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Digital Image Processing Technology based on MATLAB

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Abstract: Principle objective of Digital Image processing(DIP) so that result is more suitable than original image for specific application. Digital image processing techniques provide a multitude of choices for improving the visual quality of images (e.g. image enhancement , images segmentation , images registration) . Appropriate choice of such techniques is greatly influenced by the imaging modality, task at hand and viewing conditions. This paper will provide a combination of two concepts, image enhancement and images segmentation . This paper is an application of digital image processing technology based on MATLAB.

***Keywords*:** MATLAB， DIP, Image Enhancement , Images Segmentation , Images Registration. EM

I. INTRODAUCTION

What Is Digital Image Processing?

An image may be defined as a two-dimensional function, f(x, y), where x and y are spatial (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 .When x, y, and the amplitude values of f are all finite, discrete quantities, we call the image a digital image .The field of digital image processing refers to processing digital images by means of a digital computer. Note that a digital image is composed of a finite number of elements, each of which has a particular location and value .These elements are referred to as picture elements, image elements, pels, and pixels. Pixel is the term most widely used to denote the elements of a digital image.

Vision is the most advanced of our senses, so it is not surprising that images play the single most important role in human perception. However, unlike humans, who are limited to the visual band of the electromagnetic (EM) spectrum , imaging machines cover almost the entire EM spectrum, ranging from gamma to radio waves .They can operate on images generated by sources that humans are not accustomed to associating with images. These include ultrasound ,electron microscopy, and computer-generated images . digital image processing encompasses a wide and varied field of applications.

There is no general agreement among authors regarding where image processing stops and other related areas, such as image analysis and computer vision, start. Sometimes a distinction is made by defining image processing as a discipline in which both the input and output of a process are images .We believe this to be a limiting and somewhat artificial boundary. For example, under this definition, even the trivial task of computing the average intensity of an image (which yields a single number) would not be considered an image processing operation. On the other hand, there are fields such as computer vision whose ultimate goal is to use computers to emulate human vision, including learning and being able to make inferences and take actions based on visual inputs .This area itself is a branch of artificial intelligence (AI) whose objective is to emulate human intelligence .The field of AI is in its earliest stages of infancy in terms of development, with progress having been much slower than originally anticipated. The area of image analysis (also called image understanding) is in between image processing and computer vision.

There are no clear-cut boundaries in the continuum from image processing at one end to computer vision at the other. However, one useful paradigm is to consider three types of computerized processes in this continuum: low-, mid-, and high-level processes. Low-level processes involve primitive operations such as image preprocessing to reduce noise, contrast enhancement, and image sharpening . low-level process is characterized by the fact that both its inputs and outputs are images. Mid-level processing on images involves tasks such as segmentation (partitioning an image into regions or objects), description of those objects to reduce them to a form suitable for computer processing, and classification (recognition) of individual objects . A mid-level process is characterized by the fact that its inputs generally are images, but its outputs are attributes extracted from those images (e.g., edges, contours, and the identity of individual objects). Finally, higher-level processing involves "making sense" of an ensemble of recognized objects, as in image analysis, and, at the far end of the continuum, performing the cognitive functions normally associated with vision.

Based on the preceding comments, we see that a logical place of overlap between image processing and image analysis is the area of recognition of individual regions or objects in an image. Thus, what we call in this Search digital image processing encompasses processes whose inputs and outputs are images and, in addition, encompasses processes that extract attributes from images, up to and including the recognition of individual objects. As a simple illustration to clarify these concepts, consider the area of automated analysis of text. The processes of acquiring an image of the area containing the text, preprocessing that image, extracting (segmenting) the individual characters, describing the characters in a form suitable for computer processing, and recognizing those individual characters are in the scope of what we call digital image processing in this Search. Making sense of the content of the page may be viewed as being in the domain of image analysis and even computer vision, depending on the level of complexity implied by the statement "making sense." As will become evident shortly, digital image processing, as we have defined it, is used successfully in a broad range of areas of exceptional social and economic value

.The concepts developed in the following chapters are the foundation for the methods used in those application areas.

II. IMAGE PROCESSING OPERATIONS:-

(A) Image Restoration
(B) Image Enhancement
(C) Image Classification
(D) Image Analysis

(A)Image Restoration:
In many applications (e.g., satellite imaging, medical imaging, and astronomical imaging) the imaging system introduces a slight distortion. Often images are slightly blurred and image restoration aims at declaring the image. These operations aim to correct distorted or degraded image data to create a more faithful representation of the original scene. This typically involves the initial processing of raw image data to correct for geometric distortions, to calibrate the data radiometrically , and to eliminate noise present in the data. Thus, the nature of any particular image restoration process is highly dependent upon the characteristics of the sensor used to acquire the image data. Image rectification and restoration procedures are often termed preprocessing operations because they normally precede further manipulation and analysis of the image data to extract specific information. For that a large number of restoration techniques will be used in this framework. They will help people to recover images of different kind. Also it is useful to select the suitable restoration method (Lillesand, et al, 1994).

(B) Image Enhancement:
In order to aid visual interpretation, visual appearance of the objects in the image can be improved by image enhancement techniques such as grey level stretching to improve the contrast and spatial filtering for enhancing the edges (Fig 1). The objective of image enhancement procedures is to improve the visual interpretability of any image by increasing the apparent distinction between the features in the scene. Hence anew image would be created from the original image in order to increase the amount of information that can be visually interpreted from the data. Enhancement operations are normally applied to image data after the appropriate restoration procedures have been performed. Noise removal, in particular, is an important precursor to most enhancements .

Before Linear Stretch After Linear Stretch

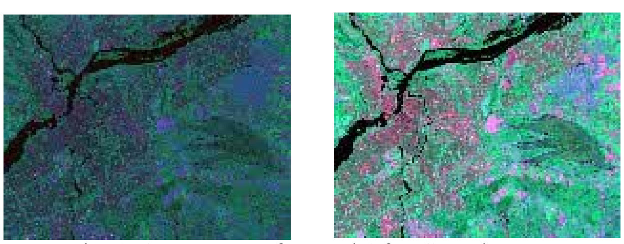


Fig. 1. An Image Before and After Stretch

Typical image enhancement techniques are as grey level and contrast. Grey level procedure is used to segment an input image into two classes. One for those pixels having values below an analyst defined gray level and one for those above this value. Grey level thresholding is a simple lookup table, which partitions the gray levels in an image into one or two categories (those below a user-selected threshold and those above). Thresholding is one of many methods for creating a binary mask for an image. Such masks are used to restrict subsequent processing to a particular region within an image. While in case of contrast most satellites and airborne sensor were designed to accommodate a wide range of illumination conditions, from poorly lit arctic regions to high reflectance desert regions. The pixel values in the majority of digital scenes occupy a relatively small portion of the possible range of image
values. If the pixel values are displayed in their original form, only a small range of gray values will be used, resulting in a low contrast display on which similar features night is indistinguishable (Sabins, 2000).

(C) Image Classification:
Image classification is the process of assigning classes to pixels in a remotely sensed data (Bortolot, 1999). Image classification is a means to convert spectral raster data into a finite set of classifications that represent the surface types seen in the imagery. These may be used to identify vegetation types, anthropogenic structures, mineral resources, or transient changes in any of these properties. Additionally, the classified raster image can be converted to vector features (e.g. polygons) in order to compare with other data sets or to calculate spatial attributes.
The role of the image classification process is to categorize all pixels in a digital image, into one of several land cover classes, or themes. This categorized data may then be used to produce thematic maps of the land cover present in an image. Normally, multispectral data are used to perform the classification and the spectral pattern present within the data for each pixel is used as the numerical basis for categorization (Fig 2.). Thus image classification is to identify and portray, as a unique gray level (or color), the features occurring in an image in terms of the object or type of land cover these features actually represent on the ground. The results of image classification are rarely perfect. Numerous factors affect the classification results, which are the objective of the classification, spectral and spatial characteristics of the data, the timeframes of the data, the natural variability of terrain conditions in the geographic region, and the digital classification technique employed Image classification is may be the most important part of digital image analysis. Image classification is conducted in two modes supervised and unsupervised.

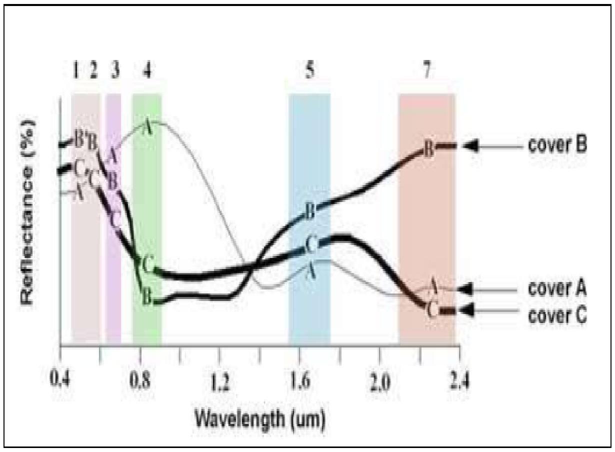


Figure 2. Example of the Land cover

a. Supervised Classification:

Supervised classification identifies examples of the information classes of interest in the image. Or a supervised classification requires the manual identification of known surface features within the imagery and then using a statistical package to determine the spectral signature of the identified feature. The spectral fingerprints of the identified features are then used to classify the rest of the image. These are called training sites. The image processing software system is then used to develop a statistical characterization of the reflectance for each information class.

This stage is often called (signature analysis) (Fig 3), and may involve developing a characterization as simple as the mean or the range of reflectance on each bands, or ascomplex as detailed analyses of the mean, variances and covariance over all bands. Once a statistical characterization has been achieved for each information class, the image is then classified by examining the reflectance for each pixel and making a decision about which of the signatures it resembles most (Eastman, 1995).

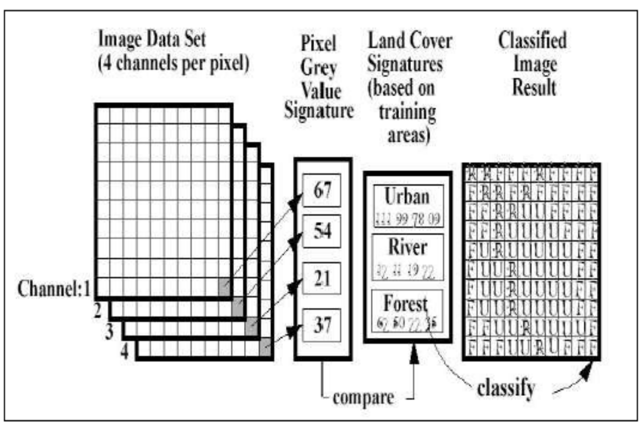


Figure 3 :steps in supervised classification

b. Unsupervised Classification:

Unsupervised classification uses spatial statistics (e.g. the ISODATA algorithm) to classify the image into a predetermined number of categories (classes). These classes are statistically significant within the imagery, but may not represent actual surface features of interest. Unsupervised classification examines large number of unknown pixels and divides into a number of classed based on natural groupings present in the image values. Unlike supervised classification, unsupervised classification does not require analyst-specified training data. The basic premise is that values within a given cover type should be close together in the measurement space (i.e. have similar gray levels), whereas data in different classes should be comparatively well separated, (i.e. have very different gray levels). The classes that result from unsupervised classification are spectral classes which based on natural groupings of the image values (Fig 4). The identity of the spectral class will not be initially known, mustcompare classified data to some form of reference data (such as larger scale imagery, maps, or site visits) to determine the identity and informational values of the spectral classes. Unsupervised classification is becoming increasingly popular in agencies involved in long term GIS database maintenance. The reason is that there are now systems that use clustering procedures that are extremely fast and require little in the nature of operational parameters. Thus it is becoming possible to train GIS analysis with only a general familiarity with remote sensing to undertake classifications that meet typical map accuracy standards. With suitable ground truth accuracy assessment procedures, this tool can provide a remarkably rapid means of producing quality land cover data on a continuing basis.

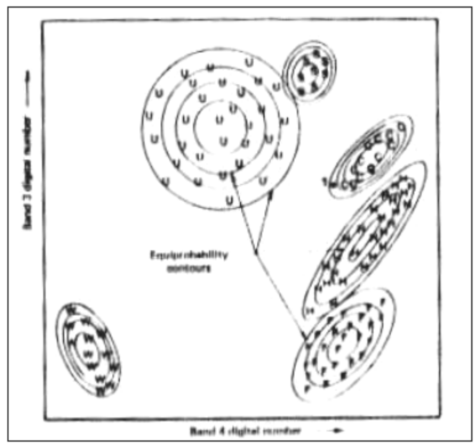


Figure 4 :unsupervised classification

Sometimes both classification modes are applied simultaneously to make the process more efficient and accurate. Such classification process is known as hybrid classification .

(D)Image Analysis:

Image analysis is the extraction of meaningful information from images, mainly from digital images by means of digital image processing techniques. Image analysis tasks can be as simple as reading bar coded tags or as sophisticated as identifying a person from their face. Computers are indispensable for the analysis of large amounts of data, for tasks that require complex computation, or for the extraction of quantitative information.

On the other hand, the human visual cortex is an excellent image analysis apparatus,

especially for extracting higher-level information, and for many applications including medicine, security, and remote sensing human analysts still cannot be replaced by computers. For this reason, many important image analysis tools such as edge detectors and neural networks are inspired by human visual perception models.

- **Interpretation and analysis**

Interpretation and analysis of remote sensing imagery involves the identification and/or measurement of various targets in an image in order to extract useful information about them (Fig 5). Targets in remote sensing images may be any feature or object which can be observed in an image, and have the following characteristics:

A. Targets may be a point, line, or area feature. This means that they can have any form, from a bus in a parking lot or plane on a runway, to a bridge or roadway, to a large expanse of water or a field.

B. The target must be distinguishable; it must contrast with other features around it in the image.

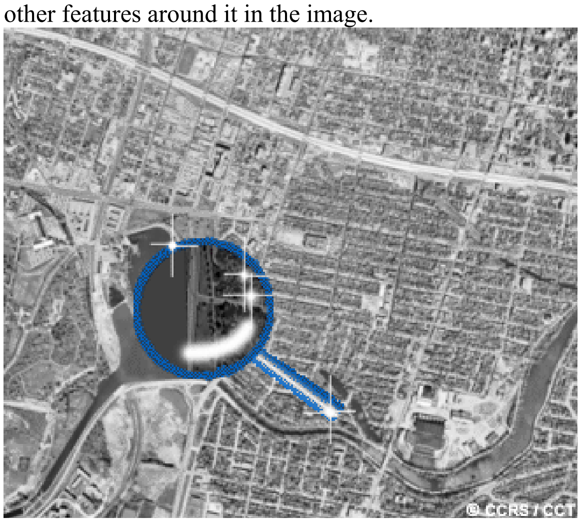


Figure 5: Extract Information

Much interpretation and identification of targets in remote sensing imagery is performed manually or visually, i.e. by a human interpreter. In many cases this is done using imagery displayed in a pictorial or photograph-type format, independent of what type of sensor was used to collect the data and how the data were collected. In this case we refer to the data as being in analog format.

Remote sensing images can also be represented in a computer as arrays of pixels, with eachpixel corresponding to a digital number, representing the brightness level of that pixel in the image. In this case, the data are in a digital format. Visual interpretation may also be performed by examining digital imagery displayed on a computer screen (Fig 6).

Figure 6: Digital Imagery Displayed On A Computer Screen

Both analogue and digital imagery can be displayed as black and white (also called monochrome) images, or as colour images by combining different channels or bands representing different wavelengths.

When remote sensing data are available in digital format, digital processing and analysis may be performed using a computer. Digital processing may be used to enhance data as a prelude to visual interpretation. Digital processing and analysis may also be carried out to automatically identify targets and extract information completely without manual intervention by a human interpreter. However, rarely is digital processing and analysis carried out as a complete replacement for manual interpretation. Often, it is done to supplement and assist the human analyst.

Manual interpretation and analysis dates back to the early beginnings of remote sensing for air photo interpretation. Digital processing and analysis is more recent with the advent of digital recording of remote sensing data and the development of computers. Both manual and digital techniques for interpretation of remote sensing data have their respective advantages and disadvantages. Generally, manual interpretation requires little, if any, specialized equipment, while digital analysis requires specialized, and often expensive, equipment.

Manual interpretation is often limited to analyzing only a single channel of data or a single image at a time due to the difficulty in performing visual interpretation with multiple images. The computer environment is more amenable to handling complex images of several or many channels or from several dates. In this sense, digital analysis is useful for simultaneous analysis of many spectral bands and can process large data sets much faster than a human interpreter. Manual interpretation is a subjective process, meaning that the results will vary with different interpreters. Digital analysis is based on the manipulation of digital numbers in a computer and is thus more objective, generally resulting in more consistent results. However, determining the validity and accuracy of the results from digital processing can be difficult.

It is important to reiterate that visual and digital analyses of remote sensing imagery are not mutually exclusive. Both methods have their merits. In most cases, a mix of both methods is usually employed when analyzing imagery. In fact, the ultimate decision of the utility and relevance of the information extracted at the end of the analysis process still must be made by humans.

- **Crossing Analysis**

The Cross operation performs an overlay of two raster maps: pixels on the same positions in both maps are compared; the occurring combinations of class names, identifiers or values of pixels in the first input map and those of pixels in the second input map are stored. These combinations give an output cross map and a cross table. The cross table includes the combinations of input values, classes or IDs, the number of pixels that occur for each combination and the area for each combination.

III. DIGITAL IMAGE PROCESSING TECHNOLOGY BASED ON MATLAB

A. Image enhancement technique

B. Image segmentation techniques

A.Image enhancement technique

Image enhancement is according to specific requirements to point highlight certain information at the same time, to weaken or remove some unwanted information, the purpose is to make the processed image more effective. It can be divided into two kinds: one kind is processing frequency domain method; the other kind is processing space method.

a. Histogram processing

(1)The meaning of histogram equalization

Equilibrium： Histogram of the image is flat, namely the emergence of each gray level with the same frequency;

Equalization: To amend the histogram of original image through the transformation function to uniform histogram;

The image looks more clearly after the equalization **.**

$s = T(r) \quad 0 \le r \le 1$

Satisfy the following conditions:

a. T(r) in the range$0 \le r \le 1$ is the single value and monotone increasing;

b.When $0 \le r \le 1$, $0 \le T(r) \le 1$

A grayscale image can be treated as random variables between [0, 1], the Pr (s) and Ps (s) respectively shows random variable r and s of probability density function.

If Pr(s) and T(r) is known, the results are as follows: the Ps(s)=Pr(r)|dr/ds| ;s probability density function is decided by the probability density function of input function and transformation function of the choice. As shown in figure 1.

To reduce the image grayscale for contrast increases, the original image as a frequency of the smaller grayscale is classed inside a few or a grayscale, so no enhancement.

If these details of grayscale images are more important, we need to adopt local area histogram equalization to balance

(1)Write the initial graphics and image grayscale,

fj， j=0,1,…,k,…,L-1;

(2)Statistic each grayscale pixel number, nj ， j=0,1,,…,k,…,L-1;

(3)Calculate the initial graphics and image histogram Pf (fj) = nj/n, n for initial image total number of pixels;

(4)Calculate the cumulative distribution function ,c(f)；

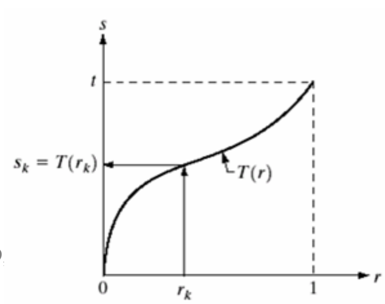
(5)Transfer function are used to calculate the grayscale after mapping,

gi=INT[(gmax - gmin)c(f)+gmin+0.5]

(6)Statistics all the number of pixel grayscale after the mapping, ni, i=0,1,…,p-1;

(7)Calculate the output of graphics and image of the histogram, Pg(gi)= nj/n，i=0,1,…,p-1;

(8)With fj and gi mapping relation, rewrite the original graphics and image grayscale, obtain the output image histogram approximation is uniformly distributed, Figure 7, comparison before and after the histogram equalization transformation.



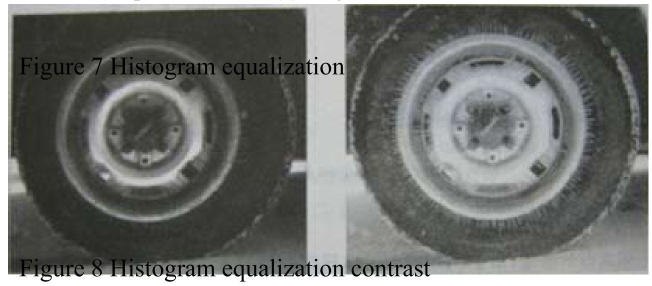


Figure 7 Histogram equalization

Figure 8 Histogram equalization contrast

B. Image segmentation techniques of MATLAB

As the first step in image analysis, image segmentation is the basis of computer vision, is a key step in image processing, often used for image compression and recognition.

- Image edge connection and segmentation

According to the different applications, it can be divided into coarse segmentation and fine segmentation. Based on the segmentation of compression and coding, the purpose is to get the color of the regional information is consistent, in order to promote the efficiency in the area code. If the same area contains a lot of changes in the details, image requires fine segmentation.

- Domain image segmentation techniques

From the edge of the fuzzy judgment connection and segmentation technique is mainly contains multiple (two or more than two) sub image and image in the whole domain of graphics and images. As shown in figure 9:

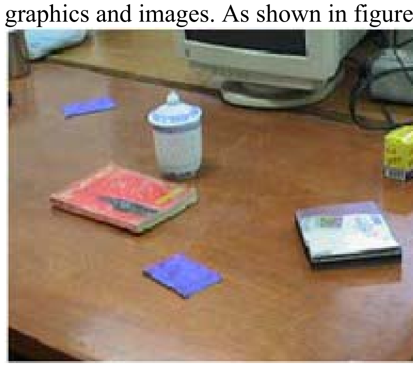


Figure 9: Artwork of books and cups

We have to introduce the concept of global image, defined as follows:

$$f(x,y) = \sum_{i=1}^{R} fi\,(x, y)$$

and *f* (*x* , *y*) *i* is mutually disjoint

Among them, f(x,y)is the input graphics and image data, namely the full domain image, fi(x,y) is the sub image ,namely the whole domain graphics and images, which is the son of graphics and image and set, and all the sub image do not overlap. In figure 3, the tea cup, books, blue color piece, the ink bottle, PC, etc is the child of the target image, the set of them constitutes the input graphics and images -- all domain image, and the mutually disjoint between each image. Global key technologies of image segmentation let each sub image form connections.

- Edge connection technology based on the fuzzy decision

As far as possible, edge connection obtain the closed edges of the target image, for accurate positioning, pattern recognition, etc .In order to get accurate edge profile, three factors must be considered: first is the selection principle of starting point;

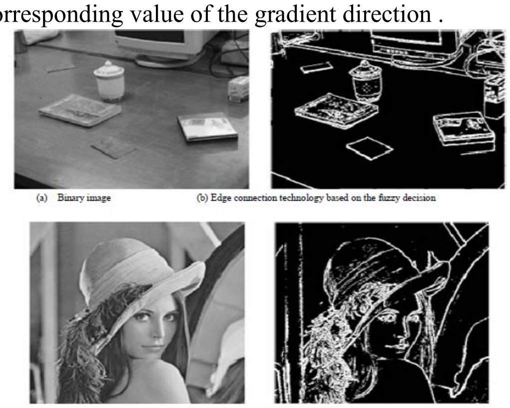
second is the selection criteria of outline of the intermediate point; third is the selection criteria of outline the endpoint.

The image edge fuzzy connection is based on the edge of the image fuzzy decision theory, gained by the Sobel operator of pixel, edge gradient magnitude and gradient direction of the edge of the similarity to connect. Similar with the basic principle of local processing and the edge of the method, the difference is that it did not give a definite threshold, but using of the theory of fuzzy membership function to judge the pixel gradient magnitude and the direction of the gradient similarity and known edge pixels, to overcome the shortcoming of the inaccurate method that distinct threshold extract the edge.

Consider (x, y) point of single pixel, set it as the initial edge pixels, use (x, y) as the center, to establish a 3 x3 neighborhood {structure (x + i, y + j) : i =? 1,... , 1; J =? 1,... , 1}, when (i, j) ≠ (0,0), we can according to the degree of similarity between the amplitude of Mag and the direction of the gradient φ to distinguish pixel (x + i, y + j) is connected to the (x, y) of edge pixels or not. Adopting the membership function of normal distribution, see below:

$$\mu_s((x+i, y+j)) = e^{-\sigma_s(t_s-\alpha_s)^2} \qquad s = Mag, \phi$$

In type, μs is pixels for (x + I, y + j) belongs to the pixels (x, y) are connected to the edge of the membership degree; t shows pixels (x + i, y + j) gradient amplitude or gradient direction; α shows pixels (x, y) gradient amplitude and gradient direction; σ is (x, y) three times the mean square of the gradient amplitude or the gradient direction in this field, when the subscript s = Mag, shows the corresponding value of the gradient amplitude, and when the subscript s=φ shows corresponding value of the gradient direction .



(a) Binary image (b) Edge connection technology based on the fuzzy decision

(c) lena binary image (d) Edge connection technology based on the fuzzy decision

Figure 3-6 Gray image and fuzzy judgment

I. ACKNOWLEDGMENT

Digital image processing is the use programming of computer to perform image processing on digital images. . Digital Image Processing with MATLAB fully integrates with Mathematic to offer more sophisticated analyses on the desktop than any standard image processing software. Designed for professionals and students, the package is the ideal framework for creating and automating custom analyses, prototyping procedures, and developing new algorithms. Today there is almost no area of technical endeavor that is not impacted in some way by digital image processing. The processing of images is faster and more cost-effective

Since MATLAB software was introduced in the mid 1980's, after years of development and perfection, it has become one of the best recognized, scientific computing and mathematical application software, it integrates numerical analysis, matrix computation, signal processing, and other functions.

This paper is an application of digital image processing technology based on MATLAB; this paper introduces the MATLAB image enhancement and image segmentation technology, inorder to lay a foundation for the future research and application

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