

XIII. Walsh Transform (Hadamard Transform)

© 13-A Ideas of Walsh Transforms

- 8-point Walsh transform

$$W[m,n] = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 \\ 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 \\ 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 \\ 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 \end{bmatrix} \begin{matrix} m \\ 0 \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \end{matrix}$$

- Advantages of the Walsh transform:

- (1) Real
- (2) No multiplication is required
- (3) Some properties are similar to those of the DFT

- Forward and inverse Walsh transforms are similar.

$$\text{forward: } F[m] = \sum_{n=0}^{N-1} f[n]W[m,n], \quad \text{inverse: } f[m] = \frac{1}{N} \sum_{n=0}^{N-1} W[m,n]F[n]$$

- Alternative names of the Walsh transform:

Hadamard transform, Walsh-Hadamard transform

- Orthogonal Property $\sum_{n=0}^{N-1} W[m_0, n]W[m_1, n] = 0$ if $m_0 \neq m_1$
- Zero-Crossing Property
- Even / Odd Property
- **Fast Algorithm**

Useful for spectrum analysis

Sometimes also useful for implementing the convolution

Walsh transform 和 DFT, DCT 有許多相似處

$$W[m, n] = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 \\ 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 \\ 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 \\ 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 \end{bmatrix}, DFT[m, n] = \exp(-j2\pi m n/N),$$

$$\mathbf{DCT} = \begin{bmatrix} 1.0000 & 1.0000 & 1.0000 & 1.0000 & 1.0000 & 1.0000 & 1.0000 & 1.0000 \\ 1.3870 & 1.1759 & 0.7857 & 0.2759 & -0.2759 & -0.7857 & -1.1759 & -1.3870 \\ 1.3066 & 0.5412 & -0.5412 & -1.3066 & -1.3066 & -0.5412 & 0.5412 & 1.3066 \\ 1.1759 & -0.2759 & -1.3870 & -0.7857 & 0.7857 & 1.3870 & 0.2759 & -1.1759 \\ 1.0000 & -1.0000 & -1.0000 & 1.0000 & 1.0000 & -1.0000 & -1.0000 & 1.0000 \\ 0.7857 & -1.3870 & 0.2759 & 1.1759 & -1.1759 & -0.2759 & 1.3870 & -0.7857 \\ 0.5412 & -1.3066 & 1.3066 & -0.5412 & -0.5412 & 1.3066 & -1.3066 & 0.5412 \\ 0.2759 & -0.7857 & 1.1759 & -1.3870 & 1.3870 & -1.1759 & 0.7857 & -0.2759 \end{bmatrix}$$

References for Walsh Transforms

- [1] K. G. Beanchamp, *Walsh Functions and Their Applications*, Academic Press, New York, 1975.
- [2] B. I. Golubov, A. Efimov, and V. Skvortsov, *Walsh Series and Transforms: Theory and Applications*, Kluwer Academic Publishers, Boston, 1991.
- [3] H. F. Harmuth, “Applications of Walsh functions in communications,” *IEEE Spectrum*, vol. 6, no. 11, pp. 82-91, Nov. 1969.
- [4] H. F. Harmuth, *Transmission of Information by Orthogonal Functions*, Springer-Verlag, New York, 1972.

© 13-B Generate the Walsh Transform

2-point Walsh transform

$$\mathbf{W}_2 = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

4-point Walsh transform

$$\mathbf{W}_4 = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \\ 1 & -1 & 1 & -1 \end{bmatrix}$$

How do we obtain the 2^{k+1} -point Walsh transform from the 2^k -point Walsh transform ?

Step 1 $\mathbf{V}_{2^{k+1}} = \begin{bmatrix} \mathbf{W}_{2^k} & \mathbf{W}_{2^k} \\ \mathbf{W}_{2^k} & -\mathbf{W}_{2^k} \end{bmatrix}$

Step 2 根據 sign changes 將 rows 的順序重新排列

$$\mathbf{V}_{2^{k+1}} \xrightarrow{\text{permutation}} \mathbf{W}_{2^{k+1}}$$

已知 \mathbf{W}_{2^k} 每個 row 的 sign change 數，由上到下分別為

$$0, 1, 2, 3, \dots, 2^k - 1$$

則 $\mathbf{V}_{2^{k+1}}$ 每個 row 的 sign change 數，由上到下分別為

$$0, 3, 4, 7, \dots, 2^{k+1} - 1, 1, 2, 5, 6, \dots, 2^{k+1} - 2,$$

若 row 的 index 由 0 開始

則 $\mathbf{V}_{2^{k+1}}$ 第 n 個 row (n is even and $n < N/2$) 的 sign change 為 $2n$

(n is odd and $n < N/2$) 的 sign change 為 $2n + 1$

(n is even and $n \geq N/2$) 的 sign change 為 $2n + 1 - N$

(n is odd and $n \geq N/2$) 的 sign change 為 $2n - N$

要根據 sign change 的數目將 $\mathbf{V}_{2^{k+1}}$ 的 row 重新排列

$$\mathbf{V}_{2^{k+1}} \xrightarrow{\text{permutation}} \mathbf{W}_{2^{k+1}}$$

$$\mathbf{W}_2 = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

$$\mathbf{V}_4 = \begin{bmatrix} \mathbf{W}_2 & \mathbf{W}_2 \\ \mathbf{W}_2 & -\mathbf{W}_2 \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix} \begin{matrix} 0 \\ 3 \\ 1 \\ 2 \end{matrix}$$

$$\mathbf{W}_4 = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \\ 1 & -1 & 1 & -1 \end{bmatrix}$$

$$\mathbf{V}_8 = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 \\ 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 \\ 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 \end{bmatrix} \begin{matrix} 0 \\ 3 \\ 4 \\ 7 \\ 1 \\ 2 \\ 5 \\ 6 \end{matrix}$$

Constraint for the number of points of the Walsh transform:

N must be a power of 2 (2, 4, 8, 16, 32,)

Although in Matlab it is possible to define the $12 \cdot 2^k$ point or the $20 \cdot 2^k$ point Walsh transform, the inverse transform require the floating-point operation.

© 13-C Alternative Forms of the Walsh Transform

標準定義

from zero-crossing

- Sequency ordering (i.e., Walsh ordering) using for signal processing
- Dyadic ordering (i.e., Paley ordering) using for control
- Natural ordering (i.e., Hadamard ordering) using for mathematics

Sequency ordering	Dyadic ordering	Natural ordering	$W[m, n]$
	←→ (Gray Code) ←→	(Bit Reversal)	
row 0 =	row 0 =	row 0 =	[1, 1, 1, 1, 1, 1, 1, 1]
row 1 =	row 1 =	row 4 =	[1, 1, 1, 1, -1, -1, -1, -1]
row 2 =	row 3 =	row 6 =	[1, 1, -1, -1, -1, -1, 1, 1]
row 3 =	row 2 =	row 2 =	[1, 1, -1, -1, 1, 1, -1, -1]
row 4 =	row 6 =	row 3 =	[1, -1, -1, 1, 1, -1, -1, 1]
row 5 =	row 7 =	row 7 =	[1, -1, -1, 1, -1, 1, 1, -1]
row 6 =	row 5 =	row 5 =	[1, -1, 1, -1, -1, 1, -1, 1]
row 7 =	row 4 =	row 1 =	[1, -1, 1, -1, 1, -1, 1, -1]

- Dyadic ordering
Walsh transform

$$W[m,n] = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 \\ 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 \\ 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 \\ 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 \end{bmatrix}$$

- Natural ordering
Walsh transform

$$W[m,n] = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 \\ 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 \\ 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 \end{bmatrix}$$

- binary code $n = \sum_{p=1}^k b_p 2^{p-1}$ to gray code

When $N = 2^k$

$$g_k = b_k, \quad g_q = \text{XOR}(b_{q+1}, b_q) \quad \text{for } q = k-1, k-2, \dots, 1 \quad m = \sum_{q=1}^k g_q 2^{q-1}$$

- gray code to binary code

When $N = 2^k$

$$b_k = g_k, \quad b_q = \text{XOR}(b_{q+1}, g_q) \quad \text{for } q = k-1, k-2, \dots, 1$$

© 13-D Properties

(1) Orthogonal Property

(2) Zero-Crossing Property

(3) Even / Odd Property

(4) Linear Property

If $f[n] \Rightarrow F[m]$, $g[n] \Rightarrow G[m]$, (\Rightarrow means the Walsh transform)

then $a f[n] + b g[n] \Rightarrow a F[m] + b G[m]$

(5) Addition Property

$$W[m, n] \cdot W[l, n] = W[m \oplus l, n]$$

註： Addition modulo 2 (denoted by \oplus)

$$0 \oplus 0 = 1 \oplus 1 = 0, \quad 0 \oplus 1 = 1 \oplus 0 = 1,$$

$$\left(\sum_{p=0}^k a_k 2^p\right) \oplus \left(\sum_{p=0}^k b_k 2^p\right) = \sum_{p=0}^k (a_k \oplus b_k) 2^p$$

Example: 3 0 1 1 , therefore $3 \oplus 7 = 4$

$$\begin{array}{r} 7 \\ 3 \\ \hline 4 \end{array} \quad \begin{array}{r} 1 \\ 1 \\ 0 \\ 0 \end{array}$$

\oplus : logic addition
(similar to XOR)

(6) Special functions

$$\delta[n] = 1 \text{ when } n = 0, \quad \delta[n] = 0 \text{ when } n \neq 0$$

$$\delta[n] \Rightarrow 1, \quad 1 \Rightarrow N \cdot \delta[n]$$

(7) Shifting property

$$\text{If } f[n] \Rightarrow F[m], \text{ then } f[n \oplus k] \Rightarrow W(k, m) \cdot F[m]$$

(8) Modulation property

$$\text{If } f[n] \Rightarrow F[m], \text{ then } W(k, n) \cdot f[n] \Rightarrow F[m \oplus k]$$

(9) Parseval's Theorem

$$\text{If } f[n] \Rightarrow F[m], \quad \text{If } f[n] \Rightarrow F[m], \quad g[n] \Rightarrow G[m],$$

$$\sum_{n=0}^{N-1} |f[n]|^2 = \frac{1}{N} \sum_{m=0}^{N-1} |F[m]|^2, \quad \sum_{n=0}^{N-1} f[n]g[n] = \frac{1}{N} \sum_{m=0}^{N-1} F[m]G[m]$$

(10) Convolution Property

If $f[n] \Rightarrow F[m]$, $g[n] \Rightarrow G[m]$,
 then $h[n] = f[n] \star g[n] \Rightarrow F[m] G[m]$

★ means the “logical convolution”

$$h[n] = f[n] \star g[n] = \sum_{l=0}^{N-1} f[l] g[n \oplus l]$$

$$\sum_{l=0}^{N-1} f[(n \oplus l)_N] g[l]$$

比較：

linear convolution

$$\sum_{l=0}^{N-1} f[n-l] g[l]$$

circular convolution

$$\sum_{l=0}^{N-1} f[(n-l)_N] g[l]$$

$$h[n] = f[n] \star g[n] = \sum_{l=0}^{N-1} f[l] g[n \oplus l]$$

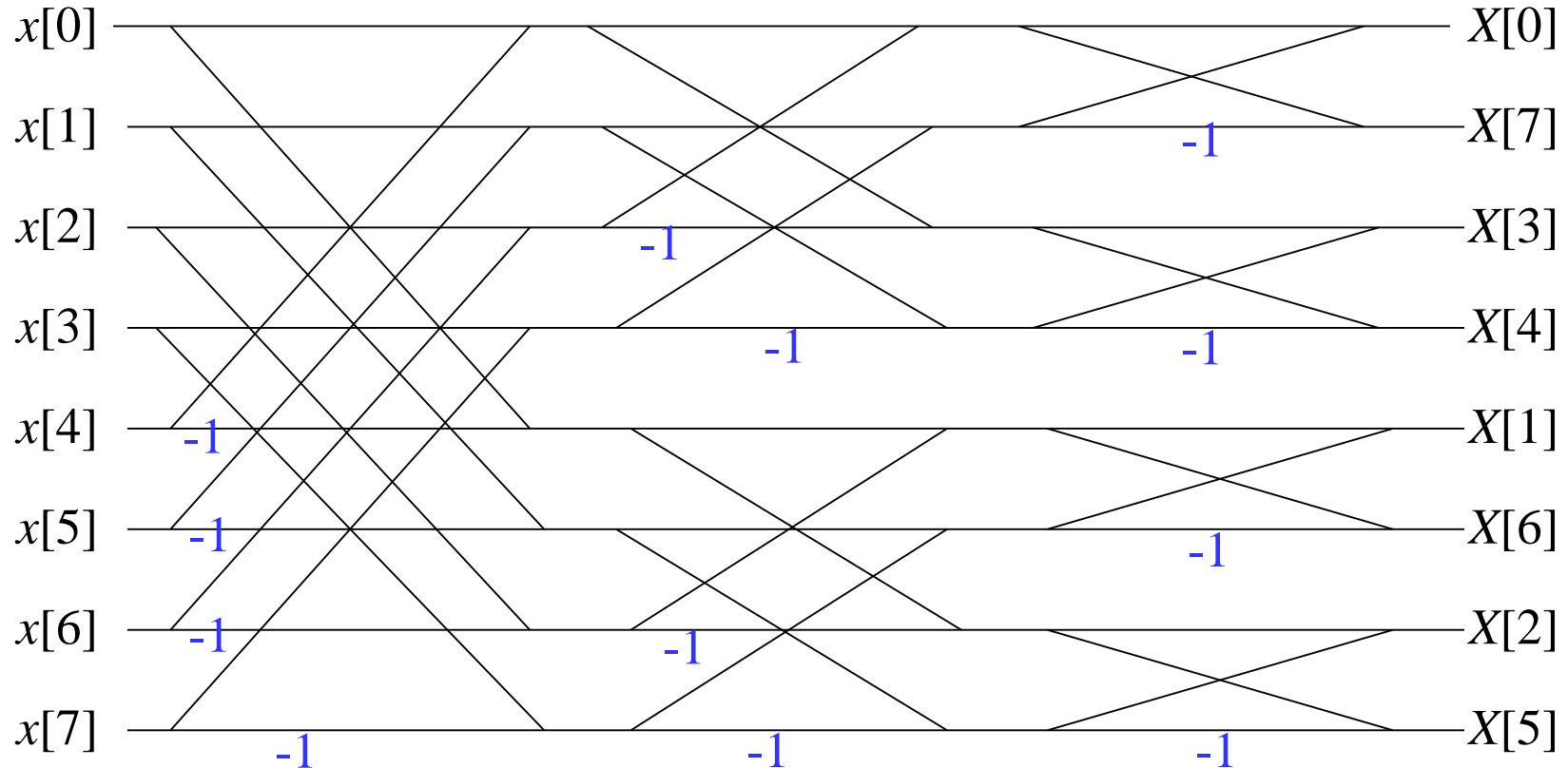
For example, when $N = 8$,

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

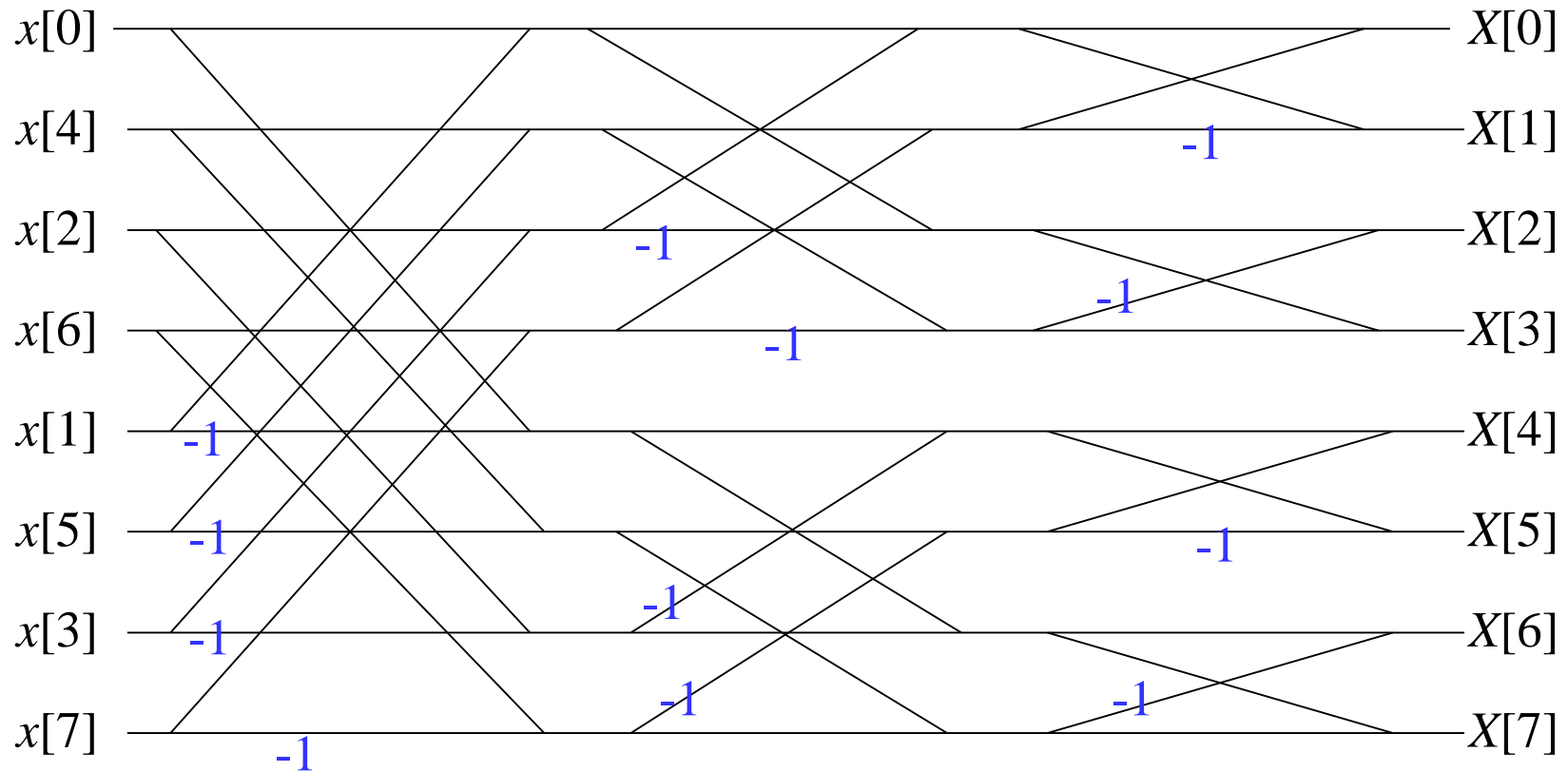
$$h[2] = f[0]g[2] + f[1]g[3] + f[2]g[0] + f[3]g[1] + f[4]g[6] + f[5]g[7] + f[6]g[4] \\ + f[7]g[5]$$

© 13-E Butterfly Fast Algorithm

(Method 1) John L. Shark's Algorithm



(Method 2) Manz's Sequence Algorithm



There are other fast implementation algorithm for the Walsh transform.

Walsh transform 適合作 spectrum analysis，但未必適合作 convolution

↓
may not be better than DFT, DCT

Applications of the Walsh transform

Bandwidth reduction

High resolution

Modulation and Multiplexing

Information coding

Feature extraction

ECG signal (in medical signal processing) analysis

Hadamard spectrometer

Avoiding quantization error

- The Walsh transform is suitable for the function that is a combination of Step functions

New Applications: CDMA (code division multiple access)

© 13-G Jacket Transform

把部分的 1 用 $\pm 2^k$ 取代

4-point Jacket transform

$$\mathbf{J}_4 = \begin{bmatrix} 1 & x & x & 1 \\ 1 & w & -w & -1 \\ 1 & -x & -x & 1 \\ 1 & -w & w & 1 \end{bmatrix} \quad w = 2^k, \quad x = 2^h,$$

2^{k+1} -point Jacket

$$\mathbf{J}_{2^{k+1}} = \mathbf{P} \begin{bmatrix} \mathbf{J}_{2^k} & \mathbf{J}_{2^k} \\ \mathbf{J}_{2^k} & -\mathbf{J}_{2^k} \end{bmatrix} \quad \mathbf{P}: \text{row permutation}$$

[Ref] M. H. Lee, “A new reverse Jacket transform and its fast algorithm,” *IEEE Trans. Circuits Syst.-II*, vol. 47, pp. 39-46, 2000.

© 13-H Haar Transform

$$\mathbf{y} = \mathbf{H}\mathbf{x}$$

$$N = 2 \quad \mathbf{H} = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

$$N = 4 \quad \mathbf{H} = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & 0 & 0 \\ 0 & 0 & 1 & -1 \end{bmatrix}$$

$$N = 8 \quad \mathbf{H} = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ 1 & 1 & -1 & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & -1 & -1 \\ 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 \end{bmatrix}$$

[Ref] H. F. Harmuth, *Transmission of Information by Orthogonal Functions*, Springer-Verlag, New York, 1972

[illegible]

$H[m, n]$ 的值 ($m = 0, 1, \dots, 2^k-1, n = 0, 1, \dots, 2^k-1$) :

$$H[0, n] = 1 \text{ for all } n$$

If $2^h \leq m < 2^{h+1}$

$$H[m, n] = 1 \text{ for } (m - 2^h)2^{k-h} \leq n < (m - 2^h + 1/2)2^{k-h}$$

$$H[m, n] = -1 \text{ for } (m - 2^h + 1/2)2^{k-h} \leq n < (m - 2^h + 1)2^{k-h}$$

$$H[m, n] = 0 \text{ otherwise}$$

運算量比 Walsh transforms 更少

Applications: localized spectrum analysis, edge detection

Transforms	Running Time	terms required for NRMSE $< 10^{-5}$
DFT	9.5 sec	43
Walsh Transform	2.2 sec	65
Haar Transform	0.3 sec	128

Main Advantage of the Haar Transform

- (1) Fast (but this advantage is no longer important)
- (2) Analysis of the local high frequency component
(The wavelet transform is a generalization of the Haar transform)
- (3) Extracting local features
(Example: Adaboost face detection)

附錄十三 SCI Papers 查詢方式

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SCI 全名：Science Citation Index

(A) SCI 相關網站：ISI Web of Knowledge

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Titles
 ISO: IEEE Trans. Signal Process.
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Categories
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24 Issues/Year,

Impact Factor (影響係數)

Key Indicators

Year ▼	Total Cites Graph	Journal Impact Factor Graph	Impact Factor Without Journal Self Cites Graph	5 Year Impact Factor Graph	Immediacy Index Graph	Citable Items Graph	Cited Half-Life Graph	Citing Half-Life Graph	Eigenfactor Score Graph	Article Influence Score Graph	% Articles in Citable Items Graph	Normalized Eigenfactor Graph	Average JIF Percentile Graph
2016	33,278	4.300	3.758	4.624	0.762	484	7.8	8.0	0.05...	1.550	99.79	6.73...	89.885
2015	22,917	2.624	2.133	3.157	0.462	496	7.8	7.6	0.06...	1.527	100.00	7.12...	86.965
2014	22,944	2.787	2.300	3.435	0.429	503	7.4	7.4	0.06...	1.473	100.00	6.90...	89.357
2013	22,913	3.198	2.658	3.592	0.439	508	7.2	7.2	0.07...	1.620	100.00	7.93...	90.927
2012	19,417	2.813	2.243	3.068	0.420	597	7.1	7.1	0.05...	1.291	100.00	Not ...	89.918
2011	16,727	2.628	2.111	2.829	0.421	527	6.9	7.2	0.05...	1.249	100.00	Not ...	88.776

(C) 關於 impact factor (影響係數)：

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Nature 的 impact factor 為 40.137

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IEEE 系列的期刊的 impact factors 通常在 1.5 到 6 之間

IEEE Trans. Image Processing 的 impact factors 在 4.828 左右

IEEE Trans. Signal Processing 的 impact factors 在 4.3 左右

中等水準的期刊的 impact factors 在 1 到 2.5 之間

(D) 要查詢一個領域有哪些 SCI journals

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<input type="checkbox"/>	4	CHEMICAL REVIEWS	159,155	47.928	0.24655	
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<input type="checkbox"/>	6	NATURE REVIEWS MOLECULAR CELL BIOLOGY	40,565	46.602	0.09573	
<input type="checkbox"/>	7	JAMA JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION	141,015	44.405	0.28035	
<input type="checkbox"/>	8	NATURE BIOTECHNOLOGY	53,992	41.667	0.16973	
<input type="checkbox"/>	9	NATURE REVIEWS GENETICS	32,654	40.282	0.10240	
<input type="checkbox"/>	10	NATURE	671,254	40.137	1.43257	
<input type="checkbox"/>	11	NATURE REVIEWS IMMUNOLOGY	34,948	39.932	0.09292	
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<input type="checkbox"/>	13	Nature Nanotechnology	48,814	38.986	0.17241	
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<input type="checkbox"/>	16	SCIENCE	606,635	37.205	1.15823	
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<input type="checkbox"/>	21	Annual Review of Astronomy and Astrophysics	9,417	30.733	0.02066	

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(G) Conference 排名

Microsoft Academic Search 有列出各領域知名的 conferences 並加以排名 (大致上也是被引用越多的排名越前面)

和通訊與信號處理相關的 conferences，大多排名於

<http://academic.research.microsoft.com/RankList?entitytype=3&topDomainID=2&subDomainID=0&last=0&start=1&end=100>

或

<http://academic.research.microsoft.com/RankList?entitytype=3&topDomainID=8&subDomainID=0&last=0&start=1&end=100>

寫論文和投稿的經驗談

研究生經常會寫論文並且投稿。要如何讓論文投稿之後能夠順利的被接受，相信是同學們所期盼的，畢竟每篇論文都是大家花了不少時間的心血結晶，若論文能夠順利的被接受，也代表了自己的成果總算獲得了肯定。然而，影響論文是否被接受的因素很多，一個好的研究成果，還是配合好的編寫技巧，才可以被一流的期刊或研討會所接受。以下是個人關於論文編寫與投稿的經驗談：

(1) 你的論文的「賣點」(優點)是什麼？人家有沒有辦法一眼看得出來你論文的「賣點」？

寫論文其實就是在推銷商品，而所謂的「商品」，就是你的「研究成果」。要說服人家接受你的商品，首先就是要強調你的商品的「賣點」。

(2) 和既有的方法的比較是否足夠？

要證明你所提出的方法是有效的，最好的方式，就是和既有的方法相比較，而且比較的對象越多越好，越新越好。

- (3) 和前人的方法相比，你的方法**創新**的地方在何處？審稿者是否能看得出來你論文創新的地方？
- (4) 就算你的文章和理論相關，最好也多提出實際應用的例子
- (5) 參考資料越多越好，越新越好
(在研究一個領域時，論文 survey 的量要足夠)
- (6) Previous work (前人已經提出的概念) 精簡介紹即可，多強調自己的貢獻。Introduction 加上 Previous work 最好不要超過一篇論文的四分之一
- (7) 英文表達能力要有一定的水準

(8) 可以多用數學式和圖來解釋概念，有時會比文字還清楚

通常東方人英文表達能力有限。審稿者經常會看你們的圖表和數學式(而非文字)來判斷你們論文的品質

(9) 同樣的道理，可以用「條列式」的方式來取代一大段文字來描述方法的觀念、流程、或優點

(10) 可以用 Conference 的期限來要求自己多寫研討會論文，之後再一個一個改成期刊論文投稿，如此一年的論文量將很可觀

(11) 多注意格式，不同的期刊或研討會，對格式的要求也不同

(12) 最後，問自己一個問題：

如果你是審稿者，你會滿意你寫的這一篇論文嗎？

若答案是肯定的再投稿