Applications of Mathematical Morphology in Image Processing: A Review

[1]Beant Kaur, [2]Sangeet Pal Kaur
[1,2]Dept. of ECE, University College of Engineering, Punjabi University, Patiala, Punjab, India

Abstract
Image processing plays an important role in today's world. It is a form of signal processing for which the input is an image and output will also be an image or any attribute. Different operations of image processing are geometric transformations such as enlargement, reduction and rotation, color corrections such as brightness and contrast adjustments, quantization, or conversion to a different color space, recovery of a full image from a raw image, format of image, image editing, image differencing, etc. Mathematical morphology is also one of the important terms in image processing. It deals with the science of shapes and geometrical structure. This paper shows the different application of mathematical morphology.

Keywords
Mathematical Morphology, Dilation, Erosion, License Plate, Structuring Element

I. Introduction

Mathematical Morphology is developed from set theory. It was introduced by Matheron as a technique for analyzing geometric structure of metallic and geologic samples. It was extended to image analysis by Serra [6]. Mathematical morphology provides an approach to the processing of digital images which is based on shapes [1]. Mathematical morphology refers to a branch of non-linear image processing and analysis that concentrates on the geometric structure within an image [2]. From a general scientific perspective, the word morphology refers to the study of forms and structures. In image processing morphology is the name of a specific methodology for analyzing the geometric structure inherent within an image [3]. The morphological filter, which can be constructed on the basis of the underlying morphological operations, are more suitable for shape analysis than the standard linear filters since the latter sometimes distort the underlying geometric form of the image. Some of the salient
points regarding the morphological approach are as follows [3]:

1. Morphological operations provide for the systematic alteration of the geometric content of an image while maintaining the stability of the important geometric characteristics.
2. There exists a well-developed morphological algebra that can be employed for representation and optimization.
3. It is possible to express digital algorithms in terms of a very small class of primitive morphological operations.
4. There exist rigorous representations theorems by means of which one can obtain the expression of morphological filters in terms of the primitive morphological operations.

Dilation and erosion are basic morphological processing operations. They are defined in terms of more elementary set operations, but are employed as the basic elements of many algorithms. Both dilation and erosion are produced by the interaction of a set called a structuring element with a set of pixels of interest in the image. The structuring element has both a shape and an origin.

II. Applications of Mathematical Morphology

Different applications of mathematical morphology are as follows:

A. Fingerprint Feature Extraction

Feature extraction stage is concerned with the finding and measuring important similarities of the fingerprint that will be used to match it [2]. Final goal of recognition system is to the two fingerprints one which is already stored in the memory system and other which is captured. Mathematical morphology is used in this application for the extraction purpose. Ridge ending and ridge bifurcation are some problems which occur in fingerprint pattern.

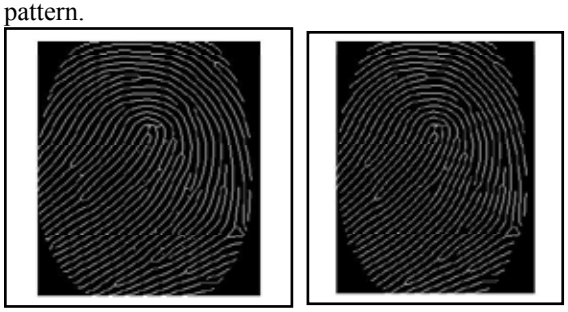

Fig. 1:(a) Thinned Image, (b) Spikes and Dots Removed Images Using Mathematical Morphology

B. Recognition of Handwritten Digits

Automatic handwriting recognition has a variety of applications at the interface between man and machine [4]. Handwritten recognition can be evaluated by different criteria like size of digit, reliability and speed of recognition but the recognition of handwritten digits is difficult because of high variability of the scanned image. Handwritten digit recognition can be classified into two categories: (1) Offline recognition, (2) On-line recognition. Offline recognition mainly processes and recognizes the user input handwritten digit which is based on the images. On-line recognition uses the geometry and temporal dynamics information of the user's input [4]. By using mathematical morphology with different operators and structuring elements, it is possible to recognize the hand written digits. Thinning process is also used to reduce the noise.

C. License Plate Detection

License Plate Recognition (LPR) is widely used in security and traffic installations. The technology concept assumes that all the vehicles already have the identity displayed [5]. The systems used for this purpose consist of illumination, camera and image processing software, used to extract the plate information. The license plate recognition system has advantage that the system can keep image record of the vehicle which is useful in order to fight crime and fraud [5]. License Plate recognition has many advantages like parking, access control, tolling, stolen cars, airport parking, etc. LPR consists of three steps: (1) license plate detection, (2) character segmentation, (3) optical character recognition. Different operators of morphology like erosion, dilation and opening are used for this kind of detection.

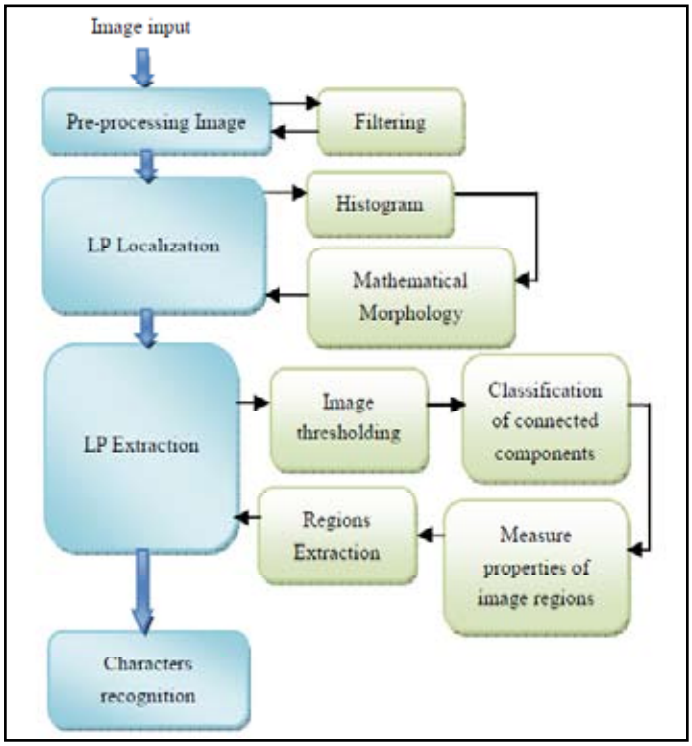

Fig. 2: License Plate System

Fig. 3(a): License Plate, (b) Extraction of License Plate

D. Border Extraction

Border extraction is one of the important functions for object identification and a pre-processing step in image segmentation and the final processed image is obtained by the detection of borders of the image. Multi-structure structuring elements in different directions are used for the border extraction. Different mathematical operators like closing, opening, dilation and erosion is used for this purpose. Subtraction of dilation and erosion used with the different structuring elements in multi directions results in the image which is border detection. Edge is one of the most important characteristics of images which include a large amount of valuable information. It is the response of discontinuous of partial characteristics of images, which also symbolizes an end of region and the beginning of another region [7].

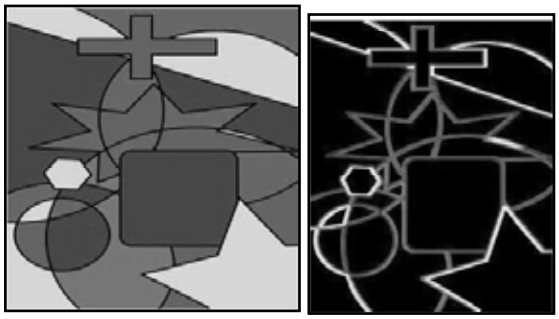

Fig. 4(a): Original Image, (b) Border Extraction Using Multi-Structure Elements

E. Denoising using Morphological Filters

Dilation removes the negative impulse and smoothes the positive impulse and Erosion removes the positive impulse and smoothes the negative impulse, opening removes the positive impulse and reserves negative impulse; closing removes the negative impulse and smoothes the positive impulse. Opening and closing combined calculations is often applied when the morphological is used. The main goal of morphological de-noising is to extract the impulse signal and depress the noise in the bearing testing signals, so the differential filter of morphological closing and opening is used for this purpose. So equation 1 is used as differential filter.

$$DIF(f) = f \bullet g - f \circ g \quad (1)$$

F. Text Extraction

Text extraction from images and video sequences finds many useful applications in document processing and detection of vehicle license plate, analysis of technical papers with tables, maps, charts, and electric circuits, identification of parts in industrial automation, and content- based image/video retrieval from image/ video databases [9]. Due to the variety of fonts, sizes, styles, orientations, alignment effects of uncontrolled illuminations, reflections, shadows, the distortion due to perspective projection as well as the complexity of image background, automatic localizing and extracting text is a challenging problem [9]. Flowchart used for text extraction is shown in fig. 5.

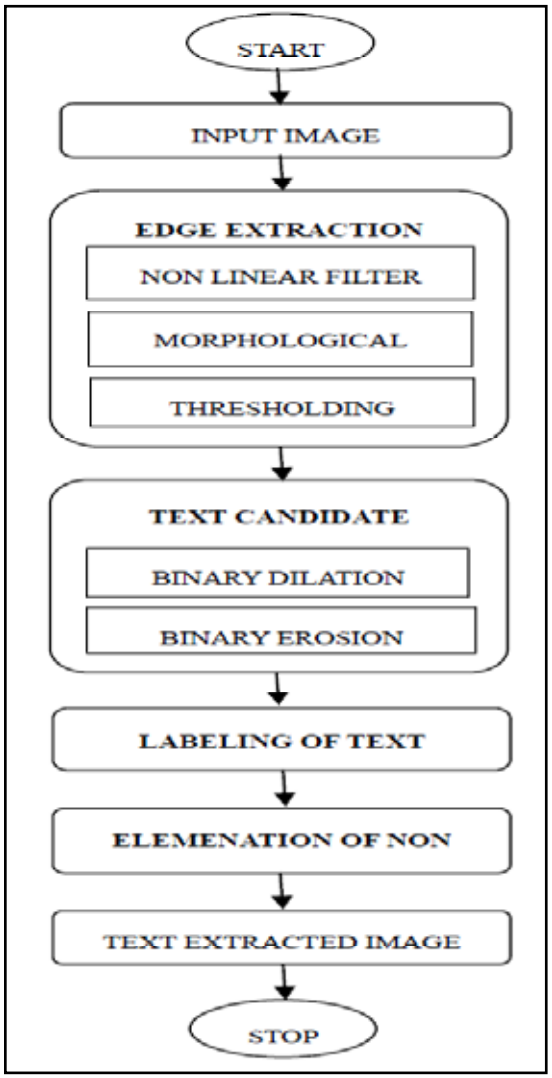

Fig. 5: Flowchart for Text Extraction Using Mathematical Morphology

G. Detection of Imperfection in Printed Circuit Boards

Morphological operators like dilation and erosion also make possible to identify the imperfections of the printed circuit boards [10]. The tested image is first converted into binary image and then morphological operators will apply on tested image and errors will be detected.

III. Conclusion

It has been concluded that mathematical morphology is an important tool used in image processing. It has many advantages. By using different morphological operators like erosion, dilation, opening, closing, etc. many algorithms come into existence and can be used in many applications like license plate recognition, character recognition, handwritten digits recognition, detection of imperfection in PCBs, text extraction.

References

[1] Robert M. Haralick, Stanley R. Sternberg,"Image analysis using Mathematical morphology", IEEE transactions on pattern analysis and machine intelligence, Vol. PAMI-9, No. 4, July 1987.

[2] Vikas Humbe, S.S. Gornale, Ramesh Manza, K.V. Kale,"Mathematical morphology approach for genuine fingerprint feature extraction", International Journal of Computer science and Security, Vol. 1, Issue 2.

[3] Wayne, Lin Wei-Cheng,"Mathematical morphology and its applications on image segmentation" , June 2000

[4] V Vijaya Kumar, A Srikrishna, B Raveendra Babu, M Radhika Mani,"Classification and recognition of handwritten digits by using mathematical morphology", Indian academy of Sciences, pp. 419-426 .

[5] Sami Ktata, Faouzi Benzarti, Hamid Amiri,"License Plate Detection using Mathematical Morphology", Sciences of Electronics, Technologies of Information and Telecommunications, 2012, pp. 1-5.

[6] M Rama Bai,"A New Approach for Border Extraction Using Morphological Methods", International Journal of Engineering Science and Technology, Vol. 2(8), 2010, pp. 3832-3837.

[7] Dawei Qi, Yuanxiang Li, Lei Yu,"The Application of Mathematical Morphological Optimization Algorithm in Edge Detection of Defected Wood Image", IEEE International Conference on Automation and Logistics Qingdao, China September 2008.

[8] Guan Zhen-Zhen, Huo Qian,"Application of Mathematics Morphological De-nosing in Fault State Identifying of Bearing", 2010 First International Conference on Pervasive Computing, Signal Processing and Applications.

[9] G. Rama Mohan Babu, P. Srimaiyee, A. Srikrishna, "Text Extraction From Hetrogenous Images Using Mathematical Morphology", Journal of Theoretical and Applied Information Technology.

[10] I. Bălan,"Using Mathematical Morphology to Detect the Imperfections of the Printed Circuit Boards", Journal of Applied Computer Science, No.1 (2) /2008, Suceava.