Application of wavelet packet analysis for speech synthesis

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Abstract— Wavelets are mathematical functions that cut up data into different frequency components, and then study each component with a resolution matched to its scale. They have advantages over traditional Fourier methods in analyzing physical situations where the signal contains Discontinuities. Wavelet packet analysis is analysis the different entropy of voice signal.

KEYWORD: wavelet packet trees, entropy.

1 INTRODUCTION

Wavelets are functions that satisfy certain mathematical requirements and are used in representing data or other functions .The fundamental idea behind wavelets is to analyze[1,2] according to scale. Indeed, some researchers in the wavelet field feel that, by using wavelets, one is adopting a whole new mindset or perspective in processing data. Wavelets are functions that satisfy certain mathematical requirements and are used in representing data or other functions. This idea is not new. Approximation using superposition of functions has existed since the early 1800's, when Joseph Fourier discovered that he could superpose sines and cosines to represent other functions. However, in wavelet analysis, the scale that we use to look at data plays a special role. Wavelet algorithms process data at different scales or resolutions. If we look at a signal with a large \window," we would notice gross features. Similarly, if we look at a signal with a small \window," we would notice small features. The result in wavelet analysis is to see both the forest *and* the trees, so to speak. This makes wavelets interesting and useful. For many decades, scientists have wanted more appropriate functions than the sines and cosines which comprise the bases of Fourier analysis, to approximate choppy signals . By their definition, these functions are non-local (and stretch out to in unity). They therefore do a very poor job in approximating sharp spikes. But with wavelet analysis, we can use approximating functions[3] that are contained neatly in finite domains. Wavelets are well-suited for approximating data with sharp discontinuities. The wavelet analysis procedure is to adopt a wavelet prototype function[4,5], called an analyzing wavelet or mother wavelet. Temporal analysis is performed with a contracted, high-frequency version of the prototype wavelet, while frequency analysis is performed with a dilated, low-frequency version of the same wavelet Because the original signal or function can be represented in terms of a wavelet expansion (using coefficients in a linear combination of the wavelet functions), data operations can be performed using just the corresponding[6] wavelet coefficients. And if you further choose the best wavelets adapted to your data, or truncate the coefficients below a threshold, your data is sparsely represented. This sparse coding[7,8] makes wavelets an excellent tool in the field of data compression. Other applied fields that are making use of wavelets include astronomy, acoustics, nuclear engineering, sub-band coding, signal and image processing, neurophysiology, music, magnetic resonance imaging, speech discrimination, optics, fractals, turbulence, earthquake-prediction, radar, human vision, and pure mathematics applications such as solving partial differential equations.

1.1 Discrete Wavelet Transform

Wavelets are functions that satisfy certain mathematical requirements and are used in representing data or other functions. The basic idea of the wavelet transform is to represent any arbitrary signal 'X' as a superposition of a set of such wavelets or basis functions. These basis functions are obtained from a single photo type wavelet called the mother wavelet by dilation (scaling) and translation (shifts).

Low frequencies are examined with low temporal resolution while high frequencies with more temporal resolution. A wavelet transform combines both low pass and high pass filtering in spectral decomposition of signals.

1.2 Wavelet Packet and Wavelet Packet Tree

Ideas of wavelet packet is the same as wavelet, the only difference is that wavelet packet offers a more complex and flexible analysis because in wavelet packet analysis the details as well as the approximation are splited. Wavelet packet decomposition gives a lot of bases from which you can look for the best representation with respect to design objectives. The wavelet packet tree for 3-level decomposition is construct the

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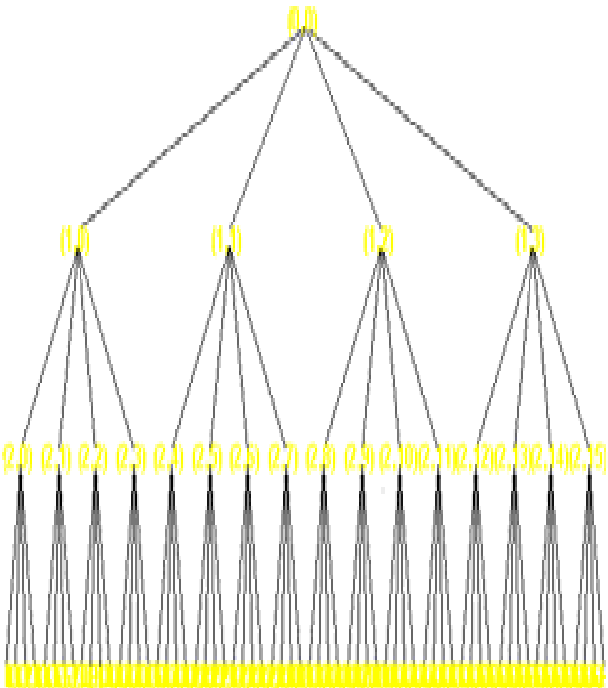
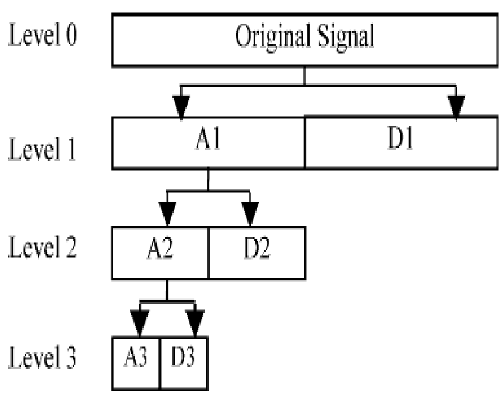
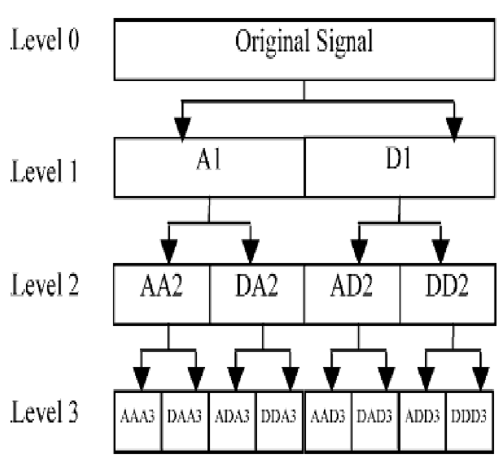




(a)



best tree. Shannon entropy criteria find the information content of signal 'S'

$$Entropy(S) = -\sum_i S_i^2 \log(S_i^2)$$

Information content of decomposed component (approximation and details) may be greater than the information content of components, which has been decomposed. In this paper the sum of information of decomposed component (child node) is checked with information of component.

2 WAVELET PACKET ANALYSIS

In wavelet analysis that every coefficient is associated with a function either a scaling function or a wavelet function depending on whether it is a 'smooth' or 'detail' coefficient. In the wavelet analysis the value are move from higher scale to lower scale and the basic function do not change. In this analysis it can be split on detail coefficient lead to change in basis set and these basis sets are called 'wavelet packets'.

The 8 data on the leaf nodes having 8 coefficients. These 8 coefficients are associated with 8 different functions. The functions associated with first two (on the left) are scaling and wavelet function with which started. All others are complex shaped function derived from wavelet function. This change in shape poses a problem in interpretation of the original signal. Wavelet packet analysis leads to different basis function.

A sequence of function $\{W^{[k]}\}_{k=0}^{k=+\infty}$ from a given function $W^{[0]}$ as follows:

$W^{[0]}(t)=\emptyset(t)$, $W^{[1]}(t)=\psi(t)$
J=scale parameter and k= translation parameter

$W_{j,k}^{[0]}(t) = \emptyset(2^j t-k)$, $W_{j,k}^{[1]}(t)=\psi(2^j t-k)$

This means

$$W_{0,0}^{[0]}(t) = \emptyset(t), W_{0,0}^{[1]}(t) = \psi(t)$$

$$W^{[2n]}(t) = \sqrt{2\sum_k h(k) W^{[n]}(2t-k)} \quad \ldots\ldots\ldots (1.1)$$

$$W^{[2n+1]}(t) = \sqrt{2} \quad \ldots\ldots\ldots (1.2)$$

2.1 Haar Wavelet Packates

Let n=0, $W^{[0]}(t)$= Haar scaling function $\emptyset(t)$,

$$\{h(k)\} = \left\{\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}\right\}$$

$$\{g(k)\} = \left\{\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}\right\} \quad , \{h(k)\}\ and \{g(k)\}$$

are Haar scaling and wavelet function filter coefficients.

$$W^{[0]}(t) = \sqrt{2}\sum_k h(k) W^{[0]}(2t-k) = \sqrt{2}\sum_k h(k)\emptyset(2t-k) = \emptyset(2t) + \emptyset(2t-1)\emptyset(t)$$

$$W^{[1]}(t) = \sqrt{2}\sum_k g(k) W^{[0]}(2t-k) = \sqrt{2}\sum_k g(k)\emptyset(2t-k) = \emptyset(2t) - \emptyset(2t-1)\psi(t)$$

Now let n=1 in eq. (1.1) and (1.2),

$$W^{[2]}(t) = \sqrt{2}\sum_k h(k)W^{[1]}(2t - k)\ \sqrt{2}\sum_k h(k)\psi(2t-k) = \psi(2t) + \psi(2t - 1)$$

.....(1.3)

$$W^{[3]}(t) = \sqrt{2}\sum_k g(k)W^{[1]}(2t-k) = \sqrt{2}\sum_k g(k)\psi(2t-k) = \psi(2t) - \psi(2t-1)$$

.....(1.4)

The plot of the function $W^{[2]}(t)$ and $W^{[3]}(t)$.
Now, let n=2 in eq.(1.1) and (1.2),

$$W^{[4]}(t) = \sqrt{2}\sum_k h(k)W^k(2t-k) = W^{[2]}(2t) + W^{[2]}(2t-1)$$

By equation (1.3),

$$W^{[4]}(t) = \psi(4t) + \psi(4t-1) + \psi(4t-2) + \psi(4t-3)$$

$$W^{[5]}(t) = \sqrt{2}\sum_k g(k)W^{[2]}(2t-k) = W^{[2]}(2t-1)$$

......(1.5)

By equation (1.3),

$$W^{[5]}(t) = \psi(4t) + \psi(4t-1) - \psi(4t-2) - \psi(4t-3).$$

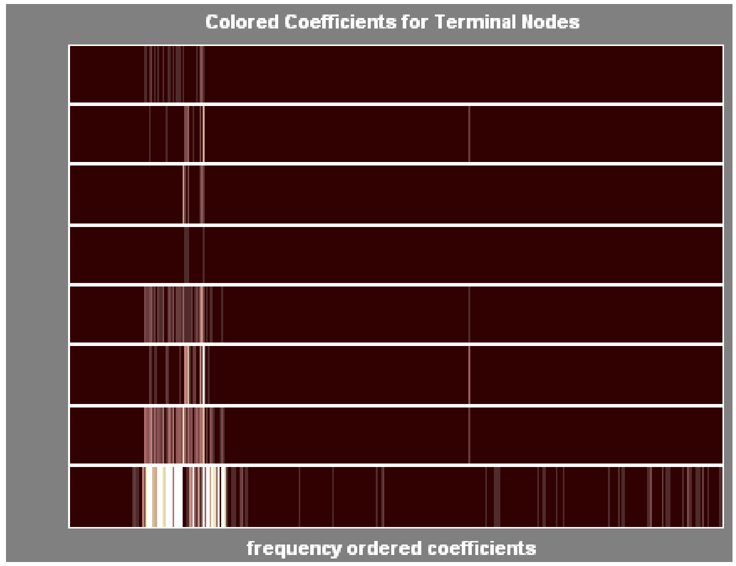
......(1.6)

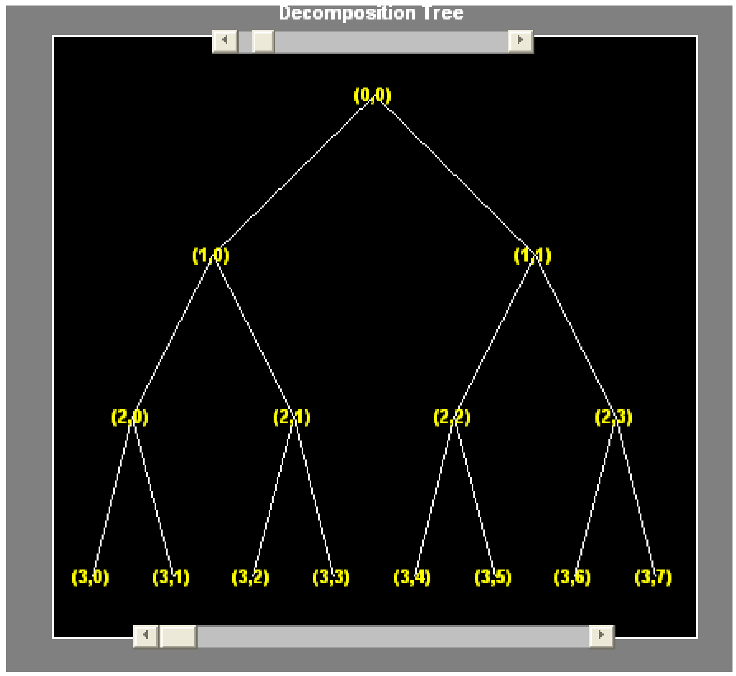
This process can be continued for n=∞.
For any orthogonal wavelet system some condition are apply:

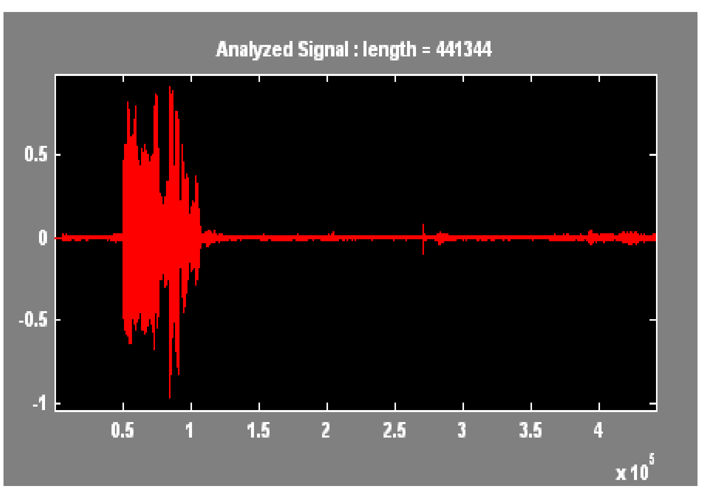
(1) $\{W^{[n]}(t)\}_{n=0}^{n=+\infty}\}$ are of same length and they are orthogonal.

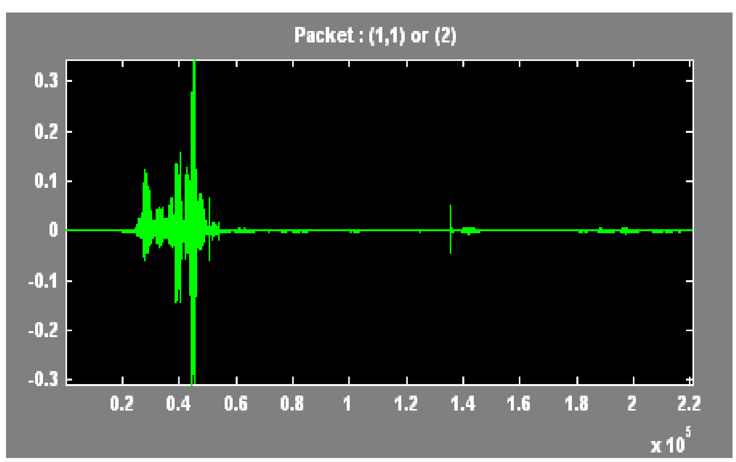
(2) A particular $W^{[n]}(t)$ and its integer translate $W^{[n]}(t-k)$ are orthogonal.

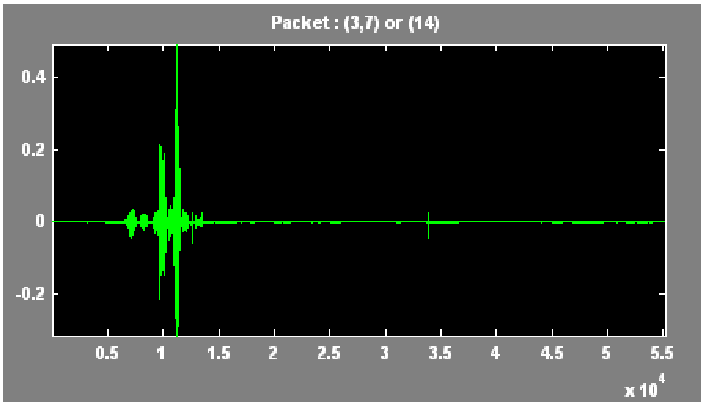
3 Entropy Analysis

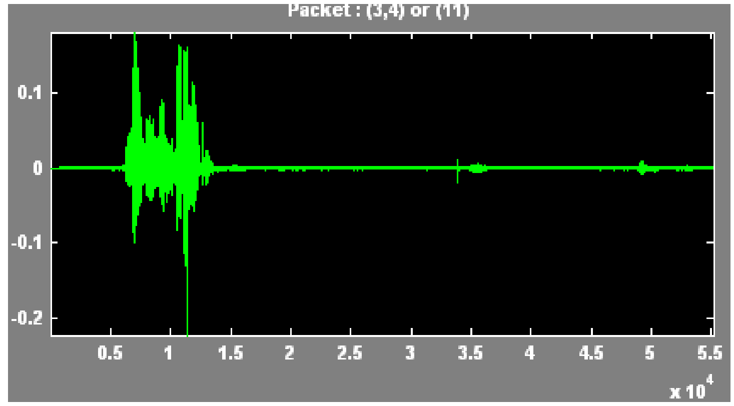


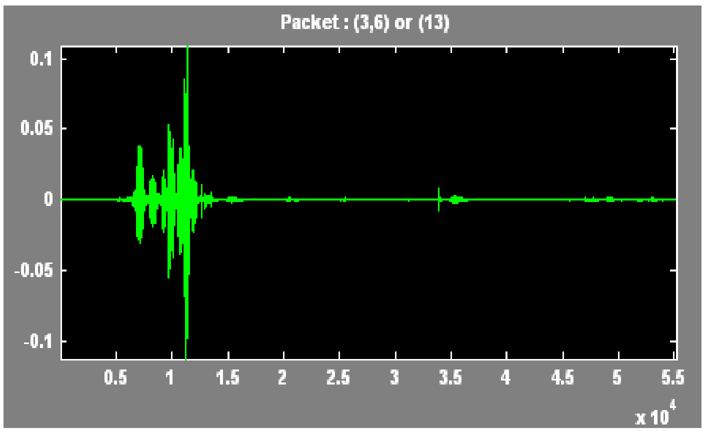


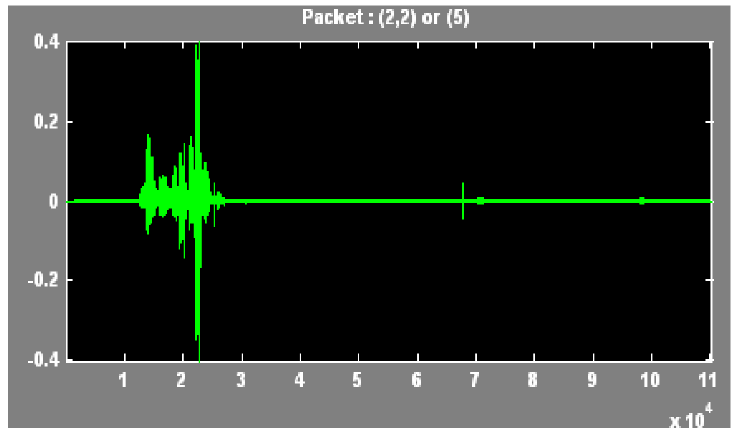


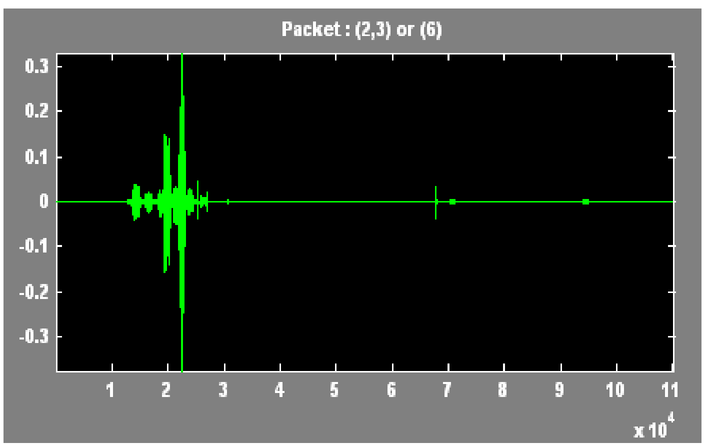


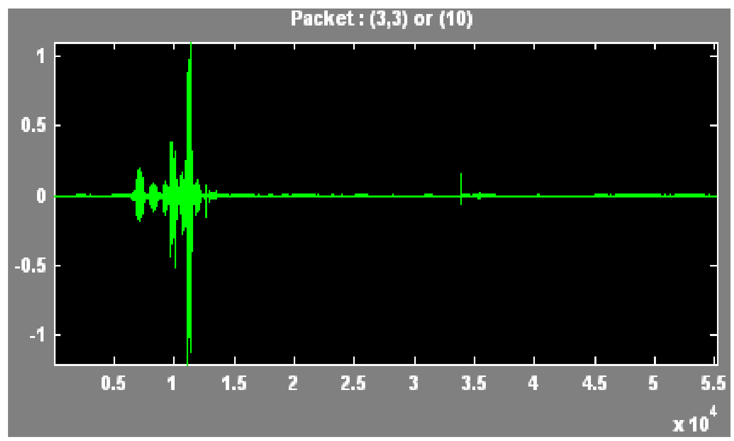

Packet : (3,7) or (14)
0.4
0.2
0
-0.2
0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5
x 10^4

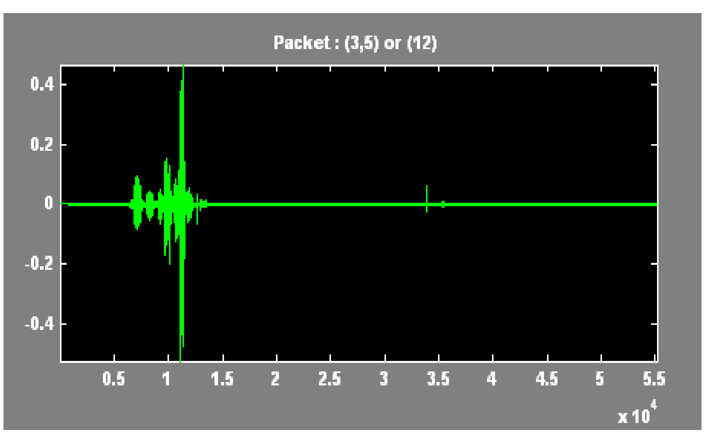

Packet : (3,4) or (11)
0.1
0
-0.1
-0.2
0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5
x 10^4

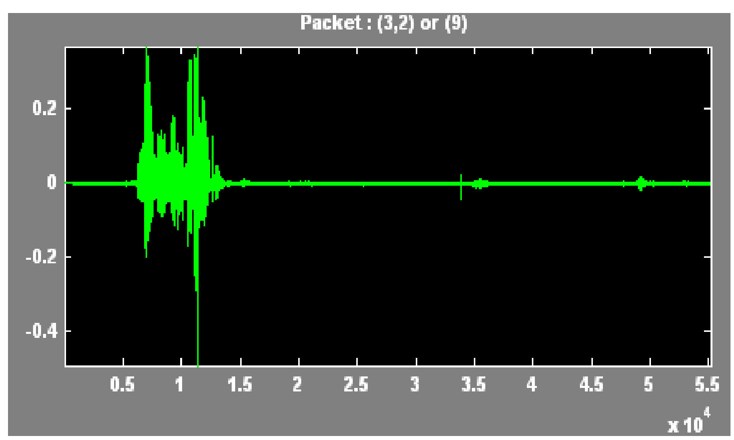

Packet : (3,6) or (13)
0.1
0.05
0
-0.05
-0.1
0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5
x 10^4

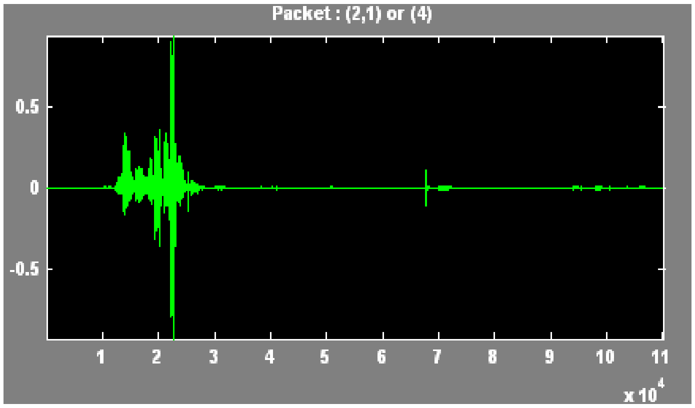

Packet : (2,2) or (5)
0.4
0.2
0
-0.2
-0.4
1 2 3 4 5 6 7 8 9 10 11
x 10^4

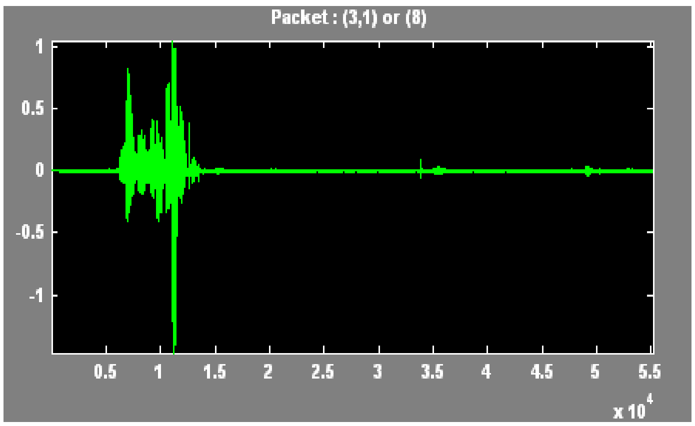

Packet : (2,3) or (6)
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
1 2 3 4 5 6 7 8 9 10 11
x 10^4

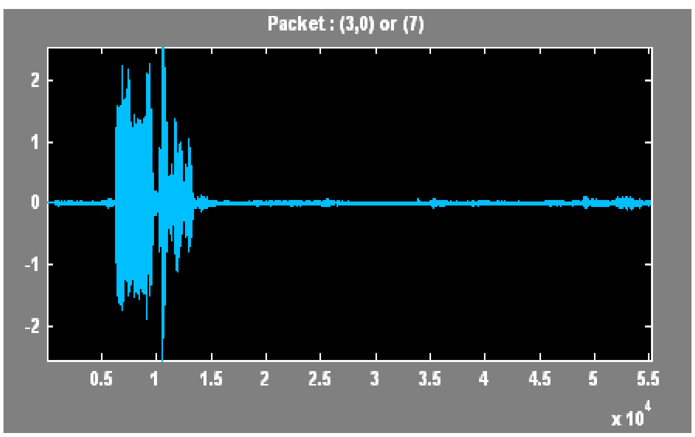

Packet : (3,3) or (10)
1
0.5
0
-0.5
-1
0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5
x 10^4

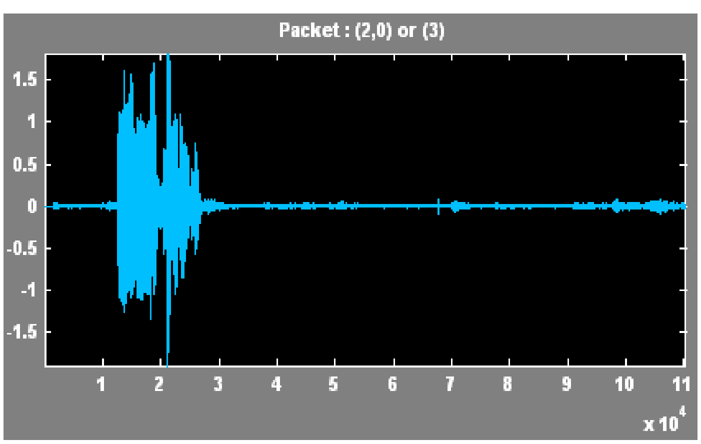

Packet : (3,5) or (12)
0.4
0.2
0
-0.2
-0.4
0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5
x 10^4

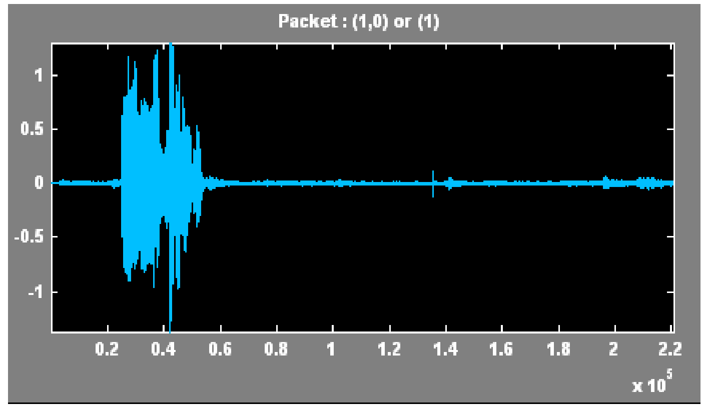

Packet : (3,2) or (9)
0.2
0
-0.2
-0.4
0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5
x 10^4











4 Conclusion

In this paper, the Wavelet Packet Best Tree using Shannon entropy has been presented. An extensive result has been taken on different voice signal. The results of discrete wavelet transform and the wavelet packet best tree are compared.

5 References

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