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HIGH EFFICIENCY HIGH SPEED 1BIT CODING USING GENERALIZED HARMONIC ANALYSIS

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1. INTRODUCTION

In high efficiency coding such as MPEG, usually the sampling rate between 32 and 48kHz, and the number of quantization bits between 12 and 16 bits are used for the original data. The band width tends to depend on the sampling frequency, and the dynamic range tends to depend on the number of quantization bits. However, from the information theory point of view, the sampling frequency multiplied by the number of quantization bits, as the transmission bit rate；quantity of information is important. Since it is possible to obtain enough dynamic range evenby 1 bit quantization, we have proposed high speed 1 bit coding.[1)]

FFT is generally used in frequency analysis, but FFT is influenced by the window and it is impossible to search for the true frequency component. This is because FFT makes the analys is signal the periodic signal where period is the analys is window.

On the other hand, generalized harmonic analysis (GHA) which was proposed by N.Wiener is the simplest method for spectrum analysis,[2)] which searches for the spectrum successively. GHA finds a sinusoid which minimizes the power of the residual signal, removes it, and carries out the same procedure substitutin. theweakest residualsignal. Therefore, the signal can be ana lyzed without the window effects.

We have in troduced GHA into the analysis of the quantization noise of high speed l bit coding, and have applied GHA to high effeciency high speed l bit coding considering the human hearing sense such as masking and the critical band.

2. HIGH SPEED 1 BIT CODING

Figure 1 shows an example of high speed 1 bit coding; the basic structure of a 7th order $\Sigma\Delta$-modulation. The $\Sigma\Delta$-modulation type converter concentrates quantization noise in the higher frequency area by setting a quantizer in the feedback loop, and is able to realize 1 bit coding using the same transmission capacity as the general multi bit system.

Figure 2 shows the spectrum of the high speed 1 bit signal coded by 7th order $\Sigma\Delta$-modulation, which is analyzed by GHA. The quantization noise is concentrated in the higher frequency area.

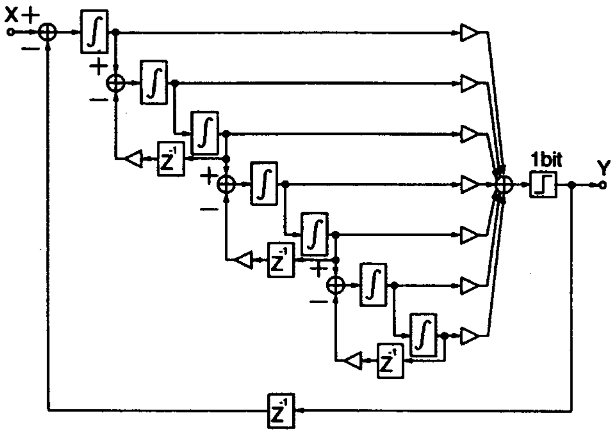

Fig.1 *The 7th order ∑Δ -mondulation high speed 1 bit coding*

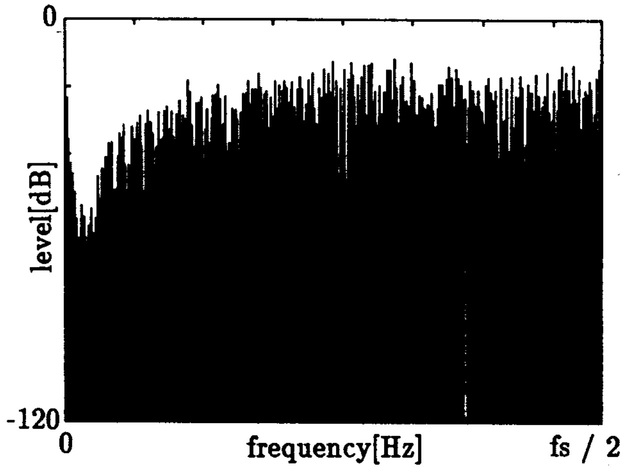

Fig.2 *The spectrum of 1 bit signal*

3. GENERALIZED HARMONIC ANALISELYS

GHA is one method for spectrum analysis which was suggested by N.Wiener in 1958. Recently M.Tohyama and A.Hirata tried to introduce this technique to analyze nonstationary signals, such as a piano tone and a singing voice. [3)]

FFT is generally used in frequency analysis, but is influenced by the worlde window and is not suitable to analyze the nonperiodic signal. On the otherh and, GHA is able to analyze the nonperiodic signal with out the window effects as mentioned above. The GHA method istheanalysismethodwhichreturnstotheoriginofsignalprocessinganddetectssinusoids one by one.

First, obtain a residual signal by removing a sinusoid from the original signal :

$$e(t, f) = x_0(t) - S(f)\sin(2\pi ft) - C(f)\cos(2\pi ft), \qquad (0, L) \tag{1}$$

where

$$S(f) = \frac{2}{L}\int_0^L x_0(t)\sin(2\pi ft)dt, \tag{2}$$

$$C(f) = \frac{2}{L}\int_0^L x_0(t)\cos(2\pi ft)dt, \tag{3}$$

$x_0(t)$ is an original signal that is given in the region . next, get the power of the residual signal:

$$x_1(t) = x_0(t) - S_1(f_1)\sin(2\pi f_1 t) - C_1(f_1)\cos(2\pi f_1 2) \tag{4}$$

Carrying out the same procedure for all sinusoids, find a sinusoidthatminizestbep of the residual signal $E(f)$,which gives the firstfrequencycomponent.

The same procedure is carried out substituting the minimum residualsignal $x_0(t)$:

$$x_1(t) = x_0(t) - S_1(f_1)\sin(2\pi f_1 t) - C_1(f_1)\cos(2\pi f_1 t) \tag{5}$$

to find the second frequency component, and so on.

Thus, detecting sinusoids one by one, then after N iterations, we have

$$x_0(t) \approx \sum_{k=1}^{N} \{S_k(f_k)\sin(2\pi f_k t) + C_k(f_k)\cos(2\pi f_k t)\} \tag{6}$$

for $0 \le t \le L$. The power spectrum is stimated by

$$P(f_k) = S_k^2(f_k) + C_k^2(f_k). \tag{7}$$

4. HIGH EFFICIENCY CODING

We have proposed a wide range of high speed 1 bit coding specializing in high quality high efficiency coding. There are two kinds of high efficiency coding bounded on the rate distortion boundary : $H = C$, where H is entropy; mean quantity of information of the signal and C is communication capacity. One is $H \le C$; the coding without any distortion, the other case is $H \le C$;in this case with some distortion, and high efficiency coding considering human hearing sense is going to be introduced.

In human hearing sense there is the masking effect and the critical band. Figure 3 shows the model of masking effect. The source signal varies momently and the quantity of information also varies. In the window with more quantity of information, more transmission bit rate is assigned than in the window with less quantity of information. Thus high effciency coding with the variable transmission bit rate is estimated.

Because high speed 1 bit coding concentrates quantization noise in the higher frequency area, GHA almost extracts the quantization noise component. So we analyze the signal only in the lower frequency range where human hearing sense is active.

GHA was applied to time-frequency analysis for the violin signal. The violin signal is cut into a train of short time, 10ms, by using a rectangular window. Figure 4 illustrates original signal. Figure 5(a) illustrates synthesized signal. The synthesized signal is composed of major 100 frequency components extracted in every window by GHA. Almost the same waveform can be reconstructed as the original, and the synthesized sound cannot be distinguished from the original. Figure 5(b) shows the residual signal left after 100components GHA analysis. When we extract 100 frequency components in every window, the transmission bit rate is 450 kbit/s.

Figure 6(a) shows the synthesized signal considering the human hearing sense and the number of extracted frequency components is 23 components per window on average, and the transmission bit rate is 105 kbit/s. Thus much of the transmission capacity is saved.

5. CONCLUSIONS

High efficiency coding of a high speed 1 bit signal by GHA considering human hearing sense is discussed. By considering human hearing sense such as masking and critical band, high quality high efficiency coding is able to be realized with the transmission bit rate from
about 80 to 180 kbit/s for several kinds of wide range music recorded by high speed 1 bit coding.

REFERENCES

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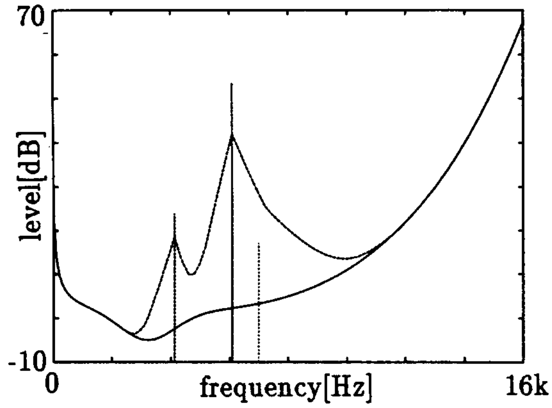


Fig.3 *The model of masking effect*

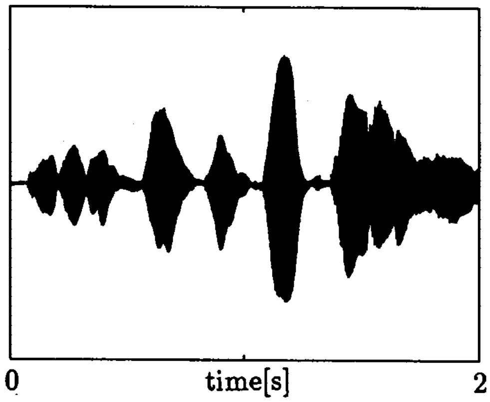
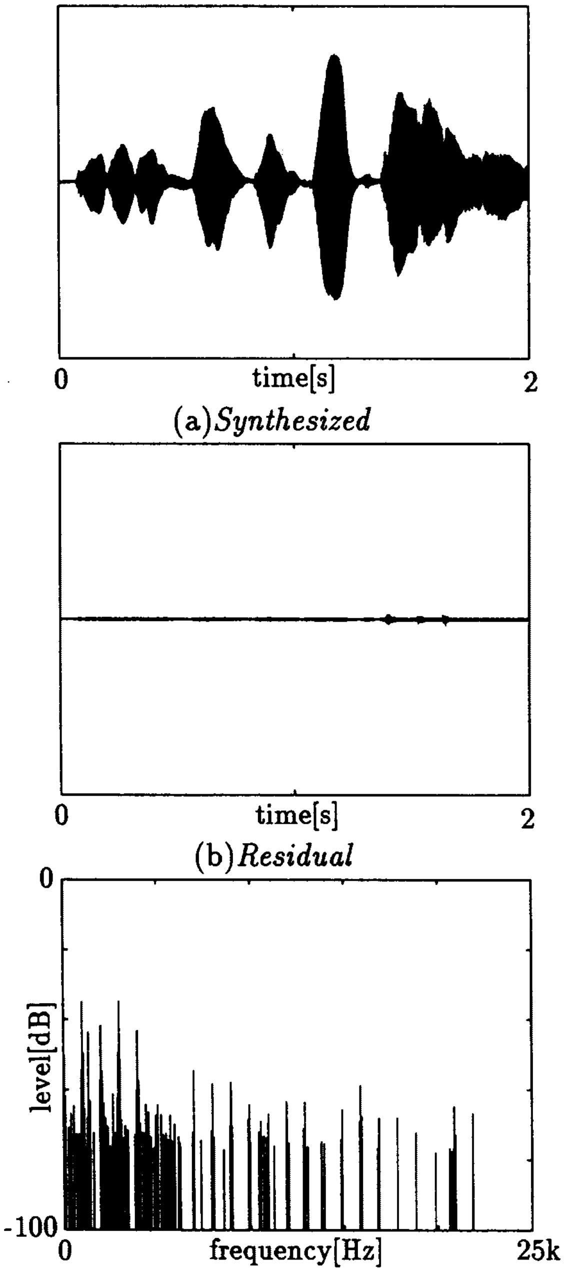
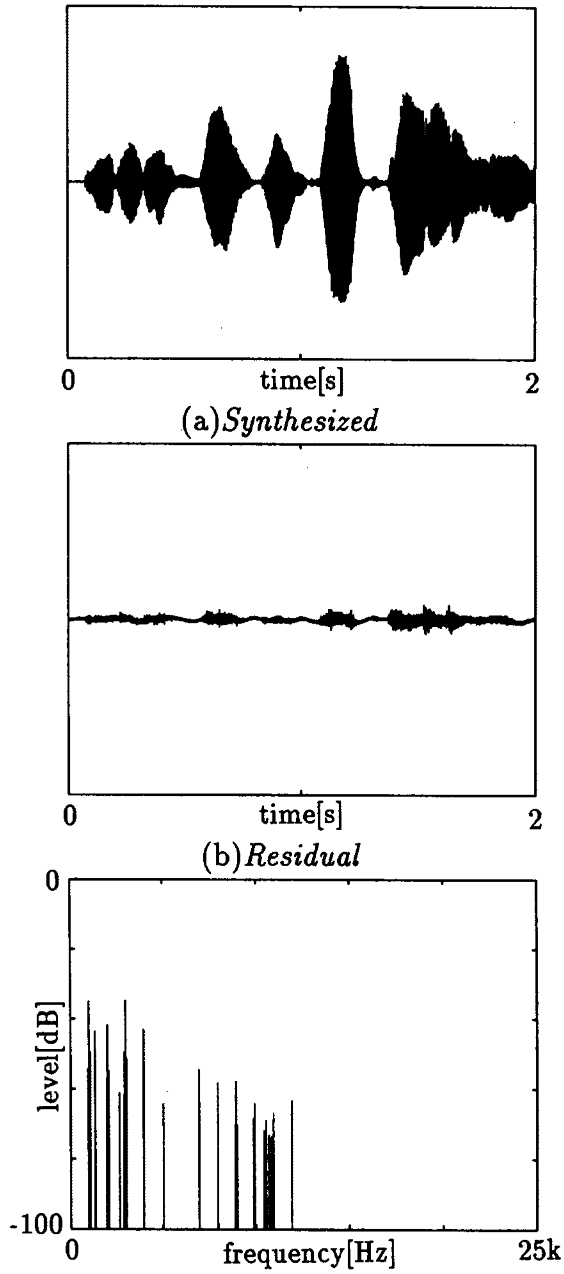


Fig.4 *The original signal*



(c)*Spectrum*

Fig.5 *Without considering human hearing sense*



(c)*Spectrum*

Fig.6 *With considering human hearing sense*