HW2 实验报告

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实验三 基于傅里叶级数的信号分解

rect.m

```
%yo 为矩形脉冲信号
%y 为其傅里叶级数, mse 为均方误差
% h 为脉高，w 为脉宽，n 为项数
function [y, yo, mse] = rect(h, w, n, x)
T = 2 * w; %周期
yo = h * rectpuls(x, w);
y = h * w / T;
for k = 1:n
    y = y + ((2 * h * w * sin(k * pi * w / T) / (k * pi)) * cos(k * 2 * pi * x / T));
end
mse = norm(y - yo);
```

fig.m

```
x = -1:0.01:1;
[y1, yo, m1] = rect(1, 1, 10, x);
[y2, yo, m2] = rect(1, 1, 100, x);
[y3, yo, m3] = rect(1, 1, 1000, x);
[y4, yo, m4] = rect(1, 1, 10000, x);
figure(1);
plot(x, y1, '-y', x, y2, '--m', x, y3, ':c', x, y4, '-.r', x, yo, 'k');

m = zeros([1,1000]);
for k = 1:1000
    [y, yo, m(k)] = rect(1, 1, k, x);
end
x2 = 1:1000;
figure(2);
plot(x2, m);
```

运行结果

下图中黑色为原始矩形脉冲信号，其余为余弦项数不同的傅里叶近似信号。近似信号的波形相比原始脉冲信号不够平滑，有很多波动与毛刺。而且波动与毛刺随着余弦项数的增加而显著减少。

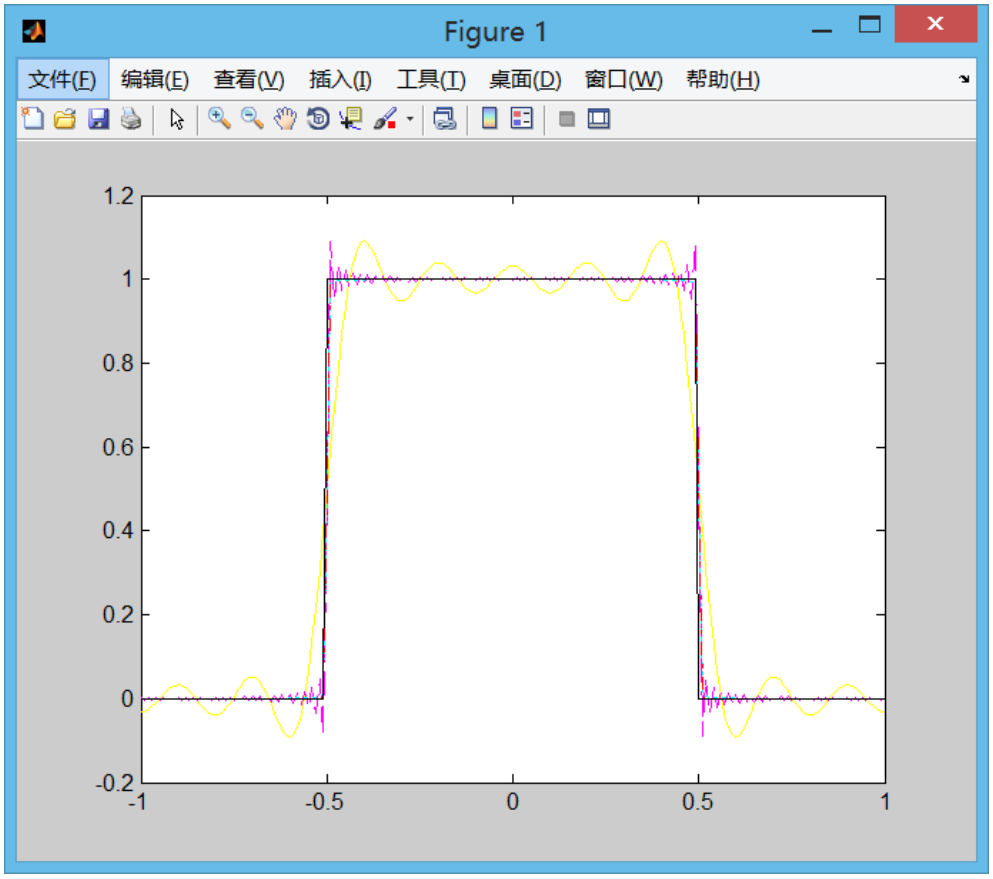

Figure 1

下图为均方误差随着余弦项数的变化曲线。可以很明显的看出，随着余弦项数的增加，均方误差递减，且递减的趋势也递减。

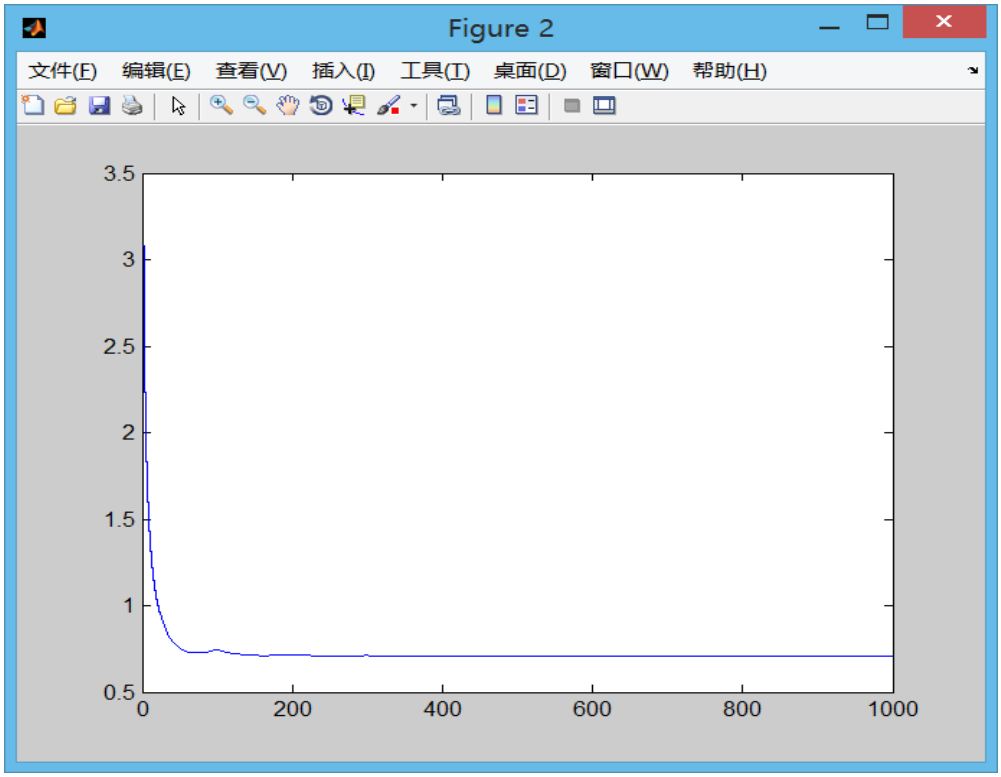

Figure 2

实验四 双音频按键识别

1. 编码规则

DTMF keypad frequencies (with sound clips)				
	1209 Hz	**1336 Hz**	**1477 Hz**	**1633 Hz**
697 Hz	1	2	3	A
770 Hz	4	5	6	B
852 Hz	7	8	9	C
941 Hz	*	0	#	D

2. DTMF 声音生成

dial.m

```
%产生 DTMF 信号
function y = dial(keyNames)
fs = 8000;
dtmf.keys = ...
    ['1','2','3','A';
    '4','5','6','B';
    '7','8','9','C';
    '*','0','#','D'];
dtmf.col = ones(4,1)*[1209,1336,1477,1633];
dtmf.row = [697;770;852;941]*ones(1,4);
dur = 0.25;
t = 0:1/fs:dur;
y = 0;
for i = 1:length(keyNames)
    keyName = keyNames(i);
    if (keyName~='1' && keyName~='2' && keyName~='3' && keyName~='A' &&
keyName~='4' && keyName~='5' && keyName~='6' && keyName~='B' &&
keyName~='7' && keyName~='8' && keyName~='9' && keyName~='C' &&
keyName~='#' && keyName~='0' && keyName~='*' && keyName~='D')
```

```
            continue
        end;
        [r,c] = find(dtmf.keys==keyName);
        tone = sin(2*pi*dtmf.row(r,c)*t) + sin(2*pi*dtmf.col(r,c)*t);
        y = [y,zeros(1,0.05*fs),tone];
end
soundsc(y,8000);
```

test.m

```
y = dial('123456789');
```

实际听起来和手机的声音很像。

3.识别按键录音

readDial.m

```
%读入 DTMF 音频识别内容
%频率 8000
function res = readDial(filename)
audio = audioread(filename);
y = abs(fft(audio,2048));
p = y.*y /10000;
row = find(p(1:250) == max(p(1:250)));
col = 300+find(p(300:380) == max(p(300:380)));
if (row < 180)
        row = 1;
elseif (row < 200)
        row = 2;
elseif (row < 220)
        row = 3;
else
        row = 4;
end

if (col < 320)
        col = 1;
elseif (col < 340)
        col = 2;
else
        col = 3;
end

keys = ...
```

```
    ['1','2','3','A';
    '4','5','6','B';
    '7','8','9','C';
    '*','0','#','D'];
res = keys(row,col);
end
```

test.m

```
res = [];
for i = 0:9
    res = [res,readDial(['dtmf-',num2str(i),'.wav'])];
end
disp(res);
```

算法先读入音频文件，然后用快速傅里叶转换算法得到频谱，然后算出功率向量，找到最匹配的按键音。
采用了 10 个分别为 0,1,2,3,4,5,6,7,8,9 的 DTMF 音频文件，识别结果为 #,1,3,3,4,6,6,7,9,9，识别率为 60%。