PROJECT - EEE407/591 - Data Compression using the FFT

Due: November 21, 2001

Data compression using transformations such as the DCT and the DFT are the basis for many coding standards such as the JPEG, MP3 and AC-3. A simplified method for transform-based compression can be simulated with the FFT as follows: a data set is segmented into N-point frames (vectors) using a sliding data window (Fig. 1). Each frame is then transformed using an N-point FFT, Fig. 2. Since the data set is real valued, only 1+(N/2) components are independent (symmetry property of the DFT). Of the 1+(N/2) independent components, only n independent components are retained for data reconstruction (n<1+(N/2)). The rest (1+(N/2)-n) of the independent components are set to zero. Symmetry in the transform-domain components is maintained in order to reconstruct a real-valued output signal. In this project, you are asked to simulate this data compression scheme using MATLAB. You need to perform simulations for different FFT sizes (N's) and different n's. Two sets of results are required, i.e., one for the case where the n <u>dominant</u> components (method 1) are retained, and another one for the case where the <u>first</u> n components (method 2) are retained. You are given a data set that contains 14848 samples. In an actual data compression scheme the retained transform components must be encoded in binary format. This will not be a requirement here, i.e., the retained transform components are left in floating-point form. The data compression scheme will be evaluated using the signal-to-noise ratio (SNR) given in equation (1). You need to write a program and perform simulations anf fill up the tables as inpage 2.

$$SNR = 10 \ \log_{10}\left(\frac{\sum_{i=1}^{14848} s^2(i)}{\sum_{i=1}^{14848} (s(i) - \hat{s}(i))^2} \right) \qquad (1)$$

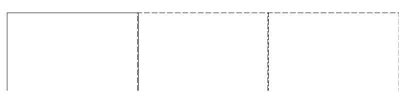

Fig. 1. Sliding Rectangular window.

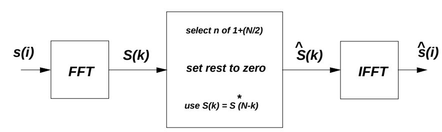

Fig. 2. FFT Data Compression.

Applying Triangular Windows (BONUS PART ADDITIONAL 10%)

For all the cases outlined in the tables of page 2, perform additional simulations using a sliding triangular window as per Fig. 3. Complete all the tables of page 3. When evaluating the SNR ignore the first and the last N/2 points, i.e.

$$SNR = 10 \ \log_{10}\left(\frac{\sum_{i=1+(N/2)}^{14848-(N/2)} s^2(i)}{\sum_{i=1+(N/2)}^{14848-(N/2)} (s(i) - \hat{s}(i))^2} \right) \qquad (2)$$

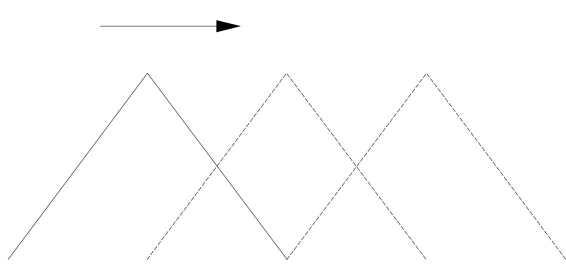

Fig. 3. Sliding Triangular window.

Tabulate your results for the case of rectangular windows and label your tables as shown below:

Table 1.A Simulations with N=64 and Rectangular Window

n	N	DOMINANT (method 1) SNR	FIRST (method 2) SNR
1	64		
2	64		
..	64		
..	64		
N/2	64		
1+(N/2)	64		

Table 1.B Simulations with N=128 and Rectangular Window

n	N	DOMINANT (method 1) SNR	FIRST (method 2) SNR
1	128		
2	128		
..	128		
..	128		
N/2	128		
1+(N/2)	128		

Table 1.C Simulations with N=256 and Rectangular Window

n	N	DOMINANT (method 1) SNR	FIRST (method 2) SNR
1	256		
2	256		
..	256		
..	256		
N/2	256		
1+(N/2)	256		

Tabulate your results for the case of triangular windows (optional)

and label your tables as shown below:

Table 2.A Simulations with N=64 and Triangular Window

		DOMINANT (method 1)	FIRST (method 2)
n	N	SNR	SNR
1	64		
2	64		
..	64		
..	64		
N/2	64		
1+(N/2)	64		

Table 2.B Simulations with N=128 and Triangular Window (optional)

		DOMINANT (method 1)	FIRST (method 2)
n	N	SNR	SNR
1	128		
2	128		
..	128		
..	128		
N/2	128		
1+(N/2)	128		

Table 2.C Simulations with N=256 and Triangular Window (optional)

		DOMINANT (method 1)	FIRST (method 2)
n	N	SNR	SNR
1	256		
2	256		
..	256		
..	256		
N/2	256		
1+(N/2)	256		

Plots

You need to plot the results tabulated above and label figures as follows:

Fig. 1. Effect of n and N with rectangular window and method 1 - SNR vs percentage of components used (n/N %) for N=64,128,256 for rectangular window and method 1. All three curves should be included in the same graph for comparisons.

Fig. 2. Effect of n and N with rectangular window and method 2 - SNR vs percentage of components used (n/N %) for N=64,128,256 for rectangular window and method 2. All three curves should be included in the same graph for comparisons.

Fig. 3. Performance of Method 1 vs Method 2 with Rectangular Window - SNR vs percentage of components used (n/N %) N=256 with method 1 and N=256 with method 2 - both curves with the rectangular window. These two curves should be included in the same graph for comparisons.

(FIG. 4- 8 are optional (10 point bonus)

Fig. 4. Performance of Rectangular vs Triangular Window with Method 1 - SNR vs percentage of components used (n/N %) N=256 with rectangular window and N=256 with triangular window - both curves with method 1. These two curves should be included in the same graph for comparisons.

Fig. 5. Performance of Rectangular vs Triangular Window with Method 2 - SNR vs percentage of components used (n/N %) N=256 with rectangular window and N=256 with triangular window - both curves with method 2. These two curves should be included in the same graph for comparisons.

Fig. 6. Effect of n and N with triangular window and method 1 - SNR vs percentage of components used (n/N %) for N=64,128,256 for triangular window and method 1. All three curves should be included in the same graph for comparisons.

Fig. 7. Effect of n and N with triangular window and method 2 - SNR vs percentage of components used (n/N %) for N=64,128,256 for triangular window and method 2. All three curves should be included in the same graph for comparisons.

Fig. 8. Performance of Method 1 vs Method 2 with Triangular Window - SNR vs percentage of components used (n/N %) N=256 with method 1 and N=256 with method 2 - both curves with the triangular window. These two curves should be included in the same graph for comparisons.

Report

Type a report that contains, project description (1 page), tables[1], figures [2], and conclusions addressing the following questions (remarks restricted to 2 pages maximum). A hard copy of the program used must be included in an appendix.

Questions to be addressed in your Conclusions Section. Itemize your responses

1. What is the effect of the parameter n (N=fixed) on the SNR? Explain.

2. What is the effect of N (n/N=fixed) on the SNR? Explain.

3. Explain the differences in the results obtained with method 1 as opposed to method 2.

4. In order to implement an actual data compression scheme then the retained transform components must be encoded in binary format. Assuming that n and N are the same for method 1 and method 2, which method will produce the lowest bit-rate (bits/second)?

5. Try to listen to the processed files using the MATLAB sound command and give some comments regarding the subjective quality of the processed record.

5. What is the effect of the triangular window on the SNR? Explain why (optional).

Grading, Due Date, ETC

- The project is assigned essentially as a take home test.

- The report is due on November 21, 2001 in class. Students on remote TV sites must get the site coordinator to sign and write the time and date received on the report.

- late submissions will be accepted until Nov. 28, 2001 with 20% penalty. If by Nov. 28, 2001 you do not complete the project, summarize and submit whatever you have in class on Nov. 28 and explain why you could not get the program to work.

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1 you can use spreadsheet printouts but label them clearly as indicated in the previous pages

2 label them as indicated above

<u>- Do your own work</u>. YOU ARE TO WORK IN GROUPS IF TWO - ONE PROGRAM AND ONE REPORT PER GROUP. You may **NOT** use the same program with another group to generate the results. If such a situation arises the students involved will get the grade of zero for the project. You need to submit your program also in electronic form on a floppy disk so that we can verify your work

THE SPEECH FILE CAN BE DOWNLOADED FROM THE EEE407 WEB SITE: