Hit-or-Miss Transform as a Tool for Similar Shape Detection

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Abstract—This paper describes an identification of specific shapes within binary images using the morphological Hit-or-Miss Transform (HMT). Hit-or-Miss transform is a general binary morphological operation that can be used in searching of particular patterns of foreground and background pixels in an image. It is actually a basic operation of binary morphology since almost all other binary morphological operators are derived from it. The input of this method is a binary image and a structuring element (a template which will be searched in a binary image) while the output is another binary image. In this paper a modification of Hit-or-Miss transform has been proposed. The accuracy of algorithm is adjusted according to the similarity of the template and the sought template. The implementation of this method has been done by C language. The algorithm has been tested on several images and the results have shown that this new method can be used for similar shape detection.

Keywords—Hit-or/and-Miss Operator/Transform, HMT, binary morphological operation, shape detection, binary images processing.

I. INTRODUCTION

THE hit-or-miss transform (HMT) is a fundamental operation on binary images , widely used for more than 40 years. It is used morphological operations to locate known objects. The term morphology is denotes as a branch of biology, but here the same word has been used for mathematical morphology as a tool for extracting image components [1]-[3].

The hit-and-miss transform is used to look for occurrences of particular binary patterns in fixed orientations. It can be used to look for several patterns (or alternatively, for the same pattern in several orientations as above) simply by running successive transforms using different structuring elements, and then running OR operation between all the results.

Morphological image processing is a type of image processing which is used to modify a structure or spatial form within an image. The three fundamental morphological operations are erosion, dilation, and skeleton. And the hit-or-miss transform is derived by using erosion operation [4].

Firstly, the erosion operation has been explained using the language of mathematical Morphology. Then, the hit-and-miss transform by using erosion operation and other simple operations is clarified.

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II. EROSION OPERATION

For sets A and B in Z^2 the erosion of A by B, is defined as

$$A \ominus B = \{z \mid (B)_z \subseteq A\} \tag{1}$$

In words, this equation indicates that the erosion of A by B is the set of all points z such that B, translated by z, is contained in A.
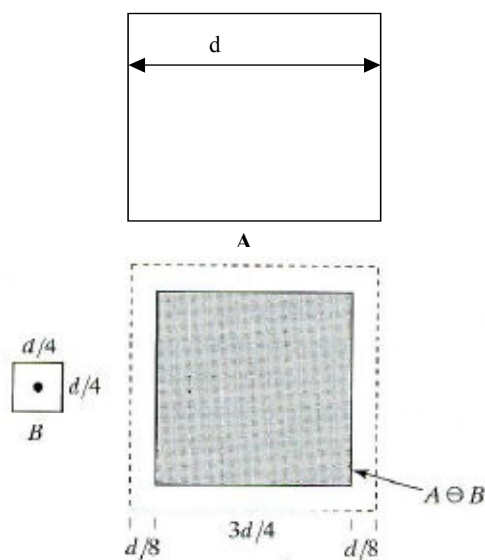

Fig. 1 A set A, a square structuring element B, and Erosion A by B

In Fig. 1 set A is shown as dashed line for reference in Fig. 1 (Erosion A by B). The boundary of the shaded region shows the limit beyond which further displacement of the origin of B would cause this set to cease being completely contained in A. Thus the locus of points within this boundary (the shaded region) constitutes the erosion of A by B. So the erosion operation shrinks the images.

III. HIT-OR-MISS TRANSFORM (HIT-MISS OPERATOR)

The Hit-or-Miss transform is a method to detect objects with a specific shape and it is derived by using erosion operation. If the pattern of the element (mask) matches the state of the pixels of image under the mask (hit), an output pixel in the center pixel of the mask is set to some desired binary state; while for a mismatch pattern (miss), the output pixel is set to the opposite binary state [4] [5].

Detection of a specific shape requires a combination of two erosion operations. The following example is to clarify how two erosion operations can be used in detecting a specific

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shape.

Example: In this example the target object is a set of horizontal rows of three consecutive pixels so the mask will be as follow [5]:

$$B_1 = \begin{bmatrix} 1 & 1 & 1 \end{bmatrix}.$$

In the first operation, the image is eroded with the mask B_1. All the objects that are smaller than the target object will be removed, however all the objects that are larger than the mask will be retained. Thus, a second operation, to remove all the objects which are larger than the target object, is required [5].

This can be done by analyzing the background of the original image. Thus, we can use an erosion of the background with a negative mask B_2 as a second step. Mask B_2 is the negative of mask B_1, therefore in mask B_2 all coefficients are zero, except for the pixels in the background that are surrounding the object. This is a negative mask for the object B_1:

$$B_2 = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 0 & 0 & 0 & 1 \\ 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

The eroded background then contains all pixels in which the background has the shape of B_2 or smaller. This corresponds to objects that have the same size of the target object or smaller. As the first erosion operation obtains all objects equal to or larger than the target object, the intersection of the background eroded with B_2 and the image eroded with B_1 gives the center pixels of all the objects with the sought object, in this example, horizontal rows of three consecutive pixels have been shown (see Fig. 2).
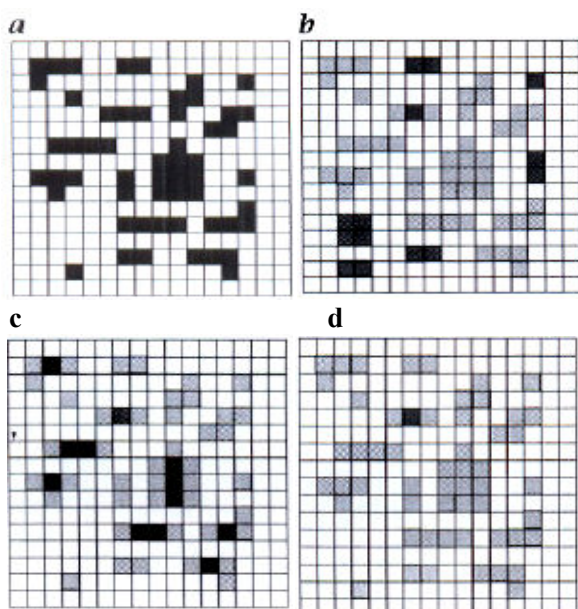

Fig. 2 Hit-miss transform for extracting all objects containing horizontal rows of three consecutive pixels: (a) original image; (b) background eroded by B_2 (negative mask of the object) (c) Image eroded by object B_1 (d) intersection of b and c extracting the objects with horizontal rows of 3 consecutive pixels[5]

In general, the hit or miss transform is defined as:

$$A (*) B = (A \ominus B_1) \cap (A^c \ominus B_2) \qquad (2)$$

With the condition that $B_1 \cap B_2 = \emptyset$, because if B_1 is not a negative mask of B_2, the hit-miss transform would result in the empty set.

With the hit or miss transform, we have a flexible tool by which we can detect objects of a given specific shape. The versatility of the hit or miss transform can easily be demonstrated by using another miss mask.

$$B_3 = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 0 & 0 & 0 & 0 & 0 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

Erosion of the background with this mask leaves all pixels in the binary image where the union of the mask B_3 with the object is zero. This can only be the case for objects with horizontal rows of one to five consecutive pixels in a 3 x 7 large background. Thus, the hit or miss transform with B_1 and B_3 gives all center pixels of objects with horizontal rows of 3 to 5 consecutive pixels in a 3 x 7 large background.

The masks of the hit-miss transform can be combined into one mask, using a hit (1), miss (0), and don't care (x) notation. The combined mask is marked by 1 where the hit mask is one, by 0 where the miss mask is one, while marked by x where both masks (B_1 and B_2) are zero. Thus, the hit-miss mask for detecting objects with horizontal rows of 3 to 5 consecutive pixels is as follow [5]:

$$B = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & x & 1 & 1 & 1 & x & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

IV. THE PROPOSED ALGORITHM FOR SIMILAR SHAPE DETECTION

The problem with hit-and-miss transform is that it cannot be used in searching of similar shapes within binary images. In this paper a modification of hit-and-miss transform is proposed. After applying this modification on hit-and-miss transform, it can be used for similar shape detection.

The hit-and-miss transform is achieved by using two erosion operations. Erosion operations should be changed as the following: If the pattern of the element (mask) matches the state of the pixels of image under the mask by a determined rate which can be set by the user, an output pixel in the center pixel of the mask is set to some desired binary state. While for a mismatch pattern (the similarity between the element (mask) and the image is less than the determined rate), the output pixel is set to the opposite binary state. The code by C language of this algorithm is as follows:

```
//The Code of the proposed algorithm written by C language
for(i=WSmall/2; i<W - WSmall/2 ; i++){
for(j=HSmall/2; j<H - HSmall/2 ; j++){
     Total =0;
     Count =0;
```

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```
   // Total = Total Number of Pixels in the mask
   // Count = Number of Matched Pixels
   for(a=-WSmall/2; a<=WSmall/2; a++){
   for(b=-HSmall/2; b<=HSmall/2; b++)
   {
      Total++;
      if(fabs(B[WSmall/2 + a][HSmall/2 + b] ==
P_Origin[i+a][j+b])/255 )
      Count++;
   }
   }

if (Count / Total >=  the determined rate /100 )
  if (Modify_B1[i-1][j]==0 && Modify_B1[i][j-1]==0 &&
Modify_B1[i-1][j-1]==0)
   Modify_B1[i][j] = 255;
else
   Modify_B1[i][j] = 0;
   }
   }
```

V. EXAMPLES FROM RUNNING SOFTWARE

Example 1: searching a small image (object number 1 as shown in Fig. 3 (b)) in the original image which has many objects, using hit or miss transform.

Fig. 3 (a) Original Image (A)

Fig. 3 (b) Mask B (Small Image)

Fig. 3 (c) A eroded by B   Fig. 3 (d) Inverse A eroded by Inverse B

Fig. 3 (e) The intersection between Figs. 3 (c) and (d)

Fig. 3 (f) Definition the small image on original image

Example 2: searching of a small image (object of a part of a car wheel as shown in Fig. 4) in the original image which has many objects similar to the target object, using the proposed algorithm with similarity rate 80%. See to Fig. 4.
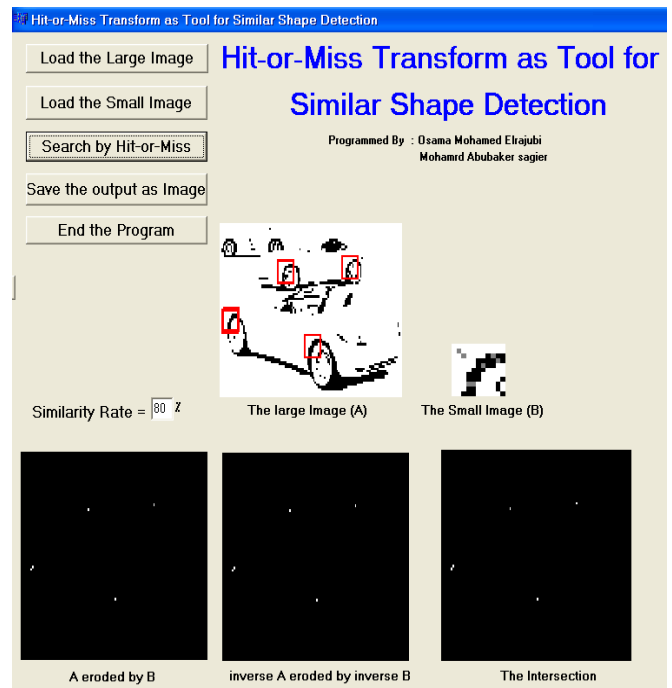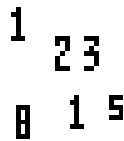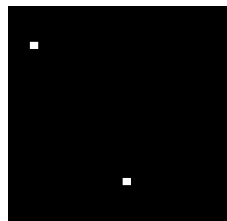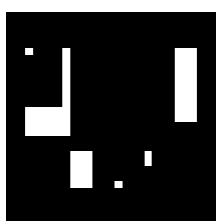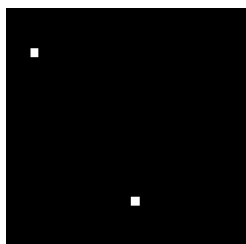

Fig. 4 The Interface of the Software with example of searching by using of the proposed algorithm

VI. CONCLUSION

The hit-or-miss transform (HMT) is a powerful morphological tool for processing binary images. The hit-or-miss operation is very sensitive to the shape, size and rotation of the two structuring elements. Hit and miss structuring elements must be specifically designed to extract the desired geometric shapes from each individual image. The problem with hit-and-miss transform is that it cannot be used for searching similar shapes within binary images. By applying the proposed modification in this paper, hit-and-miss transform can be used for searching of similar shapes.

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