OWC IMAGE DE-NOISING FILTER PERFORMANCE COMPARSION USING MATLAB BASED GUI

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***Abstract*—this project is on digital image data transmission in optical wireless communication. Two main types of optical wireless communication noise: Gaussian and shot are added during transmission of image, which corrupt the quality of the original image. To mitigate these noises different types of filters used (Gaussian filter, Mean filter, Median filter, Wiener filter) and also made its performance comparison using GUI. The performance comparison done through the value of SNR (signal to noise ratio), PSNR (peak signal to noise ratio), RMSE (root mean square error) and histogram plot.**

Keywords- *Optical wireless communication,Guassian noise, Shot noise,Guassian filter,Mean filter, Median filter,Weiner filter,SNR,PSNR,RMSE,HISTOGRAM PLOT.*

I. INTRODUCTION

The application of optical wireless communication is that it has dual facility i.e., used for illumination and for communication purpose. As in Fig1, LEDs uses to convert electrical data to optical data and transmit the data through optical wireless channel[1].

Channel adds mainly AWGN (say Gaussian noise). Image sensor/photo detector uses to receive optical data (i.e. image). At photo detector shot noise added to image data. To de-noise these noise different filters use is Gaussian filter, Mean filter, Median filter, Weiner filter. Performance comparison of various de-noise filter on basis of SNR, PSNR, RMSE and histogram plot. For ease GUI based comparison of different filter image, its calculation and histogram plot also performed. These filters results, calculation and GUI based comparison is performed on MATLAB 2015(a) software.

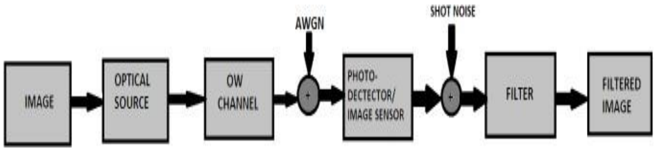


Fig1. BLOCK DIAGRAM

1. NOISE

A. AWGN (additive white guassian noise):

This noise is a statistical in nature. It is uniformly distributed over the whole image. The probability density function (PDF) Of Gaussian noise is same as that of the normal distribution, therefore called as Gaussian distribution [2].
It is defined as

$$P(z)= \frac{1}{(\sigma\sqrt{2\pi})}^{\frac{-(z-\mu)^2}{2\sigma^2}} \qquad (1)$$

Where

σ: standard deviation

P (z): PDF of function z

μ: Mean

B. Shotnoise:

It is noise arises in electronic devices and it is due the discrete nature of current flow in the device. In a semiconductor device, the cause is the random diffusion of electrons or the random recombination of electrons with holes[3].

2. FILTER

Noise added in data corrupt the transmitted data. Here, image data is used and two main noises of optical system Gaussian and shot effect is considered. Various types of filters [4] take to mitigate the noise and to retrieve the original image data.

A. Gaussian filter:

For image, 2D Gaussian function is used instead of 1D.Basically; this filter function is multiplication of two 1D Gaussian functions in two different directions. This filtering obtains by convolution of Gaussian distribution function in 2D with the image. Assuming mean as a zero, Gaussian function depend on mainly standard deviation [5].The size of kernel increases as the standard deviation value of function increases. In this filter central pixel value weight is high as compare to the edge values.

B. Mean filter:

Due to noise abrupt change in pixel value found. It replaces each pixel value with average of its neighbor including itself. Basically, mean filter eliminate the pixel value that shows abrupt change of surrounding [10]. By eliminating the abrupt change is equivalent to remove the high frequency component.

C. Median filter:

Though this filter take longer time than mean filter but it is better to reduce noise [6].In median filter, each pixel value replace by the median value of its neighbor.

D. Wienerfilter:

This is mostly use to remove noise and restore the original data. This filter result into least the mean square error of data. It is estimate the original data linearly [9]. It performs de-convolution of inverse filtering and by compression operation reduces the noise.

3. CALCULATION

A. MSE(Mean square error):

It is cumulative square error between the filtered and original image. Lower value of MSE is desirable [8]. Mathematical formula:

$$\mathrm{MSE} = \frac{1}{M * N} \sum_{m=1}^{M} \sum_{n=1}^{N} [f(m, n) - g(m, n)]^2$$

Where
M, N is the dimension of images.
f(m, n): Original image.
g(m, n): Filtered image

B. PSNR (Peak signal tonoise):

It is the ratio measured peak error between the original and filtered image. High value of PSNR shows better result, usually expressed in db. PSNR for 8-bit image calculated as:

$$\mathrm{PSNR} = 20\log_{10}\left(\frac{255}{\sqrt{\mathrm{MSE}}}\right)$$

C. SNR(Signal to noiseratio):

SNR defined as the ratio of signal power (i.e., mean of image) to noise power (i.e., standard deviation of the filtered image). It is expressed in db and its high value desirable.

$$\mathrm{SNR} = \frac{\sum_{m=1}^{M} \sum_{n=1}^{N} f(m, n)^2}{\sum_{m=1}^{M} \sum_{n=1}^{N} [f(m, n) - g(m, n)]^2}$$

D. RMSE(Root mean squareerror):

It shows the difference between original and filtered image. Mathematically defined as:

$$\mathrm{RMSE} = \sqrt{\mathrm{MSE}}$$

II. IMPLIMENTATIONSTEPS

Step 1: Read an RGB image and convert it into gray scale image.

Step 2: Take FFT of image.

Step 3: Add Gaussian noise to the image obtained in step2.

Step 4: Take IFFT of image.

Step 5: Add Poisson noise to the image obtained in step4.

Step 6: Noisy image is then converted into de-noisy image by applying different types of filters.

Step 7: Calculate SNR, PSNR and RMSE to check the performance of filter and de-noised image.

Step 8: Plot de-noised image histogram.

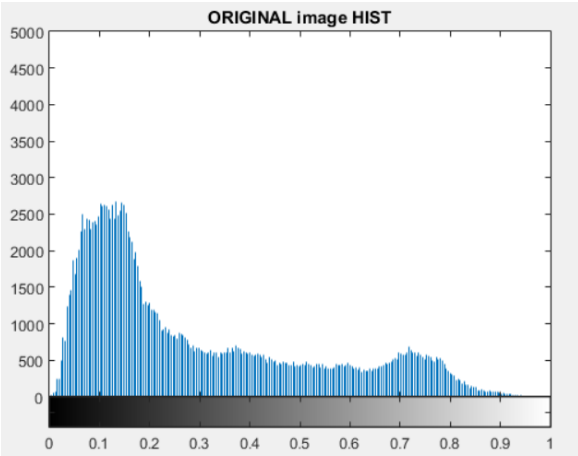
Step 9: De-noised image having high SNR, PSNR and low RMSE.

III. RESULTS

TABLE 1: CALCUATION RESULT OF DIFFERENT FILTER:

CALCULATION	GAUSSIAN FILTER	MEAN FILTER	MEDIAN FILTER	WIENER FILTER
SNR	20.12	22.41	23.27	24.34
PSNR	28.67	30.956	31.81	32.890
RMSE	9.39	7.22	6.55	5.781

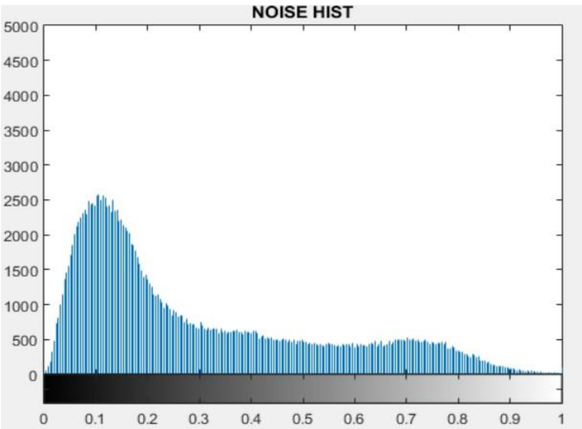
A. ORINIGAL IMAGE AND HISTOGRAM:



HISTOGRAM OF ORIGINAL IMAGE

B. NOISY IMAGE ANDHISTOGRAM:

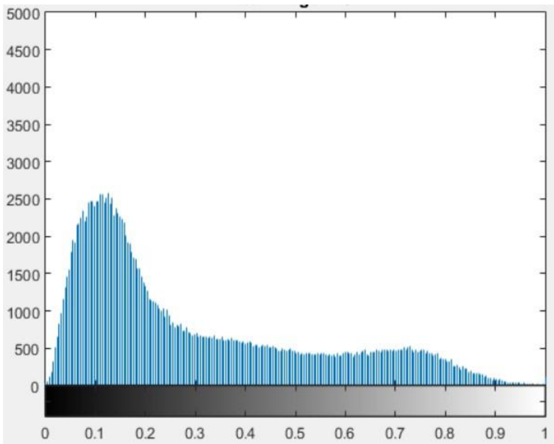
NOISY IMAGE



HISTOGRAM OF NOISY IMAGE

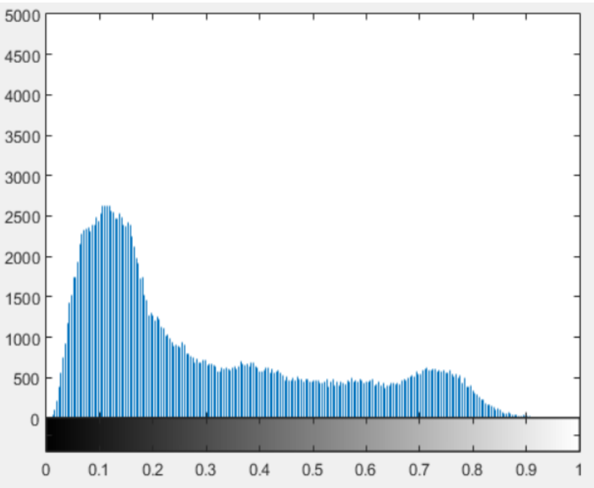
C. FILTERS IMAGES ANDHISTOGRAM

GAUSSIAN FILTER IMAGE



HISTOGRAM OF GAUSSIAN FILTER IMAGE

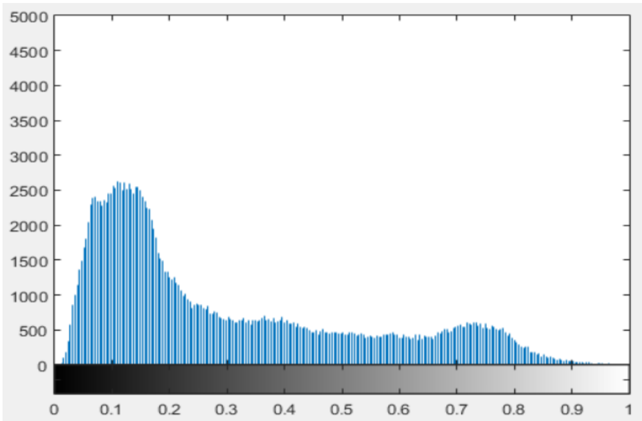
MEAN FILTER IMAGE



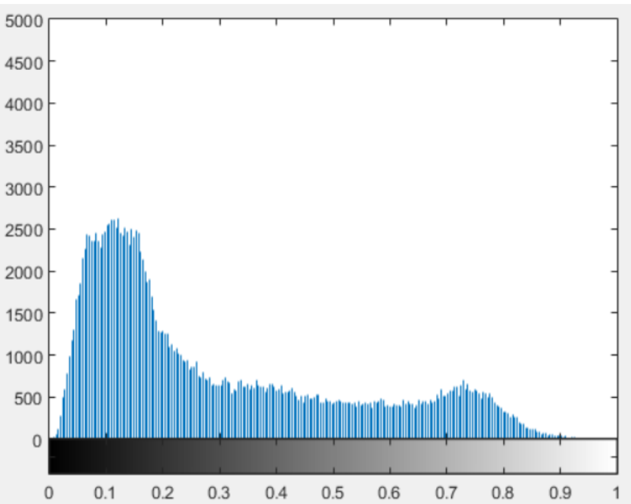
HISTOGRAM OF MEAN FILTER IMAGE

WEINER FILTER IMAGE

MEDIAN FILTER IMAGE

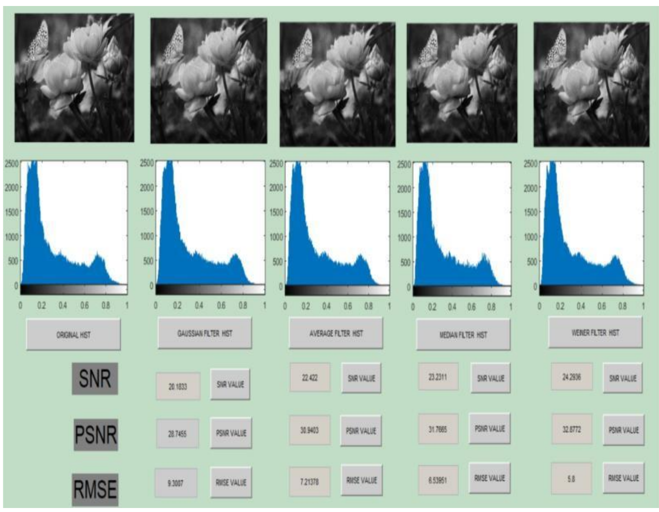


HISTOGRAM OF WEINER FILTER IMAGE



HISTOGRAM OF MEDIAN FILTER IMAGE

MATLAB GUI BASED COMPARSION:



IV. CONCLUSION AND FUTURESCOPE

Image data pass through the optical system added mainly here Gaussian and shot noise. Calculation and histogram result conclude that wiener filter performance is better among Gaussian, Mean and Median filter. GUI provide all calculation and histogram on single slide, thus it ease the comparison of filters.

However, different other noise and distortion can be included in optical channel for practical system. Channel modeling for OWC like intensity modulation at the LED's side and its direct detection can be done as futurework.

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