Lab 1：Introduction

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| Introduction   1. In the problem 2.4, we verified the commutative, associative and distributive properties of convolution for a specific set of signals. And mainly uses the conv() to solve this problem. 2. In the problem 2.5, we mainly use the conv() and filter() functions to solve the problems. We learned the system properties of linearity and time-invariance. 3. In the problem 2.10, we learned how to remove the echo of a recording of speech signal.   Lab results & Analysis：  Problem 2.4        The figure is shown below      The output results are as below. We can figure out that the answer is regardless of the order.      The two methods gave the same result. So the distributive property is verified.      The results are the same. So the associative property is verified.      As shown below, we can see that when using the commutative property, the outputs are the same if changing the input and impulse response of the system . And we can know that .        We can see from the figure below that .  But it couldn’t prove that the associative property is wrong. The reason is that System 1: y[n] = (n+1)x[n] is not a LTI system. So we can’t apply the associative property.      We can see from the figure below that yg1 is not equal to yg2. But it can’t prove the distributive property of convolution is wrong. The reason is that System 1: is not a LTI system. So we can’t apply the distributive property.    2.5    (a).        (b).  As shown in the Figure 2.5(a) and Figure 2.5(c), System 1 and System 3 is linear. and have the same output. and , so System 1 is linear. , and , so System 3 is linear.  As shown in the Figure 2.5(b), System 2 is not linear. Since and don’t have same output. , so System 2 is not linear.  (c).  As shown in the Figure 2.5(a) and Figure 2.5(b), System 1 is time-invariant. We can see the graphs of , and the graphs of and . The graph of is same to the graph of after translation. The graph of is same to the graph of after translation.  As shown in the Figure 2.5(c), System 3 isn’t time-invariant. The graph of isn’t same to the graph of after translation. , , but .        (d).  System 1: A = [1 -3/5]; B = 1; x = [1 zeros(1,19)]; h1 = filter(B, A, x);  System 2: for i = 2:21 , h2(i) = ((3/5)^(i-2)) \* h2(i-1) + x(i-1) ,end; h2 = h2(2:end);    (e). System 1: A = [1 -3/5]; B = 1; u = [ ones(1,20)]; s1 = filter(B, A, u);  System 2: for i = 2:21, s2(i) = ((3/5)^(i-2)) \* s2(i-1) + u(i-1), end; s2 = s2(2:end);      (g). . Because the System 1 is a LTI system. So, for not LTI system: System 2, .  2.10          As shown in this figure, he = .      As shown in the figure, z[n] = x[n] is a valid solution. The reason is that y[n] z[n]\*he[n].      As shown in the figure, it is her.      This figure is the sound which cannot hear the echo.      The result is not a unit impulse. The echo removal system should have infinite-length impulse response, but our system is not infinite.        For y:  As shown in the figure, we can find that for y, N=1000 and we can calculate :  So, we can get that:  So, is an equation, and we could get using the extract roots formula.  So the answer is    For y2:  As shown in the figure, for y2, N=501 and we could calculate the :  So,  So, is a binary first order equation, we can get using extract roots formula.  So the answer is    As shown in the figure, we can find for y3, =751, =2252 and calculate :  And .  Then we can get .  Finally, we use sound (y, 8192), sound (y2, 8192), sound (y3, 8192) could find out that there is no echo.  Codes:  **2.4**  % Problem 2.4(a)  x1 = [1 1 1 1 0 0 0 0 0 0];  nx1 = 0:1:9;  h1 = [1 -1 3 0 1];  h2 = [0 2 5 4 -1];  nh1 = 0:1:4;  subplot(3, 1, 1), stem(nx1, x1), title("x\_1[n]");  subplot(3, 1, 2), stem(nh1, h1), title("h\_1[n]");  subplot(3, 1, 3), stem(nh1, h2), title("h\_2[n]");  saveas(gcf, "plots/P2\_4\_a.png");  close;  % Problem 2.4(b)  x1 = [1 1 1 1 0 0 0 0 0 0];  nx1 = 0:1:9;  h1 = [1 -1 3 0 1];  nh1 = 0:1:4;  y1 = conv(x1, h1);  y2 = conv(h1, x1);  ny = nh1(1)+nx1(1):1:nh1(end)+nx1(end);  subplot(2,1,1), stem(ny, y1), title("y1[n]=x1[n]\*h1[n]");  subplot(2,1,2), stem(ny, y2), title("y2[n]=h1[n]\*x1[n]");  saveas(gcf, "plots/P2\_4\_b.png");  close;  % Problem 2.4(c)  x1 = [1 1 1 1 0 0 0 0 0 0];  nx1 = 0:1:9;  h1 = [1 -1 3 0 1];  h2 = [0 2 5 4 -1];  nh1 = 0:1:4;  y11 = conv(x1,h1);  y12 = conv(x1,h2);  y1 = y11+y12;  h12 = h1+h2;  y2 = conv(x1,h12);  ny = nh1(1)+nx1(1):1:nh1(end)+nx1(end);  subplot(2, 1, 1), stem(ny, y1), title("y1 = (x[n]\*h1[n]+x[n]\*h2[n])");  subplot(2, 1, 2), stem(ny, y2), title("y2 = x[n]\*(h1[n]+h2[n])");  saveas(gcf, "plots/P2\_4\_c.png");  close;  % Problem 2.4(d)  x1 = [1 1 1 1 0 0 0 0 0 0];  nx1 = 0:1:9;  h1 = [1 -1 3 0 1];  h2 = [0 2 5 4 -1];  nh1 = 0:1:4;  y1 = conv(conv(x1, h1), h2);  y2 = conv(x1, conv(h1, h2));  ny = nh1(1)+nx1(1):1:nh1(end)+nh1(end)+nx1(end)  subplot(2,1,1), stem(ny, y1), title("yd1[n]=(x\_1[n]\*h\_1[n])\*h\_2[n]");  subplot(2,1,2), stem(ny, y2), title("yd2[n]=x\_1[n]\*(h\_1[n]\*h\_2[n])");  saveas(gcf, "plots/P2\_4\_d\_out.png");  close;  % Problem 2.4(e)  x1 = [1 1 1 1 0 0 0 0 0 0];  nx1 = 0:1:9;  h1 = [1 -1 3 0 1];  h2 = [0 2 5 4 -1];  nh1 = 0:1:4;  he1 = h1;  he2 = [0 0 h1];  nhe2 = 0:1:6;  nye1 = nh1(1)+nx1(1):1:nh1(end)+nx1(end);  nye2 = nhe2(1)+nx1(1):1:nhe2(end)+nx1(end);  ye1 = conv(x1, he1);  ye1\_inter = conv(he1, x1);  ye2 = conv(x1, he2);  ye2\_inter = conv(he2, x1);  subplot(3,1,1);  hold on  stem(nye1, ye1, 's');  stem(nye1, ye1\_inter, 'p');  legend('y\_{e1}[n] = x\_1[n]\*h\_{e1}[n]', 'y\_{e1}[n] = h\_{e1}[n]\*x\_1[n]', 'Location', 'northeast');  subplot(3,1,2);  hold on  stem(nye2, ye2, 's');  stem(nye2, ye2\_inter, 'p');  legend('y\_{e2}[n] = x\_2[n]\*h\_{e2}[n]', 'y\_{e2}[n] = h\_{e2}[n]\*x\_2[n]', 'Location', 'northeast');  subplot(3,1,3);  hold on  stem(nye1+2, ye1, 's');  stem(nye2, ye2, 'p');  legend('y\_{e1}[n-n\_0]', 'y\_{e2}[n]', 'Location', 'northeast');  saveas(gcf, "plots/P2\_4\_e.png");  close;  % Problem 2.4(f)  x1 = [1 1 1 1 0 0 0 0 0 0];  nx1 = 0:9;  h1 = [1 -1 3 0 1];  h2 = [0 2 5 4 -1];  nh1 = 0:4;  w = x1.\*(nx1+1);  hw = nx1;  yf1 = conv(w, h1);  nyf1 = (hw(1)+nh1(1)):1:(hw(end)+nh1(end));  hf1 = [1 0 0 0 0].\*[1 2 3 4 5];  nhf1 = 0:1:4;  hf2 = h1;  nhf2 = nh1;  hseries = conv(hf1, hf2);  nhseries = (nhf1(1)+nhf2(1)):(nhf1(end)+nhf2(end));  yf2 = conv(x1, hseries);  nyf2 = (nx1(1)+nhseries(1)):(nx1(end)+nhseries(end));  figure;  hold on  stem(nyf1, yf1, 's');  stem(nyf2, yf2, 'p');  title('y\_{f1}[n] & y\_{f2}[n]');  legend('y\_{f1}[n]', 'y\_{f2}[n]', 'Location', 'northeast');  xlabel('n');  saveas(gcf, "plots/P2\_4\_f.png");  close;  % Problem 2.4(g)  x1 = [1 1 1 1 0 0 0 0 0 0];  nx1 = 0:1:9;  h1 = [1 -1 3 0 1];  h2 = [0 2 5 4 -1];  nh1 = 0:1:4;  nh2 = nh1;  xg = [2 0 0 0 0];  nxg = 0:1:4;  yga = xg.^2;  nyga = nxg;  hg2 = h2;  nhg2 = nh2;  ygb = conv(xg, hg2);  nygb = (nxg(1)+nhg2(1)):1:(nxg(end)+nhg2(end));  yg1 = [yga 0 0 0 0] + ygb;  nyg1 = nygb;  hg1 = [1 0 0 0 0].^2;  nhg1 = nxg;  hparallel = hg1 + hg2;  yg2 = conv(xg, hparallel);  nyg2 = nyg1;  figure;  hold on;  stem(nyg1, yg1, 's');  stem(nyg2, yg2, 'p');  title('y\_{g1}[n] & y\_{g2}[n]');  legend('y\_{g1}[n]', 'y\_{g2}[n]', 'Location', 'northeast');  saveas(gcf, "plots/P2\_4\_g.png");  close;  **2.5**  2.5(a)  x1 = [1 0 0 0 0 0];  x2 = [0 1 0 0 0 0];  x3 = [1 2 0 0 0 0];  nx = 0:5;  xe1 = [0 0 x1];  xe2 = [0 0 x2];  xe3 = [0 0 x3];  w1 = x1;  w2 = x2;  w3 = x3;  for i = 3:8  w1(i-2) = xe1(i) - xe1(i-1) - xe1(i-2);  w2(i-2) = xe2(i) - xe2(i-1) - xe2(i-2);  w3(i-2) = xe3(i) - xe3(i-1) - xe3(i-2);  end  w4 = w1 + 2\*w2;  subplot(3, 1, 1), stem(nx, w1), set(get(gca, 'Title'), 'String', 'w\_1[n]');  subplot(3, 1, 2), stem(nx, w2), set(get(gca, 'Title'), 'String', 'w\_2[n]');  subplot(3, 1, 3)  hold on  stem(nx, w3, 'b--s')  stem(nx, w4, 'r--p')  set(get(gca, 'Title'), 'String', 'w\_3[n] and w\_4[n]');  legend('w\_3[n]', 'w\_4[n]', 'Location', 'southeast');  saveas(gcf, "P2\_5\_a\_1.png");  2.5(b)  x1 = [1 0 0 0 0 0];  x2 = [0 1 0 0 0 0];  x3 = [1 2 0 0 0 0];  nx = 0:5;  w1 = cos(x1);  w2 = cos(x2);  w3 = cos(x3);  w4 = w1 + 2 \* w2;  subplot(3, 1, 1), stem(nx, w1), set(get(gca, 'Title'), 'String', 'w\_1[n]');  subplot(3, 1, 2), stem(nx, w2), set(get(gca, 'Title'), 'String', 'w\_2[n]');  subplot(3, 1, 3)  stem(nx, w3)  hold on  stem(nx, w4, 'r')  set(get(gca, 'Title'), 'String', 'w\_3[n] and w\_4[n]');  legend('w\_3[n]', 'w\_4[n]', 'Location', 'southeast');  saveas(gcf, "P2\_5\_a\_2.png");  2.5(c)  x1 = [1 0 0 0 0 0];  x2 = [0 1 0 0 0 0];  x3 = [1 2 0 0 0 0];  nx = 0:5;  xe1 = [0 0 x1];  xe2 = [0 0 x2];  xe3 = [0 0 x3];  w1 = x1.\*nx;  w2 = x2.\*nx;  w3 = x3.\*nx;  w4 = w1 + 2\*w2;  subplot(3, 1, 1), stem(nx, w1), set(get(gca, 'Title'), 'String', 'w\_1[n]');  subplot(3, 1, 2), stem(nx, w2), set(get(gca, 'Title'), 'String', 'w\_2[n]');  subplot(3, 1, 3)  stem(nx, w3, 'm--s')  hold on  stem(nx, w4, 'r--p')  set(get(gca, 'Title'), 'String', 'w\_3[n] & w\_4[n]');  legend('w\_3[n]', 'w\_4[n]', 'Location', 'southeast');  saveas(gcf, "P2\_5\_a\_3\_out.png");  2.5(d)  a = [1 -3/5];  b = 1;  x = [1 zeros(1,19)];  h1 = filter(b, a, x);  h2 = zeros(1,21);  nh = 0:19;  for i = 2:21  h2(i) = ((3/5)^(i-2)) \* h2(i-1) + x(i-1)  end  h2 = h2(2:end);  figure;  subplot(2, 1, 1);  stem(nh, h1);  title('y\_1[n]=(3/5)y\_1[n-1]+x[n]');  xlabel('n');  ylabel('h\_1[n]');  subplot(2, 1, 2);  stem(nh, h2);  title('y\_2[n]=(3/5)^ny\_1[n-1]+x[n]');  xlabel('n');  ylabel('h\_2[n]');  saveas(gcf, "P2\_5\_d\_out.png");  2.5(e)  u = ones(1, 20);  s1 = filter(b, a, u);  s2 = zeros(1,21);  ns = 0:19;  for i = 2:21  s2(i) = ((3/5)^(i-2)) \* s2(i-1) + u(i-1)  end  s2 = s2(2:end);  figure;  subplot(2, 1, 1);  stem(ns, s1);  title('y\_1[n]=(3/5)y\_1[n-1]+x[n]');  xlabel('n');  ylabel('s\_1[n]');  subplot(2, 1, 2);  stem(ns, s2);  title('y\_2[n]=(3/5)^ny\_1[n-1]+x[n]');  xlabel('n');  ylabel('s\_2[n]');  saveas(gcf, "P2\_5\_e\_out.png");  2.5(f)  z1 = conv(h1, u);  z1 = z1(1:20);  z2 = conv(h2, u);  z2 = z2(1:20);  nz = 0:19;  figure;  subplot(2, 1, 1);  stem(nz,z1);  title('z1[n]');  xlabel('n');  ylabel('z1[n]');  subplot(2, 1, 2);  stem(nz, z2);  title('z2[n]');  xlabel('n');  ylabel('z2[n]');  saveas(gcf, "P2\_5\_f\_out.png");  2.5(g)  figure;  subplot(3, 1, 1);  hold on;  stem(nz, s1, 'm--s');  stem(nz, z1, 'r--p');  legend('s\_1[n]', 'z\_1[n]', 'Location', 'northeast');  title('s\_1[n] & z\_1[n]');  xlabel('n');  ylabel('s\_1[n] / z\_1[n]');  subplot(3, 1, 2);  stem(ns, s2);  title('s\_2[n]');  subplot(3, 1, 3);  stem(nz, z2);  title('z\_2[n]');  saveas(gcf, "P2\_5\_g\_out.png");  **2.10**  % Problem 2.10(a)  load lineup.mat  %sound(y, 8192);  figure;  plot(y)  title('Sound befor filtering');  saveas(gcf, "plots/P2\_10\_ini\_out.png");  close;  % 2.10(a)  x = [1 zeros(1, 1000)];  nx = 0:1000;  he = zeros(1, 1001);  nhe = 0:1000;  for i = 1:1001  if i < 1001  he(i) = x(i);  else  he(i) = x(i) + 0.5\*x(i-1000);  end  end  figure;  stem(nhe, he);  title('h\_e[n]');  xlabel('n');  saveas(gcf, "plots/P2\_10\_a.png");  close;  % 2.10(b)  % This is not a problem that require to be verified by MATLAB  A = [1 zeros(1, 999) 0.5];  B = [1];  z = filter(B, A, y);  figure;  stem(conv(z,he),'\*');  hold on;  stem(y,'p--g')  title('y[n] & z[n]\*he[n]');  xlabel('n');  saveas(gcf, "plots/P2\_10\_b.png");  close;  % 2.10(c)  a = [1 zeros(1, 999) 0.5];  b = [1];  d = [1, zeros(1, 4000)];  nd = 0:4000;  her = filter(b, a, d);  nher = 0:4000;  figure;  stem(nd, her);  title('h\_{er}[n]');  xlabel('n');  saveas(gcf, "plots/P2\_10\_c.png");  close;  % 2.10(d)  % I feel that the given value 1000 and 0.5 are fine.  a = [1 zeros(1, 999) 0.5]  z = filter(1, a, y);  figure;  plot(z);  title('after filtering sound');  saveas(gcf, "plots/P2\_10\_d.png");  %close;  sound(z, 8192);  % 2.10(e)  hoa = conv(her, he);  nhoa = (nher(1)+nhe(1)):(nher(end)+nhe(end));  figure;  stem(nhoa, hoa);  title('h\_{oa}[n]');  xlabel('n');  saveas(gcf, "plots/P2\_10\_e.png");  close;  % Problem 2.10(f)  load lineup.mat  A = [1 zeros(1, 999) 0.5];  B = [1];  z = filter(B, A, y);  z=z';  rxx=conv(z, fliplr(z));  % For y1  ryy1 = conv(y, flip(y));  nryy1 = -(length(y)-1):(length(y)-1);  figure;  plot(nryy1, ryy1);  title('y[n]\*y[-n]');  saveas(gcf, "plots/P2\_10\_f1\_1.png");  close;  a1=rxx(7000);b1=2\*rxx(8000);c1=rxx(7000)-ryy1(7000);  d1=b1^2-4\*a1\*c1;  x1=(-b1+d1^0.5)/(2\*a1);  N = 1000;  yo1 = filter(1, [1 zeros(1, N-1) x1], y);  sound(yo1, 8192);  % For y2  ryy2 = conv(y2, flip(y2));  nryy2 = -(length(y2)-1):(length(y2)-1);  figure;  plot(nryy2, ryy2);  title('y\_2[n]\*y\_2[-n]');  saveas(gcf, "plots/P2\_10\_f1\_2.png");  close;  a2=rxx(7000);b2=2\*rxx(7501);c2=rxx(7000)-ryy2(7000);  d2=b2^2-4\*a2\*c2;  x2=(-b2+d2^0.5)/(2\*a2);  N = 501;  yo2 = filter(1, [1 zeros(1, N-1) x2], y2);  sound(yo2, 8192);  % For y3  ryy3 = conv(y3, flip(y3));  nryy3 = -(length(y3)-1):(length(y3)-1);  figure;  plot(nryy3, ryy3);  title('y\_3[n]\*y\_3[-n]');  saveas(gcf, "plots/P2\_10\_f1\_3.png");  close;  Note: Please indicate meaning of the symbols in all expressions. Please indicate the coordinate and unit in all figures. | |
| Experience  You can write your experience with this project. Any comment and suggestion on this course are also very welcome. | |
| Score |  |

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