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Adaptive sigma-delta modulation for enhancing pixel intensity of gray scale images

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***Abstract*—An image is a two dimensional array of pixel intensities. The pixel intensity adaptation of gray scale image using sigma delta modulation is proposed in this paper. The pixel intensity distribution of an image is represented by its histogram. Sigma Delta modulation is a most popular technique in audio signal processing. In this work the same approach is extended to grayscale image for its pixel intensity adaptation. Sigma delta modulation determines the quantization error between pixel intensities of the input image and the quantized output. The error is processed with a fixed step size, which causes increase in quantization error. In the proposed method, adaptive sigma delta modulation, where the pixel intensities is adapted according to the input image sequence thereby quantization error is made as low as possible. In this method the step size adaptation of the gray scale image is done. The step size is increased or decreased according to the pixel intensity variation of the input image sequence. Simulation results show that the peak signal to noise ratio performance of adaptive sigma delta modulation is better compared to sigma delta modulation. The histograms of the output are compared based on some histogram distance parameters. The minimum histogram Euclidean distance is obtained for adaptive sigma delta modulation.**

Keywords—Histogram Euclidean distance,Peak Signal to Noise ratio, Quantization, Sigma delta modulation.

I. INTRODUCTION

Analog-to-Digital Converters (ADC) are necessary to convert real world signals which are analog in nature to their digital forms for easy processing. It is an electronic process in which a continuously variable (analog) signal is changed, without altering its essential content, into a multi-level (digital) signal. The input to an analog-to-digital converter (ADC) consists of a voltage that varies among a theoretically infinite number of values. Examples are sine waves, the waveforms representing human speech, and the signals from a conventional television camera. The output of the ADC, in contrast, has defined levels or states. The number of states is almost always a power of two that is, 2, 4, 8, 16, etc. The simplest digital signals have only two states, and are called binary. All whole numbers can be represented in binary form as strings of ones and zeros.

There are analog modulation as well as digital modulation. Most of the A/D converters are classified based on their nyquist rate(i.e, sampling frequency is equal to twice the highest frequency component) as Oversampling, Successive Approximation Registers, Double Integration and Nyquist Rate converters [1]. For achieving better resolution oversampled PCMs [2-4] are also used, as compared to Nyquist rate converters oversampled PCMs possess better frequency distribution.

In Delta modulation analog signals is approximated by staircase function, only a single binary digit is required for each sample. At each sampling time, the function moves up (binary 1) or down (binary 0) a constant amount step size and attempts to track the original waveform as closely as possible also the analog input is compared to the most recent value of the approximating staircase function[5]. The two major drawbacks of delta modulation are 1. Slope overload distortion: occurs when modulating signal varies faster than counter recovered signal. 2. Granular noise: occurs when variation in modulating signal is smaller than step size. These drawbacks can be reduced through adaptive delta modulation. Nowadays most commonly used A/D conversion technique is Sigma Delta Modulation (SDM). The major thing that differentiate SDM from other ADCs is their oversampling and noise shaping nature[5-6]. It gives better resolution than other methods. But due its fixed step size the quantization noise produced will be very large.

In the proposed work the pixel intensity of a gray scale image is tried to adapt with the input i.e, as the output image pixel intensities is more able to follow the input pixel intensities then it seems to be more adapted to the variation in input pixel intensities. The performance of adaptive sigma delta modulation is better compared to sigma delta modulation by plotting the signal-to-noise ratio, histograms of the output based on some histogram distance parameters.

II. SIGMA DELTA MODULATION

One of the most commonly used ADC is Sigma Delta Modulation (SDM). SDM produces a fixed discrete level whatever be the input i.e, +1 or -1 at the quantizer output. Oversampling and noise shaping property of SDM makes more suitable for A/D conversion than other conventional methods. Quantization makes the range of a signal discrete, so that the quantized signal takes on only a discrete, usually finite, set of values. quantization is generally irreversible and results in loss of information. It therefore introduces distortion into the quantized signal that cannot be eliminated. One of the basic choices in quantization is the number of discrete quantization levels to use. The fundamental tradeoff in this choice is the resulting signal quality versus the amount of data needed to represent each sample. Fig.1 shows basic block diagram of SDM. It mainly consists of an integrator and a fixed step-size quantizer

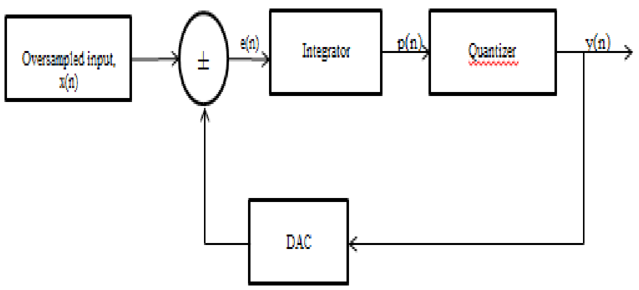

Fig.1 Basic block diagram of SDM.

The error signal is produced by comparing the input signal and the output signal. Integrated error signal is then quantized to ±1 values for any input i.e, as the integrator output becomes positive the quantizer produces +1 else produces -1.

III. PROPOSED METHOD- PIXEL INTENSITY ADAPTATION USING ADAPTIVE SIGMA DELTA MODULATION (ASDM)

Adaptive Sigma-Delta Modulation (ASDM) is a adaptation technique for adapting the step size of the quantizer according to the variance of input[7-8]. Fig.2 shows the block diagram of ASDM to adapt the pixel intensity. It mainly consists of integrator, quantizer and an adaptation module.

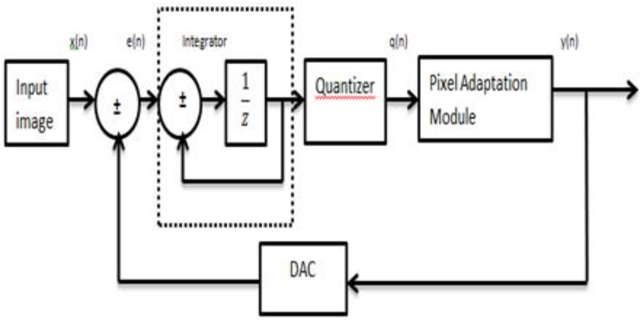

Fig.2. Block diagram of ASDM to adapt pixel intensity.

A. Algorithm

1) Input an image to be modulated.
2) Integrate the error produced by comparing the input pixel intensity and output pixel intensity.
3) Quantize the integrated output to +1 and -1 values.
4) The pixel intensities is adapted according to the input image sequence thereby quantization error is made as low as possible.

In the proposed method the histogram euclidean distance is calculated and found that the euclidean distance obtained from ASDM is smaller than SDM.

IV. EXPERIMENTAL RESULTS AND DISCUSSIONS

The histogram comparison shows that the pixel intensity of output image tracks the input image. The performance of SDM and ASDM is compared through PSNR and histogram Euclidean distance. Fig. 3.shows the input image and fig.4.its histogram Fig.5 shows the output image after SDM.Fig.9. shows output histogram after ASDM.PSNR plot of SDM and ASDM are shown in Fig.7 and Fig.10 respectively.

Fig. 3.input image

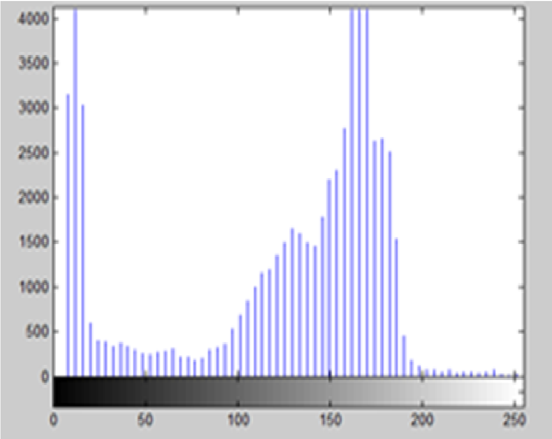

Fig.4. Histogram of input image.

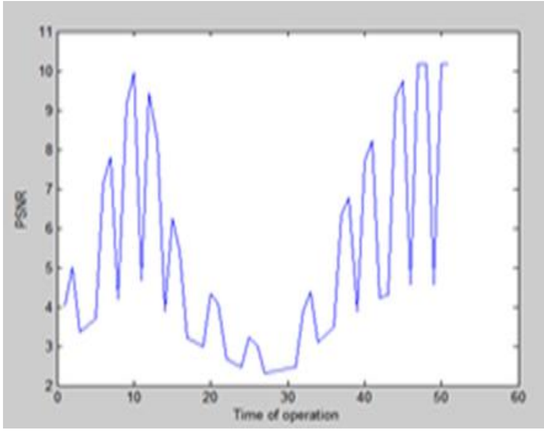

Fig.7. PSNR performance of SDM

Fig.5.Ouput image after sigma delta modulation

Fig.8. Output image after adaptive sigma delta modulation

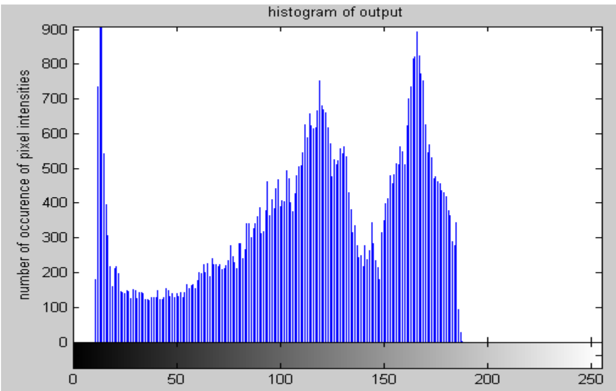

Fig.6. histogram of output image after SDM

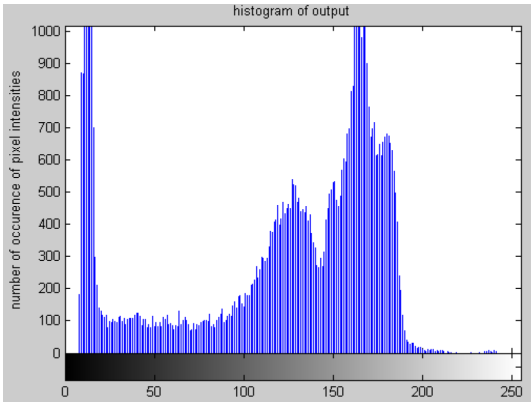

Fig.9. histogram of output image after ASDM

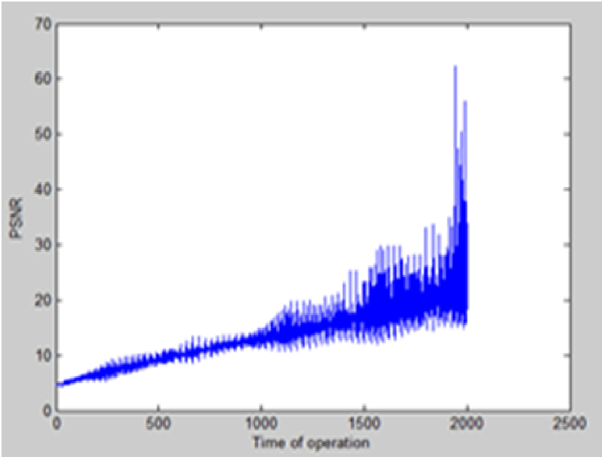

Fig.10.PSNR performance of ASDM

TABLE I . Performance comparison of SDM and ASDM based on their PSNR and histogram distance values with different grayscale images

	Cameraman.tif		**Barbara.png**	
	Histogram distance	***PSNR***	***Histogram distance***	***PSNR***
SDM	.2449	10.1783	.2342	10.17 83
ASDM	.0632	62.2308	.0627	62.23 08

□ □The above results show that the ASDM outperforms the SDM such that the ASDM is able to demodulate the input image with less distortion compared to SDM. The PSNR performance of ASDM is better. The experiment is done with two images cameraman.tif and barabara.png .Both results in same increased performance of ASDM than SDM.The table 1 shows the comparison of SDM and ASDM for different performance parameters like Histogram distance, PSNR etc.The ASDM is able to adapt to the changes in the input and is able to demodulate the input image effectively with minimum distortion compared to SDM. From the histogram analysis of the two output images it is clear that the histogram of the output image after ASDM in fig.9 is similar to that of the histogram of the input image as in fig.4.The histogram of the SDM output is seen with more distortion. Since both are the two modulation schemes the error may happen but the error is greater for SDM than ASDM.

V.CONCLUSION

The oversampling and noise shaping nature of SDM modulates the input better than the conventional methods like PCM, DM and ADM. Sigma Delta modulation is a most popular technique in audio signal processing. In this work the same approach is extended to grayscale image for its pixel intensity adaptation. Sigma delta modulation determines the quantization error between pixel intensities of the input image and the quantized output. The peak signal to noise ratio performance of adaptive sigma delta modulation is better compared to sigma delta modulation. The histograms of the output are compared based on some histogram distance parameters. The minimum histogram Euclidean distance is obtained for adaptive sigma delta modulation.

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