Morphological Image Processing

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Abstract **- Morphological image processing (or morphology) describes various image processing operations which deal with the shape of features in an image [1–4]. These operations remove imperfections in the image and are applied on binary images. The shape features of the image (i.e., edges, holes, corners, cracks) can be extracted in this process using various shaped structuring elements...**

This process is used in many industrial computer vision applications such as recognition of objects, segmentation of images, and finding defects. This article presents an introduction to morphology and we will, discuss its operations and we will show how they work . We also talk about their advantages and disadvantages and general comparison , then we will show the MATLAB implementation and discuss the results .

Keywords— Morphology , Computer Vision, , Image Processing, Dilation , Erosion , Opening , Closing ,Grayscale , Top-hat .

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I. Introduction

The identification of objects within an image can be a very difficult task. One way to simplify the problem is to change the grayscale image into a binary image, in which each pixel is restricted to a value of either 0 or 1. The techniques used on these binary images go by such names as: blob analysis, connectivity analysis, and morphological image processing (from the Greek word morphē, meaning shape or form). The foundation of morphological processing is in the mathematically rigorous field of set theory; however, this level of sophistication is seldom needed. Most morphological algorithms are simple logic operations and very ad hoc. In other words, each application requires a custom solution developed by trial-and-error. This is usually more of an art than a science. A bag of tricks is used rather than standard algorithms and formal mathematical properties.

Morphological image processing is a collection of non-linear operations related to the shape or morphology of features in an image. According to Wikipedia, morphological operations rely only on the relative ordering of pixel values, not on their numerical values, and therefore are especially suited to the processing of binary images. Morphological operations can also be applied to greyscale images such that their light transfer functions are unknown and therefore their absolute pixel values are of no or minor interest. **.[5]**

In this paper we have proposed to provide a comprehensive tutorial about review of the morphology which is discussed in section II . Then a brief explanation of its fundamental operations are in section III and section IV is about morphological reconstruction . Finally. The results of the implementation are presented V and the conclusions are discussed in section VI .

II. Morphology

The word morphology commonly denotes a branch of biology that deals with the form and structure of animals and plants. We use the same word here in the context of mathematical morphology as a tool for extracting image components that are useful in the representation and description of region shape, such as boundaries, skeletons, and the convex hull. We are interested also in morphological techniques for pre- or post-processing, such as morphological filtering, thinning, and pruning. In the following section, we will develop a number of fundamental concepts in mathematical morphology, and illustrate how they are applied in image processing. The material in this chapter begins a transition from methods whose inputs and outputs are images, to methods whose outputs are image attributes, for tasks such as object extraction and description. Morphology is one of several tools developed in the image processing that form the foundation of techniques for extracting “meaning” from an image. The material in the following section deals with methods for processing both binary and grayscale images.

Morphological techniques probe an image with a small shape or template called a structuring element. The structuring element is positioned at all possible locations in the image and it is compared with the corresponding neighbourhood of pixels. Some operations test whether the element "fits" within the neighbourhood, while others test whether it "hits" or intersects the neighbourhood A morphological operation on a binary image creates a new binary image in which the pixel has a non-zero value only if the test is successful at that location in the input image

- ✓ **Structure element :**

The structuring element is a small binary image, i.e. a small matrix of pixels, each with a value of zero or one:

i. The matrix dimensions specify the size of the structuring element.
ii. The pattern of ones and zeros specifies the shape of the structuring element.
iii. An origin of the structuring element is usually one of its pixels, although generally the origin can be outside the structuring element

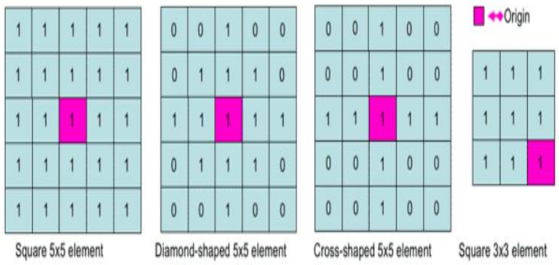


Fig.1. example of SE

A common practice is to have odd dimensions of the structuring matrix and the origin defined as the centre of the matrix. Stucturing elements play in moprphological image processing the same role as convolution kernels in linear image filtering.

When a structuring element is placed in a binary image, each of its pixels is associated with the corresponding pixel of the neighbourhood under the structuring element. The structuring element is said to fit the image if, for each of its pixels set to 1, the corresponding image pixel is also 1. Similarly, a structuring element is said to hit, or intersect, an image if, at least for one of its pixels set to 1 the corresponding image pixel is also 1.

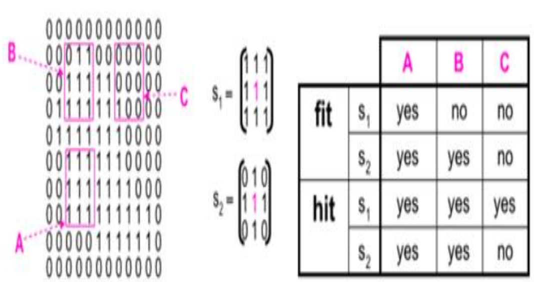


Fig.2. Fitting and hitting of a binary image with structuring elements s1 and s2.

Zero-valued pixels of the structuring element are ignored, i.e. indicate points where the corresponding image value is irrelevant.

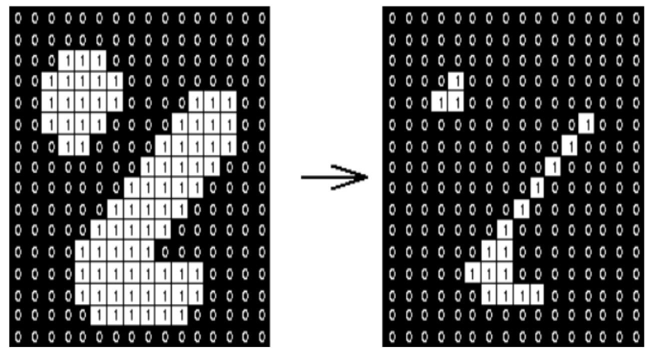
More formal descriptions and examples of how basic morphological operations work are given in the Hypermedia Image Processing Reference (HIPR) developed by Dr. R. Fisher et al. at the Department of Artificial Intelligence in the University of Edinburgh, Scotland, UK.**[6]**

III. FUNDAMENTAL OPERATIONS

✓ : Erosion

Erosion is one of the two basic operators in the area of mathematical morphology). It is typically applied to binary images , but there are versions that work on grayscale images . The basic effect of the operator on a binary image is to erode away the boundaries of regions of foreground pixels (i.e. white pixels, typically). Thus areas of foreground pixels shrink in size, and holes within those areas become larger

The erosion of a binary image f by a structuring element produces a new binary image g = f s with ones in all locations (x,y) of a structuring element's origin at which that structuring element s fits the input image f, i.e. g(x,y) is s fits f and ٠ otherwise, repeating for all pixel ١ = .coordinates (x,y)



.Fig.٣ Erosion: a ٣×٣ square structuring element **]٧[**

The erosion operator takes two pieces of data as inputs. The rst is the image which is to be eroded. The second is a (usually small) set of coordinate points known as a structuring element (also known as a kernel . It is this structuring element that determines the precise effect of the erosion on the input image. The mathematical denition :of erosion for binary images is as follows

Suppose that X is the set of Euclidean coordinates corresponding to the input binary image, and that K is the set of coordinates for the structuring element. Let Kx denote the translation of K so that its origin is at x. Then the erosion of X by K is simply the set of all points x such .that Kx is a subset of X

✓ : Dilation

Dilation is one of the two basic operators in the area of mathematical morphology . It is typically applied to binary images , but there are versions that work on grayscale images). The basic effect of the operator on a binary image is to gradually enlarge the boundaries of regions of foreground pixels (i.e. white pixels, typically). Thus areas of foreground pixels grow in size while holes .within those regions become smaller
The dilation operator takes two pieces of data as inputs. The rst is the image which is to be dilated. The second is a

(usually small) set of coordinate points known as a structuring element (also known as a kernel). It is this structuring element that determines the precise effect of the dilation on the input image. The mathematical denition :of dilation for binary images is as follows

Suppose that X is the set of Euclidean coordinates corresponding to the input binary image, and that K is the set of coordinates for the structuring element. Let Kx denote the translation of K so that its origin is at x. Then the dilation of X by K is simply the set of all points x such . that the intersection of Kx with X is non-empt

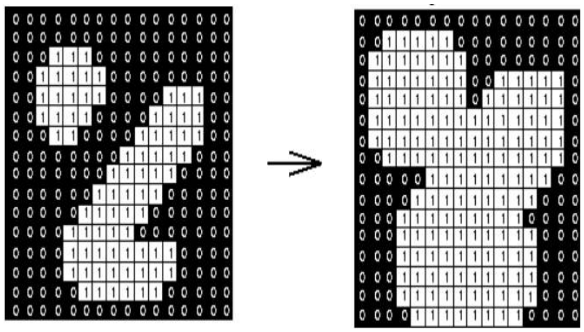


Fig.4. Dilation: a 3×3 square structuring element **[7]**

Opening and closing are two important operators from mathematical morphology . They are both derived from the fundamental operations of erosion and dilation . Like those operators they are normally applied to binary images , although there are also gray-level versions.

✓ : Opening

The basic effect of an opening is somewhat like erosion in that it tends to remove some of the foreground (bright) pixels from the edges of regions of foreground pixels. However it is less destructive than erosion in general. As with other morphological operators, the exact operation is determined by a structuring element . The effect of the operator is to preserve foreground regions that have a similar shape to this structuring element, or that can completely contain the structuring element, while .eliminating all other regions of foreground pixels

Very simply, an opening is dened as an erosion followed by a dilation using the same structuring element for both operations. See the sections on erosion and dilation for details of the individual steps. The opening operator therefore requires two inputs: an image to be opened, and a structuring element. Graylevel opening consists simply of a graylevel erosion followed by a graylevel dilation. Opening is the dual of closing, i.e. opening the foreground pixels with a particular structuring element is equivalent .to closing the background pixels with the same element

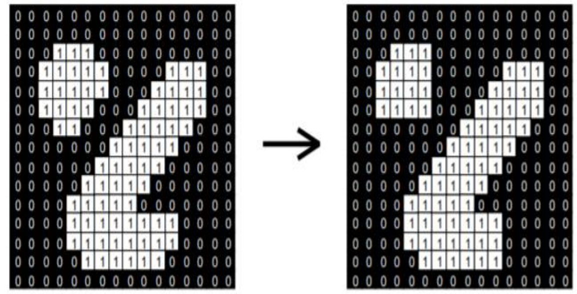


Fig.5. Opening : a 3×3 square structuring element **[7]**

✓ : Closing

Closing is an important operator from the field of mathematical morphology . Like its dual operator opening , it can be derived from the fundamental operations of erosion and dilation . Like those operators it is normally applied to binary images , although there are gray-level versions. Closing is similar in some ways to dilation in that it tends to enlarge the boundaries of foreground (bright) regions in an image (and shrink background color holes in such regions), but it is less destructive of the original boundary shape. As with other morphological operators , the exact operation is determined by a structuring element . The effect of the operator is to preserve background regions that have a similar shape to this structuring element, or that can completely contain the structuring element, while eliminating all other regions of background pixels.

Closing is opening performed in reverse. It is defined simply as a dilation followed by an erosion using the same structuring element for both operations. See the sections on erosion and dilation for details of the individual steps. The closing operator therefore requires two inputs: an image to be closed and a structuring element. Gray-level closing consists straightforwardly of a gray-level dilation followed by a gray-level erosion. Closing is the dual of opening, i.e. closing the foreground pixels with a particular structuring element, is equivalent to closing the background with the same element.

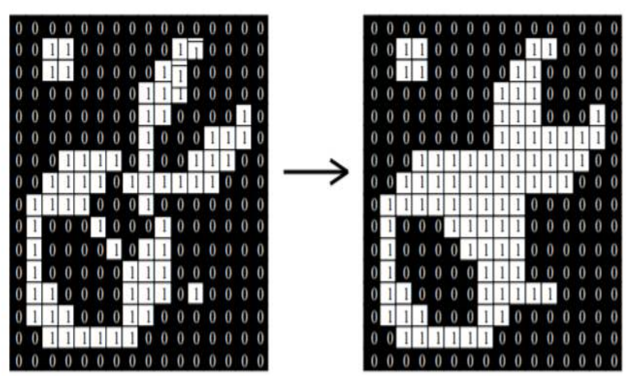


Fig.5. Closing : a 3×3 square structuring element **[7]**

IV. MORPHOLOGICAL RECONSTRUCTION

Morphological reconstruction is a useful but little-known method for extracting meaningful information about shapes in an image. The shapes could be just about anything: letters in a scanned text document, fluorescently stained cell nuclei, or galaxies in a far-infrared telescope image. You can use morphological reconstruction to extract marked objects, find bright regions surrounded by dark pixels, detect or remove objects touching the image border, detect or fill in object holes, filter out spurious .high or low points, and perform many other operations

Essentially a generalization of flood-filling, morphological reconstruction processes one image, called the marker, based on the characteristics of another image, called the mask. The high points, or peaks, in the marker image specify where processing begins. The peaks spread out, or dilate, while being forced to fit within the mask image. The spreading processing continues until the image .values stop changing

Reconstruction is a morphological transformation involving two images and a structuring element (instead of a single image and structuring element). One image, the marker, is the starting point for the transformation. The other image, the mask, constrains the transformation. The structuring element used defines connectivity. In this part we use 8-connectivity (the default), which implies that B in the following discussion is a 3 3 * matrix of 1s, with the center defined at coordinates (2, 2). In this paper we deal with binary images; gray-scale reconstruction.

If G is the mask and F is the marker, the reconstruction of G from F, denoted R F G( ), is defined by the following iterative procedure:

1. Initialize h_1 to be the marker image, F.
2. Create the structuring element: `B = ones(3)`.
3. Repeat:

$$h_{k+1} = (h_k \oplus B) \cap G$$

   until $h_{k+1} = h_k$.
4. $R_G(F) = h_{k+1}$.

Marker F must be a subset of G:

$$F \subseteq G$$

V. IMPLEMENTATION RESULTS

In this part we are going to discuss the implementation results in MATLAB .

First we take the Images courtesy of Dr. Steve Eddins, MathWorks, Inc. as the original picture then we applied our method , which is discussed in the following :

Fig.6. (a) Original image of size 1134 × 1360 pixels

Next we applied Opening by reconstruction of (a), using a structuring element consisting of a horizontal line 71 pixels long in the erosion.

Fig.7. (b) Opening by reconstruction of (a)

Then we have done Opening of (a) using the same SE. after that Top-hat by reconstruction is applied.

Fig.8. (c) Opening of (a)

Fig.9. (e) just a Top-hat

Fig.10. (d) Top-hat by reconstruction

In order to remove vertical lines we need to apply Opening by reconstruction, using a horizontal line 11 pixels long.

Fig.11. (f) Opening by reconstruction of (d)

As we can observe in fig.11. as a consequence of applying Opening by reconstruction ,some of the image details are missing (for instance I in SIN) , so to restore it we must apply Dilation of (f) using a horizontal line 21 pixels long. then choose the Minimum of (d) and (g) .

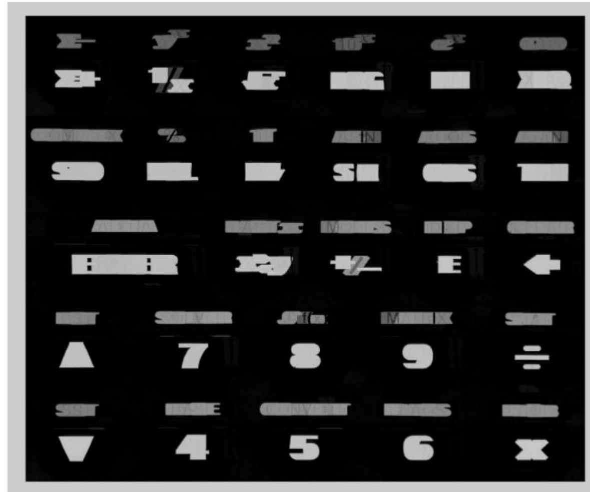


Fig.12. (g) Dilation of (f)

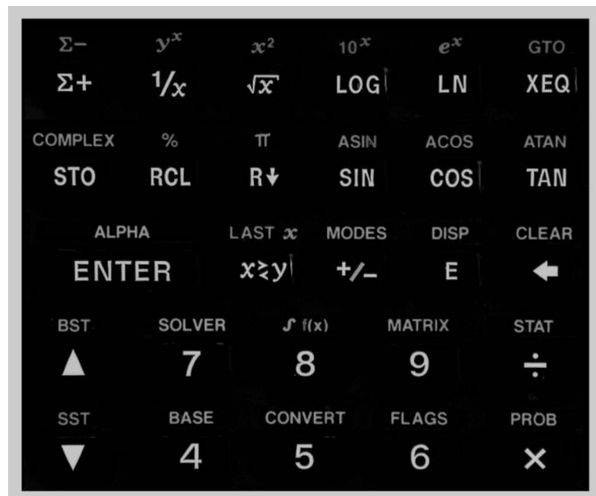


Fig.12. (h) Minimum of (d) and (g)

Finally we have applied a threshold with level of 0.3 .

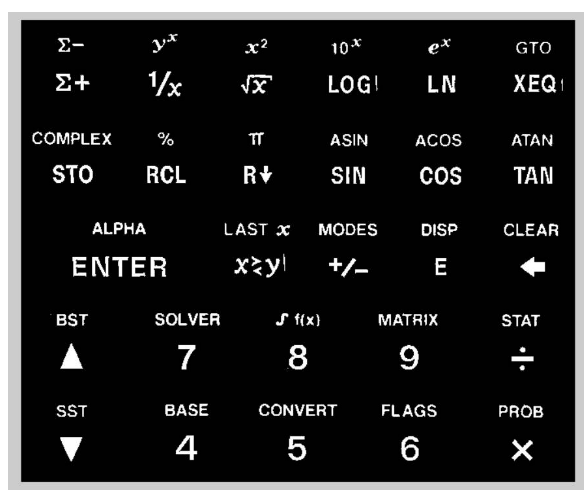
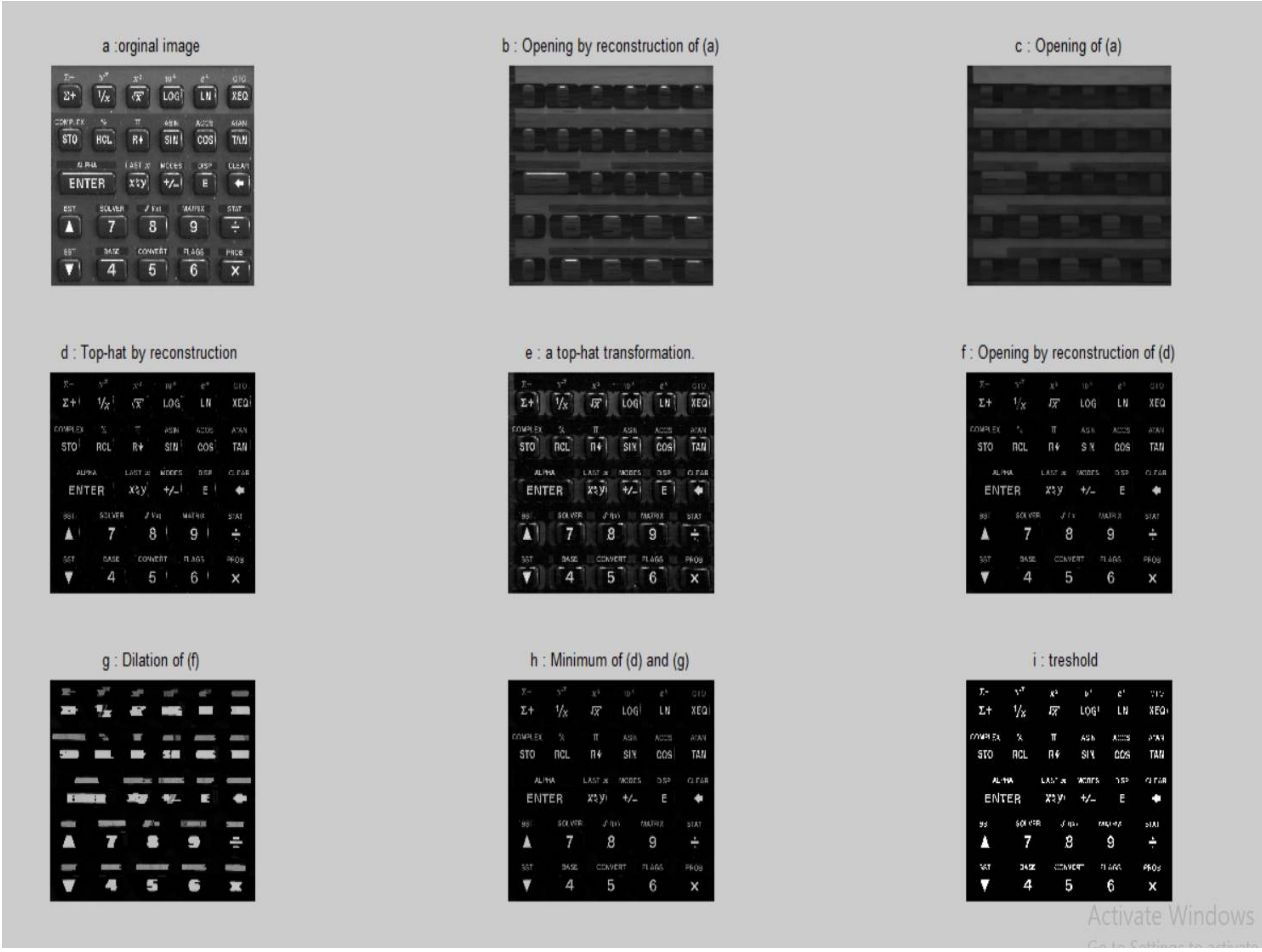


Fig.13. (i) Final image

In Fig.13. all of the steps is shown .



Then we went to the second part , which is boxing the words separately , in order to do that we need to first apply a threshold to divide large keys from small keys , then we applied a dilation to both large and small keys to make them as a connected island to be easy recognized , then we start Bounding Boxing .

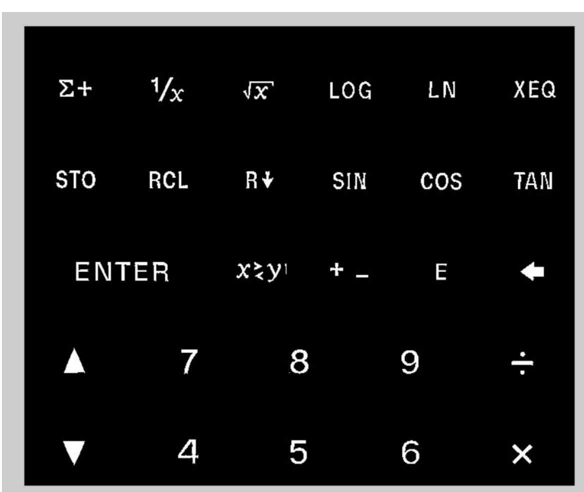


Fig.15. extracting large keys

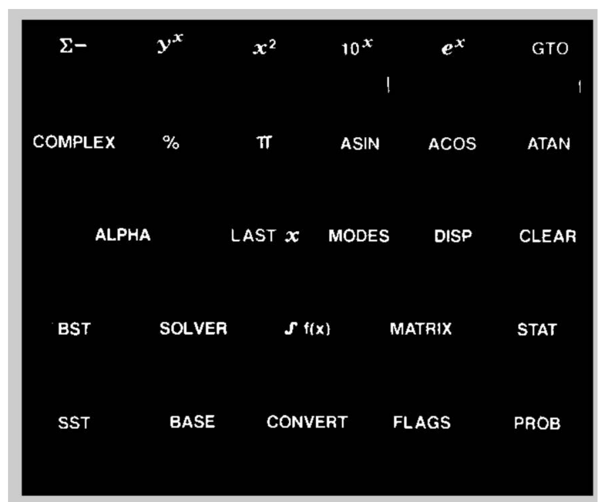


Fig.16. extracting small keys

Then we applied the dilation , using a horizontal line 31 pixels long . the result is shown in Fig. 17 .

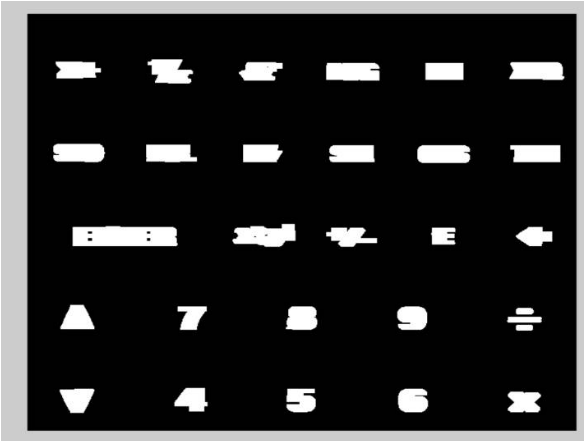


Fig. 17. Dilation of fig.15

Now we can start Bounding Boxing .then we restore the picture by using erosion .

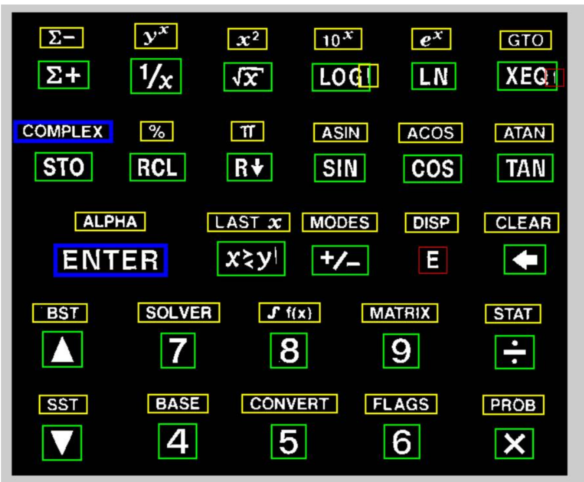


Fig.18. Final image

VI. CONCLUSION

In this paper,we have introduced the morpholgy in grayscale and morphological reconstruction , we also saw its use in image processing and we have shown the MATLAB implementation of morphology and we saw that we can use morphlogy as a object detector without using complicated methods like feature extraction and .deep learning approaches

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