3D Median Filter Design for Iris Recognition

K. Ganesh Kumar[1], Dr. K. Kiran Kumar[2]
[1]M. Tech (ES), Dept. of ECM, KL University, Guntur Dist., A.P., India.
[2]Professor, Dept. of ECM, KL University, Guntur Dist., A.P., India.

ABSTRACT - *In many applications user authentication has to be carried out by portable devices. These kinds of devices must deal with constraints like computational performance, power consumption while also maintaining high performance rates in the authentication process. This paper provides solutions to designing such personal tokens where biometric authentication is required. In this paper, a 3D median filter design for iris biometrics has been chosen to be implemented due to the low error rates.*
Keywords *– Biometric authentication, 3D median filter.*

I. INTRODUCTION

Biometrics is the science of automated recognition of persons based on one or more physiological or behavioral characteristics. Possible biometrics methods include face, fingerprint, iris, hand shape, gait, signature, etc. Biometrics is widely used in many applications, such as access control to secure facilities, verification of financial transactions, welfare fraud protection, law enforcement, and immigration status checking when entering a country. Biometrics is the only method capable of recognizing human beings using the real features of the user instead of his or her knowledge (e.g., passwords) or belongings (e.g., a magnetic stripe card) [1]. Among currently existing biometric modalities, iris recognition is considered to be one of the most secure and reliable technologies [2], [4], [6], [5]; however, while matching algorithms in iris recognition are straightforward, the signal processing prior to matching requires a significant amount of processing power.

IRIS ACQUISITION

Iris recognition is an automated method of biometric identification that uses mathematical pattern-recognition techniques on video images of Irises of an individual's eyes, whose complex random patterns are unique and can be seen from some distance.

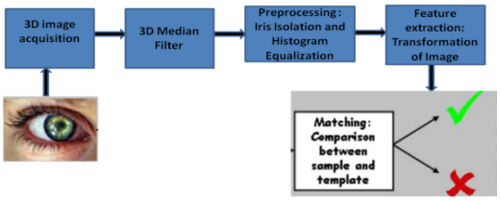


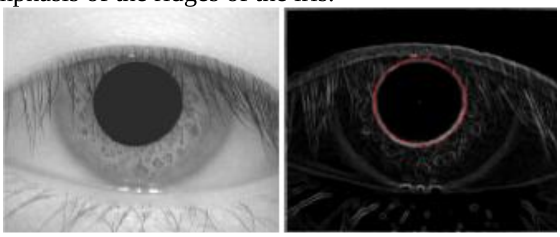
Fig.1. Block diagram of a biometric system

Iris biometrics systems do not use laser-scans to capture the image of the human eye. Instead, an infrared photo or video camera is used at a set distance to capture a high quality image of the iris. Working in the infrared range provides many advantages when compared to the visible range: iris ridges, nerves, and crypts are more evident, the border between the iris and the pupil is more pronounced; and users are not exposed to annoying flashes.

A 3D median filter takes input as 2D or 3D image this can be done using a Stereo camera.
A stereo camera is that which captures the iris image in 3D.

IRIS SEGMENTATION

The main purpose of this process is to locate the iris on the image and isolate it from the rest of the eye image for further processing. Some other important tasks that are also performed in this iris segmentation block include image quality enhancement noise reduction, and emphasis of the ridges of the iris.


(a) (b)
Fig.2 Input image (a), detected pupil edge

FEATURE EXTRACTION

Feature extraction involves simplifying the amount of resources required to describe a large set of data accurately. When performing analysis of complex data one of the major problems stems from the number of variables involved.

Analysis with a large number of variables generally requires a large amount of memory and computation power or a classification algorithm which overfits the training sample and generalizes poorly to new samples. Feature extraction is a general term for methods of constructing combinations of the variables to get around these problems while still describing the data with sufficient accuracy.

II. MEDIAN FILTER

Median filter is windowed filter of nonlinear class that is used for image quality improvement. Median filter[8] is used “salt and pepper” noise reduction and in some cases to suppress speckle noise. The median filter is a nonlinear digital filtering technique, often used to remove noise. Such noise reduction is a typical pre-processing step to improve the results of later processing (for example, edge on an image).

Median filtering is very widely used in digital image processing because, under certain conditions, it preserves edges while removing noise like salt and pepper noise

WORKING:

Like the mean filter, the median filter considers each pixel in the image in turn and looks at its nearby neighbors to decide whether or not it is representative of its surroundings. Instead of simply replacing the pixel value with the mean of neighboring pixel values, it replaces it with the *median* of those values. The median is calculated by first sorting all the pixel values from the surrounding neighborhood into numerical order and then replacing the pixel being considered with the middle pixel value. (If the neighborhood under consideration contains an even number of pixels, the average of the two middle pixel values is used.)

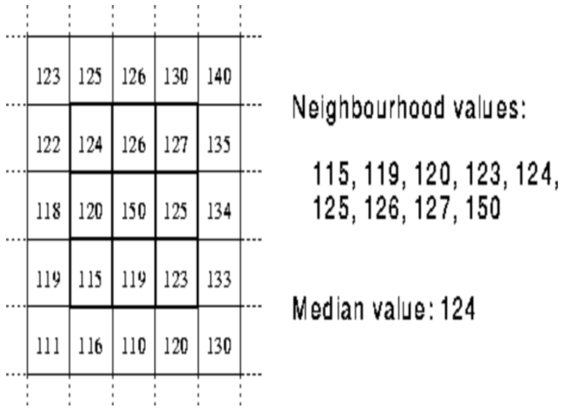


Fig.4 calculating the median value of a pixel neighborhood.

As can be seen, the central pixel value of 150 is rather unrepresentative of the surrounding pixels and is replaced with the median value: 124. A 3×3 square neighborhood is used here; larger neighborhoods will produce more severe smoothing.
By calculating the median value of a neighborhood rather than the mean filter, the median filter has two main advantages over the mean filter:

1) The median is a more robust average than the mean and so a single very un-representative pixel in a neighborhood will not affect the median value significantly.
2) Since the median value must actually be the value of one of the pixels in the neighborhood, the median filter does not create new unrealistic pixel values when the filter straddles an edge. For this reason the median filter is much better at preserving sharp edges than the mean filter.

SALT AND PEPPER NOISE

Salt and pepper noise[3] is a form of noise typically seen on images. It represents itself as randomly occurring white and black pixels. An effective noise reduction method for this type of noise involves the usage of a median filter, morphological filter or a contra harmonic mean filter. Salt and pepper noise creeps into images in situations where quick transients, such as faulty switching, take place.
As a stereo camera is used in getting iris image it gives a 3D image of iris which contains salt and pepper noise

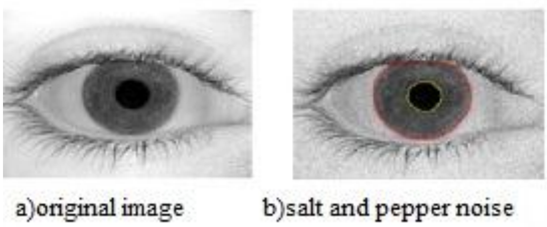


Fig.3 Iris image with salt and pepper noise

3D MEDIAN FILTER

3D median filter[9] uses 3D parallelepiped window to process volume image elements.

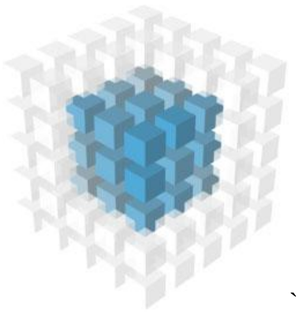


Fig. 4 Window or mask of size 3×3×3 in 3D

In special cases we can analyze and process sequences of image frames corrupted with different levels of noise. These frames of images can be stored in the selected three-dimensional matrix X3(1: M; 1: N; 1: K). The operation of a moving three-dimensional array mask is illustrated
in algorithm presented.

```
for i=1:M-2
    for j=1:N-2
      for k=1:K-2
           B (1:3, 1:3, 1:3) =...
              X3(i-1:i+1,j-1:j+1,k-1:k+1);
           Y ( i, j, k)= med(B(:));
          end
       end
 end
```

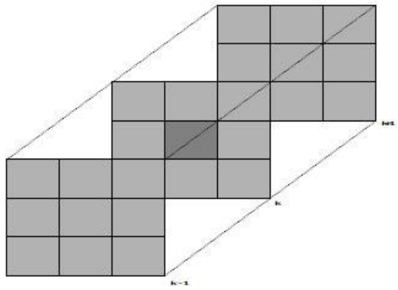


Fig.5 The three-dimensional median filter masken

Estimation of Statistical Parameters

The parameters which are used in estimation of performance are Signal to Noise Ratio (SNR), Root Mean Square Error (RMSE), and Peak Signal to Noise Ratio (PSNR) [7].

A. Estimation of SNR

SNR compares the level of desired signal to the level of background noise. The higher the SNR, the lesser the noise in the image and vice versa [7].

$$SNR = 10 \log (\sigma_g^2/\sigma_e^2)$$

Where, σ_g^2 is the variance of the original image and

σ_e^2 is the variance of error between the original and image denoised with some filter.

B. Estimation of RMSE

Mean square error (MSE) is given by

$$MSE= \sum_{i=j=1}^{N} [f(i,j) - F(i,j)]^2 \; / \; N^2$$

Where, f is the original image F is the image denoised with some filter and N is the size of image [7].

RMSE = √MSE

C. Estimation of PSNR

PSNR gives the ratio between possible power of a signal and the power of corrupting noise present in the image [7]. Higher the PSNR gives lower the noise in the image i.e. higher image quality.

PSNR = 20 log10 (255/RMSE)

APPLICATIONS:

Median filter is having following applications in image processing applications.

1. Median filtering extensively used for Salt & Pepper noise filtering purpose.
2. Its edge preserving quality makes it to useful in cases where edge blurring is unacceptable.
3. This filter also used to remove speckle noise from images

ADVANTAGES

1. Simple to understand.
2. Preserves brightness difference resulting in minimal blurring of regional boundaries.
3. Median computer algorithm can be customized.

DISADVANTAGES

1. Less effective in removing Gaussian or random intensity noise.
2. High computational cost.
3. Removes noise only if the noisy pixel occupies less than one half of neighbor- hood area.

III. CONCLUSION

As previously used 2D median filter doesn't gives a much efficient filtering of noise in images it can be replaced by an 3D median filter for better noise removal.

As the theoretical studies give that a 3D median filter is most efficient in removing salt and pepper noise in 3D ultrasound images. It can be applied to an iris biometric system for more efficient de-noising if images.

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