

ADSP HW5

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- (1) Write a Matlab program that can generate the forward and inverse N -point number theoretic transform matrices (modulus M).

$[A, B] = \text{NTTm}(N, M)$ % A: forward, B: inverse

The outputs A and B are $N \times N$ matrices. Choose the smallest positive α .

- (2) What are the two main advantages of the sectioned convolution?

Ans:

- 1) Computation Complexity is linear.
- 2) Lower hardware resource requirement, same hardware for various input length

(3)

(a) How many additions operations required for the 16-point and the 32-point Walsh transforms?

(b) Suppose that $h[n] = f[n] \star g[n]$ where \star means the logic convolution. Express $h[6]$ in terms of $f[n]$ and $g[n]$ (The 8-point Walsh transform is applied).

Ans:

a) $W_2 = 2$; $W_4 = 2 \cdot W_2 + 4$; $W_8 = 2 \cdot W_4 + 8$; $W_{16} = 2 \cdot W_8 + 16$; $W_{32} = 2 \cdot W_{16} + 32$

b) $h[6] = f[0]g[6 \oplus 0] + f[1]g[6 \oplus 1] + f[2]g[6 \oplus 2] + \dots$
 $= f[0]g[6] + f[1]g[7] + f[2]g[4] + f[3]g[5] + f[4]g[2] + f[5]g[3] + f[6]g[0] + f[7]g[1]$

- (4) What are the most important applications of

- (a) the Walsh transform and
- (b) the Haar transform nowadays?

Ans:

- a) CDMA communication, ECG signal analysis,
- b) Localized spectrum analysis, edge detection, Adaboost face detection

- (5) Which are the possible applications of the NTT? Why? (a) Filter design. (b) Compression. (c) Integer LTI system analysis. (d) Encryption.

Ans:

- (c) Integer LTI system analysis: NTT is in Integer field
- (d) Encryption: The mapping of NTT is hard to predict, also it can help speed up the calculation for modern cryptosystem.

(6) What are the two main advantages of the OFDM when compared to the original FDM?

Ans:

- 1) It is Orthogonal: no interference between different channels, $AA^T = I$, $A^{-1} = A$.
- 2) It has fast algorithm. The fast algorithm is similar to DFT.

(7)

(a) What is the results of CDMA if there are three data [1 1 0], [0 1 1], [1 0 0] and these three data are modulated by the 1st, 6th, and 11th columns (equivalent to the 1st, 6th, and 11th rows ($m = 0, 5, 10$)) of the 16-point Walsh transform?

(b) Is it better to use the NTT for CDMA? Why?

Ans:

(a)

1st column: [1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1]

6th column: [1, 1, -1, -1, -1, -1, 1, 1, -1, -1, 1, 1, 1, 1, -1, -1]

11th column: [1, -1, -1, 1, -1, 1, 1, -1, -1, 1, 1, -1, 1, -1, -1, 1]

[1,1,0] \rightarrow [1,1,-1] modulated by 1st column [1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1]

\rightarrow [1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1]

[0,1,1] \rightarrow [-1,1,1] modulated by 6th column [1, 1, -1, -1, -1, -1, 1, 1, -1, -1, 1, 1, 1, 1, -1, -1]

\rightarrow [-1,1,1,1,1,1,-1,-1,1,1,-1,-1,1,1,1,1]

[1,0,0] \rightarrow [1,-1,-1] modulated by 11th column [1, -1, -1, 1, -1, 1, 1, -1, -1, 1, 1, -1, 1, -1, -1, 1]

\rightarrow [1,-1,-1,1,1,1,-1,-1,1,1,-1,-1,1,1,1,1]

Sum up 3 channels:

[1, -1, 1, 3, 1, 3, 1, -1, 1, 3, 1, -1, 1, -1, 1, 3,
1, 3, 1, -1, 1, -1, 1, 3, 1, -1, 1, 3, 1, 3, 1, -1,
-1, 1, -1, -3, -1, -3, -1, 1, -1, -3, -1, 1, -1, 1, -1, -3]

(b)

No, because NTT computation is a lot more complicated.