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Performance analysis of image transmission with various channel conditions/modulation techniques

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ABSTRACT

This paper investigates the impact of different modulation techniques for digital communication systems that employ quadrature phase shift keying (QPSK) and quadrature amplitude modulation (16-QAM and 64-QAM) to transmit images over AWGN and Rayleigh fading channels for the cellular mobile networks. In the further steps, wiener and median filters has been adopted to the simulation are used at the receiver side to remove the impulsive noise present in the received image. This work is performed to evaluate the transmission of two dimensional (2D) gray-scale and color-scale (RGB) images with different values from signal to noise ratios (SNR), such as; (5, 10 and 15) dB over different channels. The correct conclusions are made by comparing many of the observed Matlab simulation results. This was carried out through the results that measure the quality of received image, which is analyzes in terms of SNRimage peak signal to noise ratio (PSNR) and mean square error (MSE).

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1. INTRODUCTION

Wireless channels are extremely random and time-varying, which propagates across multiple paths, where it is unlike fixed and predictable wire channels. However, the proliferation of multiple paths in the wireless system is a challenge [1-3]. The resulting phenomenon via the arrival of multiple copies of the signal sent to the receiver, causes the inter symbol interference (ISI) to be distorted, this produced highly distorted the signal sent at the receiver. In the same time, this results in time attenuation, dispersion and phase offset in the receiving signal, which is known as fading [4-6].

In the digital communication system, modulation can be defined as the process of sending a signal message, where the information are shows as the bits and the input image is utilized in the different modulation techniques [7-9]. As a result, using the 64-QAM modulation technique will improve the degraded image, this is necessary for image transfer and provides the best results compared with different modulation techniques, like QPSK and 16-QAM because it has higher data rates. Thus, the performance of the system would be acceptable even with a certain level of noise from the critical channel. In another meaning, the performance of the system can not be tolerable when the noise level is higher than this critical level [10-12].

Fading occurs because of overlapping between two or more from the signals sent to the receiver at slightly different times. However, these waves are multipath waves that unite in the receiving antenna and give the result of a signal that can vary greatly in amplitude and phase, according to the transmitted signal width, the relative propagation time of the waves and the distribution of intensity [13-15]. Unexpected delays change in regarded with various signal paths in a multipath fading channel, as well as can be statistically distinguished only. However, the central limit theorem can be applied as a random process of the complex-valued Gaussian to model the time-variant impulse response of the channel when there are a large number of paths. If the impulse response is designed as a Gaussian process with zero complex value, it is said that the channel is Rayleigh fading channel [16, 17]. However, Rayleigh's models assume that the signal magnitude that passed through this communication channel will change randomly or fades based on Rayleigh's distribution. Rayleigh fading is regarded as a reasonable model for the propagation of tropospheric and ionospheric signals and highly-built urban environments effect on the radio signals when there are a lot of objects in the environment that spread the radio signal before it reaches to the receiver. If there is too much scattering, the channel pulse response will be well designed as a Gaussian process according to the central limit theorem regardless of the individual components distribution, where there are zero mean and phase equally distributed between 0 and 2 radians when there is no predominant component to the scatter. Thus, the response envelope of the channel will be distributed to Rayleigh [18].

Image filtering do not use to improve the image quality, but it is also utilized as a pre-processing stage in many applications, which includes; image compression, pattern recognition, image encryption, and target tracking. However, noise reduction is utilized to restore the ideal image from the degraded version of the image. Image filtering algorithms are used to eliminate the various noise types that exist either in the image while being captured or injected into the image through the transmission. Thus, Median Filter is performed through taking the magnitude of each vectors within the mask and sorted based on the magnitudes, then, the medium-magnitude pixel is utilized to replace the studied pixels. While, the Wiener Filter performs an optimal trade-off between the noise smoothing and the inverse filtering because it reflects camouflage and eliminates the additive noise simultaneously [19-21].

The authors discuss in [18] the effect of various equalization techniques that use MPSK and MQAM modulation technology for digital communication systems to transfer the information of color image on the Rayleigh fading channel. The analysis of this performance has been made in terms of bit error rate through use Matlab simulation. The solution for this problem is to increase the SNR value. Thus, the various properties values, such as; average path gain, path delay, doppler spectrum and maximum doppler shifts parameters are selected accurately in the simulate the Rayleigh fading channel to turns out a realistic fade channel. However, the size of the step and the forgetting factor, etc. is also chosen for the various adaptive algorithms utilized by the linear equalizer (LE) and decision feedback equalizer (DFE) correctly. Moreover, a compression was used to transfer the color image that provides 82% less data compare with the uncompressed JPEG image. Each analysis offers the worst equalizer for the Rayleigh fading channel linear equalizer with the LMS adaptive algorithm. In addition, to reduce the signal dispersion and ISI, the maximum likelihood sequence estimate (MLSE) equalizer provides the better equalization. However, the results explained that both of DFE and LE adaptive algorithm equalization gives best result than l ms. While, DFE offers the best performance compare with the linear equalizer, other than that it gives the poor performance with the lower SNR. But the MLSE equalizer gives the better performance among all the equalizers used in this work. In general, all the results explained that utilize of the 4QAM modulation method and the MLSE equalizer give a best result for transferring the color JPG color images.

In [11] the authors demonstrated that the transmission of image via digital wireless communications by used different digital modulation techniques, like; QPSK, 16-QAM and 64-QAM are implemented through utilized the AWGN channel to design and implement the wireless digital communication system as well as know the better modulation technique suitable for transmitting the image. However, the performance of this system will be acceptable like many other digital wireless communications systems to reach a appointed noise level from the critical channel. In another meaning, the system performance cannot be very quickly when the noise level is higher than the critical level. The current designed system in this work generates worse image quality instead of losing the image sent completely when the channel is in high noise. Simulation results explained that, 64-QAM modulation techniques has higher data rates, this is necessary for image transfer, offer best results compare with the another modulation techniques (i.e., QPSK and 16-QAM) when the SNR value is 10 dB.

The authors in [22] concentrated on the transfer of images by used M-QAM OFDM system for the fading channel. The Generalized K Fading channel is evaluation through sending still images by the 16-QAM- OFDM modulated system with various values from fading and shading parameters. The images sent through composite fading channels will be exceptionally sensitive to the influence of multipath propagation, which may result the image quality degradation in the receiver. The simulation results showed that M-QAM-OFDM resulted a good tradeoff between symbol-error durability, throughput and reduce of the peak-to-average ratio of the OFDM signal. In addition, the generalized K Fading channel is very effective for prediction the fading and shadowing performance as well as showing its effects at the same time. Moreover, the results examined show the influence of fade and shading from where of bit error rate and visual quality of the received images. However, because of the mobile radio signal casing usually consists of a fast fading component overlay on a slowly fading component, thus, it is clear that from the results presented the channel model which consists of mixed distributions will be useful in design the wireless systems and networks.

Furthermore, one type of this digital data, which corresponds to to a two-dimensional gray-size (2D) image is utilized for evaluation the overall of functionalion and the performance of the OFDM system with the impact of the AWGN channel in [22]. Various configurations of the modulation techniques, likes; M-PSK and M-QAM are considered within the OFDM system for evaluation of the system as well as the necessary correct conclusions are made from comparing many of noted simulation results in Matlab. However, the OFDM system was implemented using various modulation techniques to transmit images via the AWGN channel. The recovered image quality is best at high SNR values regardless of the utilized modulation method. In the case of low-SNR, the quality of the recovered image is very low because of high amount of noise in the AWGN channel. In this work, it was found that OFDM system provides fewer errors, higher recovered image quality at the receiver and less BER with 16-QAM modulation technique compared to the OFDM systems applied with other techniques.

This paper analyze the performance of image transfer across different channels which display various effects on image transfer performance through use different filters. In this work, there are two types of digital data which corresponds to a 2D gray-scale and color-scale (RGB) of JPEG format images are used for transmission data and assess the comprehensive performance and the functionality of the system with the effect of AWGN and Rayleigh fading channels. The various channels show various impacts on the execution of the transfer of images utilizing different modulation techniques. However, wiener and median filters are used at the receiver side to remove the impulsive noise present in the received image. The remainder of the paper is orderly as follows: the proposed image transmission system model is discussed in section 2. Section 3 presents and discusses the performance evaluation of the proposed system, where the simulation results and discussion for the proposed system is highlighted. Finally, section 4 is drawn the concluding remarks of this paper.

2. PROPOSED TRANSMISION SYSTEM MODEL

Figure 1 explain the implemention of the system model, which describes the sequence of events utilize in the current work to send Gray-scale and RGB images of size 512x512 over AWGN and Rayleigh Fading channels, respectively. The communication channel is designed by adding the Gaussian white noise effect and the carrier influence. The images are reshaped based on the modulation technique used, and then sent through these channels. The test image chosen for evaluation of the proposed image transfer system appears in Figures 2 and 3. This virtual image is existing with JPG format, size 512 x 512 with 262144 pixels, where each pixel 8-bits, and accessible through the name "Penguin Image". To transfer this image available in a two dimensional (2D) matrix or signal, we need to do some pre-processing to convert this 2D image to a one dimensional (1D) signal. In the start, read the image that is obtainable from Matlab database. After that, we change it to a double coordinate then restructure the data to convert them from the (512x512) matix representation to the (1×262144) vector representation, and then we convert it to the binary that results a vector of binary data (512×512×8=2097152 bits) for gray-scale image and (512×512×8×3) for RGB image, where this image becomes now ready for transmission. This data is used as a data source or input signal for image transmission system, where this source data is modulated through use either QPSK, 16-QAM, or 64-QAM techniques. Finally, according to the modulation method utilized, we must be conversion the vector data to an appropriate format.

For instance, if we utilize QPSK modulation technique, we will conversion the vector data to the binary data (four signal elements, i.e., 00, 01, 10 and 11, which are 0, 1, 2, and 3, respectively). However, it will be a good comparison if we use another modulation techniques as the transmitter modulation, such as; 16-QAM and 64-QAM. Thus, for 16-QAM modulation, which corresponds to (sixteen signaling elements, i.e., 0000, 0001, to 1111, which are 0, 1, to 15, respectively), and for 64-QAM modulation, which is compatible with (sixty four signaling elements, i.e., 000000, to 111111, which are 0 to 63, respectively). On the receiver side, the opposite operations are achieved to effectively restore the transfered original image after recovering the digital bits. The system parameters utilize in this simulation will be tabulate in Table 1, which displays the characteristic of the original image used and the corresponding simulation parameters values that are consider in the simulation Matlab.

However, there are two types of objective metrics that are widely utilized in the evaluating image transmission techniques, such as: Peak Signal to Noise Ratio (PSNR), which is utilized to measure the image quality, also, Mean Square Error (MSE), which uses to measure the image distortion and may be explained as the square of error between the stego $P_{R_x}(i,j)$ and cover $P_{T_x}(i,j)$ images. Thus, the reconstructed images quality with size M×N in terms of PSNR is given by [23-25]:

$$PSNR = 10\log_{10}\left[\frac{255^2}{MSE}\right] \quad (1)$$

where;

$$MSE = \frac{1}{M \times N}\sum_{i=1}^{M}\sum_{j=1}^{N}\left[P_{T_x}(i,j) - P_{R_x}(i,j)\right]^2 \quad (2)$$

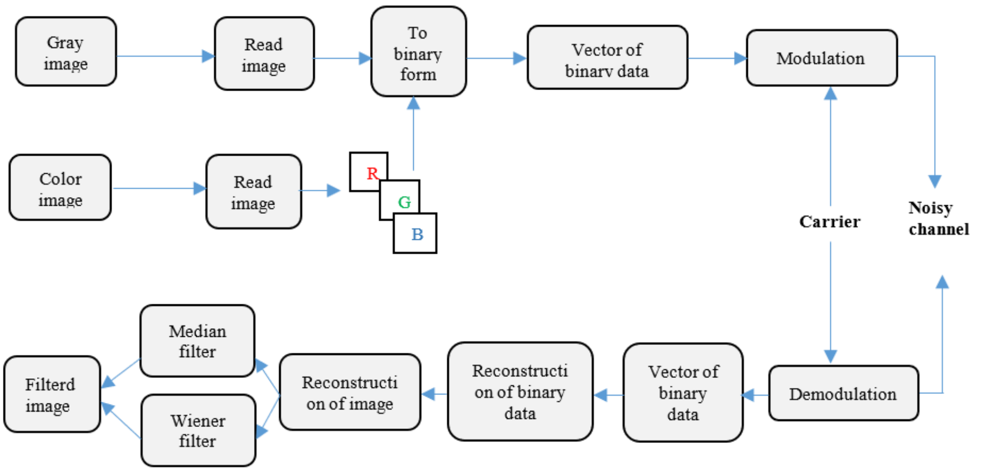


Figure 1. System model

Table 1. Features of penguin test image and Matlab simulation parameters

Properties	Corresponding Values
Original Image Size	(512 x 512) pixels
Total Pixels	262144
Size data for each pixel	8-bits
Size of the signal elements or source signal for the QPSK transmission size	262144×8/2 = 1048576 (gray-scale image) 262144×8×3/2 = 3145728 (RGB image)
Size of the signal elements or source signal for the 16-QAM transmission size	262144×8/4 = 524288 (gray-scale image) 262144×8×3/4 = 1572864 (RGB image)
Size of the signal elements or source signal for the 64-QAM transmission size	262144×8/6 = 349525 (gray-scale image) 262144×8×3/6 = 1048576 (RGB image)
Modulation Schemes	QPSK, 16-QAM, 64-QAM
Channel type	AWGN and Rayleigh fading
Range of SNR in dB	5, 10 and 15

3. RESULTS AND PERFORMANCE ANALYSIS

In this work, two types of digital data which represents two-dimensional (2D) gray-scale and RGB images are utilized to assess the overall performance and the functions of the proposed system with the effect of typical AWGN and Rayleigh fading channels and various filters, which uses on the receiver side to remove the impulsive noise in the received image in Matlab simulation. However, various configurations of prominent modulation techniques, like; QPSK, 16-QAM and 64-QAM have been used in this work to evaluate the proposed system as well as make the correct conclusions for comparing many results of simulation Matlab. In the first part of this section, we are going to compare the result of the two types of images transmission with three different SNR over AWGN channel. In the next step we compare the results with the simulation and the theoretical performance of the image transmission over over the Rayleigh fading channel. However, the graph will analyze the comparison between two images which utilizes to discuss the performance. The system has been implemented as described in section 2, with use QPSK, 16-QAM and 64-QAM as a modulation technique for analysis the performance of image transfers by using various channel conditions with and without two types from filters through Matlab simulation. These filters are Wiener and Median, respectively, which uses to remove the noise from the image. Thus, we can see that the simulation results are not the same as the original image, but they are almost identical. Simulation results are conducted to compare the images recovered for three various SNR values are 5, 10 and 15 dB, respectively, which conforming to various modulation techniques. Tables 2-7 are a good tool to come up the system performance comparison for MSE, PSNR and SNR image on different types of images, SNR channel, filters, and modification techniques for AWGN and Rayleigh fade channels. Obviously from the PSNR results, the system works well in the AWGN channel compare with the Rayleigh fading channel, as well as with a slight increase in signal strength, the image will be received ideally, where the higher PSNR will improve the quality of recovered image.

Table 2. Comparison MSE for different images, modulation schemes and filters (AWGN channel)

Image Types	SNR channel (dB)	QPSK			16-QAM			64-QAM		
		Without filter (dB)	Wiener filter (dB)	Median filter (dB)	Without filter (dB)	Wiener filter (dB)	Median filter (dB)	Without filter (dB)	Wiener filter (dB)	Median filter (dB)
Gray-scale Image	5	1.011e+03	344.469	69.3990	1.5378e+03	352.817	280.654	5.360e+03	1.9147e+03	1.2620e+03
	10	30.2378	43.7866	56.9569	540.264	128.085	70.6717	3.817e+03	1.0820e+03	442.525
	15	22.6794	40.6287	46.5855	163.711	63.1253	55.6810	2.605e+03	570.0549	156.2942
RGB Image	5	958.994	341.577	78.5478	1.6574e+03	290.013	310.983	5.2678e+03	1.6364e+03	1.2280e+03
	10	20.1701	49.470	44.6936	580.783	137.857	66.0657	3.7758e+03	1.0582e+03	461.7473
	15	0.0469	46.8864	34.5352	102.652	57.1098	50.7978	2.2483e+03	558.8409	101.2831

Table 3. Comparison PSNR for different images, modulation schemes and filters (AWGN channel)

Image Types	SNR channel (dB)	QPSK			16-QAM			64-QAM		
		Without filter	Wiener filter	Median filter	Without filter	Wiener filter	Median filter	Without filter	Wiener filter	Median filter
Gray-scale Image	5	18.0733	22.7170	29.5914	16.2617	20.2922	23.6491	10.8392	14.3343	17.1202
	10	34.6317	30.2137	31.4138	20.8047	25.9956	30.3415	12.3136	17.4765	21.6714
	15	65.2210	32.2276	35.4483	25.9900	30.0946	32.9143	13.9730	20.7669	28.3947
RGB Image	5	18.3126	22.7959	29.1795	15.9365	21.1050	23.9311	11.0145	15.7501	18.2389
	10	35.0837	30.4705	32.0114	20.4907	27.7365	30.7825	12.3607	17.7479	22.4868
	15	61.4214	31.3460	32.7572	30.0172	30.7980	32.5117	14.6123	20.6238	29.2476

Table 4. Comparison PSNR for different images, modulation schemes and filters (Rayleigh fading channel)

Image Types	SNR channel (dB)	QPSK			16-QAM			64-QAM		
		Without filter	Wiener filter	Median filter	Without filter	Wiener filter	Median filter	Without filter	Wiener filter	Median filter
Gray-scale Image	5	12.8825	14.6190	17.7593	10.7082	14.4251	16.9202	9.5892	13.4196	14.0395
	10	24.7746	29.3158	31.3390	18.0990	22.2361	26.3719	10.5305	14.7692	16.1857
	15	40.5959	30.4705	32.9241	23.4187	28.7198	32.4056	12.6452	16.4549	25.1048
RGB Image	5	16.1179	20.7003	27.3415	14.4099	20.4204	22.6888	10.6886	15.1511	16.4571
	10	27.2346	28.9960	30.4376	19.1640	27.3148	29.2925	11.2729	16.1695	19.1690
	15	49.9106	27.1929	32.7623	28.7499	30.7421	32.2226	14.1425	22.8007	28.6534

Table 5. Comparison SNRimage for different images, modulation schemes and filters (AWGN channel)

Image Types	SNR channel (dB)	QPSK			16-QAM			64-QAM		
		Without filter (dB)	Wiener filter (dB)	Median filter (dB)	Without filter (dB)	Wiener filter (dB)	Median filter (dB)	Without filter (dB)	Wiener filter (dB)	Median filter (dB)
Gray-scale Image	5	7.1056	9.4445	12.8646	6.1998	8.3359	9.8935	3.4885	5.2633	6.6290
	10	15.3848	12.6928	13.7758	8.4713	11.0853	12.9397	4.2257	6.9632	8.9046
	15	28.0195	14.1998	18.7931	11.0639	13.1333	15.5261	5.0554	9.0038	12.7833
RGB Image	5	6.8549	9.0965	12.2883	5.6668	8.0197	9.2451	3.1558	5.6945	6.3180
	10	15.2404	13.1338	14.0743	7.9439	11.0668	13.0898	3.8789	6.6412	8.9441
	15	28.4092	13.9715	15.0806	12.7071	13.0976	13.9544	5.0047	8.0275	12.8224

Table 6. Comparison MSE for different images, modulation schemes and filters (Rayleigh fading channel)

Image Types	SNR channel (dB)	QPSK Without filter (dB)	QPSK Wiener filter (dB)	QPSK Median filter (dB)	16-QAM Without filter (dB)	16-QAM Wiener filter (dB)	16-QAM Median filter (dB)	64-QAM Without filter (dB)	64-QAM Wiener filter (dB)	64-QAM Median filter (dB)
Gray-scale Image	5	3.3067e+03	1.9391 e+03	1.0893 e+03	4,268+e 03	1.964+e 03	1.222+e 03	7.1477e+03	2.4281e+03	2.1565e+03
	10	280.529	75.524 4	47.773 3	1.0074e +03	370.498	148.758	5.7548e+03	1.8417e+03	1.5650e+03
	15	59.8434	75.524 4	47.773 3	295.945	86.6346	59.2264	4.1520e+03	1.9419e+03	1.3269e+03
RGB Image	5	1.5896e+03	549.05 2	119.93 0	2.3556e +03	558.290	440.757	5.5491e+03	1.7592e+03	1.4720e+03
	10	97.2376	81.936 6	58.792 7	650.849	182.282	88.531	4.8505e+03	1.4382e+03	787.369
	15	0.6638	124.10 6	54.556 7	111.712	58.124	50.013	2.5014e+03	371.024	152.663

Table 7. Comparison SNRimage for different images, modulation schemes and filters (Rayleigh fading channel)

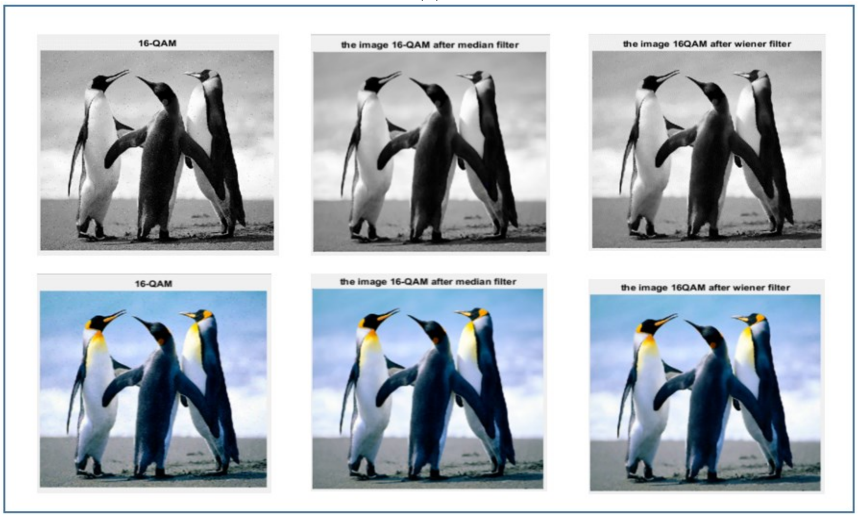
Image Types	SNR channel (dB)	QPSK Without filter (dB)	QPSK Wiener filter (dB)	QPSK Median filter (dB)	16-QAM Without filter (dB)	16-QAM Wiener filter (dB)	16-QAM Median filter (dB)	64-QAM Without filter (dB)	64-QAM Wiener filter (dB)	64-QAM Median filter (dB)
Gray-scale Image	5	4.5102	6.0964	7.1948	3.4230	5.5021	6.2104	3.0241	4.5241	6.1427
	10	9.9832	12.7439	13.7848	7.1184	9.2904	11.2719	3.4241	5.6871	6.4252
	15	18.3669	13.7439	14.7848	9.7784	12.4459	13.2718	3.8241	6.5924	8.8814
RGB Image	5	5.7575	8.0657	11.3693	4.9035	8.0297	8.5430	3.0429	4.1265	6.2524
	10	11.0159	12.1966	12.9173	7.0805	11.0214	12.1241	3.2546	4.6598	6.6524
	15	22.6539	11.2950	13.0797	11.0731	11.9191	12.4210	4.9287	8.7932	12.5219

In addition, Figures 2 and 3 show comparison of recovered images at the system receiver without filter, with median and wiener filters for different modulation schemes over AWGN and Rayleigh fading channels, respectively. However, the recovered image clearness changed by the modulation type and the filters used which gives various values of MSE, PSNR and SNR for AWGN channel and Rayleigh fading channels, respectively, based on the simulation results of the proposed algorithm to different values of SNR. It is seen that as expected the values of the PSNR and SNRimage of the received images increase with decrease of MSN when increase of the SNR values with and without filter used, where increase the value of these parameters with used median and Wiener filters respectively.

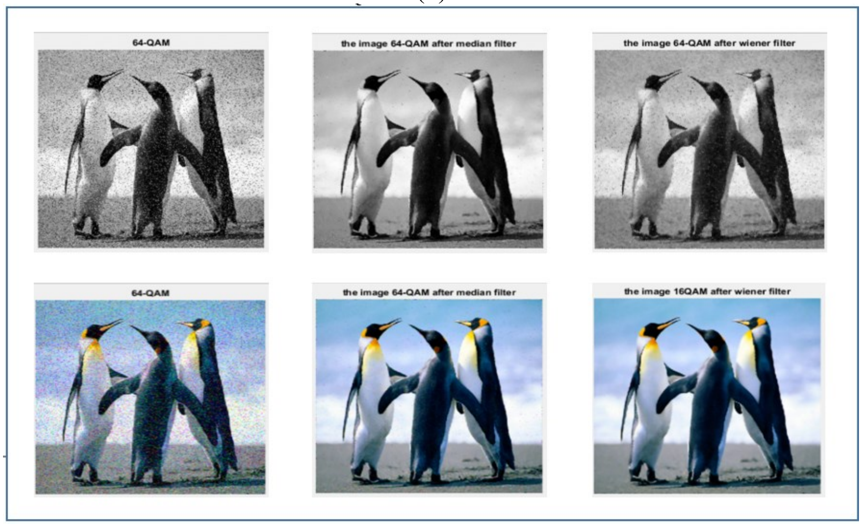
Furthermore, Figure 4 displays transmitted information as digital signal, serial symbol for M-array at the transmitter and waveform for M-array according to the symbolic information for different modulation schemes. Finally, Figure 5 presents re-obtain symbol and receiving information as digital signal after M-array for different modulation schemes. However, as we can be view from the images received, the basic problem is the transmission via the fading channels, which represent the actually existed channels in the wireless communications. Thus, the results explain that the received images quality decreases due to the rapid movement of the receiver. In addition, QPSK modulation technique give a better result of recovered images and it is more immune to the noise than other modulation techniques, because when the number of transmitted bits is increase, they are more susceptible to the interference. In other words, 64-QAM modulation technique give a worse result because it be more susceptible to the intersimple interference (ISI).

From Figure 3, the first images in the left column are the original input images. The gray scale and RGB images are the images used by different modulation techniques, like; QPSK, 16-QAM and 64-QAM will be applied in the communication system. However, the execution of the system will not be fast when raised the noise level above the critical level. The feature of the designed system in this work is that if the channel is with high noise, this makes the system generates the image quality worse rather than losing the completely image sent. Furthermore, the results of the simulation analysis for (2D) Gray and RGB images which utilizes for transmission data are presented in comparison to the theoretical results. Thus, the recovered image quality is best for higher values from SNR regardless of the modulation method utilized. While, in case of low-SNR, the recovered image quality is very low because of high amount of AWGN noise.

(a)



(b)

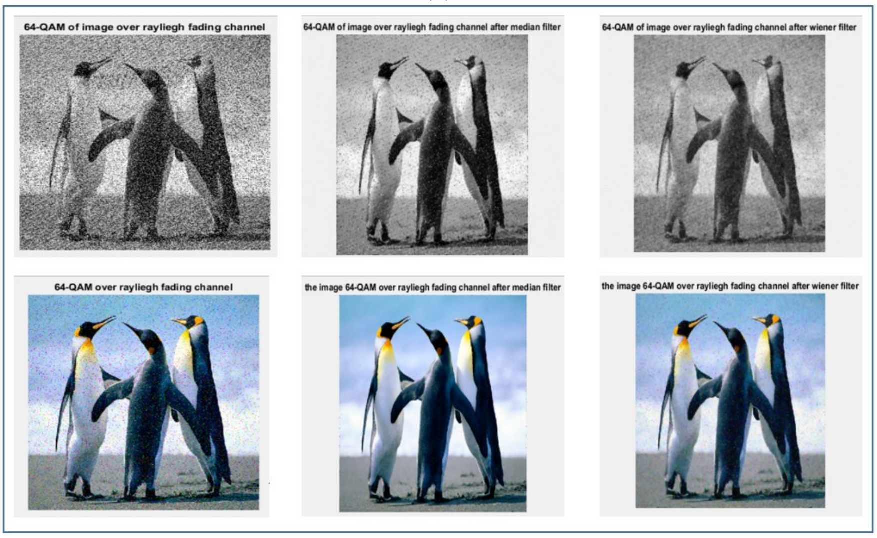


(c)

Figure 2. Comparison of recovered images at the system receiver without filter, with median filter and with wiener filter for different modulation schemes over AWGN channel;
(a) QPSK modulation scheme, (b) 16-QAM modulation scheme, and (c) 64-QAM modulation scheme

(a)

(b)



(c)

Figure 3. Comparison of recovered images at the system receiver without filter, with median filter and with wiener filter for different modulation schemes over Rayleigh fading channel; (a) QPSK modulation sheme, (b) 16-QAM modulation scheme, and (c) 64-QAM modulation sheme

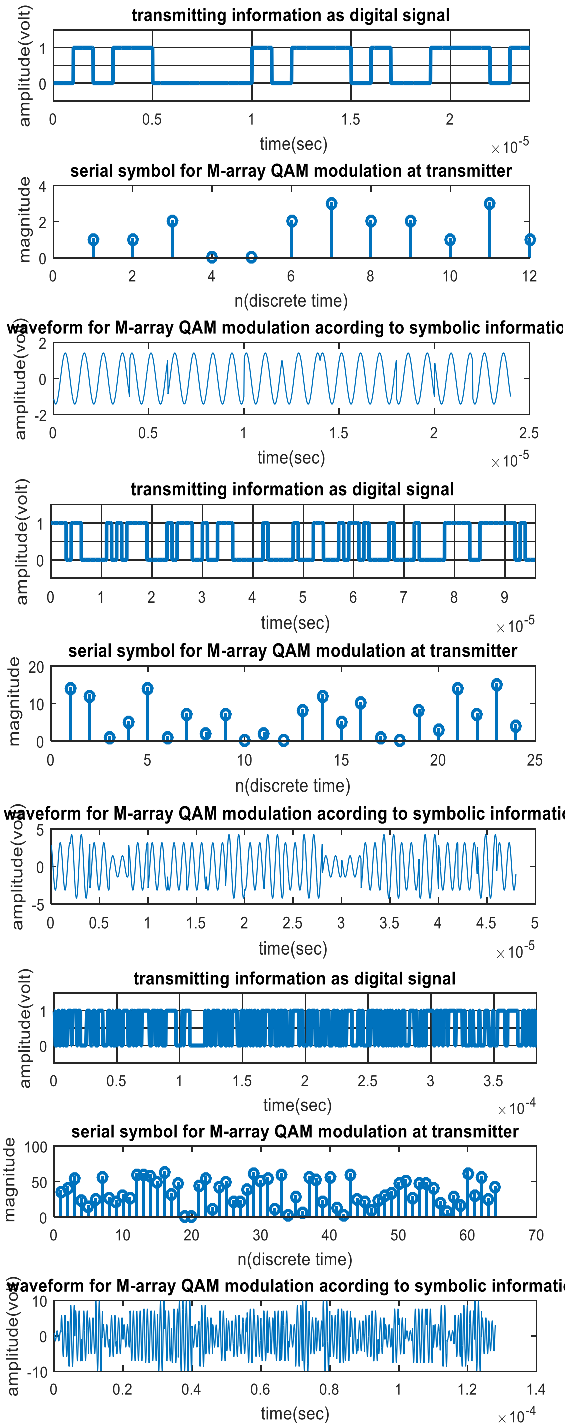


Figure 4. Transmitted information as digital signal, serial symbol for M-array at the transmitter and waveform for M-array according to symbolic information for different modulation schemes

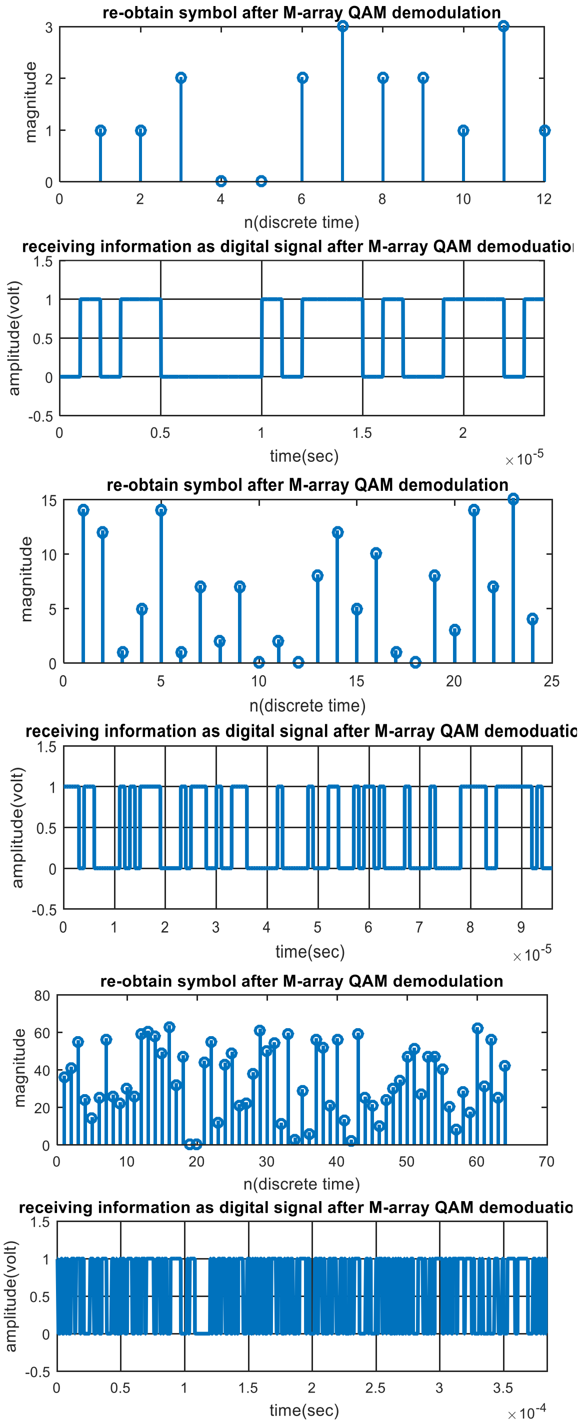


Figure 5. Re-obtain symbol and receiving information as digital signal after M-array for different modulation schemes

Figure 6 demonstrates the PSNR vs. SNR curves over AWGN channel for comparison between gray scale and RGB images for different modulation schemes. It is shown that the higher PSNR value can be get it when used QPSK compare with other modulation schemes. In addition, Figure 7 explains the PSNR vs. SNR curves over AWGN channel without filter, with median filter and with Wiener filter, respectively, using QPSK modulation scheme. As expected, it is seen that increase of the PSNR for the received image without and with (median and Wiener) filters used, where this is improving the quality of image for higher PSNR.

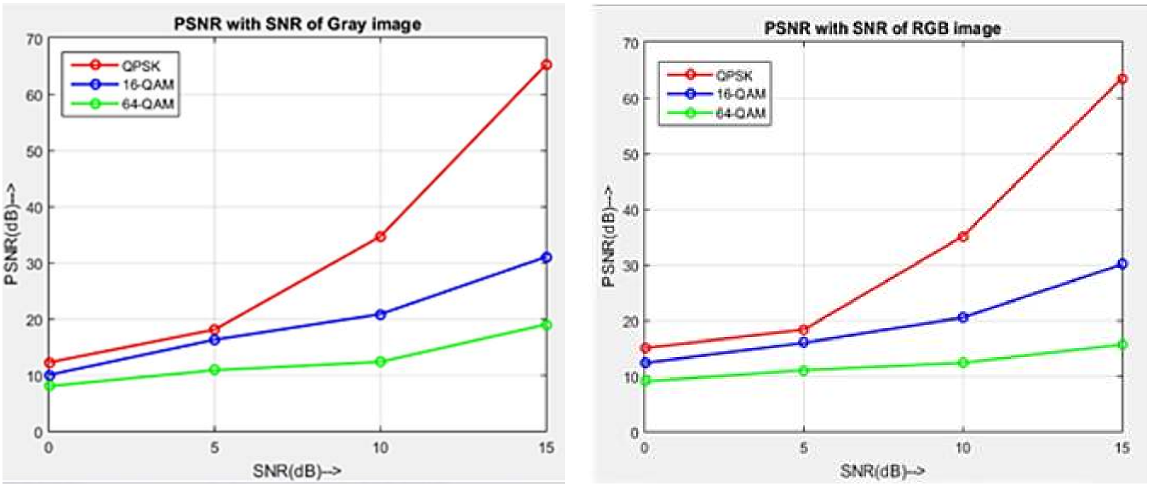


Figure 6. PSNR vs. SNR for AWGN channel and different modulation schemes

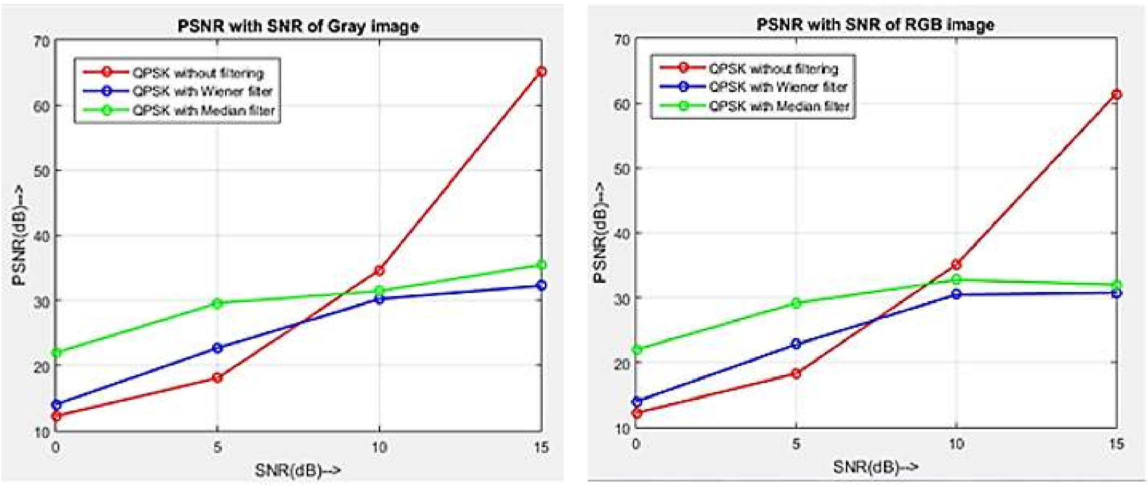


Figure 7. PSNR vs. SNR for AWGN channel and QPSK modulation scheme

4. CONCLUDING REMARKS

In this paper, we analyze the performance of image transmission over wireless digital communications through present a comparison between data handling using different modulation schemes under various channel conditions and to identify the better appropriate modulation technique for transmitting images. Generally, we examined the influence of two varios channels of AWGN and Rayleigh fading on image transfer in the wireless transceiver model. However, the transmission of images through the communication system is performed by used digital modulation techniques as well as the results are got through used Matlab software that was introduced to design and implement the wireless digital communication system. Thus, the carried out of this system which reaches to a certain level of noise from the critical channel is acceptable. In another meaning, when raised the noise level above the critical level, the system performance cannot be very quickly. The simulation results showed that the AWGN channel gives the best result than the Rayleigh fading through used the same SNR, which comes with a less efficient results. In addition, when the channel of the currently designed system is in high noise, the system generates worsing in image quality instead of losing the sent image completely.

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