IMAGE PROCESSING TECHNIQUES FOR BLIND TV GHOST CANCELLATION

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ABSTRACT

This paper describes a technique to ghosts cancellation without a Ghost Cancellation Reference signal. The existing vertical edges in TV image are used to estimate the channel characteristics. With the estimating results, the coefficients of the equalizer are updated. In this paper, a method to speed up the convergence is given. The equalizer structure for cancelling all kinds of ghosts is discussed too. A new improved solution is achieved by interpreting the TV synchronisation signal as a genuine edge.

1 INTRODUCTION

To cancel ghost interference, there have been developed Ghost Cancelling Reference (GCR) signals to be inserted into the vertical blanking period of TV system (e.g. in Japan, USA and Korea [1-3]). Since no standard GCR signal has yet been defined in many countries (for example Europe), a blind ghost cancellation method has been introduced [4]. In this paper a method to speed up the convergence is presented. Based on the work of [4], which works well for the cancellation of sharp ghosts or ghosts whose delay times are integer multiples of the equalizer tap delay (T), the equalizer structure for cancelling multiple and diffuse ghosts has been improved. The blind ghost cancellation method is based on a stochastic model to estimate original and ghost edges of TV image. Naturally, the TV synchronisation signals can be interpreted as genuine edges and therefore be used to estimate ghost parameters.

2 BASIC PRINCIPLE OF THE BLIND GHOST CANCELLING

If a TV signal is delayed, the delayed signals (ghosts) are superimposed on the main signal. Simultaneously, ghost edge is superimposed on the main signal too. The edges appearing in a noisy TV picture can be detected by (for example) the Laplace- and Roberts-Operator. Through cross correlation method between the initial vertical edges and their ghosts one can estimate the ghost delay times. Using the estimated ghost delay times one can estimate the complex value' s ghost amplitudes ($\hat{a}$) with a regression method. There are actually two kinds of disturbances besides noise, which affect the correct estimation. One is the influence of picture elements similar to the edge. This problem can be solved by a stochastic approach. To detect the ghost delay times, one can set up a histogram for both initial and ghost edges. For instance, one can set up a 3-dimensional histogram to simultaneously estimate the ghost parameters, i.e. the ghost delay times, amplitudes and phases. The x-axis depicts the ghost delay times and the y-axis the ghost amplitudes as well as the z-axis the number of cross correlation coefficient between the initial edge and its ghost (ρ) whose modulus ($|\rho|$) is larger than a defined threshold. Also one can set up two 2-dimensional histogram to separately estimate the ghost parameters, i.e. the ghost amplitudes and phases as well as the ghost delay times. The other is the mutual influence of ghosts. The more the number of the ghosts is, the greater the difference of the ghost amplitudes and the closer the ghosts lie, the greater the ghost mutual influence is. The mutual influence of ghosts is so severe that sometimes one can not correctly estimate these parameters of all ghosts. To overcome the mutual influence, an iterative method has been presented in [4].

3 SPEEDING UP CONVERGENCE

The iterative method presented in [4] can be formulated as

$$\hat{c}_{j+1}^{(i)} = \hat{c}_j^{(i)} + \mu_0 \, \hat{a}_j^{(i)} \,, \quad i=0,\ldots, M\text{-}1$$

where $\hat{c}_j^{(i)}$ is a equalizer coefficient, M is the taps number of the equalizer and μ_0 is a constant step size. $\hat{a}_j^{(i)}$, a estimated complex value's ghost amplitude, is the regression result between the *i*th initial edge and its ghost or rest ghost, namely

$$\hat{a}_j^{(i)} = \frac{\sum_{k=0}^{N-1} (x_k^{(i)} - m_x^{(i)})(y_k^{(i)} - m_y^{(i)})^*}{\sum_{k=0}^{N-1} (x_k^{(i)} - m_x^{(i)})(x_k^{(i)} - m_x^{(i)})^*}$$

where

N : number of samples in a edge area
$x_k^{(i)}$: value of the *i*th original edge samples
$y_k^{(i)}$: value of its ghost samples
$m_x^{(i)}$: mean value of this original edge samples
$m_y^{(i)}$: mean value of the ghost samples

With the update of the equalizer coefficients, the (rest) ghosts are suppressed. It results in the reduction of $e = \left| \sum_{k=0}^{N-1} (x_k^{(i)} - m_x^{(i)})(y_k^{(i)} - m_y^{(i)})^* \right|$, namely $\lim_{j \to \infty} e = 0$

It corresponds to the convergence.

If a variable step size (μ) for the coefficient update is used, the convergence can be speeded up. μ for our algorithms is selected as a proportional function of $|\rho|$, namely:

$$\mu = f(|\rho|) \; \mu_0$$

$$\rho = \frac{\sum_{i=0}^{N-1} (x_i - m_x)(y_i - m_y)^*}{\sqrt{\sum_{i=0}^{N-1} (x_i - m_x)(x_i - m_x)^* \sum_{i=0}^{N-1} (y_i - m_y)(y_i - m_y)^*}}$$

When $|\rho|$ is large, the disturbance is generally small so that the corresponding regression result is precise enough. Therefore, the value of μ can be selected relative larger. The larger the $|\rho|$ is, the larger the μ can be selected. To avoid fluctuations near convergence, the coefficients are only updated with the edges and their ghost edges whose $|\rho|$ are larger than a defined threshold (ρ_{min}). Fig. 1 shows the block diagram of this method.

The update formulation is described by:

$$\hat{c}_{j+1}^{(i)} = \hat{c}_j^{(i)} + f(|\rho^{(i)}|)\mu_0 \, \hat{a}_j^{(i)} \,, \quad i=0,\ldots, M\text{-}1$$

It can be easily proved that its convergent conditions and state are the same as [4].

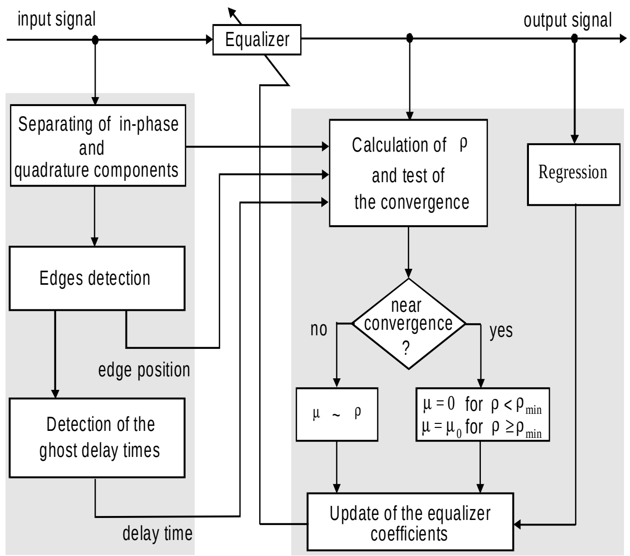

Fig. 1 Block diagram

For example, a TV picture is ghosted by 2 echoes. Fig. 2-1 and 2-2 give the update curves of the equalizer coefficients with the method proposed in [4] and the method shown in Fig. 1. The dotted line represents the update result with the latter method.

For this example, it is clearly that this method converges nearly double so fast as the former.

How fast the convergence can be actually speeded up depends on many factors, for example, the image contents, distributing situation of ghosts as well as the ghosts parameter, etc.

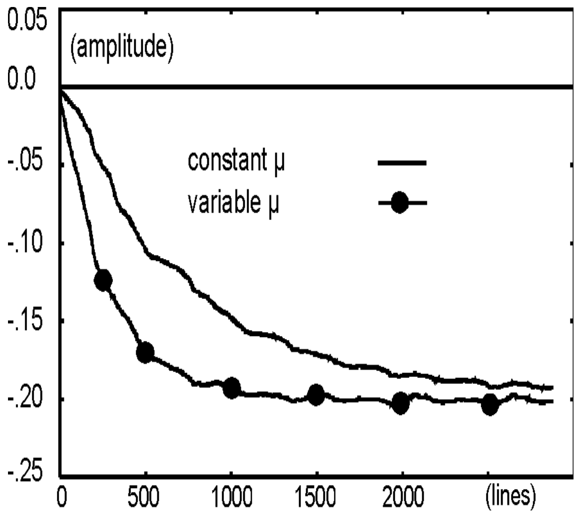

Fig. 2-1 Update curve for the first ghost

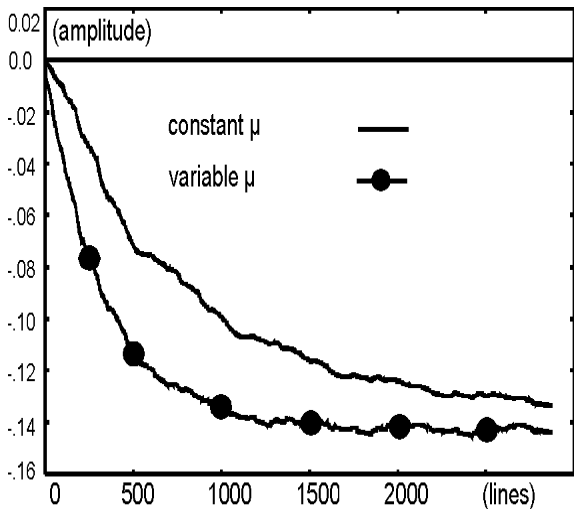

Fig. 2-2 Update curve for the second ghost

4 EQUALIZER STRUCTURE

There are not only sharp ghosts but also diffuse ghosts, and the ghost delay times may not always be integer multiples of T. Thus, equalizer must be capable of cancelling all kinds of ghosts. Fig. 3-1 shows this equalizer structure. The left part, namely the FIR filters, is used to cancel precursor ghosts, while the right part, the IIR filters, is to cancel postcursor ghosts. Each FIR-i, as shown in Fig. 3-2, is only set at each estimated delay time (τ_i), which is estimated by the stochastic approach.

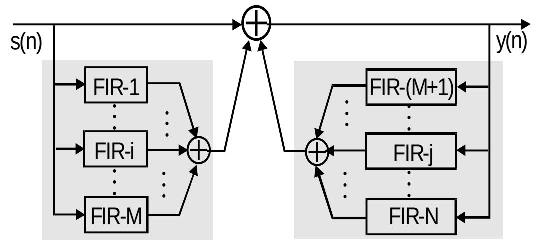

Fig. 3-1 Equalizer structure

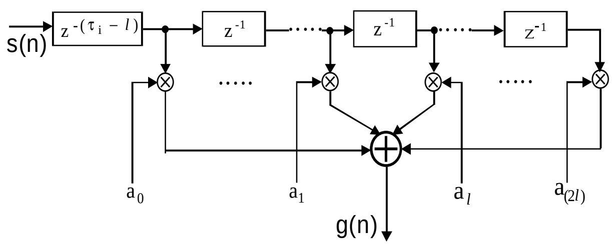

Fig. 3-2 Structure of the *i*th FIR filter

$2l$ taps are set around each delay time. For cancelling the precursor ghosts, l is dependent of the input and output desired-to-undesired signal ration, $(D/U)_{in}$ and output $(D/U)_{out}$ [5]. But for cancelling postcursor ghosts l is determined only by $(D/U)_{out}$. Furthermore, this equalizer can work well even when the estimated ghost delay time deviates from the true delay time. This is especially useful for the situation which delay time can not be correctly estimated. For the detection of instability of this equalizer the Jury's test is employed.

5 EDGE-LIKE PROCESSING OF THE TV SYNCHRONISATION SIGNAL

The sync signals in the horizontal and vertical flyback interval have certain tolerances due to different nonlinear TV distribution procedures, therefore these sync signals do not work well as GCR signals for ghost cancelling. Treating the sync signals as edges is the idea using them to efficiently cancel ghosts. Using the detected edge positions of initial sync signals and their ghosts, one can estimate the ghost delay times and amplitudes. One advantage of sync signals as edges against normal edges is that the positions of sync signals are in advance roughly known. Another advantage is that these signals have high power. Using the sync Signals in the vertical flyback interval, one can easier estimate the ghost delay times than using all the existing vertical edges in a TV image. The calculating expense is greatly reduced.

For the stationary reception of TV signals, these sync signals in the horizontal flyback play a great role by cancelling the ghosts whose delay times are less than the horizontal flyback interval. Fig. 4 shows a adaptive curve for the amplitudes of two ghosts. This curve is updated only by the horizontal sync signals treated as edge. Smooth and fast update of the equalizer coefficients is achieved by the horizontal sync signals treated as edge.

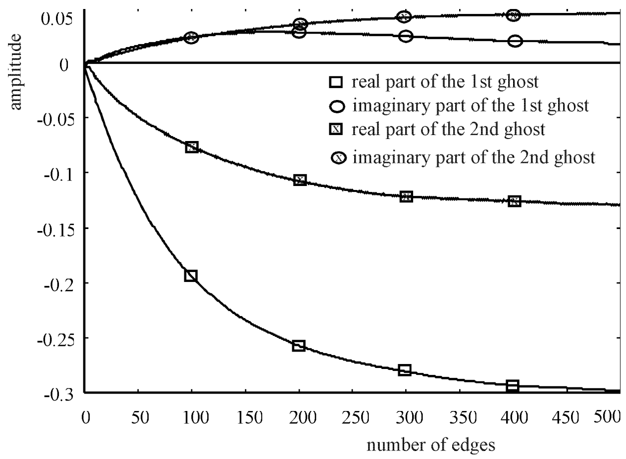

Fig. 4 Update curve only by the sync signals

The sync signals treated as edges can play a great role in the mobile reception of analog TV signals, where multiantenna scanning diversity system is used [6]. These sync signals can be used to cancel the ghosts whose phases change rapidly.

6 CONCLUSION & ACKNOWLEDGMENT

The equalizer structure for cancelling all kinds of ghosts was introduced and proved by computer simulations. It speeds up the convergence that the step size is selected as a proportional function of the cross correlation coefficient. Treating the sync Signals as edges has greatly improved the blind TV ghost cancelling method. The effectiveness has been proved.

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