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SPECTRUM DATA COMPRESSION FOR COGNITIVE RADIO NETWORK

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ABSTRACT

Incognitive radio systems, interactive perception spectrum data between cognitive users can effectively improve the overallperformance of the user's perception of communication. However, a large number of spectrum data accumulation will increasing theconsumption of resources during interaction In, lack of effective spectrum data compression algorithm cognition become a bottleneckrestricting the collaboration. This paper presents a wideband spectrum data compression algorithm based on the energy detection andsliding window, removing redundant information of noise, compressing the detail of signal with different weights, reservinguseful information, improving the compression ratio and reducing compression loss. In addition, the algorithm retains the spectrum details of the signal by the DWT transform in the case of a high compression ratio, and those details are propitious to spectrum analysis. Especially under low occupancy ratio circumstances, experimental results show that the compression performance of this algorithm increase several times compare to DCT and JPEG2000

Keywords- Cognitive Radio, DWT transform, Wideband spectrum compression

I. INTRODUCTION

In traditional management mechanism of spectrum, themost parts of the frequency band are been exclusively byparts of authorized user, this mechanism waste ofspectrum resources also limits the development ofwireless applications. The spectrum efficiency ofauthorized users is very low. Accordingly, researchershave proposed a cognitive radio (CR) to improve thespectrum utilization efficiency. In cognitive radio,cognitive users (*non-authorized users*) to use the idlefrequency band of authorized user. The cognitive usersneed to continuously monitoring spectrum to ensure the timely exit when an authorized user appears. However,various factors influence individual cognitive user isdifficult to ensure detection performance. Theresearchers propose a method that cognitive usercollaboration spectrum sensing can effectively improvingthe reliability of spectrum sensing, reducing theperception of time, reducing perception accuracy of nodeneeds, improving overall system performance, and so on. But because there is a large number of spectrumdata interaction between cognitive users that resulting inmore energy Consumption, but also the radio resourcesoccupied when data interaction.To reduce the resource consumption when spectrumdata interaction, data compression is an effective methodand has been widely used in the field of image processing.According to lossless data compression algorithm andlossy compression algorithms for the image are proposedby redundancy characteristic of data and images.Spectrum data has its own unique properties, simply usethe existing compression algorithms is difficult to meetthe demand of compression performance and complexityof the algorithm.Similarly, as a one-dimensional data, numbers ofresearch results emergence in the electrocardiogram(ECG) signal date and power monitoring of datacompression, some of the image compressionalgorithms is improved to adapt to the specificone-dimensional data compression.Currently, the compression algorithm suitable forspectrum data rarely attracts researcher's attention. Onlyin the literature, the researchers aiming at datasequence is presented a compression algorithm whichbase on ChebyShev, but higher complexity and difficult toachieve.Firstly, this paper analyzes the redundantcharacteristics of wideband spectrum data in the case ofmultiple-communication systems coexist. Then this paperproposed a wideband spectrum compression algorithmwhich base on Discrete Wavelet Transform (DWT)transform and improved energy detection which is appliedin wideband scenario in absence of priori information.Finally, we simulate the proposed algorithm and compareperformance with the existing DCT and JPEG2000 thesetwo advanced image compression algorithms.The most commonly used compression method isJPEG which base on DWT transform. JEPG2000 is

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anewer image compression technology, and it base on 2-Dwavelet transform.

II. SPECTRUM DATA CHARACTERISTICS ANALYSIS

In conventional communication systems, spectrum efficiency is low and part of the spectrum in the form ofwhite holes which allocated to the system. This meansthat a large part of the perceived spectrum data is noise data. As can be seen from the Fig 1, signal is only a smallpart of the band, as shown in Fig 1. In the conventional image compression algorithm, any data to transformdomain compress with equal weight. And we can usedifferent ways to compress the useful signal spectrum andthe noise spectrum data. A signal spectrum havesignificantly larger effect in spectrum analysis so that lessdistortion compression method have been used, theavailable information of noise spectrum is small so thathigher compression ratio can be employed by way ofcompression. This is the main starting point of thealgorithm in this paper.Spectrum data in the transform domain also hasavailable redundancy characteristic. The maincomponents of the conventional image of transform domain data are concentrated in the low frequency, butthe energy component of transform domain in spectrumdata with different characteristics. As can be seen fromthe Fig 3, after the DWT spectrum data changes can beseen the DWT components are descending order from lowfrequency to high frequency. By analyzing thecharacteristics of the above spectrum data, we can see ifusing the spectrum sensing detection results to separatenoise and signal and process them by different methodsrespectively can effectively improve the spectrumefficiency of data compression.Therefore, this paper proposes an efficient algorithm to compresses wideband spectrum data and applied incognitive radio. Firstly, use the judgment result ofspectrum sensing separation of signal and noise data, andcompression processing. Then use the DWT transformprocess spectrum data and keep the main component.

III. SPECTRUM DATA SEGMENT COMPRESSION ALGORITHM

3.1 Specific steps of the algorithm

1. Spectrum sensing bandwidth is B, Spectrumsensing frequency resolution is fr, Input the length N ofspectrum data $x(i)$, $i = 1, ...,N$ where the N coefficientsare given by $N = B/ fr$, Input the same length N of thesignal energy detection results is defined by$d(i)$, $i = 1, ...,N$, when $d(i)$ is 0 represents the samplepoint is the noise data, when $d(i)$ is 1 represents thesample point is the signal. Use $d(i)$ extracted noise data$xN$and signal data xI, where $xN= x(i)|d(i) = 0$ and$xI= x(i)|d(i) = 1$. In this paper we choose an improvedenergy detection method to obtain detection results

2. $d(i)$ is a binary-data sequence, we use blockskipping method conduct lossless compression andthen get the compressed data of energy detection results$D$. Block skipping method is an efficient algorithm tocompress binary-data and especially the data is composedof continuous 0 sequences and continuous 1 sequences.

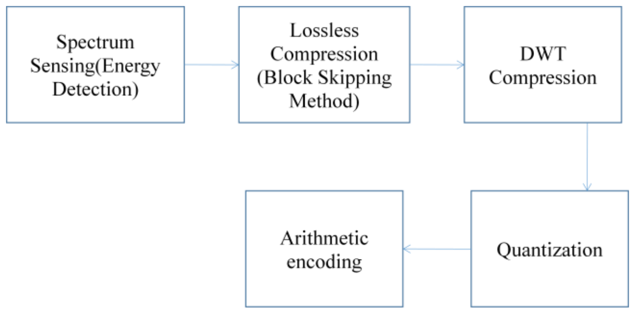

Fig.1 System Architecture

3. Compress noise data, which noise carry redundantinformation, only the average noise power withinformation of spectrum analysis required, so that thenoise data compression only retains the mean of noisepower PN.

4. According to the detection results, perceived signal identification of signal spectrum data, follow these steps:

1) For signal spectrum data xIdoing DWT transform
then get DCT coefficients Sd.

2) According to the energy threshold T retain the coefficients$Sd$of low frequency, making the total energyof low frequency is below or equal to $sum(S2$
$d) \_ T$, thenwe obtain the retained coefficients sequence SLP.

5. For the quantification of SLP, the following steps:Quantization step is $stepq= max(SLP)−min(SLP)Nql$
. Where$Nql$is quantization progression, get quantized coefficientssequence S.

6. Finally we have to encode two types of data:

1) The retained DCT coefficients vector S.

2) The compressed detection results vector D.

We have chosen to encode all these types of data withthe arithmetic encoder. Then we obtain arithmetic codedata Ca.

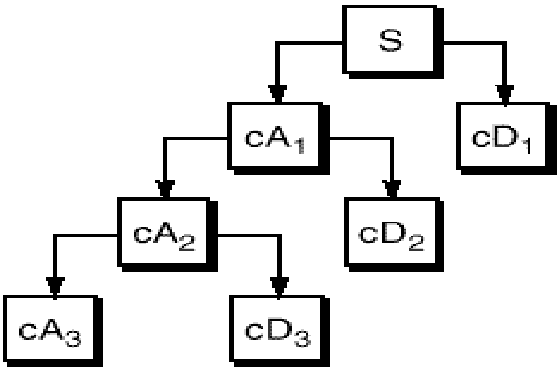

Fig.2 Wavelet Composition

7. Arithmetic code data *Ca*, The lengths of retainedcoefficients and detection results as well as mean of noiseconsisting of a compressed frame header.

3.2 Algorithm analysis

Our algorithm is different from common image compression algorithms, it decompose the spectrum datain to noise part and signal part. We retaining only mean of noise power and compress the signal spectrum data withthe method of segment compression which base on DWTtransform, the energy detection results are lossless compressed by the block skipping method. Since those processing methods reduce the noise data quantity which describes noise details and be not of much use in spectrum analysis, the compression ratio of our algorithm is higher than traditional compression algorithms. Theenergy detection results are additional overhead incompressed data, but they are composed of 01 sequencewhich could represent by Boolean data and amount ofoverhead is small. In addition, we know the fact that thereare much continuous 0 sequences and continuous 1sequences, and the energy detection results are suitablefor lossless compression with. The reason of losslesscompression is that detection results are spectrumposition information and it is important to compresseddata reconstruction.After that, we encode retained DWT coefficients andcompressed detection results vector with the arithmeticencoder.The main operations of our algorithm concentrated onDWT transform and entropy coding, and the otheroperations are much smaller. As we know, the main stepsof JPEG are DWT transform, quantization and entropycoding. So the complexity of the algorithm proposed bythis paper is similar to that of JPEG.

IV. SIMULATION ANALYSIS

4.1 Performance metrics

Two performance metrics were used for evaluating theperformance of the compression algorithms. TheCompression performance indicator is compression Ratio (CR).

4.2 Simulation results and analysis

Experimental data is L-band satellite communication spectrum sensing data, and The resolution of each sampleis 16 bits/sample. The spectrum sensing bandwidth$B$ = 50*MHz*,the frequency resolution of spectrum sensing*fr*= 10*kHz*,and data length N = 5000. This paperimplements our algorithm, DCT and JPEG2000 bymatrix laboratory (Matlab2012) in experiments. Ouralgorithm parameter settings as shown in the following table. The parameters of JPEG and JPEG2000 are the default values. Because of the ratio of noise in spectrumdepend on the spectral environment, for test compression performance in different spectral environment more effectively, this paper choose different spectrum data toe xperiment and their spectrum occupancy ratios are from0% to 60%. The spectrum occupancy ratio is the ratio ofthe total signal bandwidth and the total sensingbandwidth.Fig 2 is the compression effect, reconstructed data retains the main details of the signal and the error is very small. In this paper, our algorithm will be compared with JPEG and JPEG2000. We divide test data into 6 classes by their occupancy ratio and the test value is the meanvalue of performance metrics in same class. The numberof each class is 20. The Table 1 shows comparativeresults.As can be seen from Table 1, performance metrics ofthis compression algorithm are almost all superior to those of JPEG and JPEG2000 in all different spectrumoccupancy ratio, especially in case of low occupancyratio. And under normal circumstances, the spectrumutilization is low. Occasionally, the PRD performance ofcompression is slightly worse than JPEG2000 and JPEG.This is because the main error of segmented compressionconcentrates on noise part. But in spectrum cognition, thedetails of noise spectrum are unimportant compare tosignal details. If we only calculate PRD of signalspectrum, this algorithm is advanced. So our compression made high gain in CR performance than the traditional image compression algorithms in the case of similar errorperformance. The performance of JPEG2000 is also goodin the case of higher occupancy ratio, but the complexityof JPEG2000 is very high.

Ratio between DCT&DWT			
%	%(onlySignal)	%(onlySignal)	%(onlySignal)
0-10	47.62	6.76	4.09
10-20	24.10	7.94	4.50
20-30	17.33	6.92	4.68
30-40	14.64	6.91	4.88
40-50	13.02	6.49	4.72
50-60	12.10	6.61	4.9

Table1:Compression performance comparison

V. LIMITATION

The basic idea of the proposed DWT efficient algorithm wide band spectrum data and applied in cognitive radio. Firstly, use the judgment result of spectrum sensing separation of signal and noise data, and compression processing. Then use the DWT transform process spectrum data and keep the main component. In conventional communication systems, spectrum efficiency is low and part of the spectrum in the form of white holes which allocated to the system. This means that a large part of the perceived spectrum data is noise data. In the conventional image compression algorithm, any data to transform domain compress with equal weight. And we can use different ways to compress the useful signal spectrum and the noise spectrum data. A signal spectrum have significantly larger effect in spectrum analysis so that less distortion compression method have been used, the available information of noise spectrum is small so that higher compression ratio can be employed by way of compression.

VI. SUMMARY AND CONCLUSIONS

For take full advantage of spectrum redundant features toimprove compression performance, this paper analysis theshortcomings of traditional image compressionalgorithms in wideband spectrum data compression andpresents a wideband spectrum data compression schemebased on the frequency detection and DWT. Theperformances of the compression algorithm are test inexperiment and the results show that the CR performanceof this compression algorithm is much better than JPEG 2000and DCT in case of different spectrumoccupancyratio. Especially in case of low occupancy ratio, thecompression ratio performance increase several times compare to DCT and JPEG2000. The same time our algorithm ensures the accuracy of reconstructed data. Andthe complexity of our algorithm is closer to JPEG, muchsmaller than JPEG2000. Technologies related DWT arevery mature, easy to implement and be able to meet thereal-time requirements of cognitive radio system. So thecompression algorithm proposed by this paper can resolve the data exchange bottleneck in cooperative cognitiveradio system, and can be applied to sensor networks,spectrum monitoring etc.

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6.1 (Compression Ratio Performance)

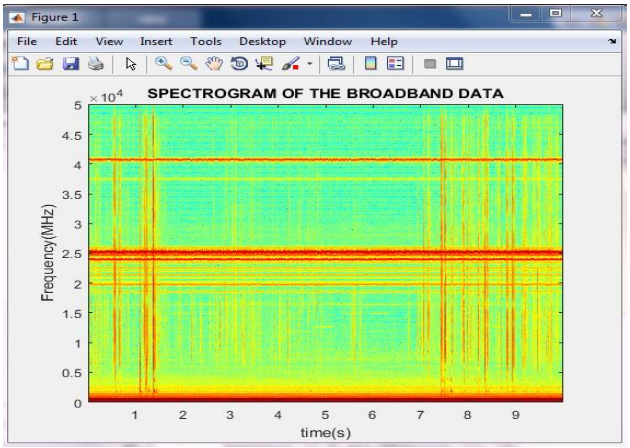

Fig.3 Spectrum of the Broad band Data

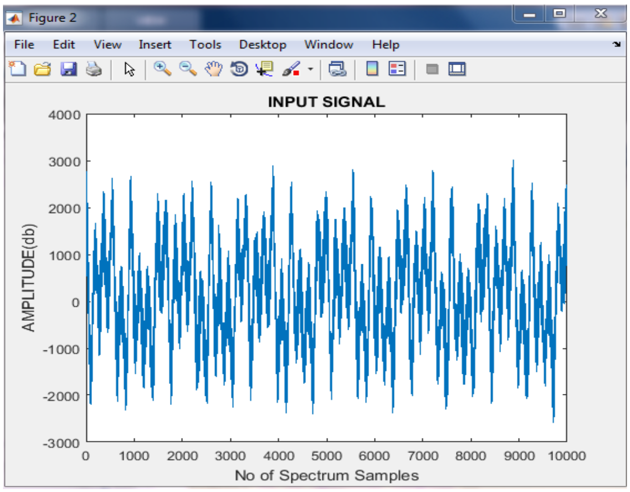

Fig.4 Spectrum of the Input Signal

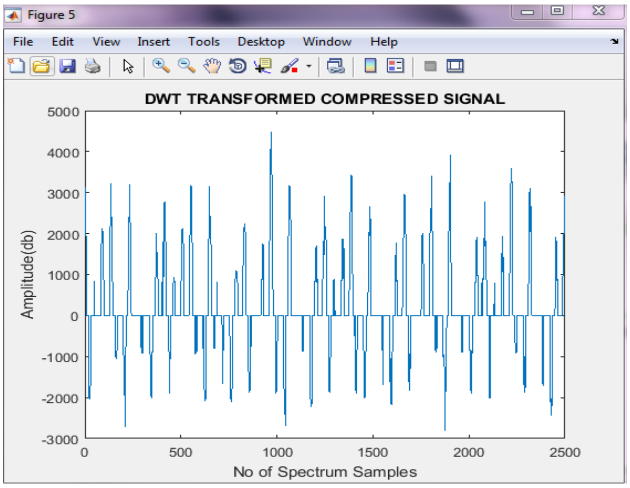

Fig.5 DWT Compressed Signal

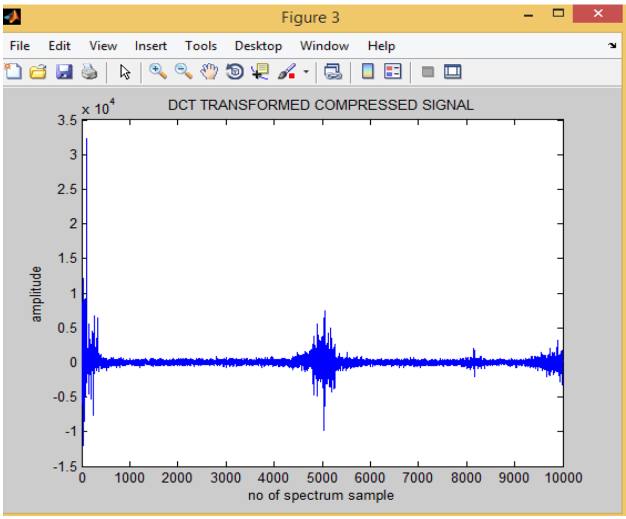

Fig .6 DCT Compressed Signal

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