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Section B: Computer Science

Research Article

A Spatial Domain for Image Enhancement using Gaussian Filter

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Abstract: Image edification method makes it possible to improve the quality of image for visual perception or to aid projected analysis of the image for feature extraction. The main problem in image processing is attributed to signal representation and modeling, enhancement, restoration and reconstruction from projections. Characterized elements of an image could be a large array of discrete dots or various luminous objects; and plays significant roles in quantizing and sampling for computer graphics. Image model is a considerable factor in choosing appropriate de-noising technique and processing domain for image enhancement. This paper presents the use of Gaussian filter to improve image model with instrumentality of Matrix Laboratory (MATLAB). The scientific demonstration showed that, the visual perception was enhanced, when the image quality was improved.

Keywords: Spatial domain, Digital image, Enhancement techniques, Gaussian filter

1. INTRODUCTION

Image signal could emanate from picture element or digital object where the two independent variables are spatially distributed. A discrete time signal with valued amplitudes represented by limited number of digits is commonly called digital signal. A time signal with continuous valued amplitude is a trait of data signal. A digital signal may be quantized as sample data [1]. For a continuous signal, the two independent variables are the spatial elements and common coordinates denoted by $x \; and \; y$. For instance, the intensity of monograph image can be represented as $\mu(x,y)$. Colour image is basically comprised of three signals representing three colours: red, green and blue.

$$\mu(x,y) = \begin{Bmatrix} r(x,y) \\ g(x,y) \\ b(x,y) \end{Bmatrix}$$

Generally, a digital image is two dimensional discrete signal, just as digitized image has a representation of $v(m,h)$. In the case of analog signals, processing operator may be performed in the time domain, whereas discrete time signals, with time domain and frequency domain are involved [2].

Every picture element in a specific image represents a particular physical quality [3]. An attribute of the element is called the image representation, a photograph represents the luminous of various object as seen by the camera [4]. The nature and performance of the image processing algorithm depend on the image model being used [5]. The use of algorithm to eliminate image degradation, like blurring and geometric distortion caused by imaging system and/or its surroundings is generally known as image restoration **[6].**

Image plays vital role in computer graphics. Noise is an unpredictable disturbance of original image. Image generation and processing comes with various interferences and influences. The interferences and other influences cause reduction in image visual quality and clarity. This paper is aimed at exploring the components of digital image and spatial domain as efficient de-noising technique, to enhance its visual perception by improving the quality.

2. LITERATURE REVIEW

Digital image is a collection of discrete picture elements, simply called pixels. Let M be any digital image with N pixels. Specific pixel of image M is represented as M (z) and z can be any value like 1 to N. M (z) can be gray level intensity of the pixel in gray scale image or RGB [7]. The individual RGB components of the pixel M (z) in image M is represented as M^R (z), M^G(z) and M^B(z) respectively. Hence, consideration for R, G and B components is ideal due to average effect that could cause loss of vital steganographic information.

2.1. The Cardinality (size) of an Image: Any image M consists of certain number of pixels. Hence, any specific pixel of image M is presented as M(z) and z can be any value like 1 to total number of pixels in the image. The cardinality or the size of the image M is the total number of picture element that is present in the image and appear as n(M). Therefore, any image M has n(M) pixels [8].

Thus $M = \bigcup_{z=1}^{n(M)} M(z)$

2.2. Components of an Image: Any sub part an image is a component of the image. In other any M can be broken down into pixel groups (or clusters) and each such cluster forms a component of the image and is identified by its unique set of pixels [9]. Thus in a image M the pixels M(z) from z = 1 to n (M(z) from z+1 to n(M) and thus forms the components of the image.

2.3. Features of an Image: Every image has two main properties, namely global and Local. The global attribute include intensity, frequency, domain description, and covariance matrix and high order element [7]. While the local attribute include edges, corners, curves, and regions with special properties.

2.4.Image Noise and Types: Noise is a disturbance in image signal caused by external interference. Noisy image can be categorized as external or internal [7]. External noise comes from electrical equipment.

Internal noise includes equipment within the system caused by circuit noise, the basic properties of noise caused by electrical noise, or the mechanical movement, jitter caused by material itself due to noise e.g –ve and +ve particles and surface of disk defects produced by tape noise [1]. Beyond this classification, various types of noise are stated below:

1. Salt and Pepper noise: Impulse noise or shot noise or binary noise.
2. Gaussian noise: Idealized form of noise, modeled by random image value.
3. Speckle noise: Can be modeled by random values multiplied by pixel values.
4. Periodic noise: Image signal which is periodic rather than random disturbance.

2.5. Image Enhancement: Processing Domains and the Techniques: The commonly used domains for enhancement can be grouped into two categories: (i) the spatial domain-based enhancement method. This is located directly in the processing of a two-dimensional space. This operates on the gray value of each pixel processing [6]. The spatial domain-based enhancement method processes image in two dimensional space directly; (ii) frequency domain-based enhancement method transforms the spatial domain [4].

2.5.1. Image Enhancement based on Spatial Domain: The f(x,y) and g(x,y) means before and after images were enhanced. If the EH is defined in each (x,y), then it get the point of operation EH; if EH is defined in the (x,y) of a neighborhood, then EH is called the template operation. EH can either act as an image f(x,y), it can also act as on a series of images {f1(.), f2(.),…,fn(.)}.

Spatial domain principle can make histogram equalization better. This is a significant enhancement by computation. But in the image processing context, it will be underexposed or overexposed. An image histogram is the corresponding image pixel gray level of each approximation in the distribution of probability density function. Histogram equalization process is based on distribution function of transform. It is like the basis of the histogram correction method [10]. The basic transformation function to transform the original image histogram form for the uniform distribution, thereby expanding the dynamic range of pixel gray values to accomplish the effect of enhancing the overall image contrast [1].

2.5.2.Image Enhancement based on Frequency Domain: This is the kind of image processing method; it processes image in the frequency domain such as: Fourier transform, wavelet transform. Frequency domain techniques are based on the manipulation of the orthogonal transform of the image rather than the image itself. Frequency domain techniques are applied for processing the image according to the frequency content. The magnitude talks about the frequency content of the image. The phase is used to restore the image back to the spatial domain [3]. The usual orthogonal transforms are discrete cosine transform [7]. The transformation enables operation on the frequency content of the image, and therefore high frequency content such as edges and other metadata or subset information can be enhanced, frequency domain operates on the Fourier transform of an image [1].

1. Edges and sharp transitions (e.g. noise) in an image contribute significantly to high frequency content of Fourier transform.

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2. Low frequency content in the Fourier transform is responsible for the general appearance of the image over smooth areas.

The frequency enhancement methods are: low-pass filter, high-pass filter, band-pass and band-stop filtering and a host of others. Homomorphism in filtering solution is non-uniform illumination [7]. The image in the dynamic range may not be a clear image. The high-pass filter technique mostly ignores image segment and highlighting details [6]. That can represent high frequency components, enhancing the part of the edge detail. This method is very suitable and applicable to edge detection of objects in the image [9].

The concept and operational logic of filter is easier to visualize in the frequency domain. Hence, improving image (x, y) is possibly done in the frequency domain based on Discrete Fourier Transform. This is particularly useful in convolution if the spatial extent of the point spread sequence h(x, y) is large than convolution theory [1].

g(x, y)= h(x, y) □ f(x, y) Whereas g(x, y) is the improved image.

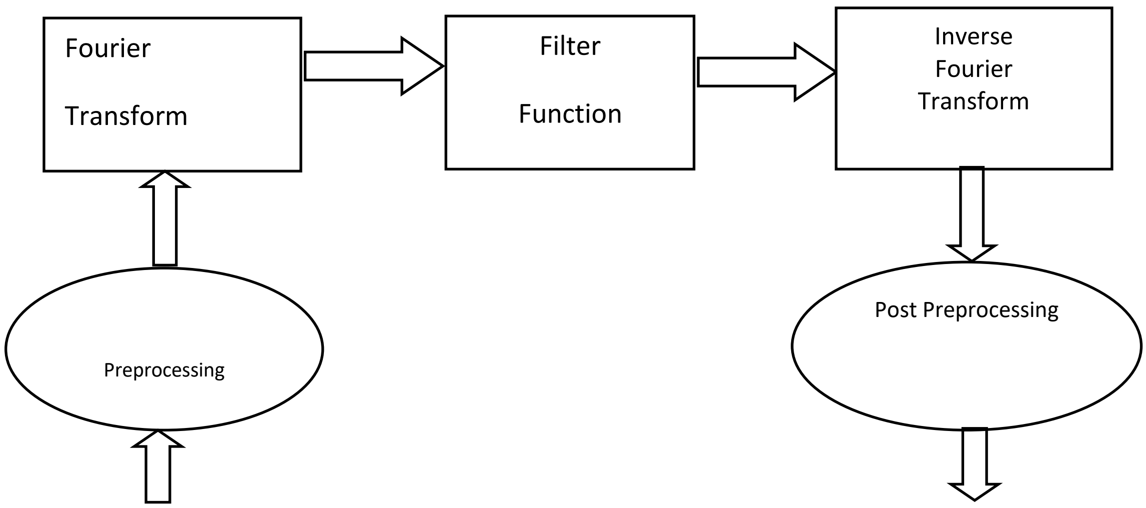

Fig. 1: Filtering Process for Frequency based Enhancement [10]

It is observed from figure above, that image is really dark with a lot of visible properties. When the low-frequency components filtered out, the figure had relatively smooth gray area.

3. METHODOLOGY

Gaussian filtering is an essential space for the weighted mean filter or weighted factor filter because it is based on the structure of the Gaussian function to select the right value of linear smoothing filter. It uses the Gaussian function of discrete two-dimensional by zero-mean for the smoothing filter as symbolically depicted in the following equations:

g(x,y) 1 f(x,y) exp((x i)2 (y j)2/2 2 (i,j) S Eq…………1

in the equation, S shows each pixel set in the neighborhood.

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$$M = \sum \exp - [(x-i)^2 + (y-j)^2 / 2\sigma] \qquad \text{Eq.}\ldots\ldots\ldots\ldots..2$$

The equation expresses the array of pixels and the corresponding weights of set S. An intuitive image or digital photograph was enhanced through Gaussian filtering mechanism. The Gaussian filter for the elimination of normal distribution noise is quite efficient because Gaussian filter smoothen an image by calculating weighted averages in a filter box.

3.1. Gaussian Filtering procedure

Input: Distorted Pixel

Output: Smoothen Pixel

S = 0

r2 = 2.Sqr(r)

For y = −n to +n Do

Begin

a = (Sqr (x) + Sqr (y)) / r2

w (x, y) = exp (-a)

S = S + w (x, y)

End

4. EXPERIMENT AND RESULTS

Having created image and/or noise model by loading image file into the workspace of Matrix Laboratory (MATLAB). Enhancement process was experimented by scientific demonstration and instrumentality of graphic handles in MATLAB, to manipulate images with library functions and transformation tool as evident on the specimen figures below:

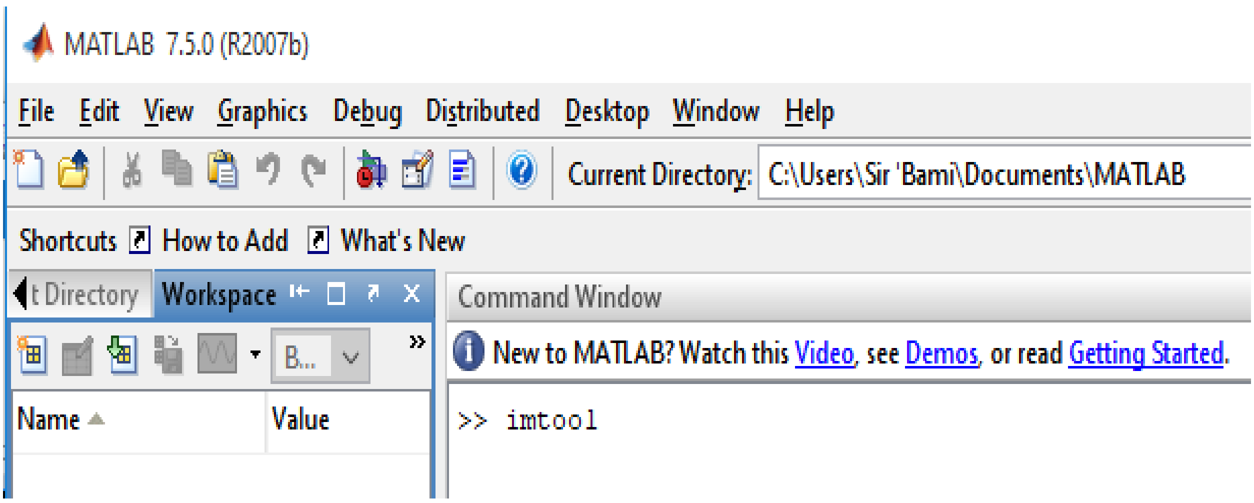

Fig. 2: MATLAB command to invoke the Image Processing Tool

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Fig. 3: MATLAB command to initialize the API for PIXEL signals

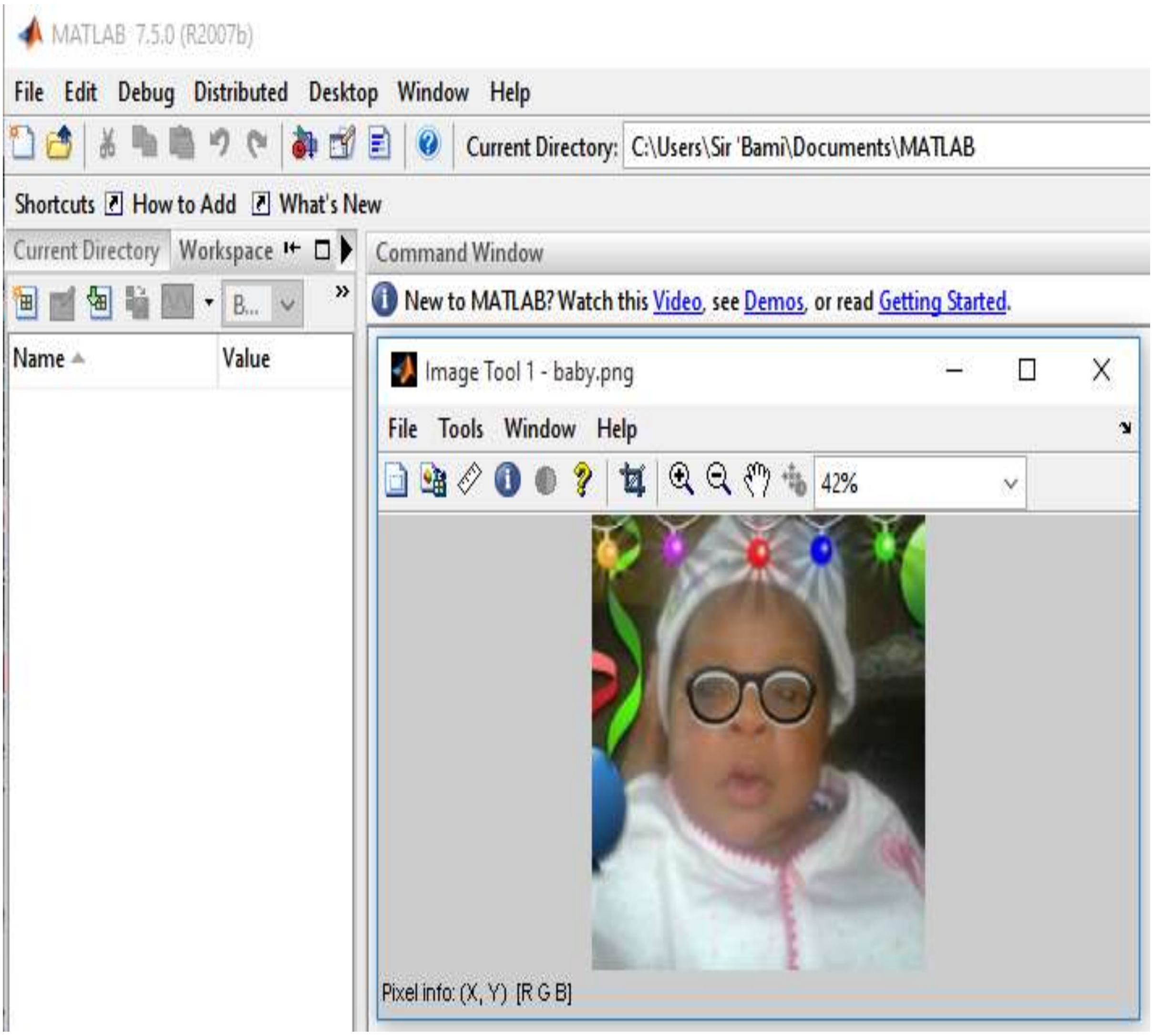

Fig. 4: MATLAB interface for loading digital photograph as noisy image model

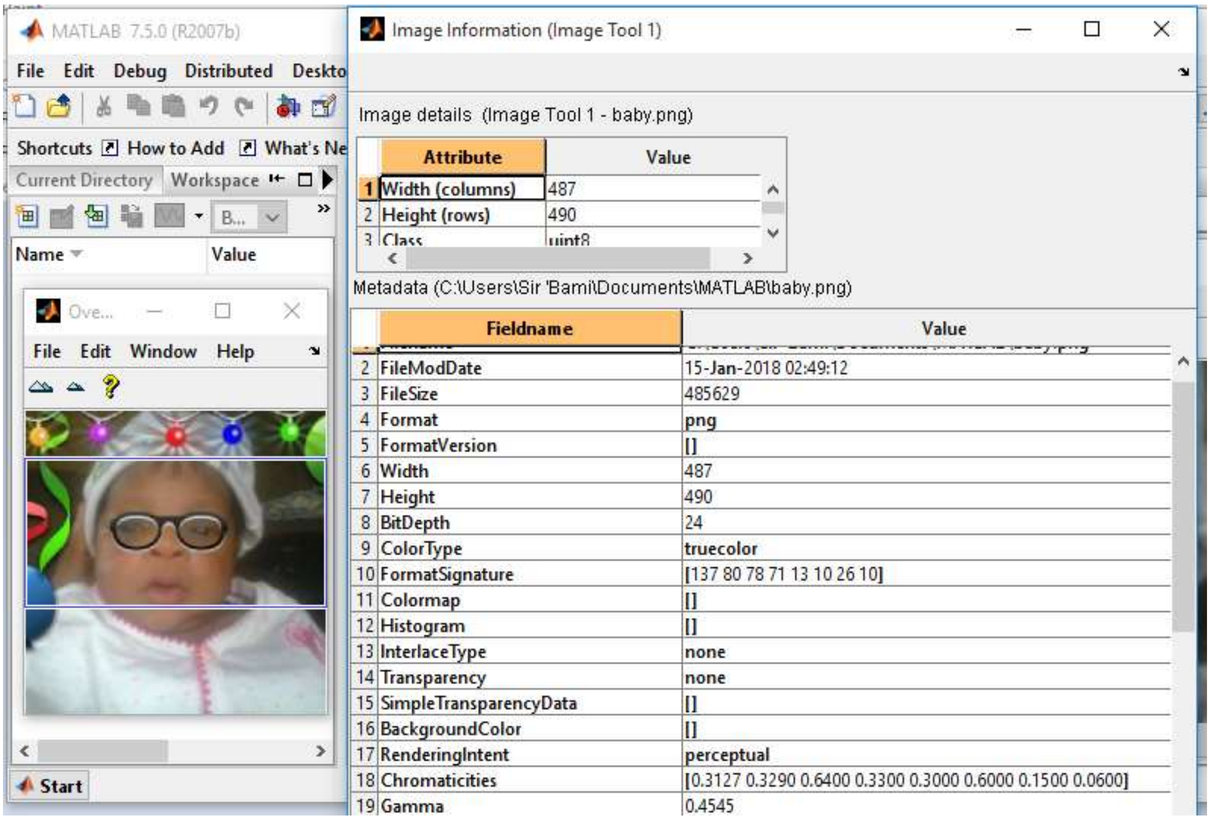

Fig. 5: Overview Navigation and Formation Attributes of the Image Model

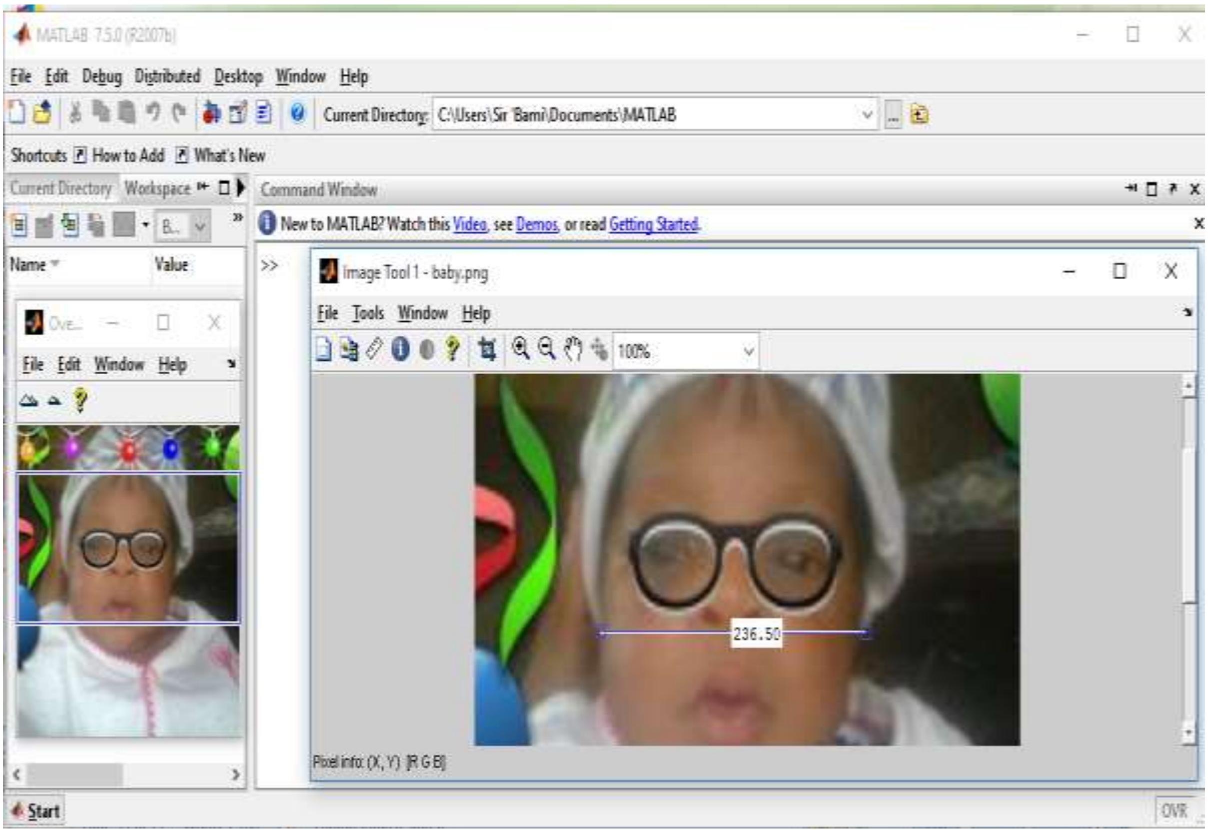

Fig. 6: Magnitude Equalization and Noisy Mapping by Distant Edges

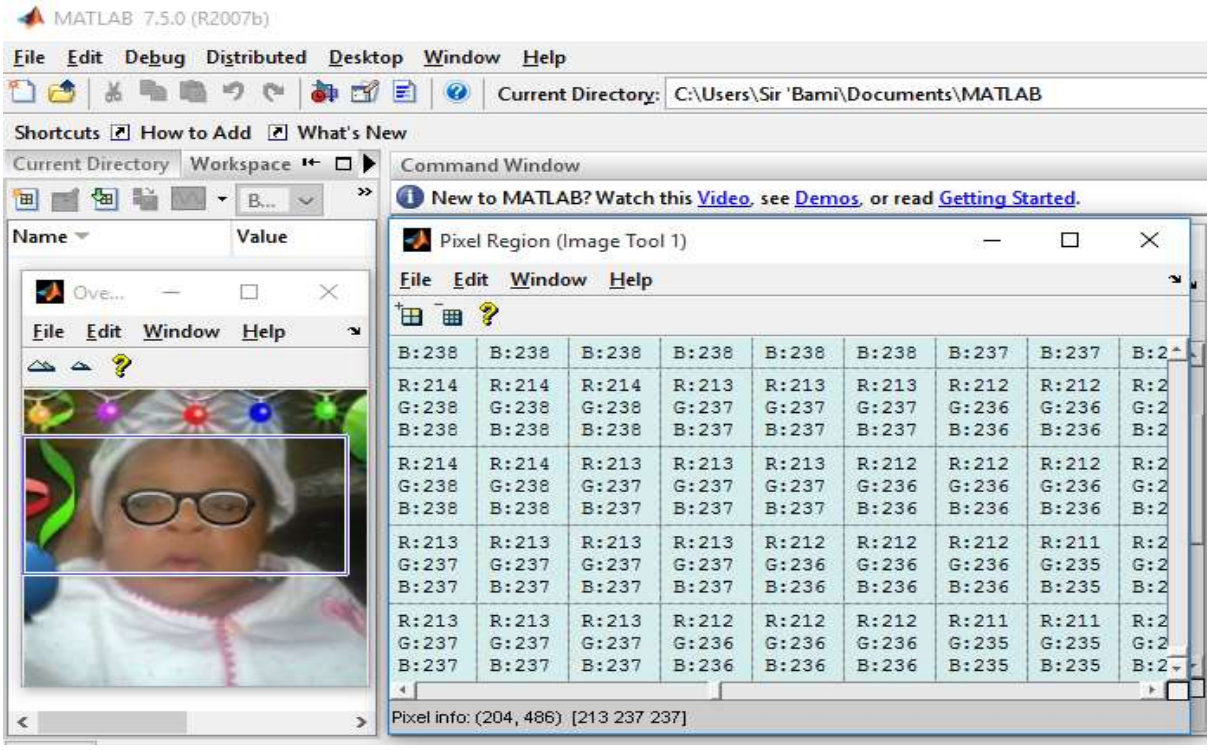

Fig. 7: Discretized signals and PIXEL inspection from neighbourhood weight

Fig. 8: Image Before Enhancement

Fig. 9: Image after Enhancement

5. CONCLUSION

Gaussian filter is quite ideal as panacea to degradation and interference elements in images, especially digital photographs. It enables direct effect at spatial dimensional space by the enhancement method for the image clarity. It is very suitable for de-noising and interference removal targeted at Gaussian and speckle noises, thereby improving image visual perception.

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