ADSP HW4 潘皆循 R09945006

2)

→ $\begin{bmatrix} X[0] \\ X[1] \\ X[2] \\ X[3] \\ X[4] \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \\ 0.9511 & 0.5878 & 0 & -0.5878 & -0.9511 \\ 0.8090 & -0.3090 & -1 & -0.3090 & 0.8090 \\ 0.5878 & -0.9511 & 0 & 0.9511 & -0.5878 \\ 0.3090 & -0.8090 & 1 & -0.8090 & 0.3090 \end{bmatrix} \begin{bmatrix} x[0] \\ x[1] \\ x[2] \\ x[3] \\ x[4] \end{bmatrix}$ (矩陣乘法)

add, add

① $\begin{bmatrix} 0.9511 & 0.5878 \\ 0.5878 & -0.9511 \end{bmatrix} \begin{bmatrix} x[0]-x[4] \\ x[1]-x[3] \end{bmatrix}$

→ $\begin{bmatrix} 0.5878 & -0.9511 \\ 0.9511 & 0.5878 \end{bmatrix} \begin{bmatrix} x[1]-x[3] \\ x[0]-x[4] \end{bmatrix}$

→ phase, case 4 → 3 MULs

② $\begin{bmatrix} 0.8090 & -0.3090 \\ 0.3090 & -0.8090 \end{bmatrix} \begin{bmatrix} x[0]+x[4] \\ x[1]+x[3] \end{bmatrix}$ (b, $-b+0.5$, $b-a$, $-b$)

→ $\begin{bmatrix} b & -b \\ b & -b \end{bmatrix} \begin{bmatrix} x[0]+x[4] \\ x[1]+x[3] \end{bmatrix} + \begin{bmatrix} 0 & a \\ -a & 0 \end{bmatrix} \begin{bmatrix} x[0]+x[4] \\ x[1]+x[3] \end{bmatrix}$ (trivial)

→ 1 MULs

⇒ 共 4 MULs

3)

$x = a+jb$, $\exp(j\theta) = \cos\theta + j\sin\theta$

$x\exp(j\theta) = (a+jb)(\cos\theta+j\sin\theta) = (a\cos\theta - b\sin\theta) + j(a\sin\theta + b\cos\theta)$

$= e + jf$

→ $\begin{bmatrix} e \\ f \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} a \\ b \end{bmatrix}$

$= \begin{bmatrix} \cos\theta & \cos\theta \\ \cos\theta & \cos\theta \end{bmatrix} \begin{bmatrix} a \\ b \end{bmatrix} + \begin{bmatrix} 0 & \sin\theta-\cos\theta \\ \sin\theta-\cos\theta & 0 \end{bmatrix} \begin{bmatrix} a \\ b \end{bmatrix}$

1 MUL; if $\cos\theta = \sin\theta$: 1 MUL

→ 若 $\cos\theta = \sin\theta$，可使後半矩陣 1 MUL，共 2 MULs

4)

a) $220 = 11 \times 20$ → $11 \times 4 + 20 \times 4 = 124$

b) $161 = 11 \times 21$ → $11 \times 6 + 21 \times 4 = 152$

c) $45 = 5 \times 9$ → $5 \times (3 \times 6 + 3 \times 6 + 3 \times 6) + 9 \times 10 = 150$

5)

i) Low complexity : $O(N)$

ii) fixed hardware architecture

6)

$x_3[n]$

$= 0.4(x[n+1]+x[n-1]) + 0.06(x[n+4]+x[n-4]) + 0.09(x[n+2]+x[n-2]) + 0.24x[n]$

$= 0.09\left((x[n+3]+x[n-3]) + 2(x[n+2]+x[n-2]) + 2^2(x[n+1]+x[n-1])\right) + 0.16x[n]$ (trivial, trivial)

→ 2 MULs

7)

a) $N = 1100$, $M = 200$

i) Direct : $3 \times 1100 \times 200 = 660000$

ii) DFT : $P = 1100+200-1 = 1299$ → 1344 point DFT

→ $2 \times 8 \times 5 \times 2 + 3 \times 1344 = 20506$

iii) Section : $L_0 = 550$ → $P_0 = 749$ → $P = 720$ → $L = 521$

→ $S = 3$ ⇒ $6 \times 3620 + 9 \times 720 = 28200$

⇒ DFT is better

b) $N = 1100$, $M = 20$

i) Direct : $3 \times 1100 \times 20 = 66000$

ii) DFT : $P = 1100+20-1 = 1119$ → 1024 point DFT

→ $2 \times 7406 + 3 \times 1024 = 17944$

iii) Section : $L_0 = 105$ → $P_0 = 124$ → $P = 120$ → $L = 101$

→ $S = 8$ ⇒ $16 \times 380 + 24 \times 120 = 8960$

⇒ sectioned convolution is better

c) $N = 1100$, $M = 7$

i) Direct : $3 \times 1100 \times 7 = 23100$

ii) DFT : $P = 1100+7-1 = 1106$ → 1152

→ $2 \times 7088 + 3 \times 1152 = 17632$

iii) Section : $L_0 = 25$ → $P_0 = 31$ → $P = 28$ → $L = 22$

→ $S = 50$ → $100 \times 64 + 150 \times 28 = 10600$

⇒ sectioned convolution is better

d) $N = 1100$, $M = 2$

i) Direct : $3 \times 1100 \times 2 = 6600$

ii) DFT : $P = 1100+2-1 = 1101$ → 1152 → 17632

iii) Section : $L_0 = 2$ → $P_0 = 3$ → $P = 3$ → $L = 2$

→ $S = 550$ ⇒ $1100 \times 2 + 1650 \times 3 = 7150$

→ Direct implement is better