods	To extract area of interest/region of intrest for further analysis.

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Image Feature Extraction	Low-level features Without using spatial Information High level features	To analyse the segmented portion

6. Applications of Image Processing:

Visual information is the most important type of information perceived, processed and interpreted by the human brain. One third of the cortical area of the human brain is dedicated to visual information processing. Digital image processing, as a computer based technology, carries out automatic processing, manipulation and interpretation of such visual information, and it plays an increasingly important role in many aspects of our daily life, as well as in a wide variety of disciplines and fields in science and technology, with applications such as [8,9]:

- ✓ Computerized photography
- ✓ Space image processing (e.g., interplanetary probe images)
- ✓ Medical/Biological image processing (e.g., interpretation of Xray images)
- ✓ Automatic character recognition (zip code, license plate recognition)
- ✓ Finger print/face/iris recognition
- ✓ Remote sensing: aerial and satellite image interpretations
- ✓ Reconnaissance
- ✓ Industrial applications (e.g., product inspection/sorting)

7. Conclusion:

This paper dealt with the image processing research areas (i.e) various techniques and the application areas in which those could be applied. To make any contribution in the field of image processing, one has to do literature review for a particular technique in the particular application area. Then make comparative analysis and propose a method in that particular domain. New qualities that are brought to imaging systems by digital computers are: Digital computers integrated into imaging systems enable them to perform not only element-wise and integral signal transformations such as spatial and temporal Fourier analysis, signal convolution and correlation that are characteristic for analog optics but any operations needed. Acquiring and processing quantitative data contained in images as signals, and connecting imaging systems to other informational systems and networks is most natural when data are handled in digital form. The only limitations of digital imaging and image processing are memory and processing speed capacities of computers.

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