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STUDY OF EFFECT OF MIMO SYSTEM ON THE IMAGE USING CANNY EDGE DETECTION OVER AWGN CHANNEL

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ABSTRACT

Digital images are transmitted through Internet from one point to another in many applications such as medical, biometrics multimedia etc. During image acquisition and transmission, the image quality is widely affected by additive noise in the channel. Image de-noising process attempts to reconstruct a noiseless image and improve its quality.

In this paper, we have proposed the de-noising of image with the help of canny edge detection method. In our proposed work, we are going to compare the resulting image and its parameters like PSNR, MAE and RMSE with and without applying canny edge detection method. Also during this comparison we are using SISO and MIMO system to get further better result and to study effect of MIMO system.

KEYWORDS— MIMO, CANNY EDGE, AWGN, SNR, MAE, PSNR.

INTRODUCTION

Digital images have numerous applications in areas such as medical imaging, biometrics, robotics, and image navigation. Some examples of medical imaging are computed tomography (CT) scan, magnetic resonance imaging (MRI), ultrasound, X-ray, myocardial perfusion, and mammography. Medical imaging has helped physicians to diagnose different diseases at their early stage. In some cases, medical images may be noisy due to some factors such as patient movement during the imaging process. Noise presented in a digital image affects its quality. Noise occurs during image acquisition and/ or transmission. During image acquisition factors such as sensor quality, changes in reflectance and illumination, and moving objects may occur and result in changing pixel values. Interferences in the transmitting channel during image transmission from one point to another may also result in noise.

In most cases, noise is an additive component that is difficult to differentiate from image information. Image denoising process attempts to reduce or eliminated the noise. Denoising an image corrupted with Additive White Gaussian Noise (AWGN) is a challenging task. In this case, denoising an image by MIMO System is followed by Canny algorithm.

Image segmentation is the process of partitioning/subdividing a digital image into multiple meaningful regions or sets of pixels regions with respect to a particular application. The segmentation is based on measurements taken from the image and might be grey level, colour, texture, depth or motion. The result of image segmentation is a set of segments that collectively cover the entire image. In image analysis, segment an image based on discontinuity detection technique (Edge-based) or similarity detection technique (Region-based). In discontinuity detection technique, one approach is to partition an image based on abrupt changes in intensity near the edges and it is known as Edge-based segmentation. Edge detection is one of the frequently used techniques in digital image processing. In Similarity detection technique, region based segmentation partitions an image into regions that are similar according to a set of predefined criteria, such as colour, intensity, or texture. Adjacent regions differ with respect to same characteristics.

LITERATURE REVIEW

In this section we present a review of some literature on Canny edge detection and MIMO System.

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A. Edge Detection Methods, Ghassan Mahmoud husien Amer and Dr. Ahmed Mohamed Abushaala

In this paper, author present a methods for edge segmentation of images; they used five techniques for this category; Sobel operator technique, Prewitt technique, Laplacian technique, Canny technique, Roberts technique. They are compared with one another and the experimental results shows that Gradient based edge detection algorithms like Robert's algorithm: have a major drawback of being very sensitive to noise and produces weak responses for genuine edges, Sobel's algorithm: less sensitive to noise but computationally it is slower, Prewitt's algorithm: the response of the prewitt kernel is too small and further processing has to be done. Different edge detection methods can be implemented as per the need of segmentation of image. An adaptive edge-detection algorithm is necessary to pro-vide a robust solution that is adaptable to the varying noise levels. The gradient-based approaches such as the Prewitt filter have a foremost downside of being very sensitive to noise. Canny edge detection algorithms is less sensitive to noise but are computationally more expensive compared to Robert's operator Sobel, and Prewitt operator . However, the Canny edge detection approach performs better than all these operators nearly under all scenarios. Canny operator performed better than Sobel, Prewitt, Roberts and LOG.

B. Performance of Image over AWGN Channel Using PSK Modulation, Reeta Charde

This paper show the effect of an image transmission and compressed image also transmitted through AWGN channel using Phase Shift Key (PSK) System and Image Compression is done by the wavelet transform. In this paper experimental results show Bit Error Rate (BER) & Root Mean Square Error (RMSE) values decreases and Peak Signal to Noise ratio (PSNR) values increases for different Signal to Noise ratio (SNR).

C. Performance Comparison of Different Multiple Input Multiple Output System, Shafeeq M and Shinto Sebastian

In this paper author compare different case of MIMO systems and use space time codes to achieve diversity at both sections of transmitter and receiver. Results shows for every E_b/N_0 values bit error rate in both simulated and theoretical cases are similar for BPSK modulation and hence it is better than QPSK modulation

D. An Improved Canny Algorithm for Edge Detection, Ping ZHOU, Wenjun YE, Yaojie XIA, Qi WANG

This paper based on the traditional Canny operator and proposes an improved algorithm based on the eight neighbourhood gradient magnitude to overcome the disadvantages of being sensitive to noise in the calculation of the traditional canny operator gradient. In this paper an adaptive threshold calculation by OTSU method. The experimental results prove that improved method can effectively detect the edge of the image and the continuity of the edge is strong, and positioning accuracy is high.

E. Image Segmentation Using Edge Detection and Region Distribution Yong-Ren Huang, Chung-Ming Kuo

In this paper, author proposed a new concept to integrate the conventional image segmentation techniques in order to accomplish the reasonable segmentation results. In which automatic seed selection by histogram classification of colour vectors to quantize image. Then the small regions are merged by the minimum distance of colour vectors and they manipulate multi-threshold method to obtain accurate object edge. The texture regions are eliminated by region merging using integrating the SRG result and edge information and the segmentation result is obtained.

OVER VIEW

A. CANNY EDGE DETECTOR

The Canny edge detector is considered a standard benchmark against which edge detection algorithms are compared. The Canny algorithm consists of four simple steps. First is smoothing by Gaussian convolution to reduce susceptibility to noise. Second, edge strength and edge directions are found by taking a 2-D spatial gradient of the image using the Sobel operator. The third step is non-maximal suppression, this uses edge direction to trace along the edge and suppress any pixel that is not considered an edge. The fourth step, hysteresis, aims at eliminating broken edges. It has two thresholds: high and low. Any pixel above the high threshold is automatically considered an edge. Any pixel between the high and low threshold that is adjacent to an edge pixel is also considered an edge.

B. AWGN CHANNEL

AWGN channel is a channel that adds a white Gaussian noise to the signal passing through it. This implies that the channel's amplitude frequency response is flat (thus with unlimited or infinite bandwidth) and phase frequency response is linear for all frequencies so that modulated signals pass through it without any amplitude loss and phase distortion of frequency components. The only distortion is introduced by the AWGN.

The received signal is simplified to

$$r(t) = x(t) + n(t)$$

Where x(t) is the original signal, $n(t)$ is the additive white Gaussian noise and r(t) is the received signal.

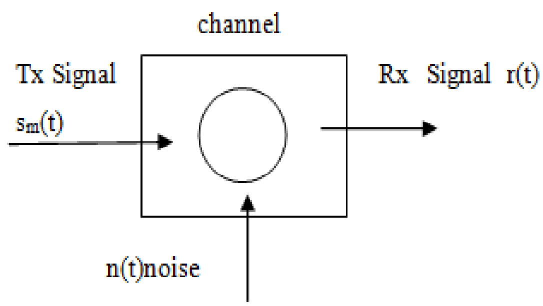

Fig.1 Model for received signal passed through AWGN channel.

C. SINGLE INPUT SINGLE OUTPUT (SISO) SYSTEMS

Single-input single-output (SISO) is a conventional radio system where neither transmitter nor receiver has multiple antennae. In a SISO system there is only one antenna at both sections of transmitter and receiver. Fig.2 represents the basic SISO system model and x(t) and r(t) are the transmitted signal of the transmitter and received signal of the receiver respectively channel.

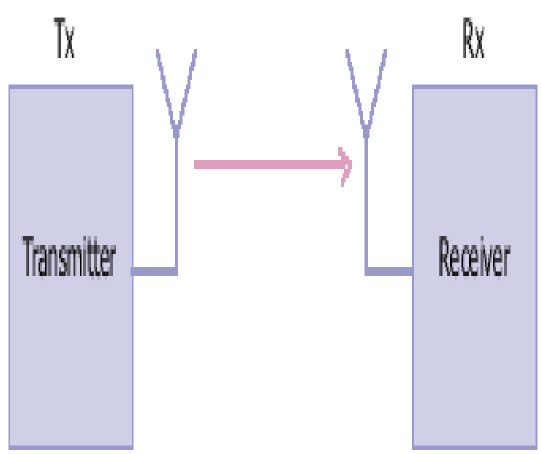

Fig.2 SISO System

D. MULTI INPUT MULTI OUTPUT (MIMO) SYSTEMS

MIMO system combines the use of multiple antennas at both transmitter and receiver side as in Fig.3. Here along a channel multiple data streams are transmitted and multiple receivers collect the signals and hence it provides speed, reliability and coverage. Here Fig.3 represents the basic 2×2 system,
Implemented with two transmit antenna and two receive antenna and it takes the advantage of multipath effect. At the receiver side the antenna accept signals from all the transmit antennas, which passes through the channel and added up.

The transmitted signal follows Gaussian distribution, and the elements of the matrix have a mean value equal to zero.

SIMO/MISO are also special cases of MIMO System:
1. Multiple-input and single-output (MISO) is a special case when the receiver has a single antenna.
2. Single-input and multiple-output (SIMO) is a special case when the transmitter has a single antenna.

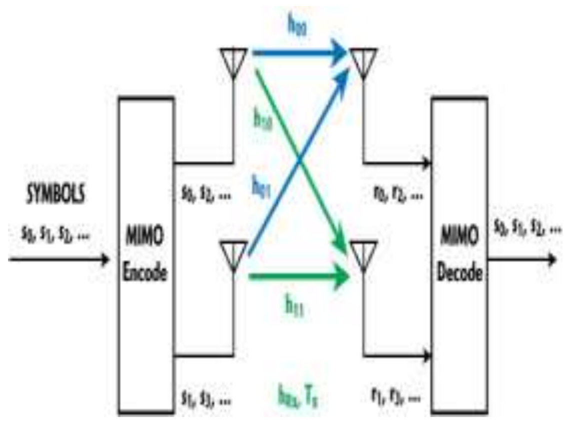

Fig.3 MIMO 2×2 System

PARAMETERS IN SURVEY

A. SIGNAL TO NOISE RATIO

SNR is the ratio of the received signal strength over the noise strength in the frequency range of the operation. Noise strength, in general, can include the noise in the environment and other unwanted signals (interference). BER is inversely related to SNR. The exact relation between the SNR and the BER is not easy to determine in the multi-channel environment. Signal to noise ratio (SNR) is an indicator commonly used to evaluate the quality of a communication link.

$$\mathrm{SNR} = 10\log_{10} 10\frac{(\mathrm{Ps})}{(\mathrm{Pn})}\mathrm{dB}$$

Ps = Signal Power
Pn = Noise Power

B. MEAN SQUARE ERROR (MSE)

MSE is a difference between original image and noisy image.

$$\mathrm{MSE} = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

Where, $I(i,j)$ is an original image and $K(i,j)$ is an is an estimate of $I(i,j)$ after Reconstruction.

C. PEAK SIGNAL TO NOISE RATIO (PSNR)
PSNR is the ratio between maximum possible pixel of an image and the pixel of corrupting noise. PSNR is usually expressed in terms of the logarithmic decibel scale.

$$\mathrm{PSNR} = 10\log_{10}\left(\frac{\mathrm{MAX}^2}{\mathrm{MSE}}\right) = 20\log_{10}(MAX) - 10.\log_{10}(MSE)$$

Here, *MAX* is the maximum possible pixel value of the image and MAE is the mean square error.

D. MEAN ABSOLUTE ERROR (MAE)
The MAE measures the average magnitude of the errors in a set of estimate, without considering their direction. It measures accuracy for continuous variables. Expressed in words, the MAE is the average over the verification sample of the absolute values of the differences between estimate and the corresponding true value. The MAE is a linear score which means that all the individual differences are weighted equally in the average.
The mean absolute error is given by

$$\mathrm{MAE} = \frac{1}{\mathrm{N}}\sum_{\mathrm{i}=1}^{\mathrm{n}}\left|\mathrm{K(i,j)} - \mathrm{I(i,j)} = \frac{1}{\mathrm{N}}\sum_{\mathrm{i}=1}^{\mathrm{n}}|\mathrm{e_i}|\right|$$

Mean absolute error is an average of the absolute errors.

$$|e_i| = |K(i,j) - I(i,j)|$$

Where $K(i,j)$ is the estimate and $I(i,j)$ the true value.

E. ROOT MEAN SQUARE ERROR (RMSE)
The root-mean-square deviation (RMSD) or root-mean-square error (RMSE) is a frequently used measure of the differences between values (sample and population values) predicted by a model or an estimator and the values actually observed. The RMSD represents the sample standard deviation of the differences between predicted values and observed values. These individual differences are called residuals when the calculations are performed over the data sample that was used for estimation, and are called prediction errors when computed out-of-sample. The RMSD serves to aggregate the magnitudes of the errors in predictions for various times into a single measure of predictive power. RMSD is a good measure of accuracy, but only to compare forecasting errors of different models for a particular variable and not between variables, as it is scale-dependent.

PROPOSED WORK
In this section, we explain the proposed methodology we are going to use in our work. In this we are using an image which is transmitted over AWGN channel, using SISO and MIMO systems, with and without using Canny Edge Detection method.

First Original Image to be feed at input, after feeding this image will be converted from colour image to gray image form then again gray scale image is converted into binary form. This binary form of image is received by Parallel to Serial converter and parallel data are converted into sequential binary data, which is feed to Binary Phase Shift Key (BPSK) modulator to modulate & generate modulated signal.

After receiving signal, set the signal to noise ratio (SNR) values for the AWGN channel. This signal passes through noisy channel which is disturbed by additive noise.The presence of noise affects image quality.

Resulting signal of the AWGN Channel is received and load to demodulator for demodulation. After demodulation, the signal is converted from binary form into image pixel form that should be identical to input image.

Parameters such as Root Mean Square Value (RMSE) and Peak Signal to Noise Ratio (PSNR) provide noise characteristics of Channel. The output of the image is applied to the Canny edge detector and the parameters, Root Mean Square Value (RMSE) and Peak Signal to Noise Ratio (PSNR) and Means Absolute error (MAE) are calculated

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in accordance with the different SNR value. At last comparison is done for these parameters PSNR, RSME, and MAE for following systems:-

1. AWGN Channel (Signal Input Single Output System) without Canny edge detection.

2. AWGN Channel (Multiple Input Multiple Output System) without Canny edge detection.

3. AWGN Channel (Single Input Single Output System) with Canny edge detection.
4. AWGN Channel (Multiple Input Multiple Output System) with Canny edge detection.

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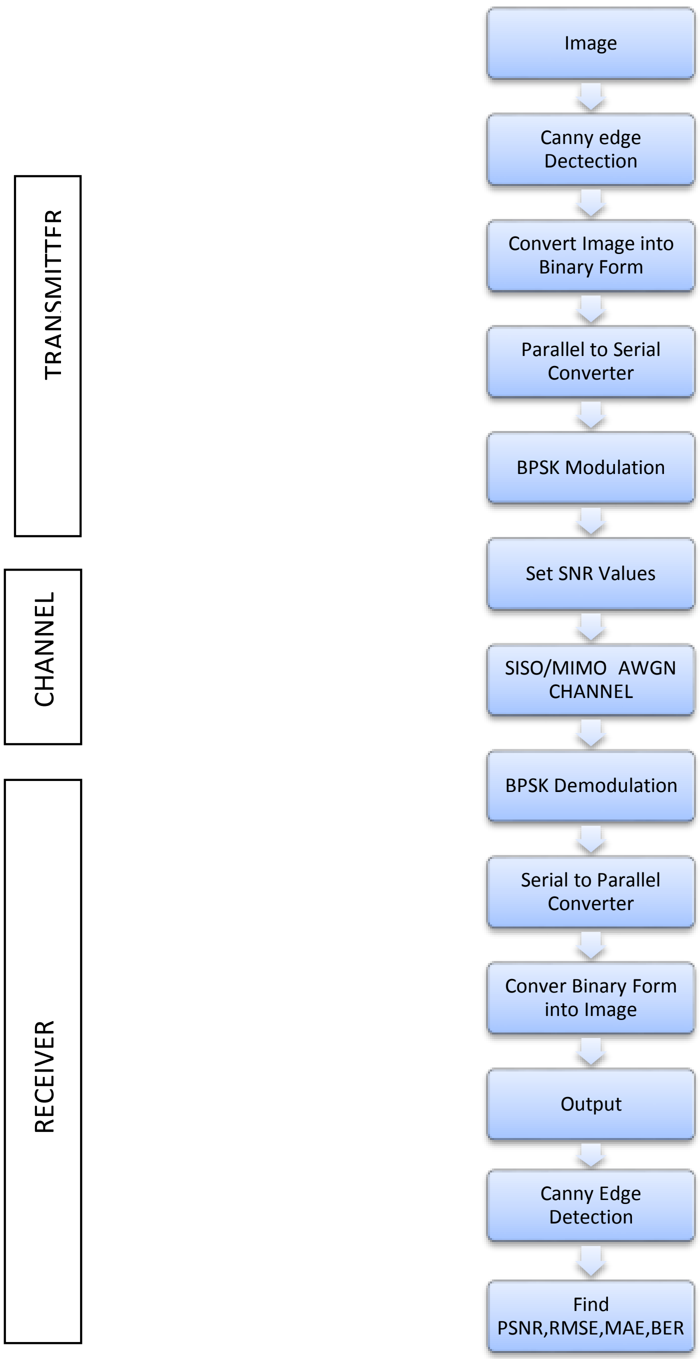

Fig.4 Flow Chart of Image transmission using Canny Edge Detection over SISO/MIMO system over AWGN channel

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