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%                                     DSP_Project_4
%
% Design of Fractional_Delay_FIR_Digital_Filters
%
clear all; % clear workspace
clc; % clear command window
N = 50;
M = 7; % M=7為奇數 0 1 2 3 4 5 6 7
%      偶數項 2 4 6, 項數 3
%      奇數項 1 3 5 7, 項數 4
% M=8為偶數 0 1 2 3 4 5 6 7 8
%      偶數項 2 4 6 8, 項數 4
%      奇數項 1 3 5 7, 項數 4
wp = 0.9*pi;
pointw = 200;
pointp = 60;
%
%
j = 0 + i;
NH = N/2;
if mod(M, 2) == 0
    Mc = M/2;
    Ms = M/2;
else
    Mc = (M-1)/2;
    Ms = (M+1)/2;
end
nma = (NH+1) * Mc;
nmb = NH * Ms;
deltaw = wp/pointw;
deltap = 1/pointp;
point = (pointw + 1) * (pointp + 1);
%
%
ra = zeros(nma, 1);
Qa = zeros(nma, nma);
for iw = 0:pointw
    w = iw * deltaw;
    for ip = 0:pointp
        p = -0.5 + ip*deltap;
        c = zeros(nma, 1);
        for ic = 0:nma-1
            n = mod(ic, NH+1);
            m = floor(ic/(NH+1)) + 1;
            c(ic+1) = p^(2*m) * cos(n*w);
        end
    end
end

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        ra = ra - 2*(cos(p*w)-1)*c;
        Qa = Qa + c*c';
    end
end
ra = wp * ra / point;
Qa = wp * Qa / point;
a = -0.5 * inv(Qa)*ra;
%
%
rb = zeros(nmb, 1);
Qb = zeros(nmb, nmb);
for iw = 0:pointw
    w = iw * deltaw;
    for ip = 0:pointp
        p = -0.5 + ip*deltap;
        s = zeros(nmb, 1);
        for is = 0:nmb-1
            n = mod(is, NH) + 1;
            m = floor(is/NH) + 1;
            s(is+1) = p^((2*m)-1) * sin(n*w);
        end
        rb = rb + 2*sin(p*w)*s;
        Qb = Qb + s*s';
    end
end
rb = wp * rb / point;
Qb = wp * Qb / point;
b = -0.5 * inv(Qb)*rb;
%
%
a2 = reshape(a, NH+1, Mc); % a 分成 Mc 小段
b2 = reshape(b, NH, Ms); % b 分成 Ms 小段
h = zeros(N+1, M+1);
h(NH+1, 1) = 1; % middle = 1
for im = 1:Mc
    h(NH+1, 2*im+1) = a2(1, im);
    h(1:NH, 2*im+1) = 0.5 * a2(NH+1:-1:2, im);
    h(NH+2:N+1, 2*im+1) = 0.5 * a2(2:NH+1, im);
end
for im = 1:Ms
    h(1:NH, 2*im) = 0.5 * b2(NH:-1:1, im);
    h(NH+2:N+1, 2*im) = -0.5 * b2(1:NH, im);
end
%
%
MR = zeros(pointw+1, pointp+1); % Magnitude Response
GD = zeros(pointw+1, pointp+1); % Group-Delay Response

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for ip = 0:pointp
    p = -0.5 + ip*deltap;
    hnp = h(:, 1);
    for im = 1:M
        hnp = hnp + h(:, im+1) * p^(im);
    end
    MR(:, ip+1) = abs(freqz(hnp, 1, 0:deltaw:wp));
    GD(:, ip+1) = grpdelay(hnp, 1, 0:deltaw:wp);
end
%
%
XX = zeros(pointw+1, pointp+1);
YY = zeros(pointw+1, pointp+1);

for ip = 0:pointp
    XX(:, ip+1) = (0:deltaw:wp)'/pi;
end
for iw = 0:pointw
    YY(iw+1,:) = (-0.5:deltap:0.5);
end
%
subplot(1, 2, 1);
plot3(XX, YY, MR);
axis([0, wp/pi, -0.5, 0.5, 0, 1.1]);
xlabel('Frequency');
ylabel('Variable p');
zlabel('Magnitude Response');
subplot(1, 2, 2);
plot3(XX, YY, GD);
axis([0, wp/pi, -0.5, 0.5, NH-0.5, NH+0.5]);
xlabel('Frequency');
ylabel('Variable p');
zlabel('Group-Delay Response');
%
%
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```
% Fractional_Delay_FIR_Digital_Filter
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