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# HYBRID MEASUREMENT FOR FACE IMAGE SIMILARITY

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۞ وَهُوَ ٱلَّذِىٓ أَنشَأَ جَنَّٰتٍ مَّعْرُوشَٰتٍ وَغَيْرَ مَعْرُوشَٰتٍ وَٱلنَّخْلَ وَٱلزَّرْعَ مُخْتَلِفًا
أُكُلُهُۥ وَٱلزَّيْتُونَ وَٱلرُّمَّانَ مُتَشَٰبِهًا وَغَيْرَ مُتَشَٰبِهٍ ۚ كُلُوا۟ مِن ثَمَرِهِۦٓ إِذَآ
أَثْمَرَ وَءَاتُوا۟ حَقَّهُۥ يَوْمَ حَصَادِهِۦ ۖ وَلَا تُسْرِفُوٓا۟ ۚ إِنَّهُۥ لَا يُحِبُّ ٱلْمُسْرِفِينَ ﴿١٤١﴾

الانعام [١٤١]

صدَقَ آلله العليّ آلعظيْم

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# DEDICATION

**Our days have come a step, and now we are celebrating the fruits of a journey of years in which our goal was clear and we were striving every day to achieve it and reach it no matter how difficult we are. We arrived with a torch of knowledge and we will take care of it so as not to extinguish. Thank God. We then thank our families who have been with us all these years.**

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# Abstract

This work presents a study on the performance of key image similarity techniques for the purpose of similarity under non-ideal conditions of noise; two- way have been studied in statistical and informative similarity.

In addition, image similarity measures has been proposed in this project: the first called Hcorr2 (Histogram-correlation 2D) and the second called Hssim (Histogram-structure similarity) which are a hybrid measures based on both: information-theoretic base and statistical base (histogram, correlation and structure).The proposed measures are compared with other existing and most popular similarity measures.

We present a face images database AT&T and the well-known image similarity techniques ;Structure Similarity Index Measure 'SSIM',correlation measure 'corr2' and Histogram Measure 'HSSIM'are considered .The performance of similarity techniques was tested under three types of noise: Gaussian noise, Impulse noise and Multiplicative noise against Peak Signal to Noise Ratio are tackled.

Experiments have shown that the proposed measures give the best results under conditions that are non-ideal (low PSNR).

# Chapter One

# Introduction

## 1.1 Introduction

The image can be defined as a two-dimensional function, where x and y are the spatial coordinates (level), and f is the density or gray level of the image at this point. When both x and y and density values f are all finite and discontinuous, we call the image a digital image. The image is a visual representation of something. In the field of Information technology, the term uses many uses: the image is an image that was created, copied, and stored in an electronic format. The image can be described in terms of vector graphics or bitmap graphics. The image stored in the bitmap data model is sometimes called a bitmap. Image Map is a file that contains information that links different locations to a specific image with hyperlinked text links.

## 1.2 A digital image

An image is a visual representation of information ( person , scene or object). We can defined an image as a two dimensional function, $f_n(x, y)$, where $x$ and $y$ are the location coordinates, and the capacity of $fn$ in any pair of coordinates $(x, y)$ is the Density or called the Gray Shadow (level) of the image at this point . The digital image is defined as a separate representation of data possessing for both locative and density information. Data of image that are obtained by either remotely sensed devices or any other devices could be introduced as digital format as follows :

$$f_n(x,y) = \begin{bmatrix} f_n(0,0) & f_n(0,1) & \cdots & f_n(0,N-1) \\ f_n(1,0) & f_n(1,1) & \cdots & f_n(1,N-1) \\ \vdots & \vdots & \vdots & \vdots \\ f_n(M-1,0) & f_n(M-1,1) & \cdots & f_n(M-1,N-1) \end{bmatrix}$$

Where $M$ and $N$ represent respectively number of rows and columns.

## 1.3 Digital Image Processing

Digital image processing is a set of techniques that work on digital images through specific calculations, which are individually used or incorporated such as editing , manipulation ,Classification, pattern recognition, feature extraction, projection, etc. Digital image processing is an area of continuous growth. It can be considered an exciting and fascinating area. Image processing has a wide range of applications, ranging from the entertainment industry to the space program.

Digital image processing, also referred to as computer imaging, can handle visual information by computer. Digital image processing is important because of the fact that our basic sense is well visualized. The human vision system allows us to collect information without happen any physical interaction; it enables us to analyze all kinds of information directly from the sense. It also gives us the ability to move around our environment. The human visual system is the most sophisticated and complex nervous system in the human body. Most scientific developments and discoveries depend on the optical system of their evolution.

Image Processing has been developed in response to three basic problems concerned with images:

- Image digitization and coding to facilitate the transmission, and storage of image.
- Image enhancement and restoration, for example interpret more easily images of the surface of other planets taken by various investigations.
- Image segmentation and description as an early stage to Machine Vision.

## 1.4 image processing system Components

The hardware components of a digital image processing system typically include the following:

- **Acquisition Devices**:

  Responsible for capturing and digitizing images or video sequences. For examples of general-purpose acquisition devices include scanners, cameras, and camcorders. Acquisition devices can be interfaced with the main computer in a number of ways, for example, USB, FireWire, Camera Link, or Ethernet.

- **Processing Equipment**:

  The main computer itself, in whatever size, shape, or Configuration. Responsible for running software that allows the processing and analysis of obtained images.

- **Display and Hardcopy Devices**:

  Responsible for showing the image contents for people viewing.Examples include color monitors and printers.

- **Storage Devices**:

  Magnetic or optical disks responsible for long-term saved of the images.The software components of a digital image processing system usually consists of modules that perform specialized tasks. The development and fine-tuning of software for image processing solutions is iterative. Consequently, image processing researchers and practitioners rely on programming languages and development environments that support modular, agile, and iterative software development. The software of favorite is **MATLAB (MATrix LABoratory).**

## 1.5 Image File Formats

The digital image can be considered as a matrix (two-dimensional matrix) for pixels and each pixel value corresponds to the corresponding point brightness in the display; this value is often expected from the output of an A / D converter (analogue to digital converter). The pixel matrix (called an image) can be described by N pixels by M m-bit (where N and M represents the number of points over the axes and m is the number of brightness values, where m -bit gives a range of $2^m$ values, ranging from 0 to $2^m$ - 1). Let m is 8 bits, which gives brightness levels between 0 and 255, which are graded from black to white, respectively, where there are gray shadows. Note that smaller m gives lower available levels that reduce the contrast available in the image.

From a mathematical point of view, any 2-D array of meaningful numbers can be called an image. In fact, you need to display images in an effective way, store them, and move them through throw nets. This need led to the development of standard digital image formats. Image formats consist of two parts, the first is the header of the file that contains information about how the image data is stored, and the second that contains numeric values for pixels. Today there are a large number of image formats[]. Table 1-1 shows many 2D image formats.

**Table1-1 Shows 2D image Format**

| Format | Name | Compression | Properties |
|---|---|---|---|
| GIF | Graphics Interchange Format | lossless compression | Ranging from 0-255, 256 colors (8 bit) |
| JPEG | Joint Photographic Experts Group | lossy compression | One of the most common type that used today |
| BMP | Bit map picture | Uncompressed | Basic image format |
| PNG | Portable network graphics | lossless compression | Colored image |
| TIF/TIFF | Tagged image (file) format | lossless compression | Detailed, extremely versatile and adaptable format variants exist |
| JPEG 2000 | JPEG 2000 is an enhancement of the JPEG standard | lossless and lossy | Used presently in professional movie editing and distribution |
| Exif | Exchangeable image file format | lossy and lossless | It is incorporated in the JPEG writing software used in most cameras |
| BPG | Better Portable Graphics | lossy and lossless | The purpose of BPG is to replace the traditional JPEG when quality is a problem |
| RAW | A camera raw image file | Lossless | Minimally contains the processed data from an image sensor. |

## 1.6 An Image Types

There are several types of image data based on different objects such as image content, bit resolution, and the type of physical image data to be stored. The different image data types listed below:

- **Gray scale images**

  Are a two-dimensional matrix with a single numeric value for each single pixel in the image; at this point, this value represents the density. The pixel value range is limited by pixel resolution. The storage of these image types is an integer of the m-bit type in a specific format. Density images are also called grayscale images. Figures 1-1 shows the gray scale image

**Figure [1-1]: shows gray scale image**

- **Binary images**

  Are a two-dimensional (2-D) matrix containing one numeric value (0 or 1) for each single pixel in the image. This type of image can be called logical images. The image has two colors in black ("off" or "background") and white ("on" or "off ground") that correspond to 0 and 1, respectively. These images are represented as a bit stream, but can be represented as 8-bit numbers, which are common image formats. An example of a binary image is the fax image. Figure 1-2 shows a binary image.

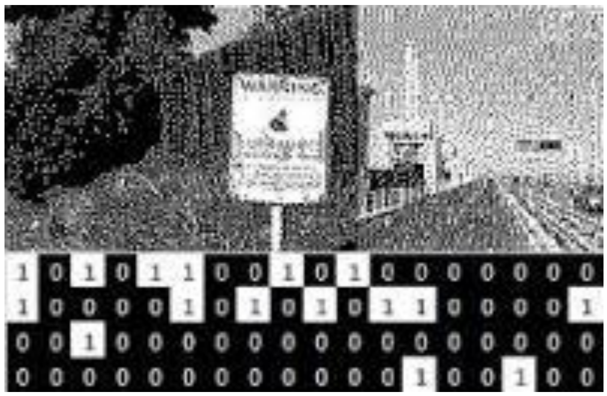



**Figure [1-2]: shows binary image**

- **RGB images**

A 3-bands array containing three values in each pixel in the image, and the pixel value corresponds to three colors (Red, Green, and Blue, RGB) representing the channel component of the image in red, green and blue, respectively. In theory, you might think of an RGB image as a different 3D plane so that images are dimensioned $R \times C \times 3$, where R and C are the number of rows and the number of columns in the image, respectively. Such images (as in Matlab) can be accessed through I (R, C, channel) coordinates within the image matrix. Graphics file formats store RGB images as a 24-bit image, where each component is 8 bits. These produce the possibility of 16 million colors. Figure 1-3 shows RGB image.

**Figure [1-3]: shows RGB image**

- **Multi-Spectrum Images**

  This type of image does not store color values as an integer. Color values are stored as a number of floating-point formats. A measurement of non-intensity or simple color is a part of a medical or scientific image. The most common image format for this type of image is TIFF format (tagged image file format) such as medical images.

Figure 1-4 illustrates the types of image data discussed with an appropriate example of the image used for storage.

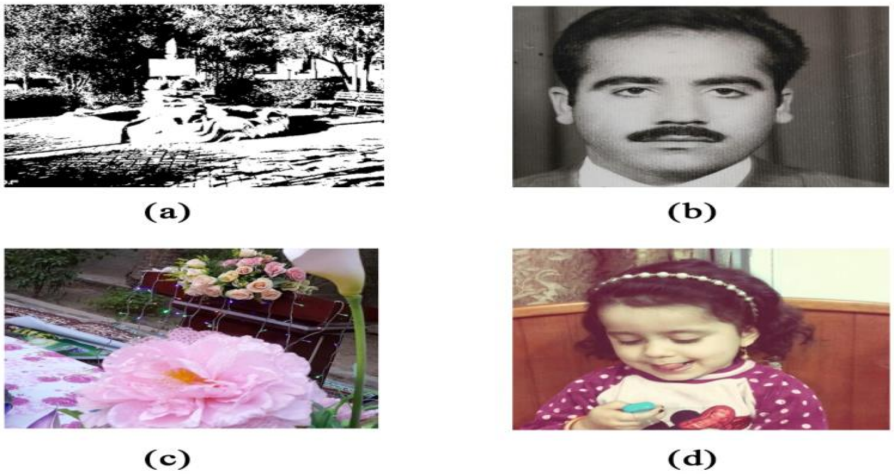



Figure **خطأ! لا يوجد نص من النمط المعين في المستند.**-2 Various image data types examples and their related storage formats.(a): Binary image in PNG format, (b): 8-bit grayscale image in GIF format, (c): 24-bir RGB color image in JPEG format, (d): Multi spectrum image pixel in TIFF format.

## 1.7 Image noise

It is a random variation of color or brightness information so it is an undesirable product that adds false and strange information to the image. The original meaning of "noise" is unwanted electrical fluctuations in signals received by AM radios causing audible noise. Image noise, of course, is inaudible. Image noise can range from slightly blurry spots on a digital image taken in good light to optical and radial images that are total noise

### 1.7.1 Image noise source

There are many sources of noise including :

- Sensor size
- Sensor temperature can affect the amount of noise caused by the image sensor
- Errors in image signal sent electronically from one place to another
- ISO factor: The ISO number indicates how quickly the camera sensor is absorbed into the light, using higher ISO, reducing image quality, and creating more noise

### 1.7.2 Type of Noise

- **Impulsive Noise**

Sometimes the pulsating noise is called the spike noise or salt and pepper noise. This is the number of random capacity pulses with a short and random interval. Pulse noise causes poor performance and degradation for important applications such as image processing and communication systems. Thus, the image containing salt and pepper noise will contain bright pixels in the dark areas and dark pixels in the bright areas. To reduce the noise effect in the PLC system, orthogonal frequency division (OFDM) technology was used.

- **Gaussian Noise**

Gaussian noise is a statistical noise with a probability density function (PDF) equal to normal distribution, also called Gaussian distribution. Noise is added to the signal which will be the worst case especially in the wireless network. . The main sources of Gaussian noise appear in digital images during the acquisition, for example, noise caused by high temperature, poor lighting or transmission. This noise is independent at each pixel. The blue channel gives more noise than other channels (red and green) because in color cameras, blue is more

- **Multiplicative Noise**

The multiplicative noise called the noise of spots when the imaging system is corrupted: radar, sonar, laser images, and microscope images. Adjust the signal or multiply the doubled noise and the main factor that has the distortion effect on the signal (distortion of the frequency, amplitude and phase of the signal) and deteriorates the signal performance. Multiple noises exist in the system of biological, space and physical engineering. Multiplicative noise is more difficult than added noise because the signal propagates through noise.

## 1.8 The Aims of the thesis

The aims of this thesis are:

1. Presenting System for the purpose of image similarity by of key image similarity techniques (statistical and information theoretic).
2. Identifying adverse conditions of the reference image that are considered in this work for the practical importance of similarity under non-ideal conditions of noise (Gaussian, Impulse and Multiplicative).

3. Finding out the effect of noise on image Similarity (According to PSNR).
4. Proposing a measures for the similarity.
5. Prove that the suggested measures are the best.

## 1.9 The Project outline

Besides chapter one , four chapters will be introduced , these are:

**Chapter two ( The propose system and similarity measure) :** this chapter consist of sections the first section presents similarity and similarity techniques and the second section presents similarty measure

**Chapter three (Experimental Result):** this chapter proposed a system for face image recognition under non-ideal condition of noise image information. Distinguish focial image affected by noise during transmission through communication channels.

**Chapter four ( conclusions and suggestions for future work ):** it presents discussions and results over a set of experiments. And discusses the conclusion and give several suggestions in the future .

# Chapter Two

# The proposed system and similarity measures

## 2.1 Introduction

This chapter introduces a proposed system for the purpose of face identification under non-ideal conditions of noise by image similarity techniques.

The noise of that affects many electronic systems including transfer of image over communication channels. In this work, study of effect noise on images, images similarity, and identification.

In addition, we propose a hybrid measure (HCorr2) (Hssim) there are based on statistical base and information theoretical base for purpose of similarity and identification.

## 2.2 Image Similarity

The image similarity depends on the matching of two images. We can also define it as giving the saved images to choose the best matches for the saved images to the image concerned. the image concerned : X Saved image : Y1 Y2...Y3 We can classify the methods by which we measure the similarity of the picture to two basic parts: statistical and theoretical information.

## 2.3 Similarity Techniques

Many matching algorithms for facial recognition systems and object have been designed based on the measurement of image similarity [48].

Image similarity measure Techniques can be classified into: statistical and information-theoretic [52]. As shown in the figure [2-1] of similarity techniques.

### 2.3.1 Statistical Techniques

A valuable information can be obtained from image by compute statistical measurements such as mean, variance and standard deviation. This information can be used to compute image similarity [٤٨].

### 2.3.1.1. Structure Similarity Index Measure (SSIM)

The measure proposed by Wang and Bovik. (2004) which was called SSIM, used a distance function to measure the similarity of two images based on statistical features, Equation 1 shows this measure:

$$\mathrm{Ssim}(a,b) = \frac{(2\mu_{\mathrm{a}}+\mathrm{co}_1)(2\sigma_{ab}+co_2)}{(\mu_a^2+\mu_b^2+co_1)(\sigma_a^2+\sigma_b^2+co_2)} \qquad (2.1)$$

where $\mu_a$, and $\mu_b$ represents the means and $\sigma^2{}_a$ and $\sigma^2{}_b$ represents the variance of $a$ and $b$,; $\sigma_{ab}$ is the covariance of $a$ and $b$, and $co_1$ and $co_2$ are constants inserted to avoid division by zero, and are defined as $co_1 = (T_1L)^2$ and $co_1 = (T_2L)^2$, $T_1$ and $T_2$ are small constants and $L$ is the maximum pixel value [3, 7].

## 2.3 .1.2 correlation measure(corr2)

One of measure similarity image is represented by 2-D correlation between reference image x and noisy image $w$ and it is given as follows :

$$\mathrm{corr2(x,y)} = \frac{\sum_i \sum_j (\mathrm{x(i,j)} - \bar{\mathrm{x}})(\mathrm{y(i,j)} - \bar{\mathrm{y}})}{\sqrt{(\sum_i \sum_j (\mathrm{x(i,j)} - \bar{\mathrm{x}})^2)(\sum_i \sum_j (\mathrm{y(i,j)} - \bar{\mathrm{y}})^2)}} \qquad (2.2)$$

$$p(x,w) = corr2(x,y) \qquad (2.3)$$

where $\bar{x}$ and $\bar{y}$ are the mean values of $x$ and $y$ respectively

### 2.3.2 Information Theoretic Techniques

Information-theoretic technique is the similarity measure for images. Information-theoretic technique is aimed to find the similarity between images according to their content (intensity values) [57].

Information-theoretic techniques are most popular image similarity measures because it is able to predict the relationship between intensity values of an image .

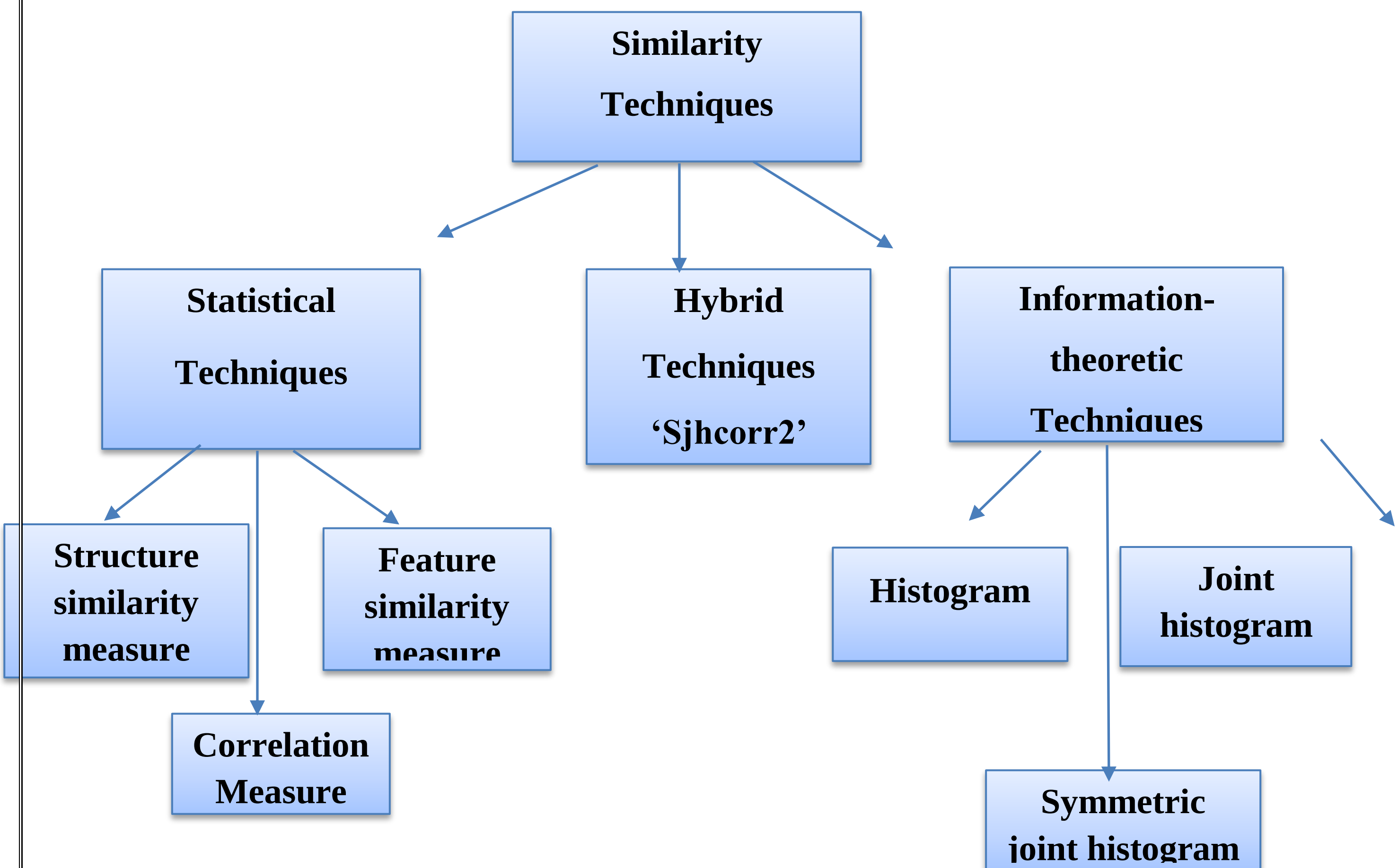



Figure 2.1 Diagram of Similarity Techniques

## 2.4 The Image Similarity System

Figure 2.2 illustrates the main steps of the Image Similarity System:

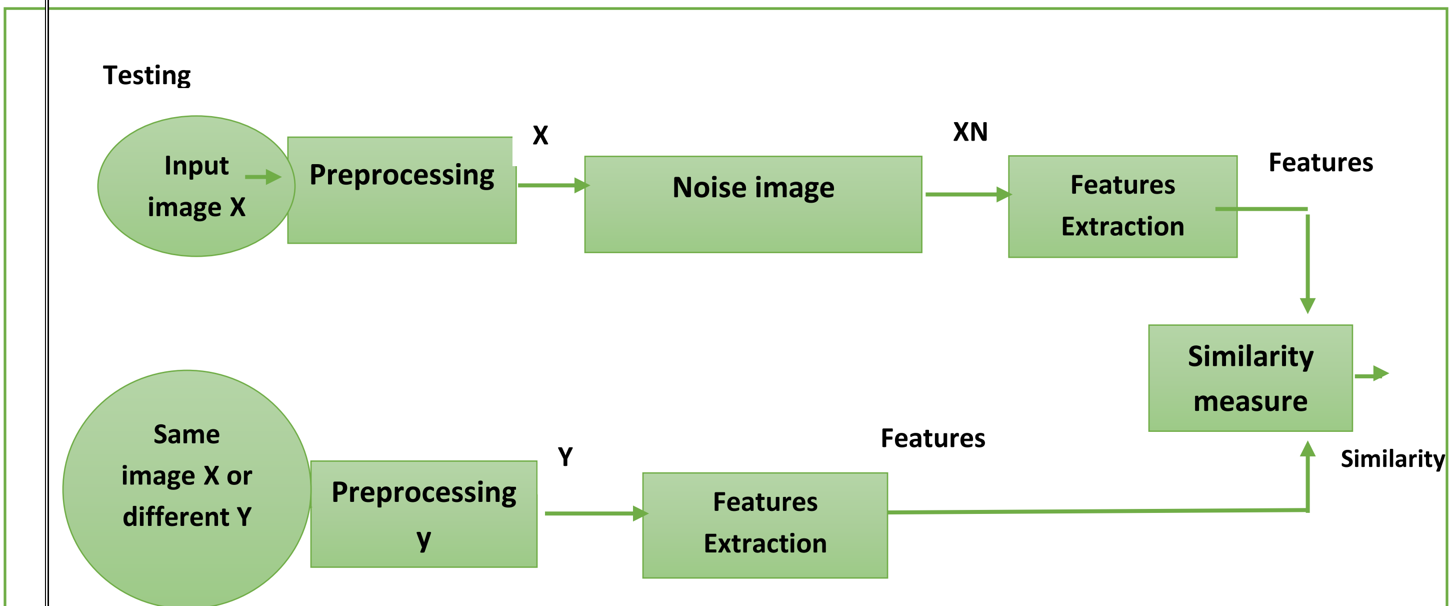



Figure 3.1 The main steps of the Image Similarity System

The first procedure of face image identification approach is:

1. Modifying Image Scales: in this step the dimensions of the images must be equal.
2. Converting Image to Grayscale: Converts the RGB image to the grayscale image.
3. Converting array to double: Convert image to double precision.

**1) Noise Image**

The second procedure is to create the noise image.

**2)Features Extraction**

The second procedure is extraction the features using to decision taking.

**3)Similarity measures**

The fourth procedure is implementation the similarity measures between the noisy image and the other image (either same image or different image) by the similarity techniques.

## 2.5 The Proposed Measure

We two measure (Hssim,Hcorr2)

### 2.5.1 Histogram -Structure Similarity Measure(Hssim)

The proposed standard for similarity. It is one of the most recent image-like measures based on the graph. Hssim is suggested because the SSIM scale can not perform well under significant noise. H relies on information theory and ssim relies on statisticals. In Hssim, the histogram was used and then merged with the ssim as following :

$$R(x,y) = \sqrt{\frac{\sum_i \sum_j \left[(H_{ij} - H_{ji}) \frac{1}{h_i + C}\right]^2}{2L^2}} \qquad (2.4)$$

where, $h_i$ is the original reference image histogram and $C$ is a tiny positive constant to avoid division by zero. Where:

$$R(x,y) \geq 0 \qquad (2.5)$$

the above value can be normalize by using the respect maximal error estimate value $R_{\infty}(x,y)$ in significant noise (very low PSNR) as follows:

$$H(x,y) = \frac{R(x,y)}{R_{\infty}(x,y)} \quad (2.6)$$

$$H(x,y) = 1 - r(x,y) \quad (2.7)$$

where $0 \leq H(x,y) \leq 1$ and $H(x,y) = 1$ for completely similar images and $H(x,y) = 0$ for completely different images. HSSIM is able to outperform SSIM with 20dB under low PSNR.

### 2.5.2 histogram –correlation 2D (Hcorr2)

The proposed standard for similarity. It is one of the most recent image-like measures based on the graph. Hcorr2 is suggested because the corr2 scale can not perform well under significant noise. H relies on information theory and corr2 relies on statisticals. In Hcorr2, the histogram was used and then merged with the corr2 as following :

$$Hcorr2(x,y) = \sqrt{C(x,y)K + H(x,y)(1-K)} \quad (2.8)$$

## 2.3 Algorithms for Proposed System

The following Algorithms and flowchart show incomplete face image and how identification it by similarity techniques.

## 2.3.1Algorithm Hcorr2 & Hssim:

**Input: A and B which are the reference image and noisy image , K is a very small constant**

**Output: Similarity, a number ranging between 0 and 1.**

**Step 1: Convert the color images into grayscale images.**

**Step 2: Convert the images into double.**

**Step 3: Compute $C$**

$$C(x,y) = \frac{\sum_i \sum_j (x(i,j)-\bar{x})(y(i,j)-\bar{y})}{\sqrt{(\sum_i \sum_j (x(i,j)-\bar{x})^2)(\sum_i \sum_j (y(i,j)-\bar{y})^2)}}.$$

**Step 4: Compute $S$**

$$S(x,y) = \frac{(2\mu_x + co_1)(2\sigma_{xy} + co_2)}{(\mu_x^2 + \mu_y^2 + co_1)(\sigma_x^2 + \sigma_y^2 + co_2)}$$

**Step 5: Compute $H$:**

$$H(x,y) = \sqrt{\frac{\sum_i \sum_j \left[(JH_{ij} - JH_{ji}) \frac{1}{h_i + c}\right]^2}{2L^2}}$$

**Step 6: Set $H\infty(x,y)$= $H(x, y)$ when noise is maximum.**

**Step 7: Normalization: h=H/ H∞ .**

**Step 8: Set h =1-h.**

**Step 9: Compute Hcorr2**

$$\mathrm{Hcorr2}(x,y) = \sqrt{C(x,y) \times K + Jh(x,y) \times (1-K)}$$

**Step 10: Compute Hssim**

$$\mathrm{Hssim}(x,y) = \sqrt{S(x,y) \times K + h(x,y) \times (1-K)}$$

**Step 11: Perform the comparisons (evaluate the results)**

**End of Algorithm**

## 2.3.2Algorithm for Create of noise Face

**Input: Reference face image A (Test), peak signal to noise ratio in dB (PSNRdB), parameter p.**

**Output: Noisy image**

**Step 1: Convert the image A from color into grayscale.**

**Step 2: Convert the image A into double.**

**Step 3: Size of A, r number of rows and c number of columns**

**Step 4: Convert psnrdB to psnr:**

$$psnr=10^{(psnrdB/10)}$$

**Step 5: Compute noise power pn:**

$$pn= \text{maximum pixel value}^{2} / psnr$$

**Step 6: Convert pn to pndB (decibel).**

**pndB= 10 logarithm base 10 (pn)**

**Step 7: Generation of r-by- c matrix of white Gaussian noise .**

**Step 8: Add white Gaussian noise to face image**

**Step9: Add Impulse noise, Multiplicative noise with parameter p to face image.**

**Step 10: Display noisy face image**

**End of Algorithm**

### 2.3.3Algorithm Noisy Face Similarity:

**Input: Noisy image N, initial value i (Counter).**

**Output: Return who is person, or unknown.**

**Step 1: Read Image of face from Database A1.**

**Step 2: Convert the image A1 from color into grayscale.**

**Step 3: Convert the image A1 into doubled.**

**Step 4: Compute (Ssim )**

$$Ssim(A1, N) = \frac{(2\mu_{A1}+C_1)(2\sigma_{A1N}+C_2)}{(\mu_{A1}^2+\mu_N^2+C_1)(\sigma_{A1}^2+\sigma_N^2+C_2)}$$

**Step 5: Compute (Corr2)**

$$Corr2(A1, N) = \frac{\sum_i \sum_j (A1(i,j)-\overline{A1})(N(i,j)-\overline{N})}{\sqrt{(\sum_i \sum_j (A1(i,j)-A1)^2)(\sum_i \sum_j (N(i,j)-\overline{N})^2)}}.$$

**Step 6: Compute (Hcorr2)**

$$Hcorr2(A1, N) = \sqrt{Corr2(A1, N) \times K + Jh(A1, N) \times (1-K)}$$

**Step 7: Compute (Hssim)**

$$Hssim(A1, N) = \sqrt{Ssim(A1, N) \times K + Jh(A1, N) \times (1-K)}$$

**Step 8: Perform the comparisons**

**End of Algorithm**

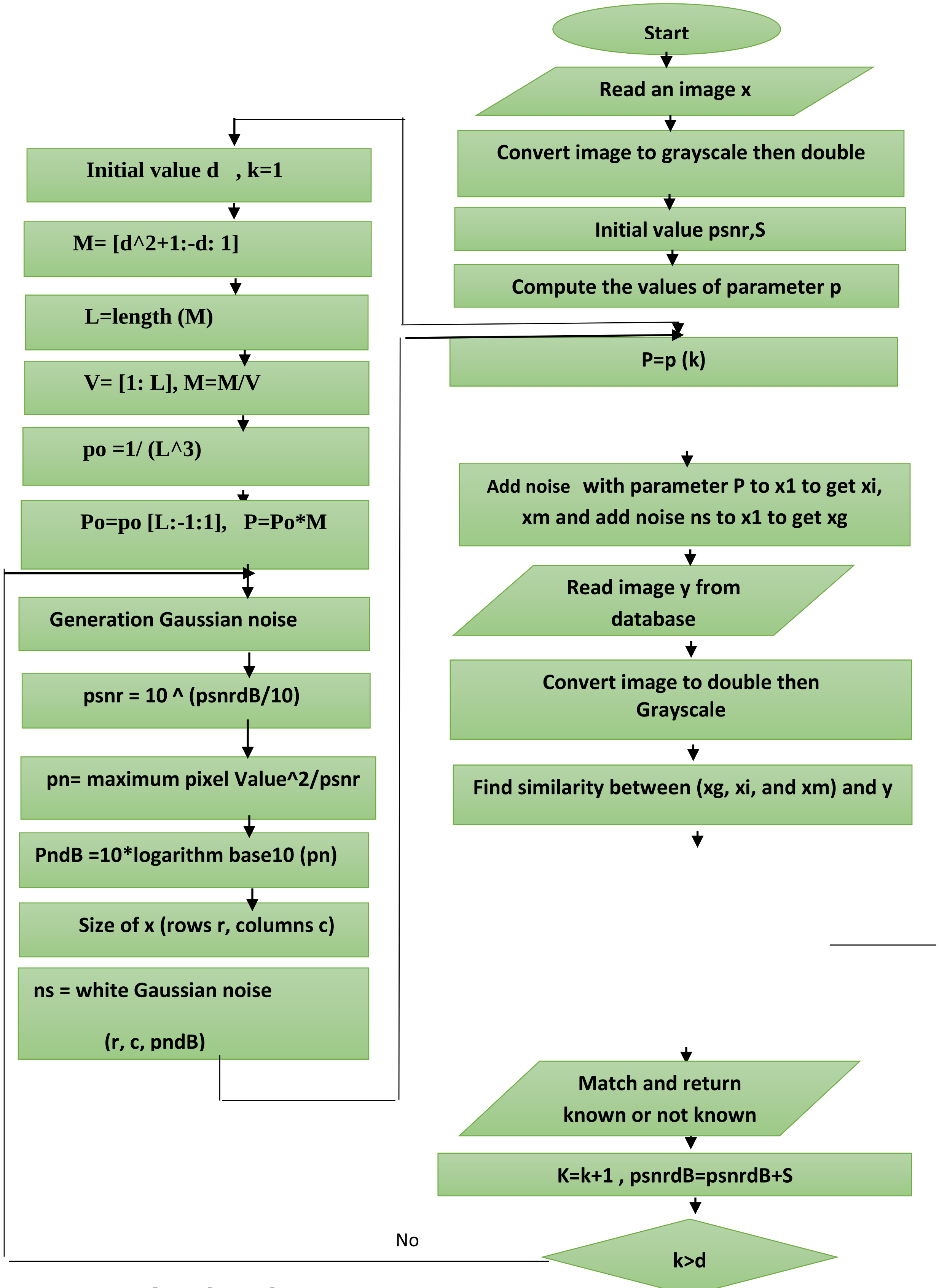



Figure 3-5 Flowchart shows SIMILARITY Noisy Face Image

# Chapter three

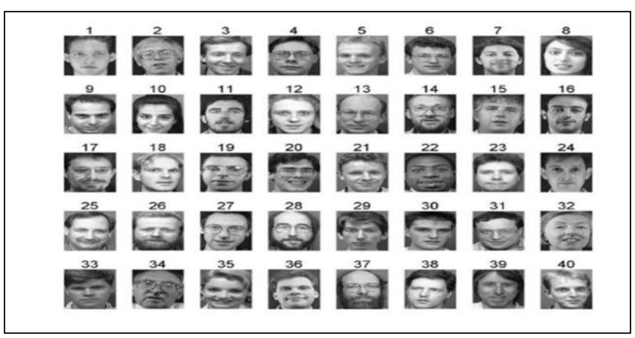
# Experimental Results

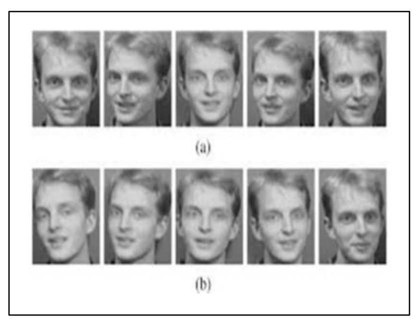
## 3.1 Introduction

Evaluating the similarity measures is illustrated in this chapter. This measures has been applied on AT&T face database.

## 3.2 AT&T Face Database

AT&T Faces Database contains a set of face images taken between April 1992 and April 1994 at the lab. There are 10 different images of 40 individuals, a total of 400 images. For some individuals, the images were taken at different times, facial expressions (open / closed eyes, smiling / not smiling), varying the lighting and facial details (glasses / no glasses). All the images were taken against a dark homogeneous background in an upright frontal position (with allowance for some side movement). The size of each image is 92x112 pixels. The numbers of male are 36 and female 4.




(a) (b)

Figure 4.1 (a) AT&T Face Database for person 40 b) Ten different images for person

## 3.3 Results and Discussions

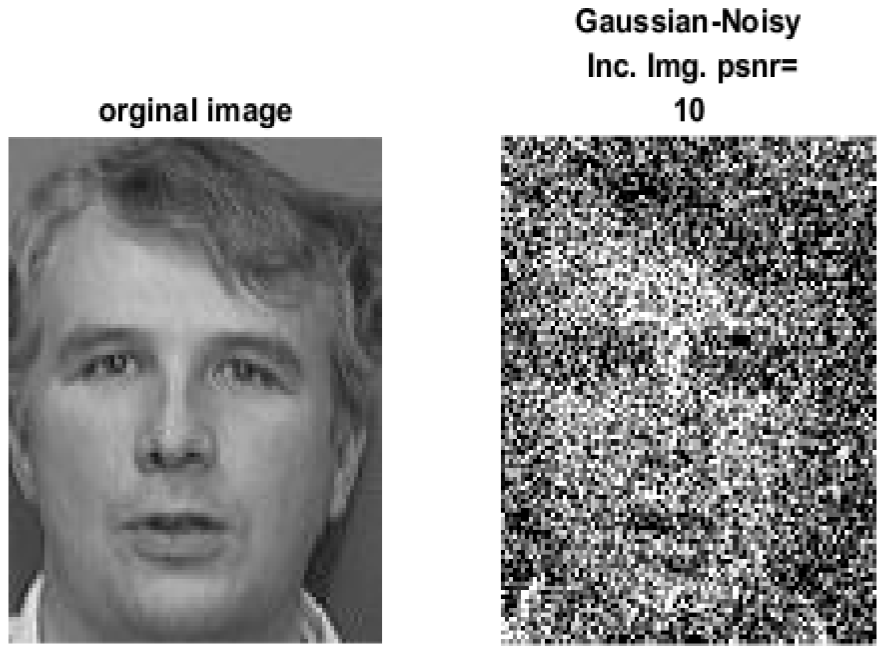
The SSIM,corr2, HSSIM, Hssim, hcorr2 measures has been tested and simulated using MATLAB language. ) is a software program produced by Math Works that can help you solve various kinds of mathematical issues that you may encounter in your studies, engineering or technical workYou can use Matlab's built-in features to solve many simple numerical issues, such as solving two equations: X + 2Y = 24 12X-5Y = 10 One of the most powerful features in Matlab is that it is able to graph many types of curves, and enables you to visualize and visualize the most complex mathematical functions and laboratory results graphically.

### 3.3.1 A Performance of the Similarity Measures under Noise

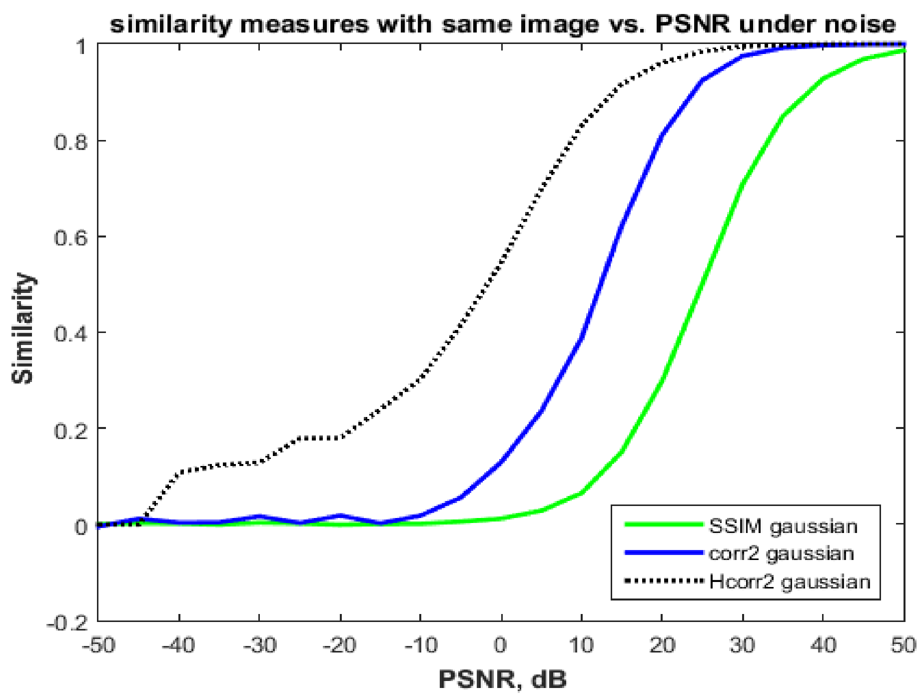
Test the performance of similarity measures under three types of noise: Gaussian, Impulse, and Multiplicative noise. Best performance for metrics under Multiplicative noise.

#### A. Case One: A Performance under Gaussian Noise

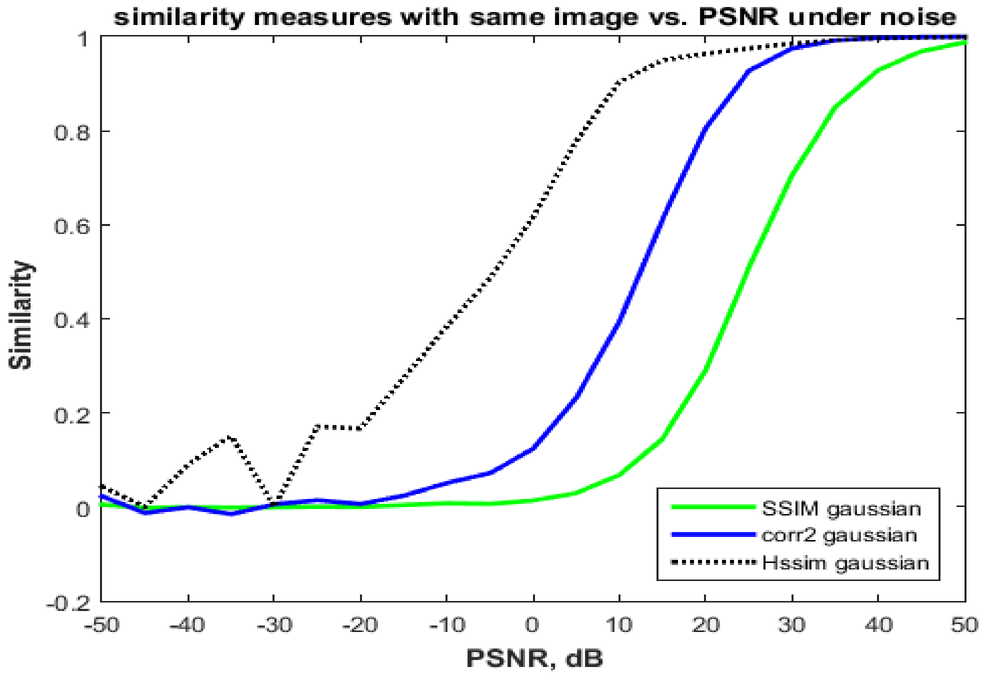
Take two images image without noise orginal image(two case either same person or image to another person) and image with a Gaussian noise than find similarity between them by these measures(ssim,corr2,Hssim,Hcorr2) and according to the following charts.




**(a) Orginal image and same image with Gaussian noise**

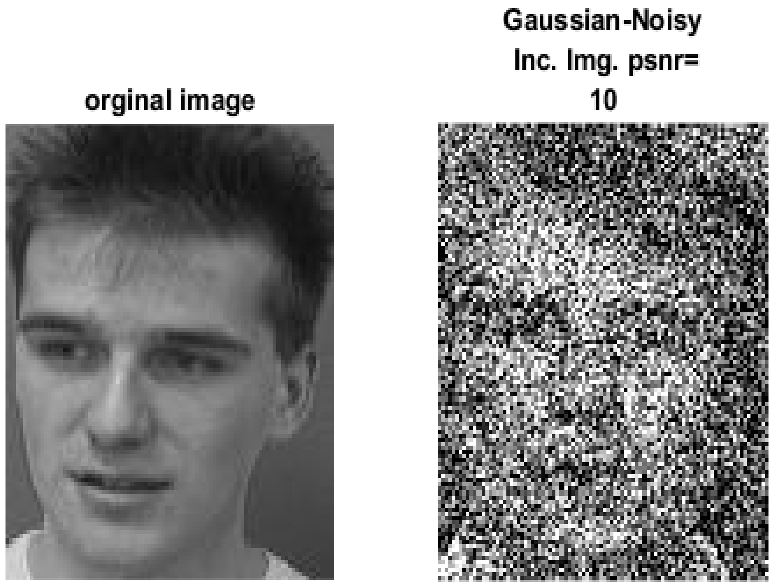



**(b)Performance similarty measure (Hcorr2) us PSNR**

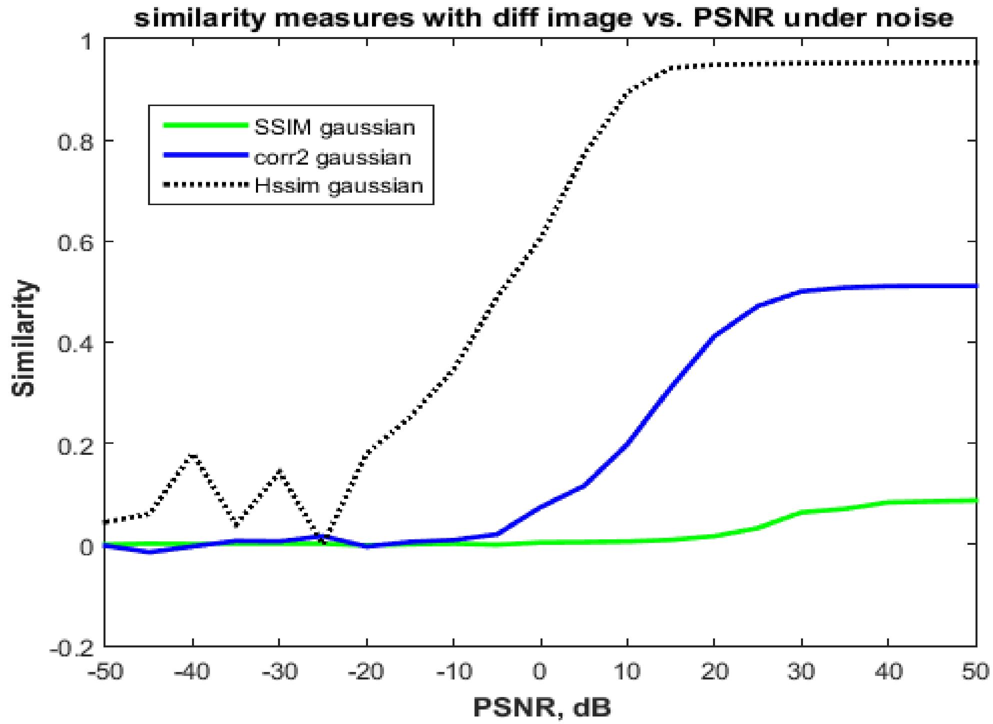



**( c ) Performance similarty measure (Hssim) us PSNR**

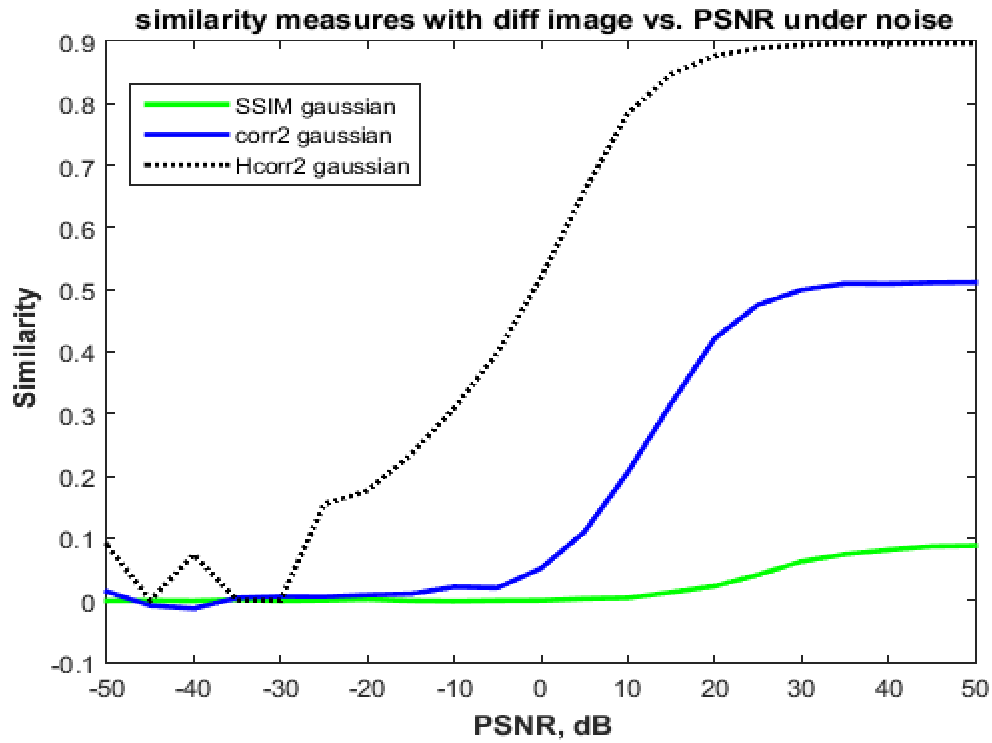
Figure 3.2 (a) Orginal image and same image with Gaussian noise (b) Performance similarty measure (Hcorr2) us PSNR (c) Performance similarty measure (Hssim) us PSNR




**(a) orginal image and different image with Gaussian noise**




**(b)Performance similarty measure (Hssim) vs PSNR**




**(C)Performance similarty measure (Hcorr2)vs PNSR**

**Figure 3.2 (a) Orginal image and different image with Gaussian noise (b) Performance similarty measure (Hcorr2) vs PSNR (c) Performance similarty measure (Hssim) vs PSNR**

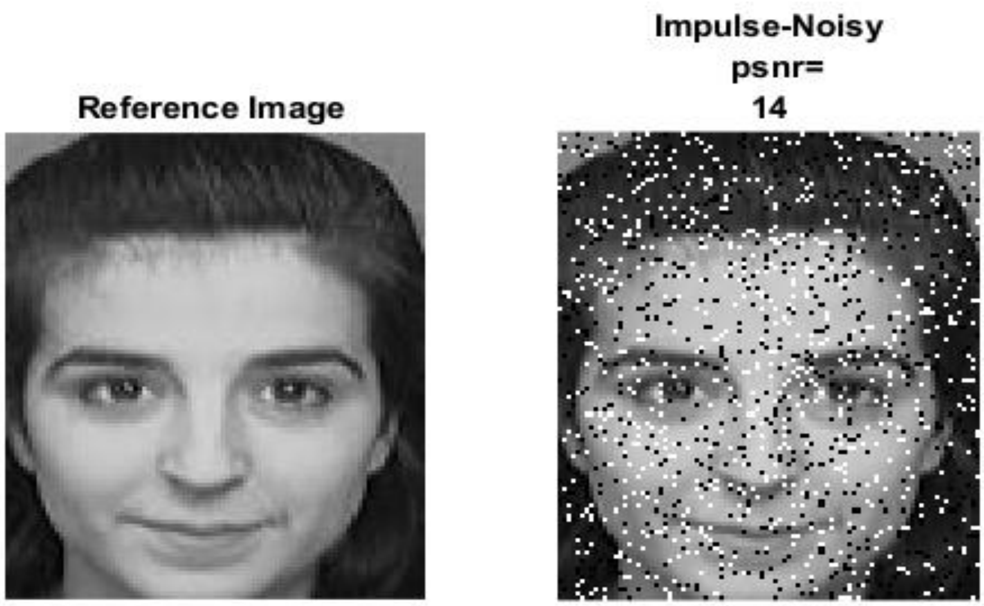
Appendix D: Comparison of Similarity Measures which is Performed Between Reference Image and Noisy Incomplete Same Image from AT&T Face Database under Gaussian Noise.

| PSNR | SSIM | Corr2 | Hssim | Hcorr2 |
|---|---|---|---|---|
| -50 | 0.0006 | 0.0000 | 0.0433 | 0.0000 |
| -45 | 0.0015 | 0.0058 | 0.0000 | 0.0010 |
| -40 | 0.0013 | 0.0075 | 0.0904 | 0.1425 |
| -35 | 0.0000 | 0.0097 | 0.1507 | 0.1447 |
| -30 | -0.0012 | 0.0108 | 0.0000 | 0.1874 |
| -25 | 0.0011 | 0.0183 | 0.1709 | 0.1756 |
| -20 | 0.0024 | 0.0009 | 0.1667 | 0.1956 |
| -15 | 0.0005 | 0.0071 | 0.2744 | 0.2334 |
| -10 | 0.0014 | 0.0245 | 0.3831 | 0.3221 |
| -5 | 0.0079 | 0.0761 | 0.4868 | 0.4125 |
| 0 | 0.0139 | 0.1275 | 0.6161 | 0.5469 |
| 5 | 0.0309 | 0.2188 | 0.7783 | 0.6984 |
| 10 | 0.0629 | 0.3989 | 0.9032 | 0.8305 |
| 15 | 0.1406 | 0.6134 | 0.9500 | 0.9157 |
| 20 | 0.3481 | 0.8141 | 0.9637 | 0.9596 |
| 30 | 0.6790 | 0.9744 | 0.9851 | 0.9950 |
| 35 | 0.7997 | 0.9918 | 0.9924 | 0.9984 |
| 40 | 0.8759 | 0.9973 | 0.9964 | 0.9995 |
| 45 | 0.9181 | 0.9991 | 0.9984 | 0.9998 |

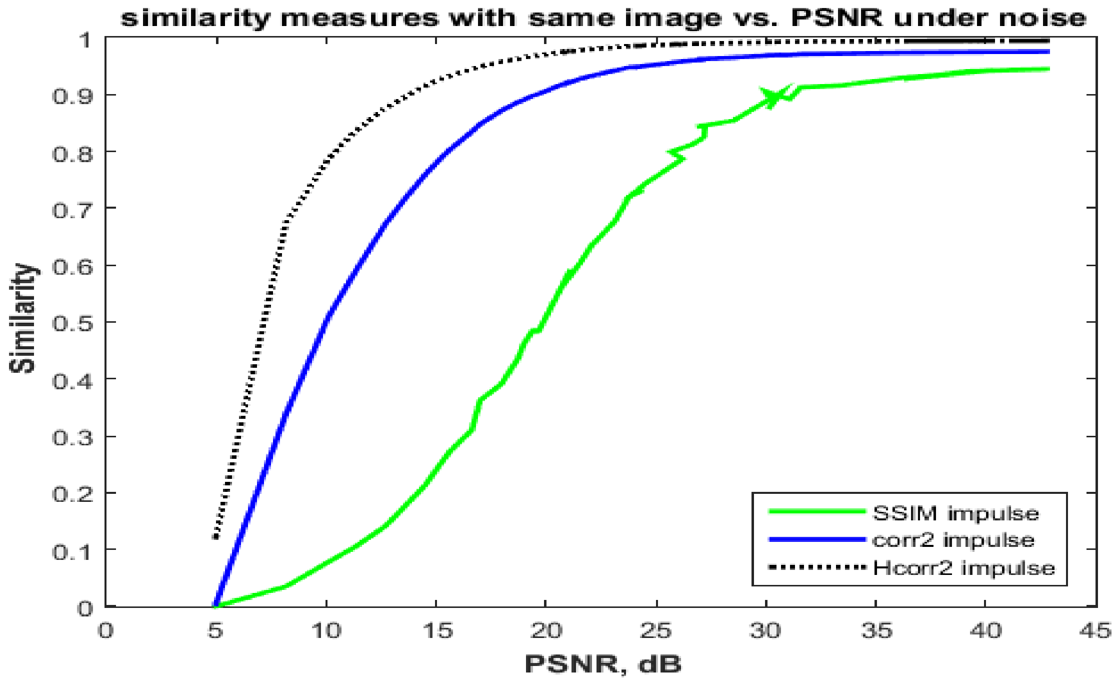
| | | | | |
|---|---|---|---|---|
| 50 | 0.9371 | 0.9997 | 0.9993 | 0.9999 |

## B.Case two: A Performance under Impulse Noise

Take two images image without noise orginal image(two case either same person or image to another person) and image with a Take two images image without noise orginal image(two case either same person or image to another person) and image with a Impulse noise than find similarity between them by these measures(ssim,corr2, Hssim,Hcorr2) and according to the following charts.

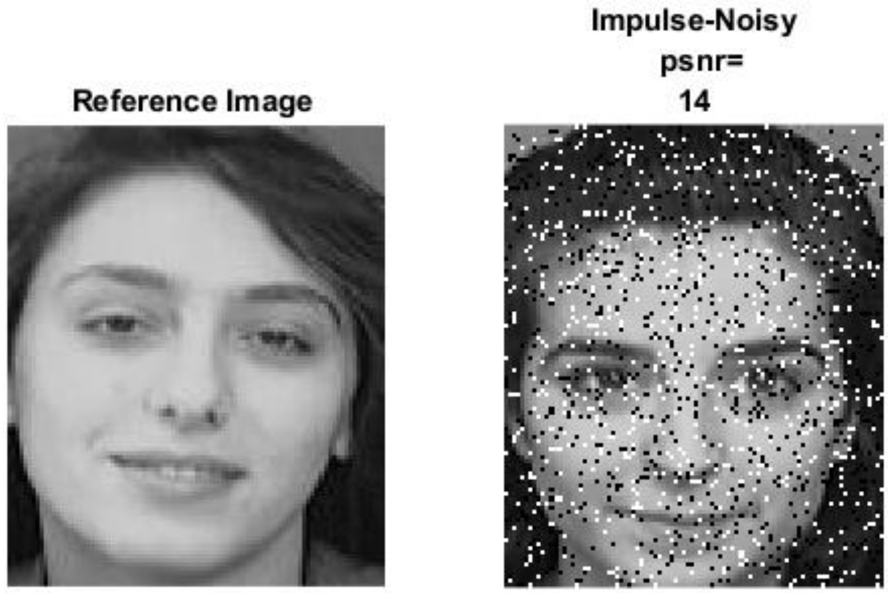



**(a) Orginal image and same image with Impulse noise**

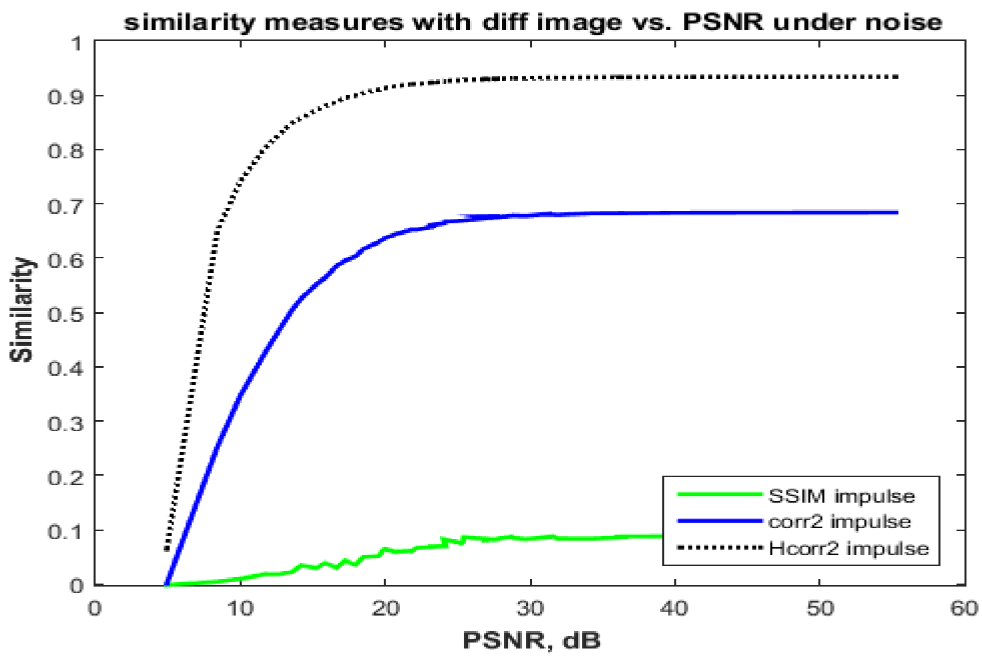



**(b)Performance similarty measure (Hcorr2) vs PSNR**

**Figure 3.3 (a) Orginal image and same image with Impluse noise (b) Performance similarty measure (Hcorr2) vs PSNR**




(a)Orginal image and different  image with Impulse  noise



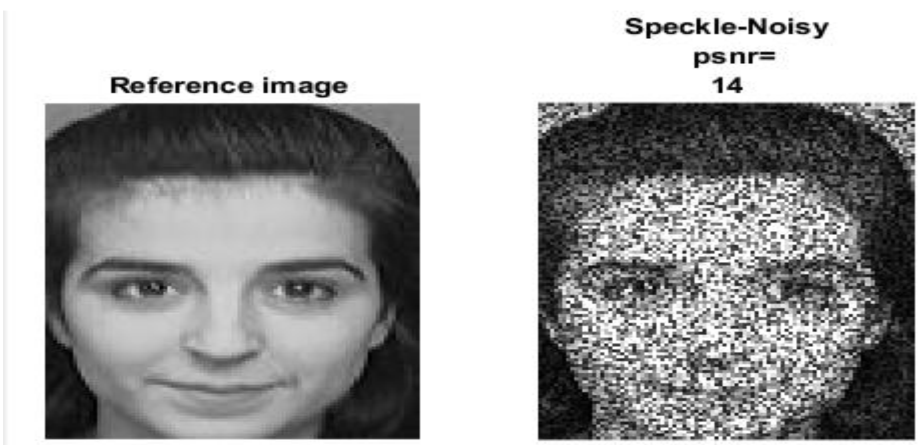

(c) Aperformance similarty measure vs PNSR

**Figure 3.4 (a) Orginal image and different  image with Impluse  noise**

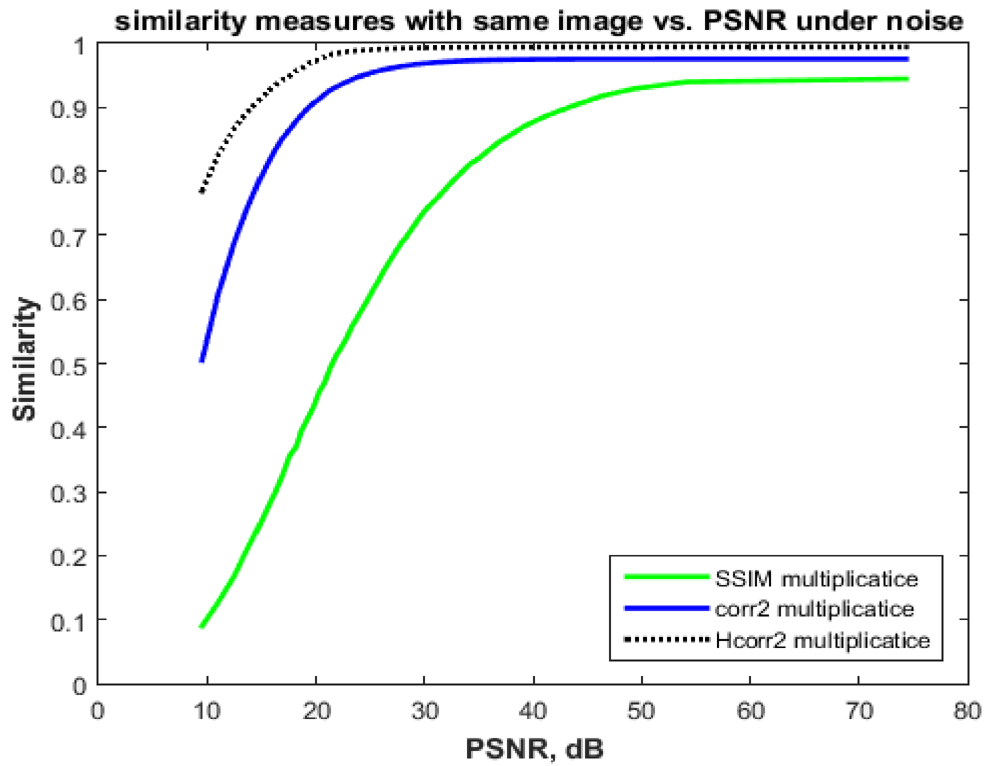
**(b) Performance similarty measure vs PSNR**

## C.Case three: A Performance under Multiplactive Noise

Take two images image without noise orginal image(two case either same person or image to another person) and image with a Take two images image without noise orginal image(two case either same person or image to another person) and image with a  Multiplactive noise than find similarity between them by these measures(ssim,corr2, Hssim,Hcorr2) and according to the following charts.

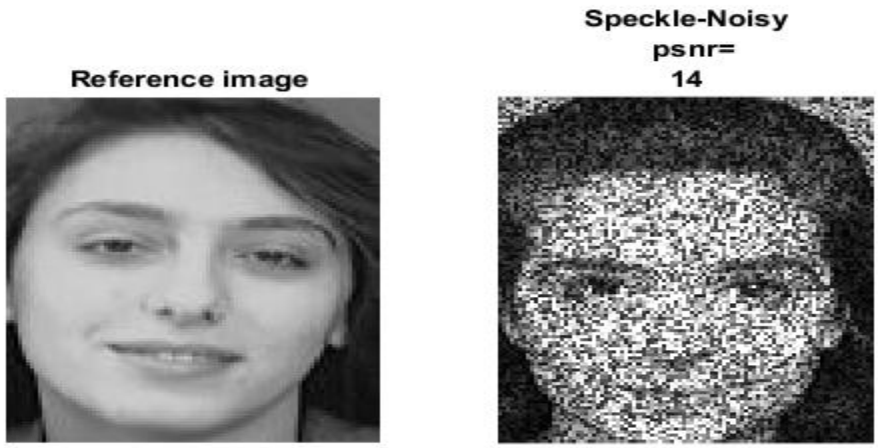



**(a) Orginal image and same image with multiplactive noise**

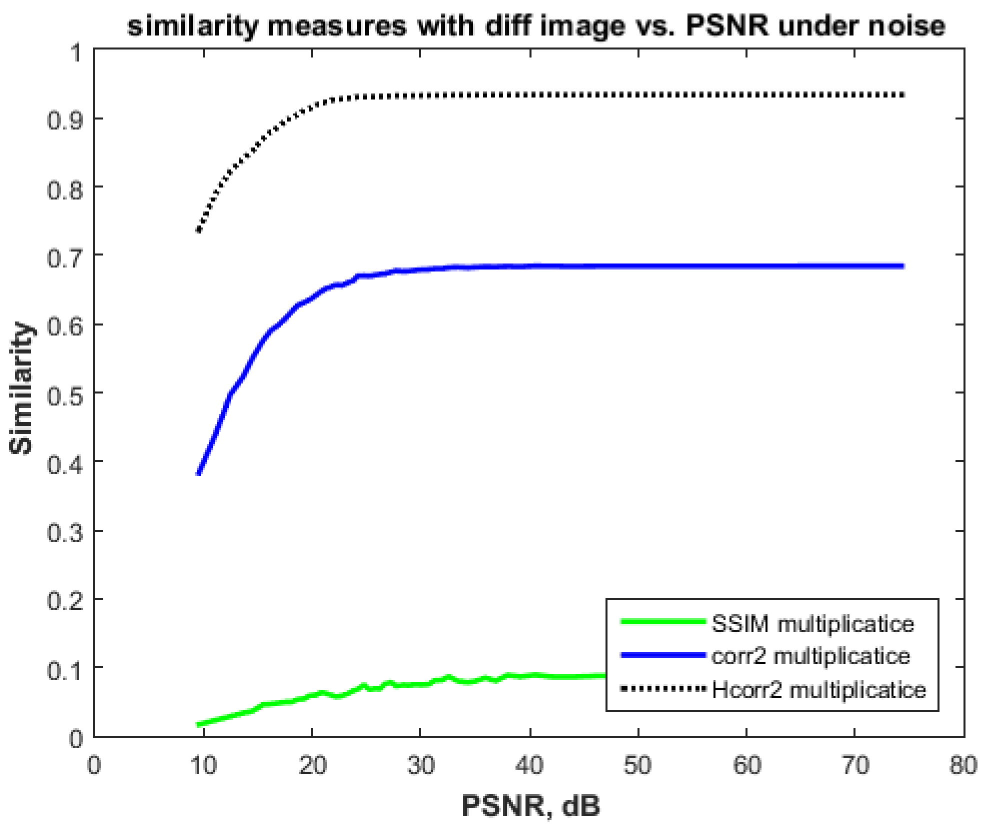



**(b)Performance similarty measure (Hcorr2) vs PSNR**

**Figure 3.4 (a) Orginal image and same image with multiplactive noise (b) Performance similarty measure vs PSNR**




**(b) Orginal image and different image with multiplactive noise**




**(b)Performance similarty measure (Hcorr2) vs PSNR**

**Figure 3.5 (a) Orginal image and different image with multiplactive noise (b) Performance similarty measure vs PSNR**

Appendix H: Comparison of Similarity Measures which is performed between incomplete and noisy image from AT&T Face Database under (Multiplicative noise)

| PSNR | SSIM | Corr2 | Hssim | Hcorr2 |
|---|---|---|---|---|
| 4.3195 | 0.0014 | 0.000 | 0.1131 | 0.1586 |
| 7.4355 | 0.0263 | 0.2201 | 0.6928 | 0.6501 |
| 9.5571 | 0.0479 | 0.3413 | 0.8006 | 0.7529 |
| 10.8269 | 0.1150 | 0.5028 | 0.8464 | 0.8368 |
| 12.3113 | 0.1317 | 0.5948 | 0.8752 | 0.8789 |
| 16.2672 | 0.3041 | 0.6649 | 0.8937 | 0.9473 |
| 16.9536 | 0.4791 | 0.6681 | 0.9080 | 0.9539 |
| 17.7508 | 0.3989 | 0.7224 | 0.9402 | 0.9547 |
| 18.2706 | 0.4485 | 0.7587 | 0.9443 | 0.9686 |
| 18.8463 | 0.4488 | 0.7925 | 0.9547 | 0.9712 |
| 21.7021 | 0.5829 | 0.8415 | 0.9570 | 0.9836 |

| | | | | |
|---|---|---|---|---|
| 22.8901 | 0.6241 | 0.8534 | 0.9589 | 0.9867 |
| 22.8156 | 0.6706 | 0.8904 | 0.9683 | 0.9873 |
| 23.6991 | 0.7397 | 0.9018 | 0.9688 | 0.9900 |
| 24.0527 | 0.7560 | 0.9137 | 0.9769 | 0.9905 |
| 25.4153 | 0.7807 | 0.9371 | 0.9809 | 0.9910 |
| 24.5056 | 0.7800 | 0.9391 | 0.9835 | 0.9907 |
| 26.0515 | 0.7941 | 0.9417 | 0.9890 | 0.9917 |
| 27.0778 | 0.8194 | 0.9561 | 0.9892 | 0.9919 |
| 28.1709 | 0.8575 | 0.9524 | 0.9904 | 0.9922 |
| 30.5838 | 0.8762 | 0.9600 | 0.9921 | 0.9925 |
| 31.6093 | 0.9061 | 0.9661 | 0.9923 | 0.9931 |
| 36.9396 | 0.9155 | 0.9678 | 0.9943 | 0.9933 |
| 38.2698 | 0.9397 | 0.9711 | 0.9931 | 0.9937 |
| 42.9247 | 0.9436 | 0.9730 | 0.9953 | 0.9942 |
| 47.4212 | 0.9440 | 0.9748 | 0.9971 | 0.9942 |

# <u>Chapter Four</u>

# Conclusions and Suggestion For Future Work

## 4.1 Conclusions

Through experiments conducted on Face images of AT&T database for the purpose of similarity n under non ideal conditions using similarity techniques, we can conclude the following:

1. The proposed measures gives larger similarity than the other measures under noise conditions (PSNR -35dB).
2. Although the two images differ (two images for same person or different person), the proposed measures and similarity measures (Corr2) give similarity .
3. The proposed measures (HCorr2 and Hssim) outperform existing measures.

## 4.3 Suggestions for Future Works .

During the development of this work, many recommendations come to the mind of the researcher. In this context, some ideas may be considered for further works to the proposed system:

Designing other types of noise image (image deficiencies).

1) Simulating similarity measures for purpose of identification.
2) Using database well-known worldwide (for example FEI Face Database).
3) Designing anew similarity measure and use it for purpose of face identification.