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Detecting Faces in Noisy Images using Hit-Miss Transform (HMT)

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Abstract: The object of this paper is to detect faces in noisy images. All sample images show homogeneous background faces. The transformation of the Hit-Miss is used to detect object boundaries and remove the noise effect. Two filters are cascaded to handle high noise levels in a special way. An application for face detection in noisy conditions is presented. The algorithm is implemented on faces taken from the Manchester face database after adding Gaussian noise to them.

Keywords : About four key words or phrases in alphabetical order, separated by commas.

I. INTRODUCTION

Noise may occur in digital images because of many reasons. Most of the computer vision systems depend on reducing the information in the input image by applying an edge detection process. This comes from the fact that edge-based techniques are major part of segmentation methods, where edges are detected and objects are isolated as a result of that. In this paper, the morphological Hit-Miss transform is re-introduced. It is used as a first step in a face location system, which is designed mainly to deal with noisy images. This paper is organized as follows; initially it deals with the general HMT algorithm, further it deals with the hexagonal correlation. How to deals with noise handling, Practical implementation is carried out.

II. HIT-MISS TRANSFORM (HMT)

Many steps are involved in the implementation of the morphological Hit-Miss Transform (HMT). The first step is to convert the gray scale image to a binary image. This process represents a real challenge in the detection algorithm, and might be the main cause behind any shape distortion. Several approaches are suggested to carry out this task, such as using four threshold level m ± s and m ± 0.3s (where m and s are the mean and standard deviation of the image respectively). The m + s and m – s thresholds are used to extract bright and dark objects. On the other hand, m ± 0.3s are used to extract low contrast objects. More computations are required for this method. A single threshold is also used and recommended for applications where the implementation time is important. On the other hand, a major problem is associated with the single threshold usage. How to determine its value? A suggested solution is to use an above the mean threshold. How much above the mean is a problem dependent issue. This might lead to inaccurate description, especially when the objects contained in the image are of different nature (i.e., some parts of the image contain bright objects while other parts contain dark objects). In order to overcome this, another approach has been developed and implemented in some places.

The new approach depends on dividing the image into local regions. The local mean for every local region is found and used to convert it to a binary region. The mean of the image of Figure 1 is equal to 51. Dividing this image into quarters will result in local parts and local means, as shown in Figure 2. As it should be, the rounded average of local means is equal to the image mean. At regions separating two or more local regions, the average of neighbouring means is considered. This technique is called the splitting technique and it is used throughout the HMT implementation in this paper.

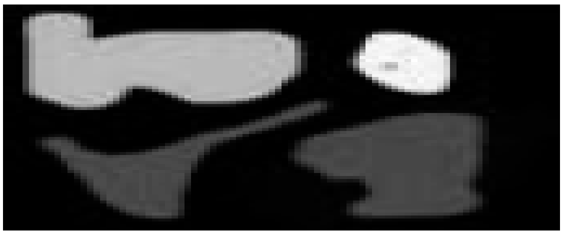

Fig.1. The New Original Image with mean=51.

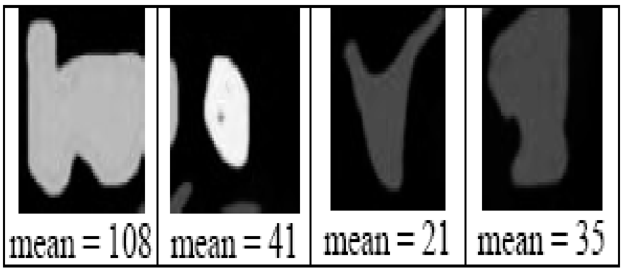

Fig.2. Dividing the input image into quarters.

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A. Hit-Miss Filter Algorithm

Step 1: Converting the input image to a binary image:
The splitting technique is used to convert the gray scale input image to a binary image. The resultant image is called B1. The negative of B1 is called B2.

Step 2: Implementing the hit-filter:The binary image B1 is correlated with a hit filter. The size of the filter mask is almost equal to the size of the objects to be detected. The resultant image is called H1. Any detected object is represented by a white pixel in H1.

Step 3: Implementing the miss-filter: The binary image B2 is correlated with a miss filter. All objects of size smaller or equal to the size of the miss filter are detected and represented by white pixels in the resultant image M1.

Step 4: Final AND operation: The AND operation is performed between H1 and M1. This will provide the final output of the HMT.

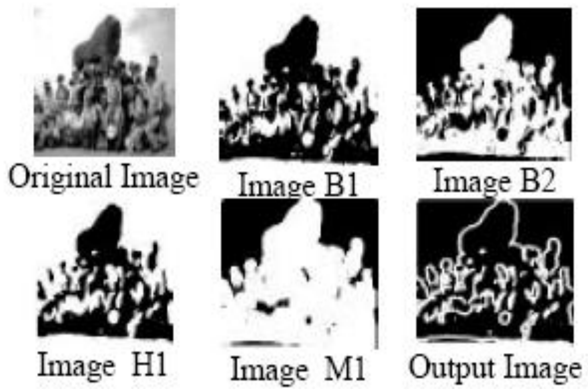
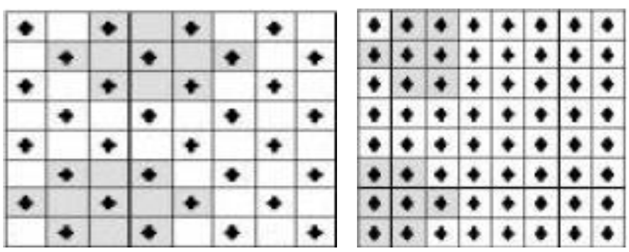


Fig.3. The practical implementation of the HMT

B. Applying the Hexagonal Correlation

Traditional edge detectors are designed to be implemented in square windows. The simple indexing for coordinate positions is the major advantage for using square windows. On the other hand, neighbours of the center pixel are not equidistant. This causes the accuracy of the diagonal and off diagonal directions to be reduced in their magnitude. The hexagonally based masks seem to overcome these problems. A pioneering work for transition from hexagonal pixel locations to its equivalent rectangular locations and masks is presented in, where the hexagonal pattern is converted into rectangular coordinates. Figure (4) explains the conversion process. Only one of the hexagonal masks shown in Figure 4(a) is used.



(a) (b)

Fig.4. Hexagonal points with hexagonal masks (shaded mask) and Transformation to rectangular points.

All the classical hit and miss filters are replaced by their corresponding hexagonal filters. Hexagonal filters are faster by 38.5 %.

C. Handling Noise

To handle high noise levels, two HMTs are cascaded. The first HMT accepts the gray scale input image and provides a binary edge detected image for the second HMT. Some differences exist between the two HMTs. In the second HMT, The hit and miss filters are implemented directly to the input image, because it is already a binary image.

Larger size of filters is usually required for the first HMT as it deals with higher levels of noise. In the same manner, reducing the size of filters in the second HMT will speed up the process. Figure (5) shows the cascaded system. Practically, it is found that better face detection results are obtained if below the mean thresholds are applied in the second HMT.

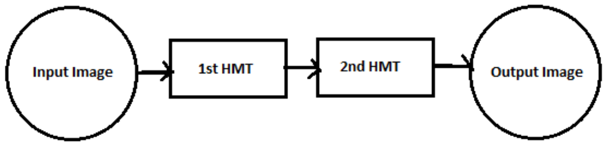


Fig.5. The Cascaded HMT System

D. Detecting the Edges of Noise Face Images

To test the previous system, human faces are subjected to different levels of Gaussian noise. All the face images are obtained from the Manchester face database, which includes images of 30 different individuals. It is divided into 2 sets; a training set and a testing set where ten images of every person are included in each set. The majority of people are between 25 and 35 years of age. There are seven females and twenty-three males in the database [9]. Gaussian noise with mean value of 10 and different standard deviation values (STD) is applied to some faces. The noisy image is placed at the input of the system shown in Figure 5.. The noisy images and the output of the every stage are shown in Figure 6.

III. FACE DETECTION

In this section a detection technique that is used for detecting faces in noisy images is presented. The detection is applied directly to the output image of figure 5. Simple idea stands behind the detection strategy; after the noise is eliminated all the useful information are contained within the face region. Problems will occur if the noise or the backgrounds are not eliminated; as they will be considered regions of desired data. Fortunately, the HMT has proven success in removing the high noise levels. Thus, the useful data are contained within the face region only.

A. The Centre of Mass

The centre of mass (centroid) of the binary output image is used as an indication for the location of useful data. The centre of mass (centroid) is computed by dividing the first-order spatial moments (in the x and y) direction) by the zero-order spatial moment.

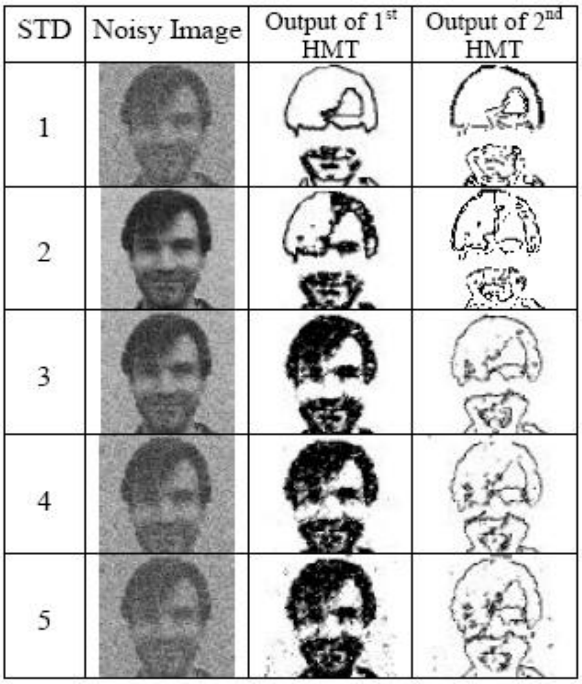


Fig.6. Applying multi-stage HMT to noisy images

For simple objects like circles, the centre of mass is located at the centre of the object. The horizontal position of the centroid is determined by finding the energy contained in every column of the image. This energy is multiplied by its horizontal index and the summation of all the multiplication products is found. Finally, the summation is divided by the total energy of the image to find the position of the centroid in the horizontal direction. To find the position in the vertical direction, the previous process is repeated, but this time the energy of every row is found and multiplied by its vertical index. Again, the summation of all the products is divided by the total energy. To implement this algorithm for face detection, some factors are to be considered. Firstly, the centroid should be found only for edge detected images, otherwise, the energy of the background or noise might lead to wrong detection.

Secondly, the centroid determines the location of objects if a single object exists in the image, for two or more objects, other techniques should be followed. If the background is known; finding local centroids for certain regions in the image might be better than finding a global centroid.

B. Face Detection Process

The face is composed of almost two symmetrical halves. Theoretically, the centroid is located on or near by the vertical line that divides the face into two symmetrical halves. The distances between the centroid and the face boundary are taken as measures for the limits of the face region. In this paper three distances are defined a, b and c. The horizontal distance between the centroid and the face boundary to the right is called ‘a’. The horizontal distance between the centroid and the left face boundary is called ‘b’. Finally, ‘c’ is the vertical distance between the centroid and the upper face boundary. The distances are shown in figure 7.

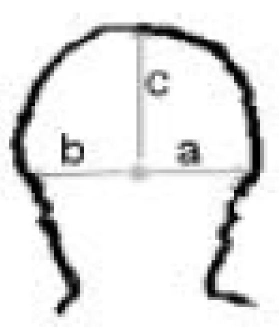


Fig.7. Determining the a, b and c

A rectangle that is centered at the location of the centroid and has the width of (a + b) and the length of (2 X +c) is isolated from the original image. The face region is contained in this rectangle. Practically, the centroid may not be located exactly in the middle of the face Because of different lighting conditions and rotation problems. Another problem that exists is missing edges on the face boundary. Such problem is usually caused by noise or high thresholds. To overcome these problems, an approximation step is implemented. The following rules are applied:

if b > a then a = b

else if a > b then b = a

if c < a then c = 1.5 X a

The implementation of these rules depends mainly on the nature of the faces. If it is likely that missing boundaries will exist then it is preferable to implement them. Using these rules, only a single horizontal distance needs to be found. The remaining two distances can be estimated. The estimation rules will be implemented throughout this paper. Small parts of the background maybe detected when implementing them. The detailed implementation of this algorithm is shown in Figure 8. Figure 8.a shows the noisy image with mean value of 10 and standard deviation value (STD) equals to 5. The output of the second HMT is shown in Figure 8.b. The position of the centroid is shown in Figure 8.c, and Figure 8.d shows the detected image. Other implementations are shown in Figure 9. The face detection algorithm requires 0.035 seconds when implemented on a PIII-650 processor. This makes it quite suitable for real-time environments.

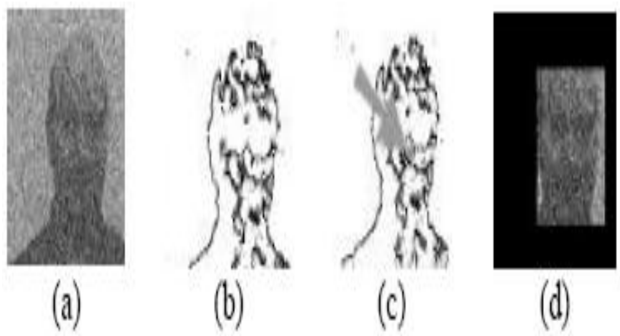


Fig.8. Implementing the detection algorithm

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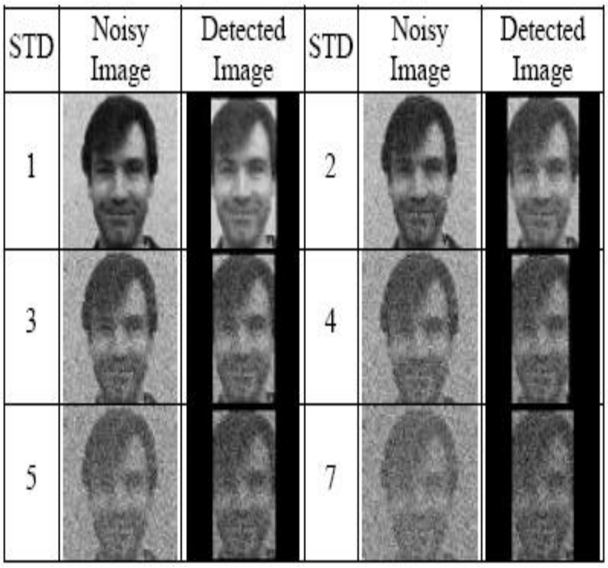

Fig.9. Implementing the detection algorithm to different noisy faces

IV. CONCLUSION

The morphological HMT is a powerful tool for detecting edges in real-life images. Being slower than ordinary edge detectors is the only problem with HMT. However, implementing the hexagonal correlation principle has helped in speeding up the process. The detection algorithm presented in this paper can detect about thirty faces per second, given that every image is of size 256 X 256. In all the test images, the face regions were successfully detected. However, for the same face and under different noise levels, the size of the detected regions may differ slightly, but the major features that give the face its identity (i.e. eyes, mouths, and nose) are correctly detected. The detection algorithm works well for faces with simple background. It would be interesting to carry out this method for other types of images and for other applications. Other stages should be added to support the centroid finding method. Feature Extraction method can detect the regions of interest and local centroids can verify faces.

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