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Face Recognition over FFT-OFDM Computer Networks

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Abstract

An image error test measure based on normalized mean squared error (MSE), called (NMSE), is presented. The performance of the proposed error measure has been tested over FFT-OFDM system under the effect of Gaussian noise, impulse noise and Rayleigh noise. A comparison with the well-known structural similarity measure (SSIM) has been made under different baseband modulation schemes: BPSK, QPSK. It is shown that the NMSE measure outperforms SSIM at low SNR where it gives higher similarity for similar images, and test structural similarity measure (SSIM) for face recognition over FFT-OFDM system and compare the performance under different kind of noise for different SNR, where in low SNR probably need re-transmission image over OFDM.

Keywords: OFDM, FFT, QAM, image; digital communications, similarity.

INTRODUCTION

With increasing demand for high data rates in modern applications, OFDM is the main parallel transmission multi-carrier system which enables signals to be transmitted in parallel at different frequencies simultaneously from the same source [2]. Usually OFDM system use IFFT and FFT to multiplex the signals in parallel with reduced complexity algorithm at the transmitter and receiver respectively. The system employs guard interval or cyclic prefix (CP) so that the delay spread of the channel becomes longer than the channel impulse response; this is to minimize inter-symbol interference (ISI) between symbols [2,3,4].

Image transmission became important due to the increasing multi-media applications. However, noise can damage image features, hindering face recognition. In this work, we study image quality over FFT-OFDM communication system systems.

BACKGROUND

In this section we present an outline of FFT-OFDM system.

FFT OFDM:

In Figure 1, the data d_k is processed by M-ary QAM baseband modulator to map the data before IFFT, with N subcarriers. Its output is the sum of the information signals in the discrete time as follows [2]:

$$x_k = \frac{1}{\sqrt{N}} \sum_{m=0}^{N-1} X_m e^{\frac{j2\pi km}{N}} \quad (1)$$

where $\mathbf{x} = \{x_k | 0 \leq k \leq N-1\}$ is the signal represented by a sequence in the discrete time domain, $\mathbf{X} = \{X_m | 0 \leq m \leq N-1\}$ are complex numbers in discrete frequency domain representing DFT [1]. The cyclic prefix (CP) is added before transmission to minimize the inter-symbol interference. At the receiver side, the processed is reversed to obtain and decoded the data. The CP is removed to obtain the data in discrete time domain. The data is then processed to the Time-Domain (TD) windowing to eliminate narrowband interference before FFT.

At the receiver, FFT is performed on the received signal in discrete frequency domain as follows:

$$X_m = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} x_k e^{-j2\pi km/N} \quad (2)$$

See Figure1 for a basic FFT-OFDM communication system.

Image Structural Similarity Index (SSIM):

In 2004, Wang et al. [5] introduced a new measure for image quality index named Structural Similarity index method (SSIM). There has been a wide use for this measure in image processing and communications.

The SSIM measure between two images X and Y is defined as follows:

$$SSIM(X,Y) = \frac{(2\mu_x\mu_y + C_1)(2\sigma_{xy} + C_2)}{(\mu^2{}_x + \mu^2{}_y + C_1)(\sigma^2{}_x + \sigma^2{}_y + C_2)} \quad 3)$$

Where μ_x and μ_y represent the local means of images x and y, respectively, σ_x and σ_y represent the standard deviations, σ_{xy} is the cross-covariance of the two images ,$\sigma^2{}_x$ and $\sigma^2{}_y$represent the variances, respectively, while the constants C_1 and C_2 are defined as $C_1 = (K_1L)^2$ and $C_2 = (K_2L)^2$ with $K_1 = 0.01, K_2 = 0.03$ and L=255 [4]. SSIM ranges from 0 (no similarity) to 1 (full similarity).

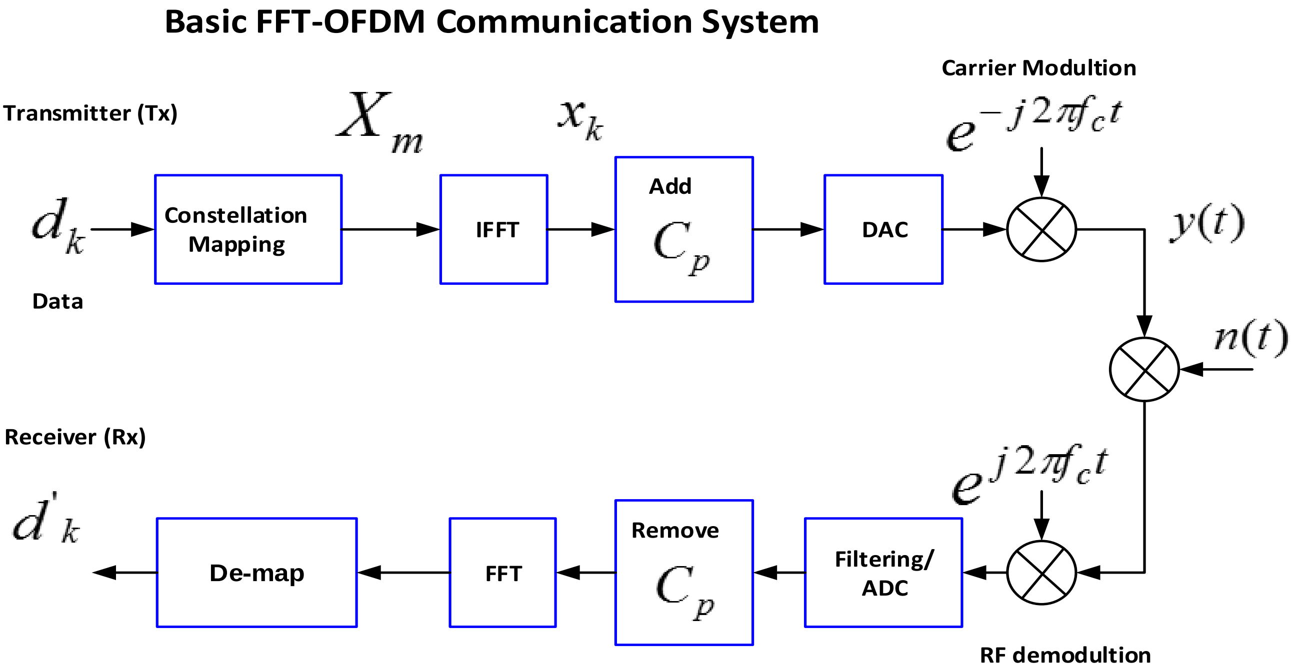

Figure 1: Basic FFT-OFDM communication system.

PROPOSED MEASURE FOR ERROR TEST

In this work we propose an error test measure (NMSE) based on normalized mean-squared error (MSE) between two M-by-N images X, Y as follows:

$$RMSE(X,Y) = \frac{\frac{1}{M\times N}\sum_i^M \sum_j^N [x_{i,j} - y_{i,j}]^2}{\sqrt{\sum_i^M \sum_j^N [x_{i,j}]^2}} \quad (4)$$

$$NMSE(X,Y) = 1 - \frac{RMSE(X,Y)}{\max[RMSE(X,Y)]} \quad (5)$$

It will be shown that this measure NMSE outperforms the well-known SSIM for testing error in image transmission under Gaussian noise plus impulsive noise for OFDM system communications.

TEST ENVIRONMENT

The proposed SSIM measures have been tested under Gaussian noise and impulse noise. Rayleigh noise has been considered as it is a source of noise in many image processing systems. The arrival time of this noise process at an instant k is formulated as a Poisson process b_k with parameter λ, while the amplitude of any noisy sample is formulated as a Gaussian process g_k with zero mean and variance of σ^2. The overall impulsive noise process i_k is given by Al-Mawali *et al.*[6]:

$$i_k = b_k . g_k \quad (6)$$

If the random variable that represents the time count of arrival (since the last impulse) is T, then the probability of arriving m samples after the previous impulse, p(m), will be:

$$p(k) = p(T = k) = \exp(-\lambda).(\lambda^k / k!); \quad k = 0,1,2,... \quad (7)$$

noting that:

$$\varepsilon(T) = \mathrm{var}(T) = \lambda \quad (8)$$

The power of the Gaussian amplitude σ^2 will contribute a total noise power of:

$$n_p = \sigma^2 / \lambda \quad (9)$$

This is so because the occurreace of noise is not expected but on distant sample

Hence, we define r, the Peak Signal to Noise Ratio (PSNR), as follows:

$$r = \frac{L^2}{n_p} = \lambda \frac{L^2}{\sigma^2} \quad (10)$$

As we assume both Gaussian and impulse noise, SNR is defined as:

$$SNR = \frac{P_X}{P_n} \quad (11)$$

where

$$P_n = P_{n_i} + P_{n_g} \quad (12)$$

If $r = \frac{p_{n_g}}{p_{n_i}}$

then

$P_n = P_x + SNR$;

where $P_n = P_{n_i} + P_{n_g} = (1 + r)P_{n_i}$ (13)

$$P_{n_i} = P_n/(r+1);\ p_{n_g} = r * P_{n_i}\ ; \quad (14)$$

The Rayleigh fading channel is widely applicable to OFDM technique [7]; it can be represented as statistical model assuming that the magnitude of propagating signal passed through a medium will vary randomly. Furthermore, Rayleigh fading is suitable to simulate wireless transmission of 1 to 20 km, and mobile OFDM technique thereby meets the requirement of the investigation [8]; where the impulse response is modelled as a zero mean complex-valued Gaussian process [9]. Rayleigh distributions are defined for fading channel when all the received signals are reflected signals and there is no dominant component [10,11], and the Rayleigh distribution has a probability density function (PDF) given by:

$$P(x) = \left(\frac{x}{B}\right) \exp\left(\frac{-x^2}{2B}\right) \quad ; \quad x \geq 0\ ,\ B = b^2 \quad (15)$$

where b is a real positive parameter called Rayleigh parameter [12].

Rayleigh-distribution has mean and variance given by:

$$\mathcal{E}\{X\} = b\sqrt{\pi/2} \quad (16)$$

$$\mathrm{var(X)} = B\,\frac{(4-\pi)}{2} \quad (17)$$

The second moment (power) of Rayligh noise is given by:

$p\ = \mathcal{E}\{X^2\} = 2B$

where $b = \sqrt{\mathrm{p}/2}$

The Rayleigh noise power is $p \neq B\,\frac{(4-\pi)}{2}$ since $\mathcal{E}\{X\} \neq 0$.

Note that it is possible to reduce the impulse noise effects using various approaches (see [13] for example); also, it is possible to enhance the system performance using DWT-OFDM (see [14]).

IMPLEMENTATION AND RESULTS

We simulated the FFT-OFDM system shown in Figure 1 and implemented similarity measures: the well-known SSIM and the proposed error test (NMSE) as per the equations above. In Figures (2-11), it can be seen that NMSE outperforms SSIM especially for BPSK and QPSK modulation. Note that NMSE is used for error detection her.

Performance under Gaussian Noise:

See Figs. 2 and 3, where the proposed error measure outperforms ssim in similarity detection.

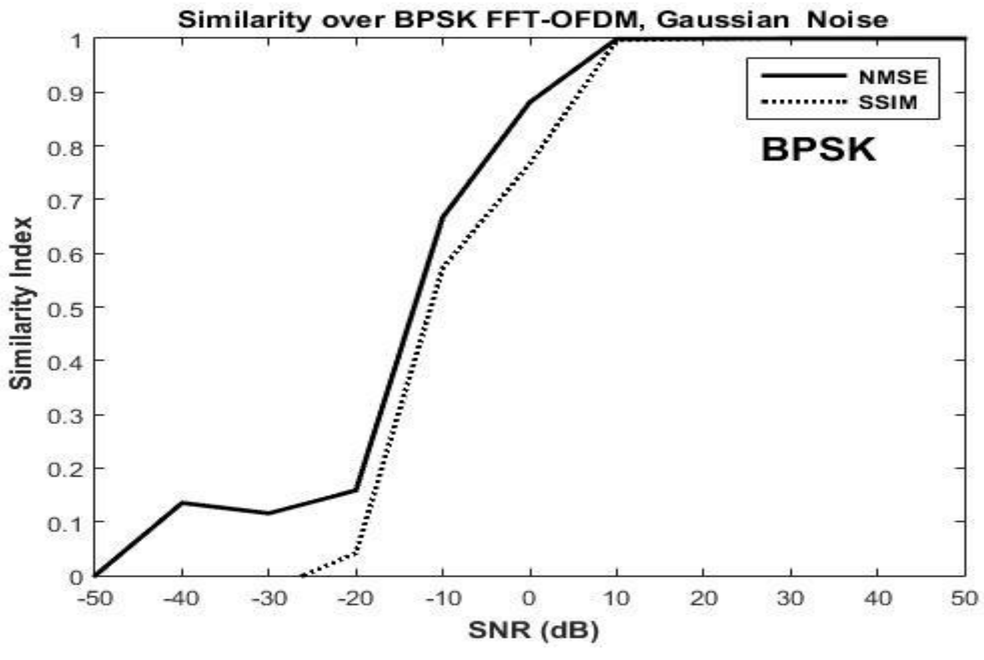

Figure 2: Performance comparison between SSIM and NMSE using similar images under Gaussian noise over BPSK modulation .

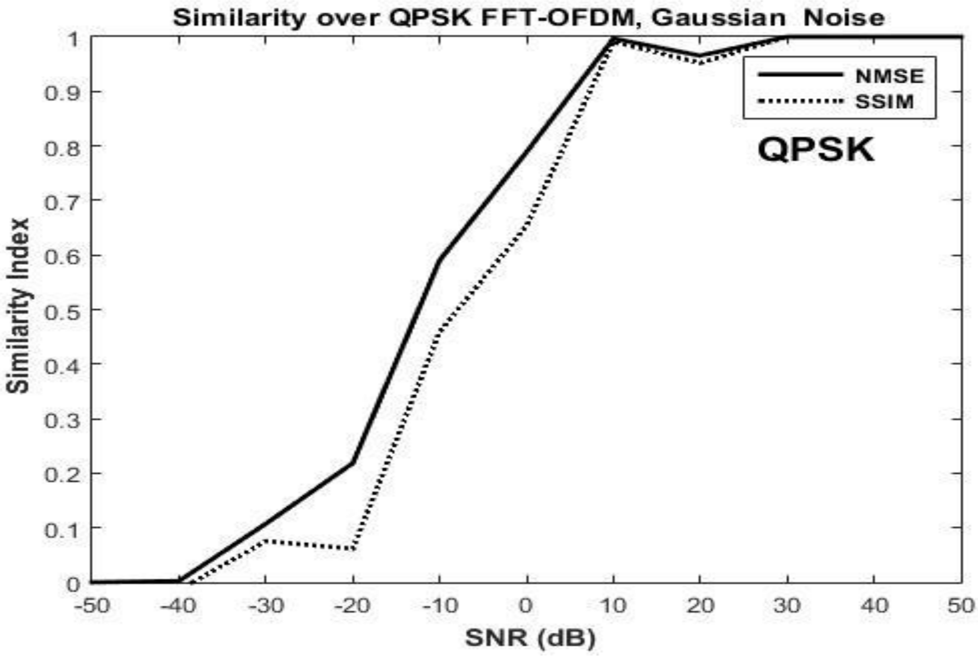

Figure 3: Performance comparison between SSIM and NMSE using similar images under Gaussian noise over QPSK modulation
.

Performance under Impulse Noise: See Figs. 4 and 5.

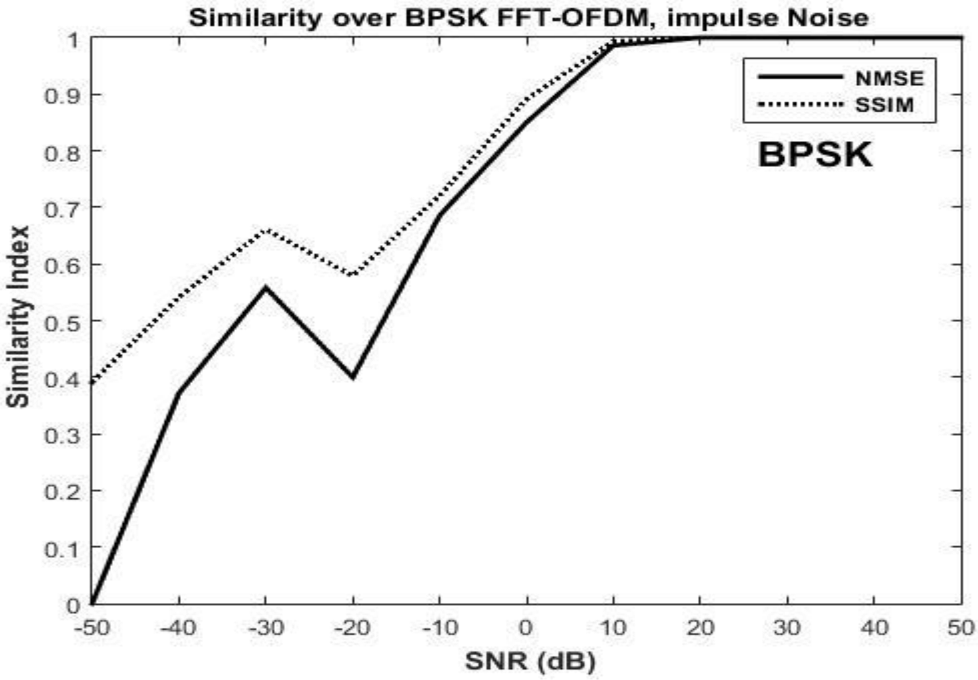

Figure 4: Performance comparison between SSIM and NMSE using similar images under Impulse Noise over BPSK modulation .

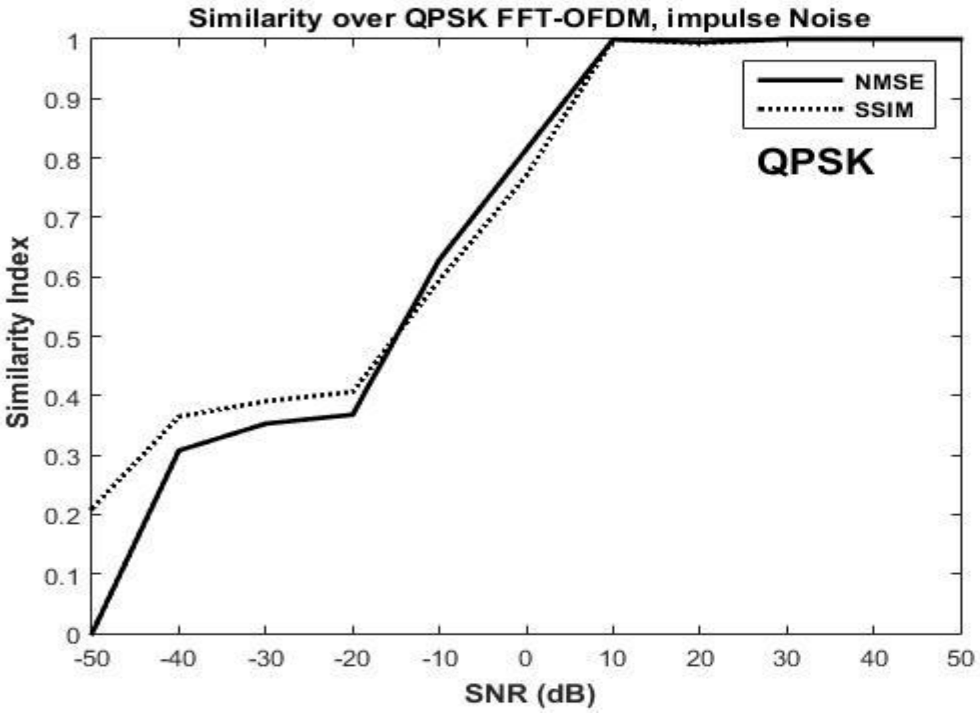

Figure 5: Performance of SSIM vs. NMSE using similar images under impulse noise over QPSK modulation.

Performance under Gaussian noise plus Impulse Noise: See Figs. 6, 7.

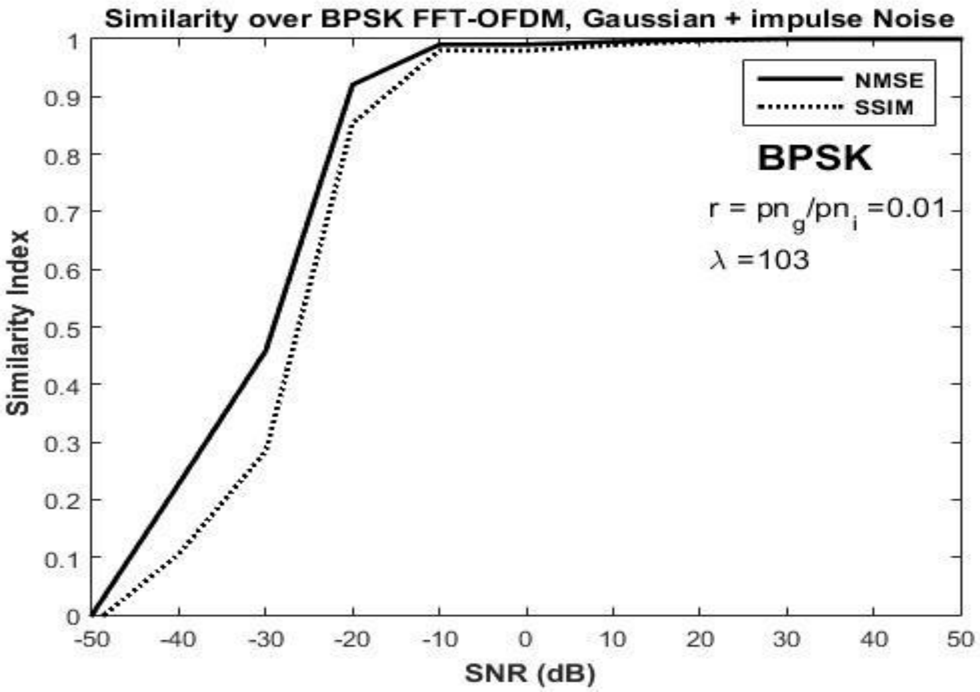

Figure 6: Performance of SSIM vs. NMSE using similar images under Gaussian noise and impulse noise over BPSK modulation.

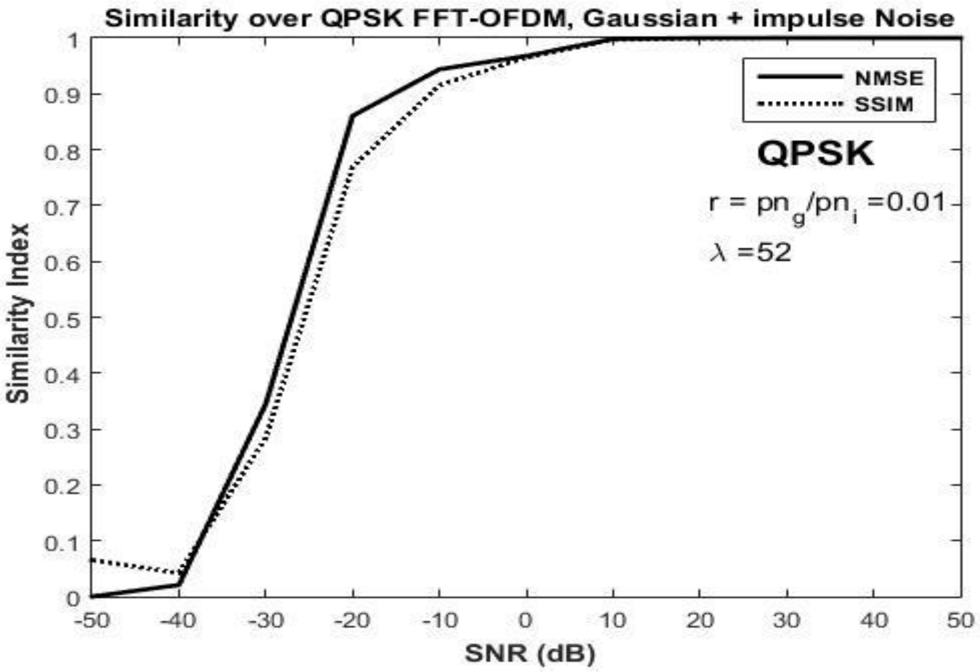

Figure 7: Performance of SSIM vs. NMSE using similar images under Gaussian noise and impulse noise over QPSK modulation**.**

Performance under Rayleigh Noise: See Figs. 8, 9.

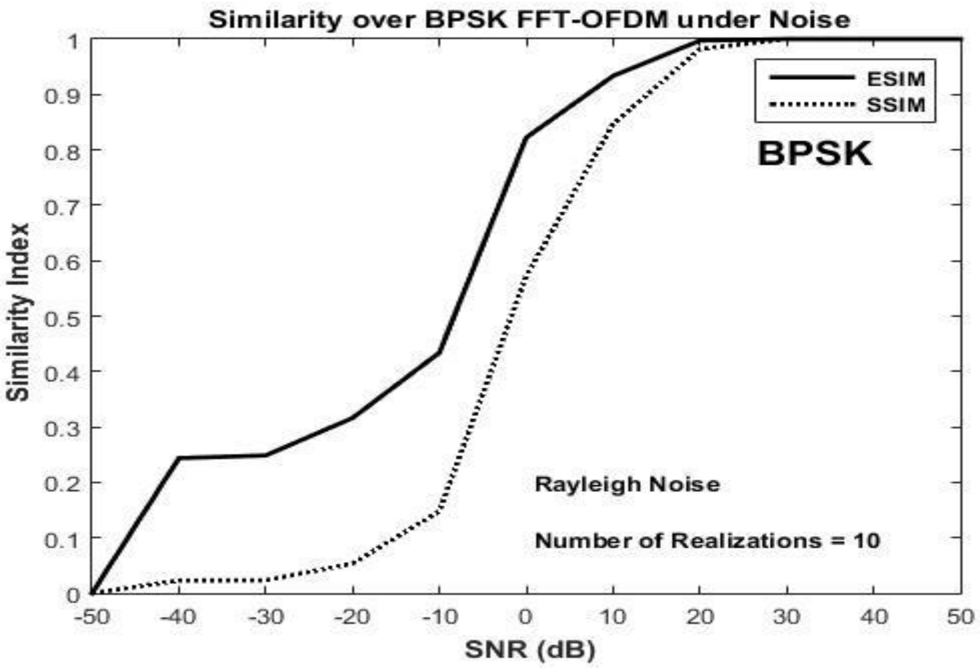

Figure 8: Performance of SSIM vs. NMSE using similar images under Rayleigh noise over BPSK modulation.

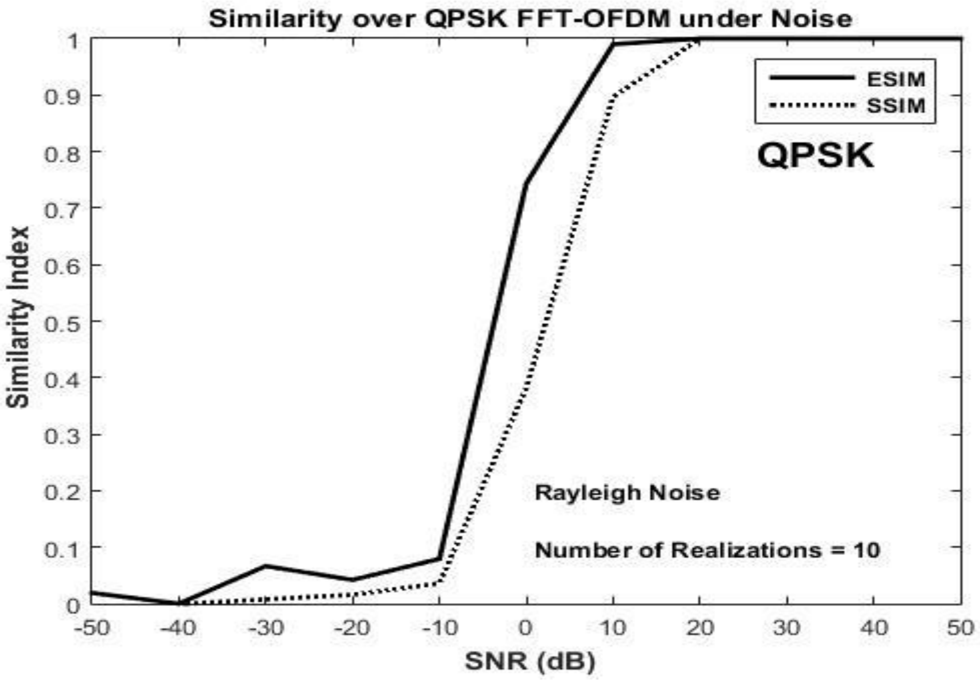

Figure 9: Performance of SSIM vs. NMSE using similar images under Rayleigh noise over QPSK modulation .

5.5. Performance under Gaussian and Rayleigh Noise: See Figs. 10, 11.

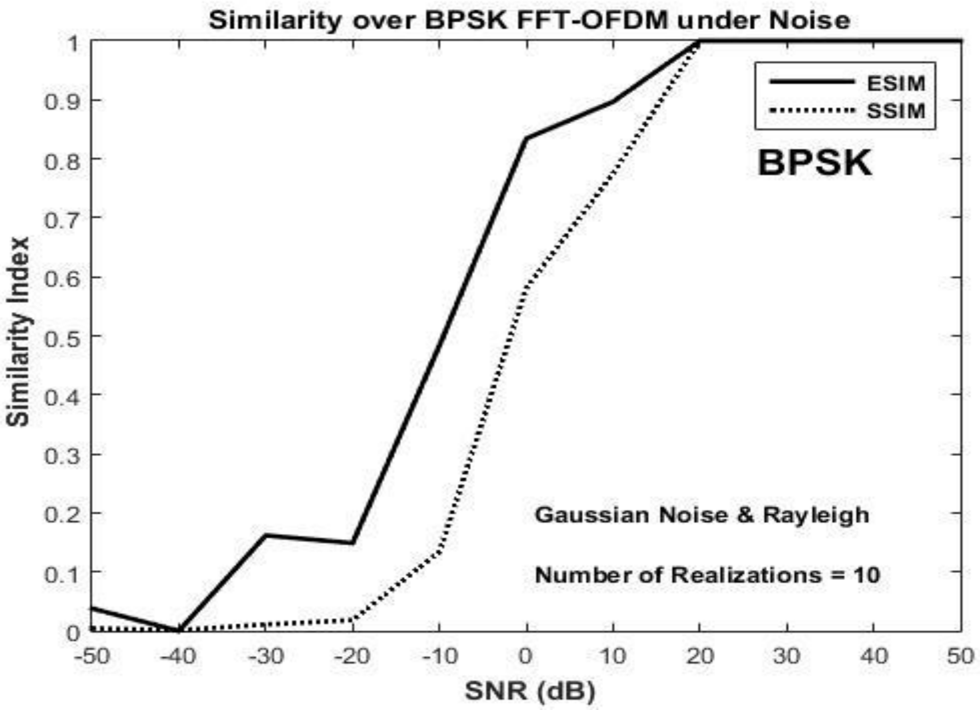

Figure 10: Performance of SSIM vs. NMSE using similar images under Gaussian noise plus Rayleigh noise over BPSK modulation.

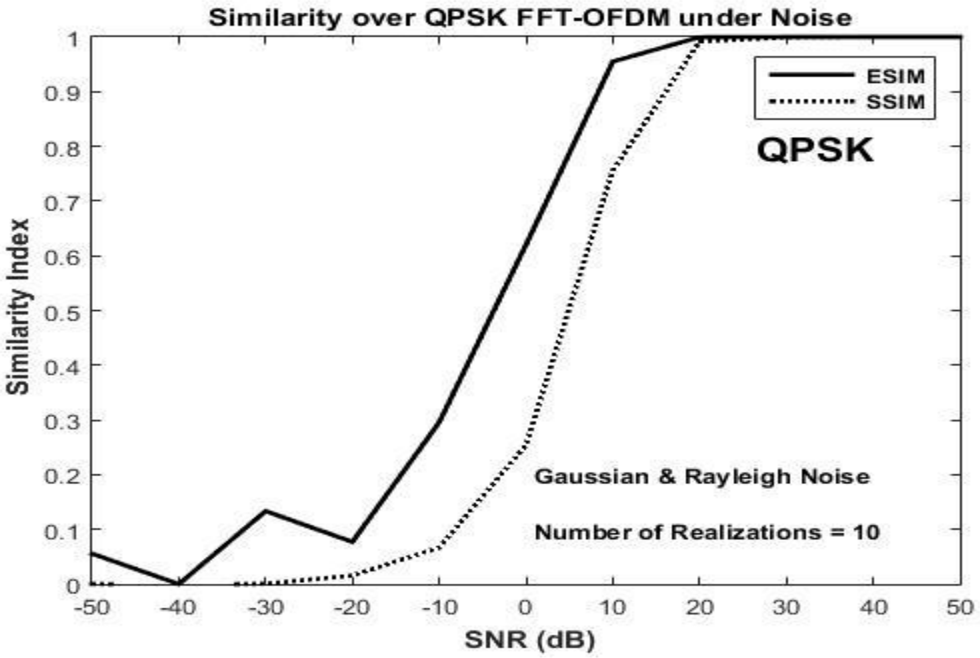

Figure 11: Performance of SSIM vs. NMSE using similar images under Gaussian noise plus Rayleigh noise over BPSK modulation.

FACE RECOGNTION

The database AT&T This database contains (10) different images (poses) of each person, the set consist of images for forty (40) persons taken at different illuminations, rotation and facial expressions and facial details like black or white face, long or short hair, each image with size 92×112 pixels.

We will take 10 person's from the database to test recogntion.

Face Recogntion with BPSK modulation

We take person3-pose6 from database and compare with each person's pose 6 under different SNR (10 realizations) over BPSK modulation. See **Table 1**.

Table 1: Recognition failure rates using P3_Pose6 as a reference versus each person_Pose6 from 10-face sub-database of AT&T Face Database over BPSK modulation under various kinds of noise.

Person 3_pose6		Recognition Failure Rates (BPSK)				
SNR	N Number of Attempts	Gaussian	Impulse	Gaussian & Impulse	Rayleigh	Gaussian & Rayleigh
-30	10	3	0	0	9	5
-25	10	2	0	0	6	3
-20	10	0	0	0	5	1
-15	10	0	0	0	4	0
-10	10	0	0	0	2	0
-5	10	0	0	0	1	0
0	10	0	0	0	1	0
5	10	0	0	0	0	0
10	10	0	0	0	0	0
15	10	0	0	0	0	0
20	10	0	0	0	0	0
25	10	0	0	0	0	0
30	10	0	0	0	0	0

Face Recogntion over QPSK Modulation

We take person3-pose6 from database and compare with each person's pose 6 under SNR (10 realizations) with QPSK modulation. See **Table 2**.

CONCLUSION

In this paper we proposed an efficient error measure for image transmission over FFT-OFDM system under Gaussian, impulse, and the Rayleigh noise. The proposed measure is based on normalized mean – squared error. It is shown by numerical simulation that the proposed measure (NMSE) outperforms the (SSIM) in error evaluation under Gaussian noise using BPSK and QPSK. Then we tested the performance of Face Recognition (FR) if test image is transmitted over OFDM for examination in a remote center, we found that at low SNR (e.g., -30 dB), we may need to re-transmit the reference image (test image) several times over multipath OFDM to get correct decision.

Table 2: Recognition failure rates using P3_Pose6 as a reference versus each person_Pose6 From 10-face sub-database of AT&T Face Database over QPSK modulation under various kinds of noise.

Person 3_pose6		Recognition Failure Rates (QPSK)				
SNR	**N number of Attempts**	**Gaussian**	**Impulse**	**Gaussian & Impulse**	**Rayleigh**	**Gaussian & Rayleigh**
-30	10	3	0	0	7	7
-25	10	2	0	0	6	4
-20	10	1	0	0	5	1
-15	10	0	0	0	4	1
-10	10	0	0	0	3	0
-5	10	0	0	0	1	0
0	10	0	0	0	1	0
5	10	0	0	0	0	0
10	10	0	0	0	0	0
15	10	0	0	0	0	0
20	10	0	0	0	0	0
25	10	0	0	0	0	0
30	10	0	0	0	0	0

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