An Illustrative Analysis of Mathematical Morphology Operations for MRI Brain Images

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Abstract— **Mathematical morphology is an implement for extracting image components that are helpful in the demonstration and explanation of region shape, boundaries, skeletons, and convex hull. Morphological operations are used in pre and post processing for thinning, filtering. Morphology is a development method used to extract image meaningful. In this paper, study the different morphology methods that using in Gray Scale and Binary Dilation and Erosion.**

Keywords— **Image processing, Medical image, Enhancement, Mathematical Morphology, Histogram.**

I. INTRODUCTION

Magnetic resonance imaging (MRI) is a test that uses a magnetic field and pulses of radio wave energy to make pictures of organs and structures inside the body. In many cases MRI gives different information about structures in the body. It is used to find problems such as tumors, bleeding, injury, blood vessel diseases. MRI also may show problems that cannot be seen with other imaging methods [16].

The objective of image enhancement is to get better the image value so that image, processed is enhanced than the original image for a specific application or set of objectives. Image enhancement is an important area of image processing for both human and computer vision [5]. It is widely used for medical imaging and as pre-processing applications. Image enhancement processed consists of a collection of techniques that seek to improve the visual appearance of an image. The main reason of image enhancement is to carry out detail that is unknown in an. Enhancement is one of the most significant images processing technology which is essential to improve the visual form of the image representation in upcoming automated image processing such as image analysis, detection, segmentation and recognition.

Mathematical morphology is a method of nonlinear filters, which could be used for image processing, including noise suppression, feature extraction, edge detection, image segmentation, shape recognition, texture analysis, image restoration and reconstruction, image compression etc [1]. Mathematical morphology is a well recognized method for image analysis, which has found enormous applications in many areas, mainly image analysis.

This paper is organized as follows: section II presents Brain Image Enhancement, section III presents Mathematical Morphology, section IV presents additional basic operators, section V presents the Results and Analysis, section VI present the results and discussions, VII present the conclusion.

II. BRAIN IMAGE ENHANCEMENT

MRI of the brain is a safe and effortless test that uses a magnetic field and radio waves to create detailed images of the brain and the brain stem. MRI of the brain can be useful in evaluating problems such as persistent headaches, weak point, and blurry vision or seizures, and it can help to detect certain chronic diseases of the nervous system, such as multiple sclerosis [18][17].

Enhancement is the alteration of an image to adjust impact on the viewer. Generally enhancement alters the original digital values to bring out specific features of an image, and Highlight the certain characteristics of an image. The processed image result is more suitable than the original image for a specific application. A known technique for contrast enhancement of images is Histogram Equalization (HE). The most part of method is used, because of its simplicity and moderately better performed on the output images.
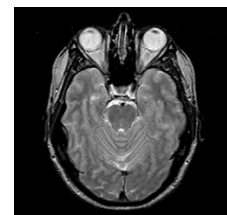

Fig. 1 MRI Brain Image

III. MATHEMATICAL MORPHOLOGY

Mathematical Morphology is developed from set theory. Morphology was originally developed for binary images, and was shortly extended to grayscale functions and images. Morphology is a broad set of image processing, process that process images supported on shapes [4]. Morphology is most commonly applied to digital images, but it can be employed as well on graphs, meshes, solids, and many other spatial structures.

Mathematical morphology is a way of nonlinear filters, which could be used for image processing as well as noise suppression, feature extraction, edge detection, image segmentation, shape recognition, texture analysis, image restoration and reconstruction, image compression etc [1]. Mathematical morphology provides an approach to the processing of digital images which is based on shapes [3].

Binary Dilation and Erosion, The places of black and white pixels represent an explanation of a binary image. The black pixels be considered and the others are treated as a background. The primary operations are Dilation and Erosion from these some complex operations such as opening and closing can be composed [8].

Gray scale Dilation and Erosion, in gray scale binary images are simply expandable to gray scale images using min, max operations. Erosion and dilation of an image the operation assigns to each pixel with minimum and maximum value create in the neighborhood of the matching pixel in the input image [8].

There are four basic operations of mathematical morphology: dilation, erosion, opening and closing. They have their own features in binary image and grayscale (multi-value) image.

Dilation is defined as the maximum value in the window. Hence the image after dilation will be brighter or increased in intensity. It also expands the image and mainly used to fill the spaces. Erosion is just opposite to dilation. It is defined as the minimum value in the window .The image after dilation will be darker than the original image. It shrinks or thins the image. Opening and closing both parameters are formed by using dilation and erosion. In opening, firstly image will be eroded and then it will be followed by dilation. In closing, the first step will be dilated and then result of this is followed by erosion [4].

A. Dilation Operation

Dilation operation is one of the bases of morphology processing. Dilation is the operation of "lengthening" or "thickening" in binary image. This special way and the extent of thickening are controlled by structural elements. Mathematically, dilation is defined as set operation. A is dilated by B, written as A B, is defined as [1]
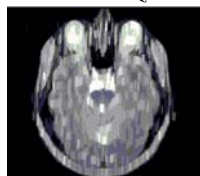
$$A \oplus B = \{z \mid (\hat{B})_z \cap A \neq \phi\}$$

Fig. 2 Dilate image

Among them, φ is for the empty set, B is for the structure element, and $\hat{B}$ is for the reflection of collection B. In short, that A is dilated by B is the set composed of the origin positions of all structural elements. After mapping and translation, B at least has one overlap with A [1][5].

B. Erosion operation

Erosion operation is also one of the bases of morphological processing. Erosion "shrinks" or "thins" the objects in binary image. As in the dilation, the way to shrink and the extent is controlled by a structure element. The mathematical definition of erosion is similar to dilation. A is eroded by B, recorded as AΘ B, and defined as [1]

$$A \ominus B = \{z \mid (B)_z \subseteq A\}$$

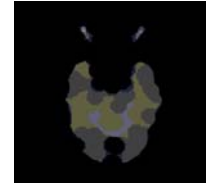
Fig. 3 Erosion image

Among them, φ is for the empty set, B is for the structural element, and Ac is in the supplement of collection A. In another word, that A is eroded by B is the set composed of the origin positions of all structural elements, in which the background of translation B does not overlay on A's [1][5].

C. operations of opening and closing

Opening operation generally makes the contour of objects smoother, and disconnects narrow, discontinuous and remove thin protrusions. Similarly with opening operation, closing operation also makes an outline smooth, but the opposite is that it usually eliminates discontinuity and narrows long, thin gap, clears up small holes, and fill the ruptures of the contour line [1].

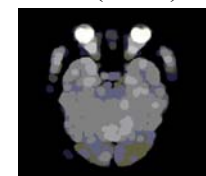$$A \circ B = (A \ominus B) \oplus B$$

Fig. 4 Open and closing

As the same case with binary image, opening operation first using b to erode f plainly, and then using b to do dilate operation on the results obtained [1][5].

D. Closing and opening operation

Also, using B to do closing operation on A, expressed as $A \bullet B$, definite as [1]

$$A \bullet B = (A \oplus B) \ominus B$$

Fig. 5 Closing and opening

$A \bullet B$ is a complement of all translation union of B that do not overlap A.

IV. ADITIONAL BASIC OPERATORS

Bwareaopen- Morphologically open binary image (remove small objects). It removes from a binary image all connected components (objects) that have fewer than P pixels, producing another binary image, BW2. The default connectivity is 8 for two dimensions, 26 for three dimensions, and conndef (ndims (BW), 'maximal') for higher dimensions. Figure.6, A shows the output areaopen image. **Bwhitmiss**- binary hit-miss operation. It performs the hit-miss operation defined by the structuring elements SE1 and SE2. The hit-miss operation preserves pixels whose neighborhoods match the shape of SE1 and don't match the shape of SE2. **Bwulterode**- Ultimate erosion. It computes the ultimate erosion of the binary image BW. The ultimate erosion of BW consists of the regional maxima of the Euclidean distance transform of the complement of BW. Figure.6, B shows the output ulterode image.

Imbothat- Bottom-hat filtering. It performs morphological bottom-hat filtering on the grayscale or binary input image, IM, returning the filtered image, IM2. Figure.6, C shows the output bothat image. **Imextendedmax**- Extended-maxima transform. It computes the extended-maxima transform, which is the regional maxima of the H-maxima transform. H is a nonnegative scalar. Regional maxima are connected components of pixels with a constant intensity value, and whose external boundary pixels all have a lower value [2]. Figure.6, D shows the output extendedmax image.

Imextendedmin- Extended-minima transform. The regional minima of the H-minima transform. h is a nonnegative scalar. Regional minima are connected components of pixels with a constant intensity value, and whose external boundary pixels all have a higher value [2]. **Imfill**- Fill image regions and holes. It displays the binary image BW on the screen and lets you define the region to fill by selecting points, BW must be a 2-D image [2]. It returns the locations of points selected interactively in locations, indices into the input image [2]. Figure.6, E shows the output imfill image.

Imimposemin- Impose minima. It modifies the intensity image I using morphological reconstruction so it only has regional minima wherever BW is nonzero. BW is a binary image the same size as I. Figure.6, F shows the output image. **Imclose**- Morphologically close image. It performs morphological closing on the grayscale or binary image IM, returning the closed image, IM2. The morphological close operation is a dilation followed by erosion, using same structuring element for both operations. Figure.6, G shows the output image.

Imtophat- Top-hat filtering. Top-hat filtering the grayscale or binary input image IM. Top-hat filtering computes the morphological opening of the image (using imopen) and then subtracts the result from the original image. imtophat uses the structuring element SE. Figure.6, H shows the output image. Bwmorph- Morphological operations on binary images. It applies a specific morphological operation to the binary image BW[6]. Applies the operation n times. The operation is repeated until the image no longer changes [15].

Bothat Performs the morphological "bottom hat" operation, returning the image minus the morphological closing of the image (dilation followed by erosion) [6][15]. Figure.6, I shows the output image. Branchpoints Branch points of skeleton [15][6]. Figure.6, J shows the output image.

Bridges unconnected pixels, that is, sets 0-valued pixels to 1 if they have two nonzero neighbors that are not connected [15][6]. Figure.6, K shows the output image. Clean Removes isolated pixels (individual 1s that are surrounded by 0s), such as the center pixel in this pattern [14][15]. Figure.6, L shows the output image. Diag-Diagonal fill to eliminate 8-connectivity of the background [15][9]. Figure.6, M shows the output image. Dilate-Performs dilation using the structuring element [14][6]. Figure.6, N shows the output image.

Endpoints- End points of skeleton [15][9]. Figure.6, O shows the output image. Fill- Fills isolated interior pixels (individual 0s that are surrounded by 1s), such as the center pixel in this pattern [14][6]. Figure.6, P shows the output image. Hbreak- Removes H-connected pixels [6][9]. Figure.6, Q shows the output image. Majority- Sets a pixel to 1 if five or more pixels in its 3-by-3 neighborhood are 1s; otherwise, it sets the pixel to 0 [15][6]. Figure.6, R shows the output image. Remove- Removes interior pixels. This option sets a pixel to 0 if all its 4-connected neighbors are 1, thus leaving only the boundary pixels on. Figure.6, S shows the output image.

Shrink- It removes pixels so that objects with holes shrink to a connected ring halfway between each hole and the outer boundary. Figure.6, T shows the output image. **Skel**- removes pixels on the boundaries of objects but does not allow objects to break apart. The pixels remaining make up the image skeleton. Figure.6, U shows the output image. **Spur**- Removes spur pixels. Figure.6, V shows the output image. **Thicken**- thickens objects by adding pixels to the exterior of objects until doing so would result in previously unconnected objects being 8-connected [6][15]. **Thin**- thins objects to lines. It removes pixels so that an object without holes shrinks to a minimally connected [9][15]. Figure.6, (w) shows the output image. **Tophat**- Performs morphological "top hat" operation, returning the image minus the morphological opening of the image (erosion followed by dilation) [6][14]. Figure.6, (x) shows the output image.

V. ANALYSIS AND RESULTS FOR BRAIN IMAGE

In this paper, we study about Mathematical Morphology based approach for contrast enhancement. The good contrast image is helpful for feature analysis and diagnosis. All the above methods are applied on brain MRI images. In below diagram Figure.6 shows the different images for Morphological methods.
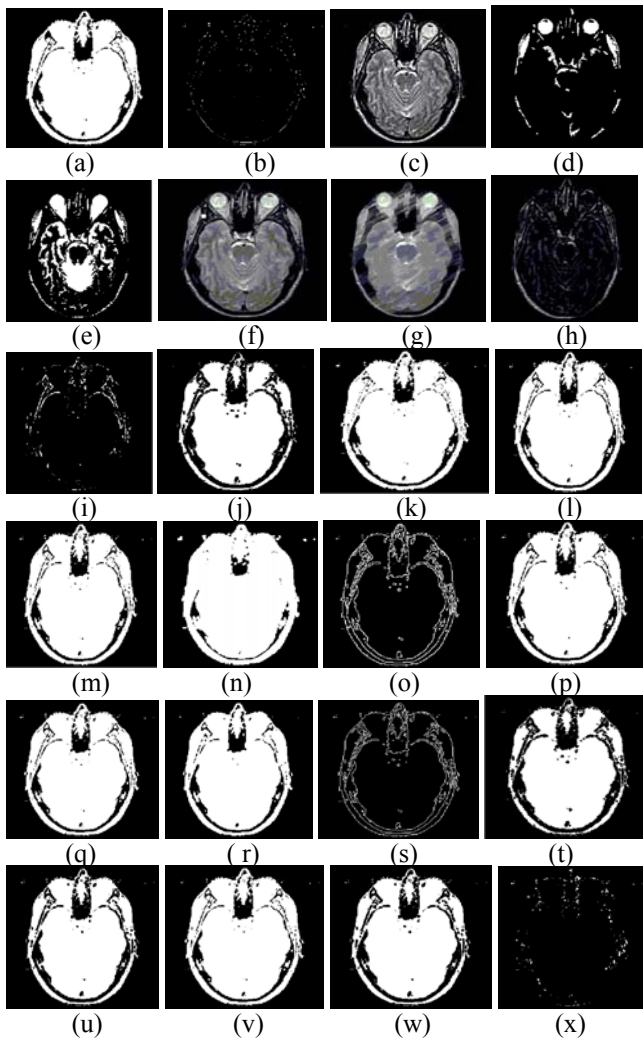
Fig. 6 (a) Bwareaopen image, (b) Bwulterode image, (c) Imbothat image, (d) Imextendedmax image, (e) Imfill image, (f) Imimposemin image, (g) Imclose image, (h) Imtophat image, (i) Bothat image, (j) Branchpoint image, (k) Bridge image, (l) Clean image, (m) Diag image, (n) Dilate image, (o) Endpoints image, (p)Fill image, (q) Hbreak image, (r) Majority image, (s) Remove image, (t) Shrink image, (u) Skel image, (v) Spur image, (w) Thin image, (x) Tophat image
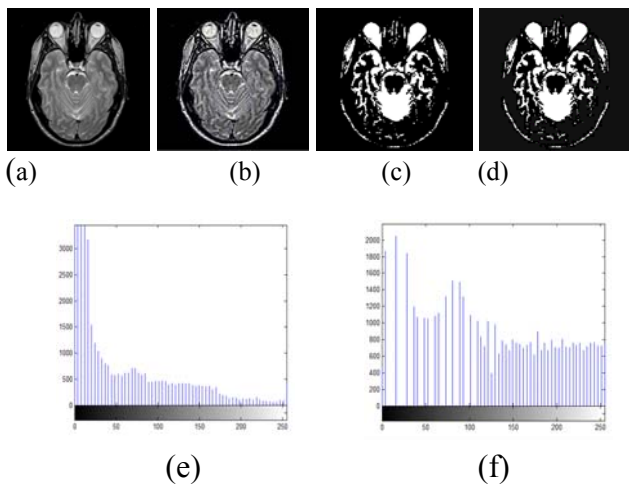
VI. RESULT AND DISCUSSION

Fig. 7 (a)(b) original image, (c)(d) HE image, (e) Histogram for image (c), (f) Histogram for image (d)

By using the above all methods we can develop the image which unidentified, through the output image by using the Histogram Equalization technique to equalize the image to improve the dynamic range to identify the tumors, In the above figure 7. (a) and (b) Shows the image and HE images its used to identify the hidden parts of the image.

VII. CONCLUSION

The mathematical morphological operations are applied to enhance the image contrast. It is useful for further broadly to the field of Medical image processing. In this paper various morphological operations using dilation and erosion to obtain new images for identifications of imperfections. It will show the clear spots of analysis to improve the image. The Applications of mathematical morphology give up a high value image and it expose most of the unidentified locations clearly. Mathematical morphology will be given more powerful results in the future.

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