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Filtering and Reconstruction System for Gray Forensic Images

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***Abstract*—**Images are important source of information used as evidence during any investigation process. Their clarity and accuracy is essential and of the utmost importance for any investigation. Images are vulnerable to losing blocks and having noise added to them either after alteration or when the image was taken initially, therefore, having a high performance image processing system and it is implementation is very important in a forensic point of view. This paper focuses on improving the quality of the forensic images.

For different reasons packets that store data can be affected, harmed or even lost because of noise. For example, sending the image through a wireless channel can cause loss of bits. These types of errors might give difficulties generally for the visual display quality of the forensic images.

Two of the images problems: noise and losing blocks are covered. However, information which gets transmitted through any way of communication may suffer alteration from its original state or even lose important data due to the channel noise. Therefore, a developed system is introduced to improve the quality and clarity of the forensic images.

***Keywords*—**Image Filtering, Image Reconstruction, Image Processing, Forensic Images.

I. Introduction

THE concept of the Image processing is reaching out into our daily life such as medicine, authentication forensic, chemistry and various fields. It allows huge number of wider algorithms to be implemented to the input data and can evade problems for instance having noise and signal distortion during processing. The image process area has many applications involve different process like image enhancement and image detection [1].

In terms of forensic, digital images are considered as important resource to collect information as evidence [2]. Regarding the forensic images, there are many types of information that can be collected from those images to help investigators. For example: shoe marks, forensic evidential examinations (e.g. firearms, fingerprints, documents, handwriting, etc.) [2], [3].

The forensic images clarity and accuracy is essential and of the utmost importance for any investigation. Images are vulnerable to losing blocks and having noise added to them either after alteration or during when the image was taken initially, therefore, having a high performance image processing system and it is implementation is very important in a forensic point of view [2], [3].

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This paper aimed at improving the quality of the forensic images and help investigators to collect information that can support the investigation process. A developed system is proposed for this purpose. The first part of the proposed system includes implementing different filters to remove noises from images in order to improve their resolution. Moreover, the second part of the system presents a developed algorithm to reconstruct the lost blocks from the images.

II. Overview of Image Processing

Image processing means computer imaging where the application involves a human interaction into the visual loop. This means the images are to be examined and acted upon by users. The major topics inside the field of image processing include image restoration, image compression and image enhancement [1].

In computer science; image processing refers to any form of signal processing. The input of image processing is an image like: a photograph or video frame, however, the output of image processing can be both an image and a set of features related to the image [1].

Image processing usually also known as digital image processing; digital image processing means that 'the use of computer algorithms to perform image processing on digital images' [1], [4].

Usually image-processing techniques include treating the image as a two-dimensional signal and applying standard signal-processing techniques to it.

There are many different applications of image processing such as: face detection, computer vision, image reconstruction, image filtering, and medical image processing.

A. Forensic Images and the Needed of Image Processing Techniques

In terms of forensic science, it is stated that there is a need of professional photographing skills in the use of digital cameras to capture and ensure a good quality output image. Also, there is a growing request for skilled engineers and computer-vision experts to process images. Besides, it is recognized that a range of digital camera technology is compulsory in dealing with the demands of forensic science. By identifying the various imaging requirements we can determine the needs of forensic imaging [5].

However, because of the increasingly use of digital camera, more ways to process the image have been discovered. For example, 3D reconstruction is being used for face recognition and reconstruction. The facial reconstruction is being used as a routine procedure in reconstructing facial detail for making a three dimensions (3D) image model from two dimension (2D) images files. On the other hand, the use of 3D faces has yet to be adopted world wide [5].

Another example of using image processing application is that a forensic case study which is focusing on hair matching (DNA pattern recognition) used some image software, included an image analysis package, image combining software and image management system [5], [6].

This forensic case study used high quality digital images where the image pixel values enabled the assignation of numerical values to such features as colour and pigmentation characteristics.

Regarding image filtering most advanced and complex spatial filtering processes are being used to improve graphic information. The well-known linear and non-linear filters like the low and high pass and the median filters can increase or decrease the change rate that follows the transition intensity of an image. There is one activity in which we can use filters like these ones such as in the analysis of the finger-prints where detail level is needed [6], [7].

Table I categorizes the processing activity range that is used on digital forensic images [7]:

TABLE I
THE RANGE OF IMAGE PROCESSING APPLICATIONS BEING USED FOR FORENSIC IMAGES

Image Processing Technique	Process Input	Process Output	Example
Image Enhancement	Image A	Image B	Debluring and Contrast.
Image Analysis	Image	Data	Height measurement.
Pattern Recognition	Image	Classified Data	Shoe-mark pattern-coding.
Image Comparison	>1 Image	Correlate Data	Facial mapping, shoe-mark comparison.
Image Reconstruction	Data, Image, and/or Information.	Image	Crime scene, computer model.

III. RELATED WORK

An image reconstruction method was introduced in [8]. The effects of different types of wavelets on image reconstruction were investigated. A simulated model of the multi-resolution technique was used in this work. Images of varying sizes, backgrounds, textures and intensities were used to test the algorithms and determine results.

The results indicate that shorter wavelets perform better than longer wavelets. The results also demonstrate that orthogonal wavelets seem to perform better than bi-orthogonal wavelets.

A proposed method for determining the mean line implement the Gaussian filter through convolves the registered profile with the filter impulse response was introduced in [9]. The method requires extrapolating the profile at both ends by fragments being some polynomial functions of the spatial variable. The mean square dissimilarity between the profile and the mean line reaches a minimum is because the coefficients of the polynomials are selected.

Experimental results proof that the proposed technique eliminates the edge effect even if the amplitude of the form component significantly exceeds the roughness component.

Another algorithm that uses the wavelet-domain which can retrieve the missing blocks of an image sent through a wireless connection was presented in [10]. This algorithm has been designed for the compression of wavelet-based JPEG2000 file formats. However, the entire blocks could still be lost due to the way the wireless communication system works. The way this algorithm works is that it checks the accuracy or the existence of the lost blocks edges and then applies the effect meant to reconstruct the missing blocks.

Silva et al. [11] has identified that unidentified human remains through the comparison of ante mortem and post-mortem radiographs has found wide acceptance in recent years. For example, in a forensic case, a body of unknown adult male who had died because of a traffic accident was identified by matching images of ante- and post-mortem radiographs of the frontal sinus. Also, general discussion on identification using frontal sinus radiographs been presented in the work, besides clearly shown the reliability of this technique, in reference to the uniqueness of the frontal sinus in humans.

IV. FILTERING AND RECONSTRUCTION PROPOSED SYSTEM

The proposed system includes two parts for filtering and reconstructing the forensic images. Two filters were applied in the filtering part. Those filters are Mean and Median to remove noises from the tested images. In addition, a reconstruction algorithm is developed to retrieve the lost blocks.

B. The Proposed Filtering Algorithm

The proposed filtering algorithm works by using the mean and median filters to the Gaussian and Salt and Pepper noises from the tested images. In order to test the ability of the proposed filtering system different densities of noises were applied on the images. Mean and median filters were tested to reduce and remove the "Gaussian" noises with densities of 0.02 & 0.025. However, the same filters were used to reduce and remove the salt and pepper noise with densities of 0.25 & 0.35. Fig. 3 represents the original image before adding noises or removing any blocks. The CCTV captured this tested image for a thief and then it being published on a news web site.

The mean filter is simply works by replacing each pixel value in an image with the mean average value of its neighbours, including itself. This has the effect of removed pixel values, which are unrepresentative of their surroundings. It uses a convolution mask such as the following 3×3 masks; see Fig. 1 [12].

Straightforward computing of the convolution of an image with this kernel carries out the mean filtering process. The syntax of the mean filter used is: *K = filter2( ).*

The coefficient of this sum is one; therefore the brightness of the image will be retained, and the coefficients are all positive. This means it will tend to blur the image.

$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$
$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$
$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$

Fig. 1 3×3 Averaging Kernel often used in Mean Filtering

However, the 2-D median filter function is also used to reduce noise in an image, but sometimes it does a better job than the mean filter of preserving useful detail in the image.

The syntax of the function is: *B = medfilt2()*, this function implements median filtering of the matrix A. It uses the default 3-by-3 neighbourhood.

The median filter considers each pixel in the image one by one and looks at nearby neighbours to decide whether or not it is representative of its surroundings. The median is calculated by first sorting all the pixel values from the surrounding neighbourhood into numerical order and then replacing the pixel being considered with the middle pixel value [12].

Fig. 2 shows 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 neighbourhood is used here. Though, larger neighbourhoods will produce more severe smoothing [12].

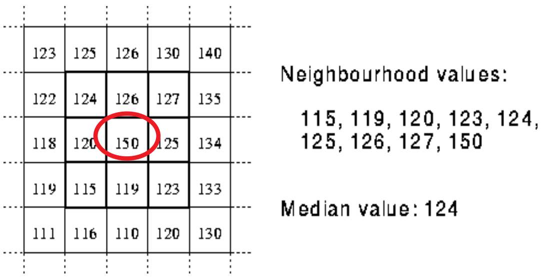


Fig. 2 Calculating the Median Value of a Pixel Neighborhood

Fig. 3 Original Image

C. The Proposed Reconstruction Algorithm

The proposed reconstruction algorithm has been applied to reconstruct the small and large missing blocks. It also produces a histogram of the damaged image in order to determine the blocks locations.

The histogram represents the plot of the gray level values versus the number of pixels at that value. The advantage of the histogram is that it is providing us with information about the nature of the image [13].

The algorithm does convert the forensic image to gray scale using *rgb2gray* function in MATLAB. In order to filter out the blocks that have been utilise the distribution of the gray levels. For that the histogram is used to count the number of pixels in each gray level from 1 to 256. Also, the threshold will appear as a vertical red bar on the histogram, as shown in Fig. 4.

The reconstruction algorithm also produces a binary image; it is a black and white image. White represents the blocks and black represents everything else, see Fig. 5. The binary image is obtained by *thresholding*values.

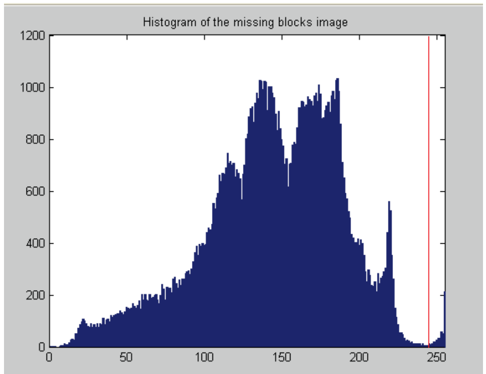


Fig. 4 A Histogram of a Damaged Image

Adobe Photoshop software has been used to remove some small and large blocks from the tested image. This has been done in order to test and train the reconstructed system.

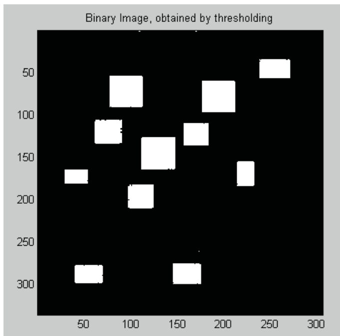


Fig. 5 A Binary Image to Detect the Large Missing Blocks from the Tested Image

The reconstruction process involves using a loop by filling each pixel using the *roifill* function through MATLAB. The bounding box of each block gives the measurement of the coordinates of the left and the lower corner. In addition, width and height of each of the bounding boxes. For example:

$$xleft=round(blockMeasurements(k).BoundingBox \quad (1)$$

$$ylower=round(blockMeasurements(k).BoundingBox \quad (2)$$

$$width=ound(blockMeasurements(k).BoundingBox \quad (3)$$

height=round(blockMeasurements(k).BoundingBox *(4)*

yupper = ylower + height;
xright = xleft + width;

In order to use this bounding box for interpolative filling of the box, we enlarge the box by 2 pixels, to the left, right, up and down. For example:

xleft = xleft - 2;
xright = xright +2;
yupper = yupper +2;
ylower = ylower -2;

The *roifill* function fills the image enclosed in the polygon by interpolating the pixels inside it.

The job of *roifill* function is to fill in a specified region of the interested polygon in a gray scale image. The *roifill* function smoothly interpolates inward from the pixel values on the boundary of the polygon by solving Laplace's equation [13]. The Laplace's equation is often written as:

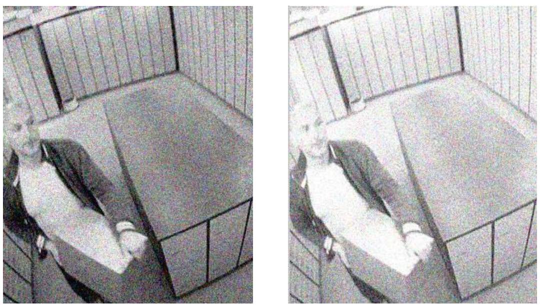
$$\nabla 2\varphi = 0$$

where $\nabla 2$ 'is the Laplace operator and φ is a scalar function'.

V. Results and Discussion

The proposed filtering algorithm was applied to the gray scale images after adding "Gaussian" and 'salt and pepper' noise with two different densities. Two noise densities had been tested to compare and evaluate the noisy images after filtering; Figs. 6 (a) and (b) show the tested image after adding the Gaussian noise. However, Figs. 7 (a) and (b) show the tested image after adding the Salt and Pepper noise.

Median and mean filters were applied to remove those noises. Results are shown in Figs. 8 and 9.



(a) (b)

Fig. 6 (a) The Tested Forensic Image with additive Gussian noise (Density=0.02), (b) The Tested Forensic Image with additive Gussian noise (Density=0.25)

(a) (b)

Fig. 7 (a) The Tested Forensic Image with additive Salt and Pepper noise (Density=0.25), (b) The Tested Forensic Image with additive Salt and Pepper noise (Density=0.35)

Results in Figs. 8 (a) and (b) demonstrate that mean and median filters are sufficient to efficiently remove the Gaussian noise with low density of 0.02. The noises have been completely removed, but the gray level of the filtered image is slightly lighter than in the original image. However, both filtered images are a little bit smoother than the original one.

(a) (b)

Fig. 8 (a) Filtered Image after Applying Mean Filtering to Remove Gaussian noise with (Density=0.02), (b) Filtered Image after Applying Mean Filtering to Remove Gaussian noise with (Density=0.02)

(a) (b)

Fig. 9 (a) Filtered Image after Applying Mean Filtering to Remove Gussian noise with (Density=0.25), (b) Filtered Image after Applying Mean Filtering to Remove Gussian noise with (Density=0.25)

Results shown in Figs. 9 (a) and (b) prove that mean and median filtering are not very sufficient to remove the medium density of the Gaussian noise. Moreover, the grey level of the filtered images is so far in compare with the original images.

(a) (b)

Fig. 10 (a) Image after Applying Mean Filtering to Remove Salt and Pepper noise with (Density=0.25), (b) Filtered Image after Applying Mean Filtering to Remove Salt and Pepper noise with (Density=0.25)

(a) (b)

Fig. 11 (a) Filtered Image after Applying Mean Filtering to Remove Salt and Pepper noise with (Density=0.35), (b) Filtered Image after Applying Mean Filtering to Remove Salt and Pepper noise with (Density=0.35)

Results in Fig. 10 show that median filter is sufficient to efficiently remove the “salt and pepper” noise withmedium density of 0.25 noises in contrast to the mean filter.The noise in the filtered image (a) was reduced, but not completely removed. However, thenoise is completely removed from the filtered image (b). The median filter performs well with the medium level of noise density more than the mean filter.

On the other hand, results shown in Fig. 11 prove that again the median filter is sufficient enough to completely remove the high level density of the Salt & Pepper noise in contrast to the mean filter. Noise in the filtered image (a) has been reduced but not wholly removed. On the contrary, noise in the filtered image (b) has been fully removed. The Median filter shows a great performance with the high level of noise density more than the Mean filter.

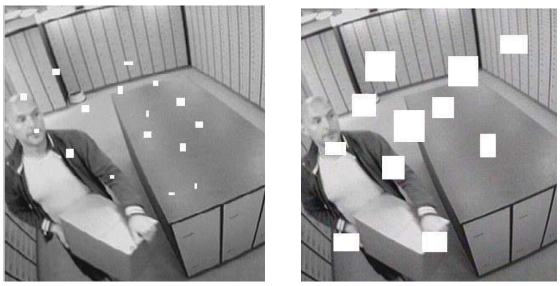


Fig. 12 Small and Large Missing Blocks

However, Adobe Photoshop software was used to remove blocks from the original rested image to train the system, as shown in Fig. 12.

Fig. 13 The Resulted Images after Reconstructing the Small Blocks

Fig. 14 The Resulted Images after Reconstructing the Large Blocks.

The proposed reconstruction algorithm is able to sufficiently reconstruct the small missing blocks, as shown in Fig. 13. However, the grey level of the reconstructed image is slightly lighter than the original one.

On the other hand, Fig. 14 shows the resulted image after reconstructing the large missing blocks. The proposed reconstruction algorithm could not retrieve the large missing block completely.

VI. Conclusion and Future Work

The aim of this paper is to improve the quality of the grey forensic images. It is important for images to have a high resolution as they can provide more details. For this purpose two filtering algorithms were based on Median and Mean were introduced.

To evaluate the filters performance two different types of noises were tested. Results proved that the median filter is better for removing noises than the mean filter.

On the other hand, the reconstruction algorithm was able to sufficiently reconstruct the small blocks; however, it is not showing a high performance in terms of reconstruction the large missing blocks.

Moreover, the proposed reconstruction algorithm is able to determine the missing blocks position through a binary image. Detecting the missing blocks position is necessary for the quality of the reconstructed image.

In order to achieve better results more filters should be added to the filtering system. Besides, the reconstruction algorithm should be improved to perform good results while retrieving the large missing block. The filtering and reconstruction algorithm is on the way to be developed to work with the coloured forensic images as well.

REFERENCES

[1] S. Umbaugh, “Computer Vision and Image Processing: a practical approach using CVIP tools”, UK: Prentice Hall PTR, 1998
[2] M. Breeuwsma, “Forensic imaging of embedded systems using JTAG (boundary-scan),” Digital Investigation, vol. 3, pp. 32-42, 2006
[3] D. Venkateshwar, “Implementation and Evaluation of Image Processing Algorithm on FPGA,” International Journal of Theoretical and Applied Computer Sciences Processing, vol. 1, pp. 1-10, 2006
[4] C. Behrenbruch, “Image filtering techniques for medical image post-processing: an overview,” The British Journal of Radiology, vol. 77, pp. 2-6, 2004
[5] E. Brooks, and E. Comber, “Digital imaging and image analysis applied to numerical applications in forensic hair examination,” Journal of Science and Justice, vol. 51, pp. 28–37, 2010
[6] Z. Geradts, “Content Based Information Retrieval in Forensic Image Databases,” Unpublished PhD thesis. Netherland: University of Utrecht, 2001
[7] C. Akujuobi, “The effects of different wavelets on image reconstruction,”Proceedings of the IEEE. Bringing Together Education, Science and Technology, vol. 55, pp. 5-10, 1996
[8] D. Janecki, “Gaussian filters with profile extrapolation,” Precision Engineering, vol. 35, pp. 602– 606, 2011
[9] J. Rane, J. Remus and G. Sapiro, "Wavelet-domain reconstruction of lost blocks in wireless image transmission and packet-switched networks," in Proc. ICIP , vol. 1, pp.309-312, 2002
[10] R. Silva, F. Prado and I. Caputo, “The forensic importance of frontal sinus radiographs,” Journal of Forensic and Legal Medicine, vol.16, pp.18–23, 2008
[11] G. Yang, P. Burgerb, D. Firmin and S. Underwoodad “Structure adaptive anisotropic image filtering,” Image and Vision Computing, vol. 14, pp. 135- 145, 1996
[12] H. Aziz, “Medical Image Reconstruction Using Wavelet and Multi – Wavelet Algorithms,” Unpublished dissertation. Coventry: Coventry University, 2010
[13] P. Bauszat, M. Eisemann and M. Magnor, “Guided Image Filtering for Interactive High-quality Global Illumination,”Computer Graphics forum, vol. 30, pp.1361-1368, 2011

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