ISTANBUL UNIVERSITY ENGINEERING FACULTY
JOURNAL OF ELECTRICAL & ELECTRONICS
YEAR : 2002 **(627-633)**
VOLUME : 2
NUMBER : 2

ELIMINATION OF WHITE NOISE FROM VIDEO SIGNALS OF TELEVISION TRANSMISSION BY USING DIGITAL RECURSIVE ESTIMATION

[1]Mehmet ENGIN **[2]Rasim Saltuk ALAKUS** **[3]Erkan Zeki ENGIN**

[1,3] Ege University, Faculty of Engineering, Electrical & Electronics Engineering Department 35100, Bornova, Izmir, Turkey

[2] Vestel Electronical Industry & Trading Company 45030, Manisa, Turkey

[1]E-mail:mengin@bornova.ege.edu.tr [2]E-mail: saltukalakus@hotmail.com
[3]E-mail:erkanzeki@yahoo.com

ABSTRACT

During the transmission of television signals, because of several sources of electromagnetic noises, video signals are corrupted with white gaussian noise. Generally, the noise is easily observable during the terrestrial transmission of video signals with less then 50 dB IF levels. With the method we have discussed in this paper white noise is eliminated by using recursive estimation of video signals from its past values.

Keywords: *Television signal, white gaussian noise, recursive estimation.*

1. INTRODUCTION

Television Standards and Transmission

Today there are three basic transmission systems in the world. These are PAL, SECAM and NTSC. Generally, PAL system is used in many European countries, Secam is used in France and NTSC is used in America.

In television transmission, the picture is refreshed every 50 times per second for PAL, SECAM and 60 times per second for NTSC system.[1]

For PAL and SECAM systems each picture consists of 625 horizontal lines. Which means for each picture there are 625 lines of video information transmitted. While for NTSC system 525 lines are used for this purpose.

Received Date : 26.3.2002
Accepted Date: 4.6.2002

The horizontal lines are separated from each other by synchronization pulses. By the help of this synchronization pulses the deflection part of the television is synchronized with the image.[1]

Historically, monochrome televisions were invented first. As a result, televis ion broadcasting was originally monochrome.

Hence when the new color TV was invented, a system of color signal transmission had to be implemented which could not only produce acceptable black and white pictures on monochrome receivers but also be capable of producing high-quality colored pictures. In order to achieve this burst signal is invented. Burst signal is a modulated sub-carrier. The phase of video signal is compared with the burst signal phase and the color is determined according to this phase difference. When a monochrome TV set decodes the video signal, it does not take into account the burst signal so it directly forms the monochrome picture.

Below there is an oscilloscope image of a horizontal line (Image 1). From this graph synchronization pulses and the burst signal can be observed. Synchronization pulses are the ones, which are below 0-volt level. Burst signal is the signal just after the synchronization pulse. This data is taken from a monochrome bar pattern. The brightness of the pattern is stair case type, from the brightest to the darkest one. The high voltage part causes white dots while low voltage causes darker dots.

Image 2 is a horizontal line of a color image. It could be seen that image has three parts. These parts are in red, green, and blue. The color of the image is determined by the phase of image according to burst signal while the dc level of the video signal determines brightness level.

Interlace Property

Normally video cameras produce 25 pictures per second. But this causes flickering effect in TV sets. In order to avoid this effect each picture is divided into 2 pictures of 262.5 horizontal lines with odd and even fields. Image 3 shows the voltage waveform of interlaced odd and even parts.[2]

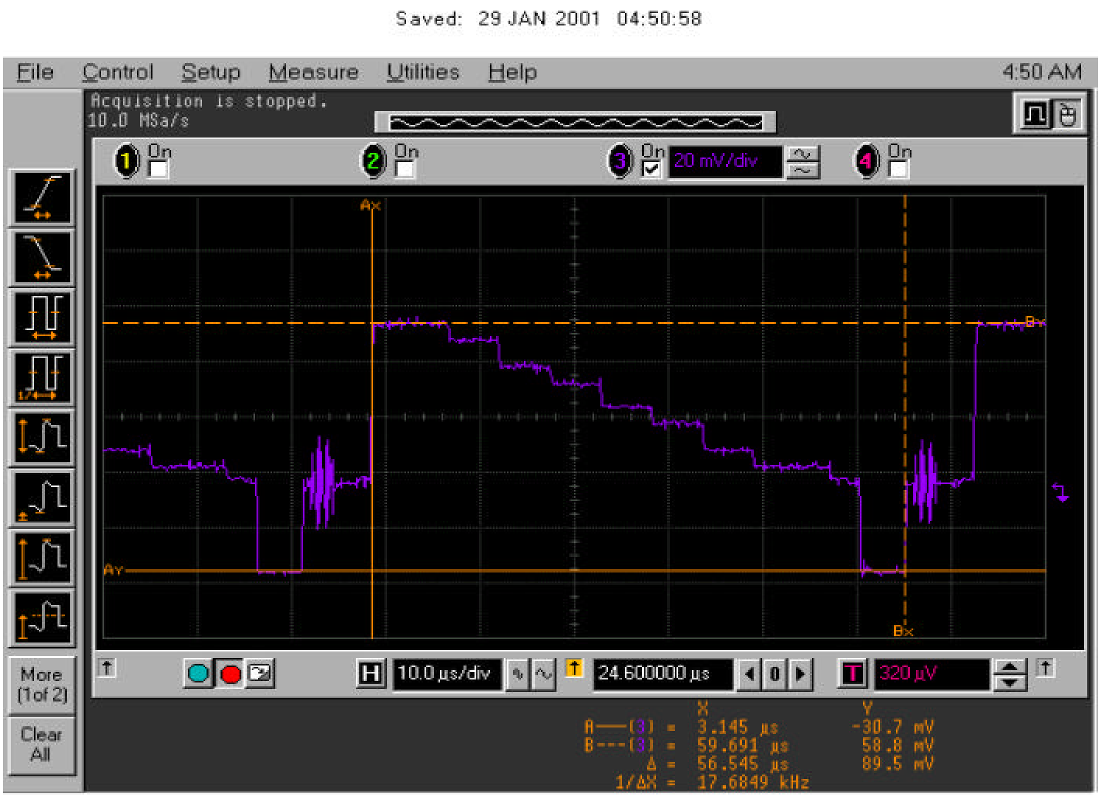


Image 1

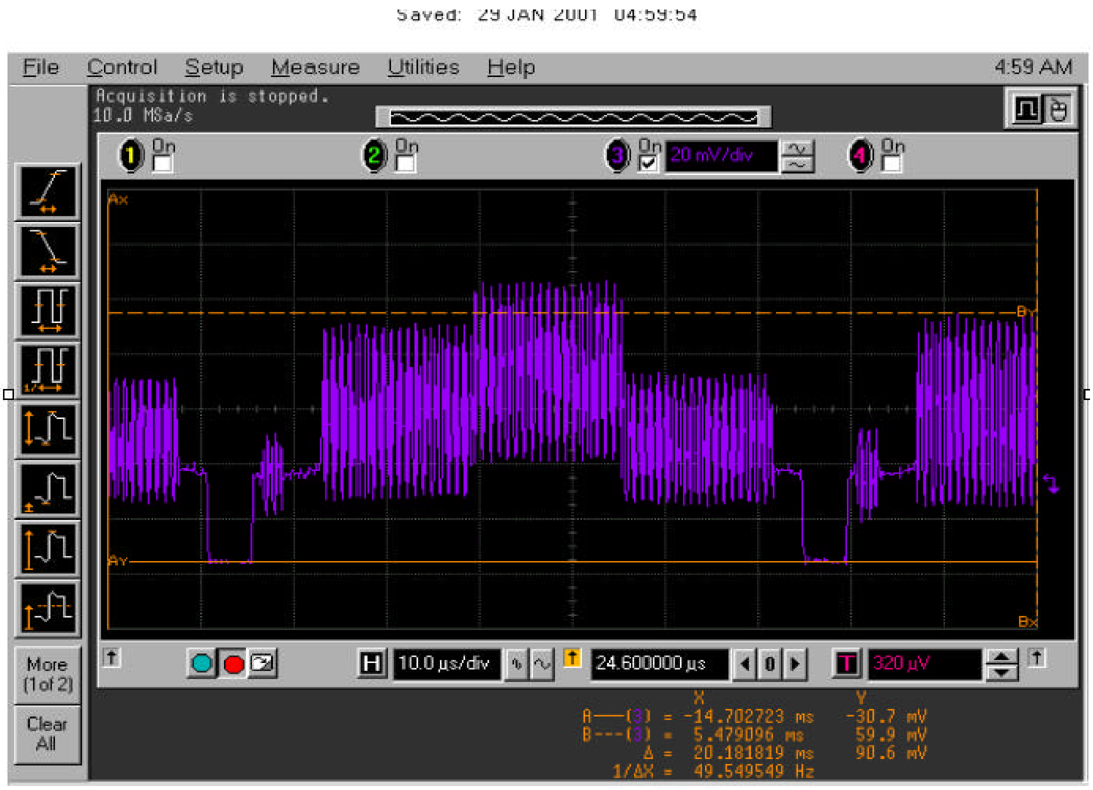


Image 2

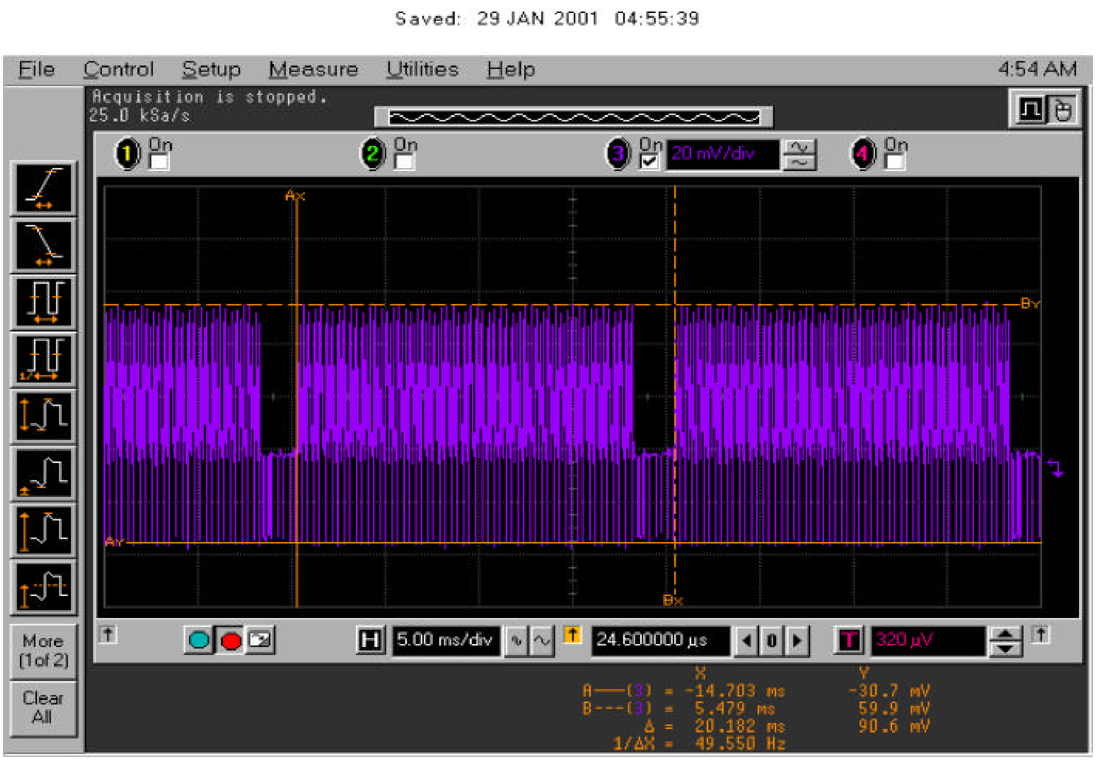


Image 3

2. PROBLEM SETTING

During weak transmission of television signals white noise is observable on the horizontal scan lines. Our aim is to develop a method, which will eliminate the noise, hence improve the picture quality. By this way, for weaker signal levels the performance of the television will improve.

For white noise elimination we propose the following steps:

A-) Digitalization of the Analog Signal:

TV video signals span 6 MHz of frequency spectrum. (For different standards this changes from 6 to 7 MHz). In order to full digitialize the signal without loss of any information AD converter should have a sampling rate of minimum 12 MHz. Also for this AD conversion each dot should be in 8 bits in order have enough resolution.

B-) Efficient Algorithm:

An efficient algorithm should be implemented. It has to be as compact as possible, because sampling rate it too high, and for to display the picture as the new pictures arrive, simultaneous, fast processing is required.

C-) DA Converter:

After the processing of the video signal it will pass to a DA converter for analog display of the TV sets.

3. DEVELOPMENT OF THE ALGORITHM

a-) Formation of Video Matrix :

Each horizontal line should be assigned to the row of a matrix. By this way 212 to 679 (12 MHz x t of Horizontal scan time) matrix is formed.

At this matrix, 212 is the half of 525 lines which comes from the interlace property and the other value comes from the sampling of the horizontal signal with the frequency twice the bandwidth of the video image.

b-) Assigning Video to Matrices :

With the matrix type stated in part a, three matrices are obtained. We can name this matrices as A, B and C. A will represent the odd interlaced image, B is the even part of the interlaced image and C will represent the odd part of the previous image.

c-) Noise Reduction Algorithm :

When these three matrices are obtained, noise reduction algorithm will start to evaluate the latest interlaced image matrix A by using its characteristic properties and the C matrix.

The first method to eliminate noise is to low pass filtering of the image. This can be done in the following way:

Let A(x, y) = t, where (x, y) are the coordinates and t is the amplitude of the video signal. Because of white noise property, the neighboring dots also contain varying amplitude and signed noise.

Estimate of A(x, y) can be obtained from the below formula which is in fact a low pass image filter.

$$EsA(x,y) = (1-k)\times A(x,y) + \frac{k}{4}\times\begin{pmatrix} A(x-1,y-1)+A(x-1,y+1) \\ +A(x+1,y-1)+A(x+1,y+1)\end{pmatrix} \quad (1)$$

The formula stated above will contain the original A(x, y) multiplied by (1 – k) and k/4 times the neighboring dots sum value. The result of this equation is the low pass filtering of the point A(x, y).

The second important idea of image noise reduction is using the fact that, the previous picture which is C(x, y) matrix should have a value t’ which will be close to the value of A(x, y) = t, if the picture is not moving at that point during the transition from the previous image.

So final estimation formula will be as it has stated below :

$$EsA(x,y) = k_1 \times A(x,y) + \frac{k_2}{4} \times \begin{pmatrix} A(x-1,y-1) + A(x-1,y+1) + \\ A(x+1,y-1) + A(x+1,y+1) \end{pmatrix} + k_3 \times C(x,y) \qquad (2)$$

where $k_1 = 1 - k_2 - k_3$.

d-) Determination of k Values :

Although estimation formula has been deduced above k_2 and k_3 parameters is not obtained. Estimation of the k_2 and k_3 parameters requires two important concepts in image estimation theory.

Determination of the k_2 Parameter:

Decision of low pass filtering of the image at a specific point is important. If the low pass filtering algorithm is applied at the age of an image, the edges are smoothed hence the picture quality is reduced. So an edge detection algorithm is required. When an edge is detected at the image, the low pass filtering operation will stop and hence the value of k_2 will converge to zero.

Edge Detection Algorithm:

A simple edge detection algorithm can be achieved in the following way

$$EdgeDetect(x,y) = \begin{vmatrix} A(x,y) - A(x-1,y-1) \\ + A(x-1,y+1) \\ + A(x+1,y-1) \\ + A(x+1,y+1) \end{vmatrix} \qquad (3)$$

$$k_2 = \frac{1}{(EdgeDetect(x,y) + \lambda)} \qquad (4)$$

(where λ is an experimental positive constant greater then 1)

Above algorithm has many advantages. First of all it covers both x and y-axis with only one subtraction. This is achieved by taking difference of A(x, y) and A(x-1, y-1) where both x and y axis is considered. Second k_2 parameter is dependent on the sharpness of the image that, for stepper edges k_2 gets smaller hence affect of low pass filtering is reduced and for smoother edges, k_2 gets bigger, hence effect of low pass filtering increase and noise is easily eliminated.

Determination of the k_3 Parameter:

From the above algorithm it is obvious that at the edges of the image low pass filtering will smooth the edges and the sharpness of the picture will reduce. Because of this effect, at the edges, the above algorithm reduces k_2 parameter. At this point the determination of the k_3 parameter begins to be important.

K_3 multiplier forces the value of the previous image to affect the latest image. Generally if the picture is not moving, the previous image should have the same value as the latest image. It is obvious that determination of the k_3 parameter depends on the motion estimation algorithm. If a motion is detected k_2 will be converge to zero.

Motion Estimation Algorithm:

A simple motion estimation algorithm can be achieved in the following way

$$Cmove(x,y) = C(x,y) + C(x-1,y-1) + C(x-1,y+1) + C(x+1,y-1) + C(x+1,y+1) \qquad (5)$$

$$Amove(x,y) = A(x,y) + A(x-1,y-1) + A(x-1,y+1) + A(x+1,y-1) + A(x+1,y+1) \qquad (6)$$

$$Movement(x,y) = |Amove(x,y) - Cmove(x,y)| \qquad (7)$$

$$k_3 = \frac{1-k_2}{2} \times \frac{1}{Movement(x,y) + 1} \qquad (8)$$

Algorithm proposed above has two important advantages. First of all, it brings a simple definition to motion estimation. If a dot and the surrounding dots sum value does not change with the change of the image it means that there is no movement hence the value of the dot C(x,y) can be used to estimate the value of A(x,y).

Secondly, value of k_3 is arranged so that it can have a maximum value equal to k_1. It is very logical in a sense that if there is no movement detected the estimated A(x,y) is the mean of A(x,y) and C(x,y).

f-) Reconstruction of the Video Image from the EsA(x,y) Matrix:

Above estimation is done for every dot of the image, as a result we will have the full Estimated A(x,y) matrix EsA(x,y) which will be send to D/A converter and processed by the video processor.

After this operation B(x,y) matrix will be moved to C(x,y) matrix, A(x,y) matrix will be moved to B(x,y) matrix and new A(x,y) matrix will be received from the A/D converter. As it can be seen B(x,y) matrix is only used as buffer matrix because of the interlace property of the television transmission system. Algorithm will evaluate odd and even traces alternately and separately.

4. MATLAB SIMULATION

We have implemented the above algorithm with matlab program. However in order to have good performance during simulating the above algorithm we used the below assumptions.

1-) A, B, C matrix logic although necessary for television transmission system, in our matlab program we did not consider the interlace property. Hence we use two matrices A, B where A is the latest image matrix and the B matrix represent the previous image. By this way, we did not consider the interlace property of television transmission in order to avoid additional matrix operations. However, the logic of noise reduction by edge detection and motion estimation algorithm is completely the same, which we proposed for interlaced system.

2-) At the matlab simulation, we made the program only for monochrome images. The reason for this can be understood from the explanations made at the introductory section. Color decoding of television transmission is achieved by modulated sub-carrier phase. (burst signal synchronization). Representation of the color decoding in matlab is difficult and unnecessary. However brightness (black to white) of the picture is directly related with the dc level of the video signal. Hence in matlab studies, the amplitude of the image can directly be used as brightness information by defining monochrome vector with the matlab command **COLORMAP(GRAY)** which enables 1 to 64 brightness levels of monochrome image. It is important to note that achieving good results at monochrome pictures in Matlab program will give also good result at color pictures in standard television pictures.

3-)In order to simulate white noise , we implemented images with white noise by using **randn** property of Matlab. This command enabled us to add white gaussian noise with variance 1.

5. CONCLUSION

By using several estimation methods based on past values of image and image processing techniques such as edge detection, which is also a method based on using past values for predicting correct value of an image, we have eliminated the white noise in the video signal.

According to the algorithm we have proposed above, we have simulated some different patterns at the matlab simulation program. We achieved very good performance and the noise at the image is considerably reduced in the matlab simulation.

However, in order to further improve the algorithm some real time work should be done. This will require a 12Mhz sampling rate AD converter, high quality DA converter and fast processing DSP processor. With this setup, video samples can be obtained from the scart connections of a standard TV set and real time process can be achieved.

As a second part of this project, this work should be done and the performance of the algorithm should be checked.

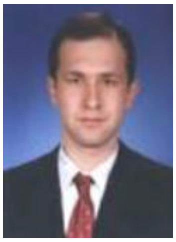
REFERENCES

[1] Geoffreu H. Hutson et.al, Color Television System Principles, Engineering Practice and Applied Technology, Second Edition, pp. 23,46.

[2] Adnan Ataman et al, Televizyon Tekniði, pp.26,27.

Mehmet Engin received the M.S degree from Marmara University and Ph.D. degree from Kocaeli Univesity, 1988 and 1996, respectively. From 1996 to 1999, he was Assistant Professor at Kocaeli University where he worked on Department of Electronic and Computer Education and Research Unit of Biomedical Engineering. He is currently Assistant Professor at Electrical & Electronics Engineering Department of Ege University and also Chairman of Circuit and Systems Branch. He lectures on Medical Electronics, Signal and System Analysis and Advanced Signal Processing in Biomedical Systems. His research interests include biomedical signal processing and biomedical instrumentation, wavelet transform and its applications to biomedical signal processing.

Rasim Saltuk Alakus was born in Erzincan, Turkey, on May 16, 1977. He received B.Sc. degree in 1999 from Bilkent University, Ankara, Turkey. Currently, he is continuing his M.Sc. education at Ege University. He is working in the television section of the R&D department of Vestel Electronics as a hardware design engineer since 1999. His interests are switch mode power supplies, digital image processing and control theory.



Erkan Zeki Engin received the B.S. degree in Electrical and Electronics Engineering from Ege University, 2000. Currently, he is continuing his M.Sc. education at Ege University and also is a Teaching Assistant at the same university. His research interests include biomedical signal processing, wavelet transform and its applications to biomedical signal processing, neural network and digital image processing.