

Multi-type Noise Removal in Lead Frame Image Using Enhanced Hybrid Median Filter

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Abstract— Image filtering technique plays a very important role in digital image processing. It is one of the major steps in image enhancement and restoration. This filtering technique can remove noise and preserve the details of the image for feature extraction processes. However, filtering process can still be considered as a huge challenge for image filtering technique. Common noises in the image such as Salt & Pepper, Gaussian, Speckle, and Poisson Noise are still posing problems in filtering process where the quality and the originality of the images can be degraded and disturbed. Meanwhile, a single filtering technique is usually fit to deal with only certain specific noise. This paper presents an enhanced Hybrid Median Filter (H₆F) technique to improve image filtering process. The technique involves 3x3 sub-mask and determination of new pixel value from the median value of the three steps which are the median calculation of '+'-neighbours, median calculation of all sub-masks and selection of centre pixel value. The H₆F technique has been computed on lead frame inspection system. The results have shown that the technique has been able to remove multi-type of noises efficiently and produce exceptionally low Mean-Square Error (MSE) while consuming the acceptable amount of execution time when compared to other filtering techniques.

Keywords— image filtering; hybrid median filter; multi-type noise

I. INTRODUCTION

Images in digital image processing are normally corrupted, and its quality is usually degraded by the undesired signal called noise. Noise can be described as a random signal, and the main source of this signal comes from light levels and sensor temperature [1]. Besides that, the presence of noise also come from environmental conditions that affect the imaging sensor, dust particles that exist in the scanner and the interference in transmission channel [2]. Noise exists in various types and characteristics. Common types of noise that have been studied in digital image processing are Salt and Pepper noise, Gaussian noise, Speckle noise and Poisson noise [3].

According to [4], noise can destroy most of the part of image information which can lead to image distortion and reduce the visual quality of the image [5]. Due to noise, the digital image also could lose essential information for human or machine to analyse. Failing to analyse image correctly might give a negative impact on us especially in a critical area such as medicine that deal with human life and in industrial production in which can endanger the end user of the product. To address these noise related problems in digital image processing, image filtering technique has generally been applied to restore the originality of the image.

This technique is important to improve the accuracy of image processing algorithm. There are many image filtering techniques that have been developed such as a median filter to remove Salt and Pepper noise [6], Gaussian filter to remove Gaussian noise [7] and others [8], [9].

Image processing techniques have been used and applied in industrial production for quite some time specifically in machine's Vision System (VS) to check the quality or condition of specific products. Among the products that require quality inspection is a lead frame (Fig. 1). The lead frame is a thin layer of metal frame inside a chip package that carries signal from the die to outside in which semiconductors are attached during the package assembly process. The quality of the lead frame is very important because if there is any tiny defect, it can seriously endanger the performance and reliability of the Integrated Circuit (IC) device. The small size of the design and the reflective surface of the lead frame are the big challenges that need to be overcome to obtain good and high-quality images. Normally, the image of lead frame taken during the inspection using VS contains various types of noise and image filtering techniques have been commonly applied to deal with these noises. However, even though these techniques have been able to remove the specific or single type of noise, they still face difficulties when dealing with the images that contain multi-types of noise.

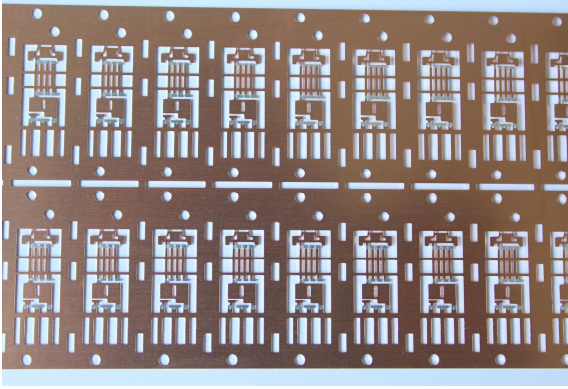


Fig. 1 A sample of lead frame image

Therefore, this research focuses on developing image filtering technique to remove multi-types of noise using an enhanced Hybrid Median Filter known as H_6F on lead frame image since there is a lack of study on lead frame images. This H_6F has been developed based on the widely-used Hybrid Median Filter (HMF) technique. The technique has been tested on lead frame inspection system and its performance was compared to other six image filtering techniques by using MSE method and execution time was taken. This research also focuses on the low-density type of noises since the vision system that use to inspect lead frame image is in a controlled condition that normally noises that present in the image is quite low. Basically, MSE method was used to investigate whether the filter used can remove noise or not. The execution time was taken to ensure the filter has a good quality of algorithm and determine whether it has acceptable time for the vision system to execute the program as mention in [1].

According to [2], the primary mechanism for image enhancement and restoration during the early development of image processing were the linear filters. This was due to their mathematical simplicity, simple design and easy implementation. However, the image that was processed using this linear filter tends to blur on the edges of the image and the filter did not remove Gaussian noise adequately. Many researches were conducted previously to improve image filtering methods. Non-linear filters were found to be the better filters in removing noise [3]. Among them are the common Median Filter (Med Filter), Minimum Filter (Min Filter) and Maximum Filter (Max Filter).

A. Median Filter

Firstly, as described in [4] and [5], Median Filter is a non-linear filtering method that is known for its ability to remove impulsive type noise, while preserving sharp edges and fine details in digital images. In this filtering process, the value of the pixel at a certain point 'p' will be computed and replaced by the median value of its 8-neighbourhood pixel. It can be defined as the following equation:

$$g_med(p) = median\{f(p), where p \in N_8(p)\} \quad (1)$$

where $g_med(p)$ is the output of the Median Filter at image point p , $median\{.\}$ is the median operator, $f(p)$ is the input image of point p and N_8 is the 8-neighbourhood pixel of point p .

B. Minimum Filter

The second non-linear filter which is Min Filter will enhance the dark values of the pixel in the image by increasing its area. This method is similar to the dilate function that processes the darkest area in the surrounding pixel and extends the region. Min Filter will select the minimum value of the 8-neighbourhood pixels of pixel 'p' (darkest point) and replace it at the pixel 'p'. The output $g_min(p)$ of Min Filter at image point p can be defined as:

$$g_min(p) = \min\{f(p), where p \in N_8(p)\} \quad (2)$$

where $g_min(p)$ is the output of the Min Filter at image point p , $\min\{.\}$ is the minimum operator, $f(p)$ is the input image of point p and N_8 is the 8-neighbourhood pixel of point p .

C. Maximum Filter

The third non-linear filter which is Max Filter acts as the opposite of Min Filter. Max Filter will select the maximum value of the 8-neighbourhood pixels of pixel 'p' (brightest point) and replace it at pixel 'p'. The definition of Max Filter can be written as:

$$g_max(p) = \max\{f(p), where p \in N_8(p)\} \quad (3)$$

where $g_max(p)$ is the output of the Max Filter at image point p , $\max\{.\}$ is the maximum operator, $f(p)$ is the input image of point p and N_8 is the 8-neighbourhood pixel of point p .

In general, Max Filter is good for removal of Pepper noise type while Min Filter performs better in removing Salt noise type [6].

D. Hybrid Median Filter (HMF)

HMF [7] is a nonlinear filter that commonly used in image processing to remove impulsive noise. It can preserve the edges of an image better than the basic median filter. After this three-steps ranking operation technique is developed, it is widely used and improved ever since by others [8], [9] with the aim to remove noise better. HMF has a vital role in image processing and can be written as:

$$hmf(p) = median\left\{\begin{array}{l} median\{f(p), where p \in +_5(p)\} \\ median\{f(p), where p \in x_5(p)\} \\ f(p) \end{array}\right\} \quad (4)$$

where $hmf(p)$ is the output of the HMF filter at image point p , $median\{.\}$ is the median operator, $f(p)$ is the input image of point p , $+_5$ is the '+' neighbours of point p and x_5 is the 'x' neighbours of point p . If point 'p' has (x, y) coordinate, then '+'-neighbours of point 'p' are at coordinate (x-1, y), (x+1, y), (x, y-1) and (x, y+1) while 'x'-neighbours of point 'p' are at coordinate (x+1, y+1), (x+1, y-1), (x-1, y+1) and (x-1, y-1), of point p .

In 2013, this hybrid technique was used to remove impulse noise and was tested on rice image as studied in [10]. As mentioned in this study, HMF can remove impulse noise smooth and efficiently. Besides that, it also preserves the edges and brightness difference better when compared to Median Filter.

E. Hybrid Cross Median Filter (H_1F)

Hybridization of image filtering techniques has been introduced since more than two decades ago to improve image filtering processes. The Hybrid Cross Median Filter or H_1F has been considered as a non-linear filtering technique for image enhancement and was first introduced in 2011 to remove Gaussian noise from brain tumor image [7]. The results show that H_1F works better than HMF and Median filter in removing Gaussian noise with the performance is measured by Root Mean Square Error (RMSE) method and Peak Signal Noise Ratio (PSNR) method. H_1F can be expressed as the following:

$$H_1F(p) = \max \left\{ \begin{array}{c} \text{median}\{f(p), \text{where } p \in L_3(p)\} \\ \text{median}\{f(p), \text{where } p \in R_3(p)\} \\ f(p) \end{array} \right\} \quad (5)$$

where $H_1F(p)$ is the output of the H_1F filter at image point p , $\text{median}\{.\}$ is the median operator, $f(p)$ is the input image of point p , L_3 is the LT neighbours of point p and R_3 is the RT neighbours of point p .

As defined in equation [4], H_1F works by determining the median 'm' of the median value of the pixel of LT neighbours of point 'p', the median value of the pixel of RT neighbours of point 'p' and the pixel value of point 'p'. This median 'm' is then replaced the pixel value of point 'p'. If point 'p' has (x, y) coordinate, then LT neighbours are at point (x-1, y-1) and (x+1, y+1) while RT neighbours are at point (x+1, y-1) and (x-1, y+1).

F. Hybrid Min Filter (H_2F)

Hybrid Min Filter or H_2F is another hybrid image filtering technique, and it has played an important role in image processing and vision system. H_2F is different from Min Filter and has been used to remove Salt noise. This filter was proposed in the same paper that proposed H_1F and tested with medical image to remove Gaussian noise [7]. The H_2F will take the minimum of the median value of the pixel of LT neighbours of point 'p', the median value of the pixel of RT neighbours of point 'p' and the pixel value of point 'p' and then use it to replace the pixel value of point 'p'. H_2F can be defined as:

$$H_2F(p) = \min \left\{ \begin{array}{c} \text{median}\{f(p), \text{where } p \in L_3(p)\} \\ \text{median}\{f(p), \text{where } p \in R_3(p)\} \\ f(p) \end{array} \right\} \quad (6)$$

where $H_2F(p)$ is the output of the H_2F filter at image point p , $\text{min}\{.\}$ is the minimum operator, $\text{median}\{.\}$ is the median operator, $f(p)$ is the input image of point p , L_3 is the LT neighbours of point p and R_3 is the RT neighbours of point p .

G. Hybrid Max Filter (H_3F)

The fourth hybrid technique is known as Hybrid Max Filter or H_3F . It is different from usual Max Filter and suitable for Pepper noise. According to [7], H_3F can remove Gaussian noise from brain tumor image significantly better than H_1F and H_2F . H_3F performs by taking the maximum of median value of the pixel of LT neighbours of point 'p', the median value of the pixel of RT neighbours of point 'p' and

the median value of the pixel of point 'p' and then replace the pixel value of point 'p'. This hybrid technique can be written as:

$$H_3F(p) = \max \left\{ \begin{array}{c} \text{median}\{f(p), \text{where } p \in L_3(p)\} \\ \text{median}\{f(p), \text{where } p \in R_3(p)\} \\ f(p) \end{array} \right\} \quad (7)$$

where $H_3F(p)$ is the output of the H_3F filter at image point p , $\max\{.\}$ is the maximum operator, $\text{median}\{.\}$ is the median operator, $f(p)$ is the input image of point p , L_3 is the LT neighbours of point p and R_3 is the RT neighbours of point p .

H. Hybrid Sigma Filter (H_4F)

Besides that, in 2013, the authors in [2] have proposed another hybrid technique called Hybrid Sigma Filter or H_4F . H_4F will take the median of the median value of the pixel of sigma neighbours of point 'p', the median value of the pixel of all neighbours of point 'p' and value of the pixel of point 'p' and then use it to replace the pixel value of point 'p'. This H_4F technique has been considered to work well for medical images. This H_4F can be written as:

$$H_4F(p) = \text{median} \left\{ \begin{array}{c} \text{median}\{f(p), \text{where } p \in N_8(p)\} \\ \text{median}\{f(p), \text{where } p \in \varepsilon_5(p)\} \\ f(p) \end{array} \right\} \quad (8)$$

where $H_4F(p)$ is the output of the H_4F filter at image point p , $\text{median}\{.\}$ is the median operator, $f(p)$ is the input image of point p , N_8 is the 8-neighbourhood pixel of point p and ε_5 is the sigma neighbours of point p . If point 'p' has (x, y) coordinate, then sigma neighbours are at the point (x-1, y), (x+1, y), (x, y-1) and (x-1, y-1).

I. Hybrid Min Max Filter (H_5F)

The first introduction of Hybrid Min Max Filter or H_5F was in 2012. This H_5F is the hybridization of H_2F and H_3F to remove Salt and Pepper noises. It is presented through the work done in [11]. This technique was tested using knee image with various noise level. Through the investigation, H_5F has the best performance in removing random Impulse noise when compared with Fuzzy Hybrid Max Filter, Median Filter, Mean Filter, M3 Filter (hybridization of Mean and Median Filter), Enhanced Hybrid Median Filter and H_3F . Basically, H_5F works by first applying H_2F and then H_3F . It can be written as the following definitions:

$$g(p) = \min \left\{ \begin{array}{c} \text{median}\{f(p), \text{where } p \in L_3(p)\} \\ \text{median}\{f(p), \text{where } p \in R_3(p)\} \\ f(p) \end{array} \right\} \quad (9)$$

$$H_5F(p) = \max \left\{ \begin{array}{c} \text{median}\{g(p), \text{where } p \in L_3(p)\} \\ \text{median}\{g(p), \text{where } p \in R_3(p)\} \\ f(p) \end{array} \right\}$$

where $g(p)$ is the output of the H_2F filter at image point p , $H_5F(p)$ is the output of the H_5F filter at image point p , $\max\{.\}$ is the maximum operator, $\text{min}\{.\}$ is the minimum operator, $\text{median}\{.\}$ is the median operator, $f(p)$ is the input image of

point p , L_3 is the LT neighbours of point p and R_3 is the RT neighbours of point p .

In 2014, this hybrid H_5F technique was tested on brain images for Gaussian noise removal, dog image for speckle noise removal and the Lena image for impulse noise removal with comparison with Wiener filter technique. It has been concluded in [12] that H_5F can independently remove Gaussian noise, Speckle noise and impulse noise in the respective images with significantly higher performance than Wiener filter. However, the images that contain multi-types of noises have neither been tested by this H_5F nor the previous hybrid techniques.

II. MATERIAL AND METHOD

In this research, an enhanced Hybrid Median Filter or H_6F has been proposed and tested. H_6F has been developed based on the modification of HMF. The proposed technique uses 3x3 sub-mask and the determination of new pixel value from the median value of the three following steps: a) median calculation of '+' neighbours of point 'p'; b) median calculation of all sub-mask of point 'p' and c) selection of centre pixel value of point 'p'. Fig. 1 shows the process of H_6F .

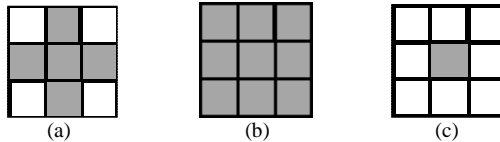


Fig. 2 Determination of H_6F pixel from the three steps: (a) median calculation of '+'-neighbours; (b) median calculation of all sub-mask; and (c) selection of centre pixel value

If point 'p' has (x, y) coordinate, then '+' neighbours of point 'p' are at coordinate $(x-1, y)$, $(x+1, y)$, $(x, y-1)$ and $(x, y+1)$. All the sub-masks are at coordinate $(x+1, y+1)$, $(x, y+1)$, $(x-1, y+1)$, $(x+1, y)$, (x, y) , $(x-1, y)$, $(x+1, y-1)$, $(x, y-1)$ and $(x-1, y-1)$. Mathematically, H_6F can be written as:

$$h_6f(p) = \text{median} \left\{ \begin{array}{l} \text{median}\{f(p), \text{where } p \in +_5(p)\} \\ \text{median}\{f(p), \text{where } p \in N_8(p)\} \\ f(p) \end{array} \right\} \quad (10)$$

where $h_6f(p)$ is the output of the H_6F filter at image point p , $\text{median}\{\cdot\}$ is the median operator, $f(p)$ is the input image of point p , $+_5$ is the '+'-neighbours of point p and N_8 is the 8-neighbourhood pixel of point p . The algorithm of H_6F technique can be defined as follows:

- Read the original image,
- Convert the original image from RGB to grayscale,
- Determine the 3x3 sub-mask with padded replicate,
- Find the median of '+'-neighbours,
- Find the median of all sub-masks,
- Select the centre pixel value,
- Calculate the median of value from step (4), (5) and (6),
- Replace the centre pixel value with the newly calculated value in step (7).

The performance of H_6F technique has been analysed and compared to other hybrid techniques by using Mean Square

Error (MSE) method. This MSE method basically represents the average difference between the original image and the predicted image [13]. MSE can be defined as:

$$MSE = \frac{1}{MN} \sum_{j=1}^M \sum_{k=1}^N (X_{j,k} - X'_{j,k})^2 \quad (11)$$

where MSE is the output of MSE value, $X_{j,k}$ is the desired output image, $X'_{j,k}$ is the predicted output image and m and n are the total number of pixels in the horizontal and the vertical dimensions of the image respectively.

The lower the value of MSE indicates better performance of the technique.

III. RESULTS AND DISCUSSION

The H_6F filtering technique has been tested on a sample of 20 lead frame images, and the average of MSE was taken. The performance of H_6F has been compared to the performances of other six hybrid filtering techniques of HMF, H_1F , H_2F , H_3F , H_4F , and H_5F . Five types of noises which are Salt and Pepper, Gaussian, Speckle, Poisson and Multi-types noise (the other four noises combined together) were added to the input images of all six filtering techniques. The execution time for each algorithm was also taken for comparison and analysis. All experiments have been conducted on MATLAB R2014a and computer used for simulations was an Intel Core i7-6700K CPU with 4.00 GHz working frequency and 8G RAM.

Table 1 shows the average MSE value of all filters when Salt and Pepper noise with different densities were added into the 20 input images.

TABLE I
AVERAGE VALUE OF MSE FOR 20 LEAD FRAME IMAGES TESTED TO DIFFERENT DENSITIES OF SALT AND PEPPER NOISE

Filter	MSE Value for Salt and Pepper Noise with Different Density ($\times 10^4$)				
	0.02	0.04	0.06	0.08	0.10
HMF	1.7239	2.4767	3.5636	4.3974	5.8098
H_1F	3.0217	6.6056	11.8923	16.8483	23.9703
H_2F	16.1565	30.0393	44.9280	58.2558	72.5367
H_3F	11.9881	21.7785	33.3967	43.1139	53.9259
H_4F	3.0245	3.5538	4.4541	5.1490	6.0320
H_5F	6.9675	8.9170	11.8489	12.3597	16.6682
H_6F	1.2777	1.5823	2.1725	2.6285	3.4207

Based on Table 1, it can be concluded that the most successful image filtering technique in removing Salt and Pepper noise with different densities is H_6F . The proposed technique has the lowest MSE value for each type of densities for Salt and Pepper noise which indicates that the technique has the low average difference between the original image and the filtered output image. Therefore, it can be said that this filter has recovered almost all part of the interrupted pixels in the image by the Salt and Pepper noise. The nearest filters that have as good performance as H_6F are HMF followed by H_4F , H_1F , and H_3F . The H_2F and H_5F techniques performed poorly and the MSE values are more than 10 times higher compared to the H_6F .

Next, the performance of all filters when Gaussian noise with different densities was added into the 20 lead frame

images is investigated. The average MSE values calculated were presented in Table 2.

TABLE II
AVERAGE VALUE OF MSE FOR 20 LEAD FRAME IMAGES TESTED TO DIFFERENT DENSITIES OF GAUSSIAN NOISE

Filter	MSE Value for Gaussian Noise with Different Density ($\times 10^5$)				
	0.02	0.04	0.06	0.08	0.10
HMF	1.3776	1.7703	2.4000	3.2696	4.4154
H ₁ F	2.1492	2.5129	3.1116	3.9521	5.0121
H ₂ F	2.3645	2.1011	2.1207	2.3999	2.9244
H ₃ F	3.3458	4.2989	5.4206	6.7938	8.3960
H ₄ F	1.2889	1.6556	2.2909	3.1580	4.3182
H ₅ F	1.7168	1.7374	2.0377	2.5804	3.4034
H ₆ F	1.0996	1.4782	2.1171	3.0051	4.1618

According to Table 2, the results show that HMF, H₄F, H₅F, and H₆F have quite identical performance while H₁F, H₂F, and H₃F have low performance in removing Gaussian noise. The proposed H₆F technique has the lowest MSE value for densities of 0.02 and 0.04. Meanwhile, for Gaussian noise with densities of 0.06, 0.08 and 0.10, H₅F produced the lowest MSE value, and H₆F has the second lowest MSE value with a slightly different value compared to H₅F.

The average value of MSE for 20 lead frame images tested with different densities of Speckle noise was calculated and presented in Table 3.

TABLE III
AVERAGE VALUE OF MSE FOR 20 LEAD FRAME IMAGES TESTED TO DIFFERENT DENSITIES OF SPECKLE-NOISE

Filter	MSE Value for Speckle Noise with Different Density ($\times 10^4$)				
	0.02	0.04	0.06	0.08	0.10
HMF	11.7941	20.3009	28.1036	35.1146	42.0792
H ₁ F	16.3148	29.3951	41.7514	53.4867	65.5970
H ₂ F	22.3600	40.6160	58.2489	75.5437	94.6686
H ₃ F	18.1158	29.5966	39.6721	49.2563	58.5291
H ₄ F	11.7212	18.8937	25.1873	30.7675	35.9953
H ₅ F	19.3271	32.3048	44.2900	55.5255	68.2614
H ₆ F	9.9348	17.1326	23.5186	29.2564	35.0315

By referring to Table 3, the filtering technique that removes speckle noise efficiently is H₆F technique. This technique had come up with the lowest MSE value compared to the other six filtering techniques. Besides that, HMF and H₄F also performed with quite a similar result while H₁F, H₂F, H₃F, and H₅F performed poorly. The H₂F technique has the higher MSE value with almost double the H₆F's MSE value. The average MSE values for execution of the filtering technique on Poisson noise for 20 lead frame images are shown in Table 4.

In Table 5, the best performance in removing multi-type of noise in the lead frame image is H₆F. The proposed filtering technique has the lowest average MSE value. HMF, H₄F, and H₅F also can be classified as good multi-type noise removal because the MSE value is almost same as H₆F. Meanwhile, H₁F, H₂F, and H₃F perform appallingly with a high value of MSE.

TABLE IV
AVERAGE MSE VALUE FOR 20 LEAD FRAME IMAGES TESTED TO POISSON NOISE

Filter	MSE Value for Poisson Noise ($\times 10^4$)
HMF	4.0027
H ₁ F	5.6263
H ₂ F	9.2556
H ₃ F	8.0819
H ₄ F	4.9510
H ₅ F	8.8169
H ₆ F	3.3432

The lowest average MSE value in Table 4 is H₆F followed by HMF, H₄F, H₁F, H₃F, H₅F, and H₂F respectively. Therefore, H₆F can be categorized as a good filtering technique in removing Poisson noise compared to the others. The lowest performance in removing this noise is H₂F with MSE value more than double the H₆F's MSE value. HMF that has the second lowest MSE value performs only slightly different with H₆F and has a quite similar MSE value with H₄F.

The multi-type of noise with different density is then experimented, and the outcome of each filter are shown in Table 5.

TABLE V
AVERAGE VALUE OF MSE FOR 20 LEAD FRAME IMAGES TESTED TO DIFFERENT DENSITIES OF MULTI-TYPE NOISE

Filter	MSE Value for Multi-type Noise with Different Density ($\times 10^5$)				
	0.02	0.04	0.06	0.08	0.10
HMF	2.2348	3.2841	4.5678	5.9531	7.7536
H ₁ F	3.8647	5.7050	7.9105	10.1986	12.9972
H ₂ F	5.2282	7.2271	9.2039	11.3535	13.6884
H ₃ F	5.8614	8.8117	1.2154	15.3969	19.3294
H ₄ F	2.0046	2.8587	3.8880	4.9869	6.4445
H ₅ F	3.0908	4.0721	5.1840	6.3880	7.8451
H ₆ F	1.7925	2.6779	3.7579	4.9213	6.4432

On the other hand, the execution time of each filter algorithm was taken 20 times by using MATLAB function 'tic' and 'toc'. The average times for all filters were then calculated and presented in Table 6

TABLE VI
AVERAGE OF TIME TAKEN TO EXECUTE EACH FILTER

Filter	Execution Time (s)
HMF	3.019784
H ₁ F	2.990989
H ₂ F	2.841072
H ₃ F	2.847189
H ₄ F	2.991438
H ₅ F	3.504634
H ₆ F	2.988173

As referred in Table 6 all the filters take around 2.8 seconds to 3 seconds to complete their tasks. Only H₅F takes about 3.5 seconds to complete the algorithm due to its complex algorithm which consists of the combination of H₂F and H₃F. The lowest execution time is H₂F which has a very slightly different with H₃F. The other three techniques which are H₆F, H₁F, and H₄F have shown moderate results and share almost same execution time. But H₆F has a tiny

different value of about 0.01 second which makes it a better filter algorithm than H_4F .

The following figures represent the input image, examples of the image with noise and the output image after applying filtering technique.

Firstly, Fig. 3 shows the example of an original image of a lead frame that was taken by a camera and converted to a grayscale image and used as the input image.

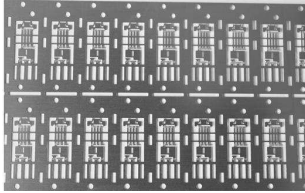


Fig. 3 A sample of grayscale lead frame image that is used as input image

In Fig. 4, black and white pixels can be seen scattered in the image. These black and white pixels that randomly appeared are known as Salt and Pepper noise with 0.10 density.

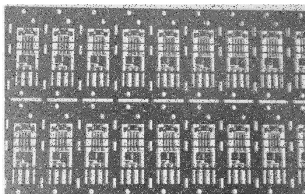


Fig. 4 An example of Salt and Pepper noise in image

Besides that, an example of Gaussian noise with a density of 0.10 in the image is shown in Fig. 5.

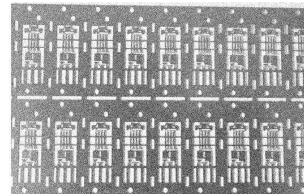


Fig. 5 Gaussian noise added to lead frame image

Next figure shows the example image with Speckle noise (Fig. 6).

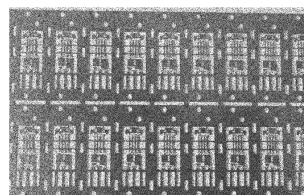


Fig. 6 A sample of Speckle noise in input image

In Fig. 7, Poisson noise is shown, and it is modelled by Poisson process.

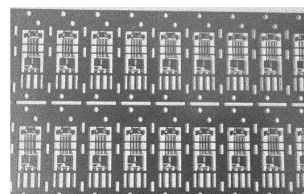


Fig. 7 A lead frame image with Poisson noise

Image with multi-type of noise which Salt and Pepper, Gaussian, Speckle and Poisson noise is added together is presented in Fig. 8.

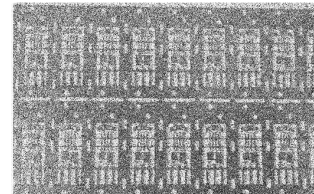


Fig. 8 Lead frame image with multi-type of noise

Based on human vision perspective, image filtered by H_6F technique (Fig. 9) has a better view and look almost same as the original image compared to H_2F technique (Fig. 10). This indicates that the H_6F can remove multi-type of noise efficiently and able to recover the original pixel quite well.

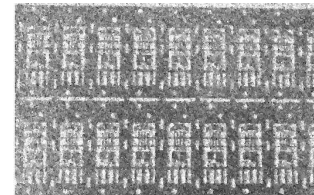


Fig. 9 Output image of H_6F technique

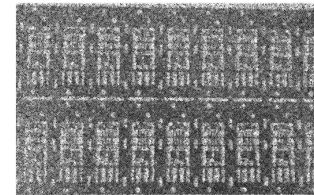


Fig. 10 Output image of H_2F technique

Filtering image with multi-type of noise is considered as a big challenge in image processing. This is due to its complicated attributes such as the probability of salt and pepper, Gaussian distribution and Poisson process that are added together to the image. This noise can affect the Vision System inspection. For example, in Fig. 8, it is very confusing for human or machine to determine the originality of the image. Therefore, H_6F is one of the good techniques to solve this issue. It is important to improve the image quality for visualization and analysis by eliminating the bad factors to recover the useful information from the degraded image as highlighted in [22], [23].

IV. CONCLUSION

This research has shown that H_6F is a better filtering technique in removing Salt and Pepper noise, Speckle noise, Poisson noise and multi-type of noise when compared to other filtering techniques. This technique also works well with Gaussing noise for the density of 0.02 and 0.04. After conducting this H_6F in lead frame images, the results have shown that it has the lowest MSE values for almost all noises tested, which mean that the filter performs well in removing noises in images. The nearest ones that can challenge the performance of this filter are HMF and H_4F . In the analysis of execution time, the results have also shown that H_6F had slightly lower and acceptable execution time which indicates that the algorithm of H_6F can be considered

as having higher quality than H_4F 's algorithm and it can save more time. Although the lowest execution time is owned by H_2F and H_3F respectively, the accomplishment on removing noises in lead frame images are lower in both of them when compared to H_6F technique. Finally, with this performance achievement, it would be possible to apply H_6F in Vision System in order to improve the performance of quality inspection.

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