Assignment 2

1 Filtering

f1-C horizontal partial derivative

f2-D vertical partial derivative

f3-B mean filter, blur and smooth

f4-E it is a sharpening filter, a strong Laplacian filter, with positive central pixel value

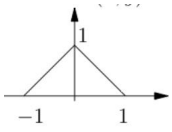
f5-A to sharpen edges and lines in horizontal direction

2 Interpolation

a) Linear interpolation means to transform from discrete to continuous, and in two dimensions the corresponding function is bilinear.

Linear interpolation is to connect each point with straight lines, so each line is linear.

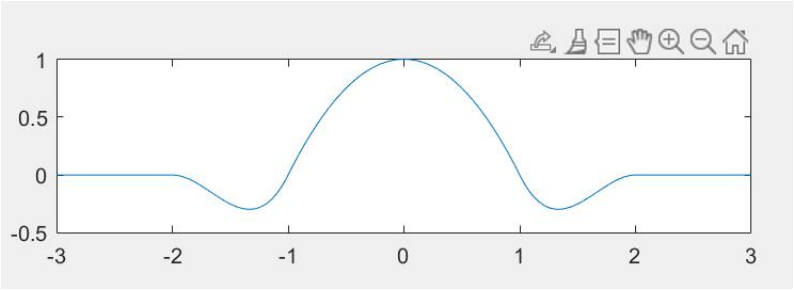
Flin(x) is continuous, but not differentiable, because the derivative function of this function is not continuous (the line is not smooth)



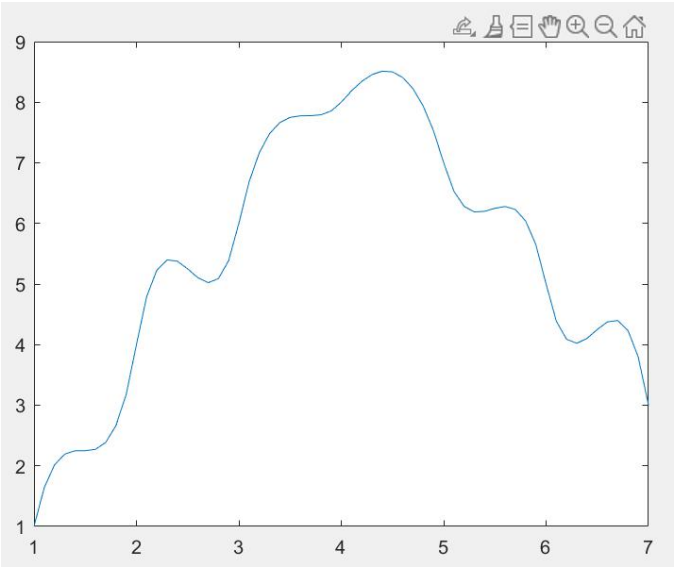
b) g(x)=1-x if x[0,1]

1+x if x[-1,0]

c) g(x)

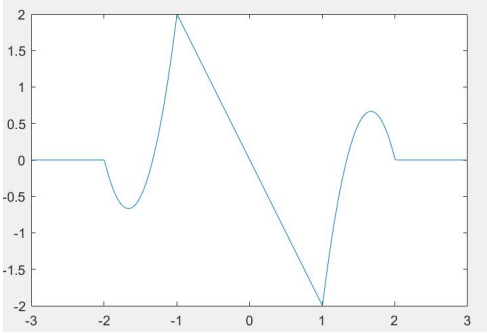


Fg(x)



Fg(x) is continuous and differentiable.

Because we use g(x) is differentiable(smooth), because the derivative of g(x) function exists at all points in its domain, and it is also continuous, has no break in its domain. And its left-hand limit is equal to the right-hand limit and the derivative exists at each interior point of the domain. Here is the plot of derivative of g(x).



So the convolution of any f and g(x), which is the function of interpolation is continuous and differentiable.

3 Classification using Nearest Neighbor and Bayes theorem

3.1

0.4015 ‘s nearest neighbor is 0.4003, so class 1

0.3995 class 1. 0.3991 class 1.

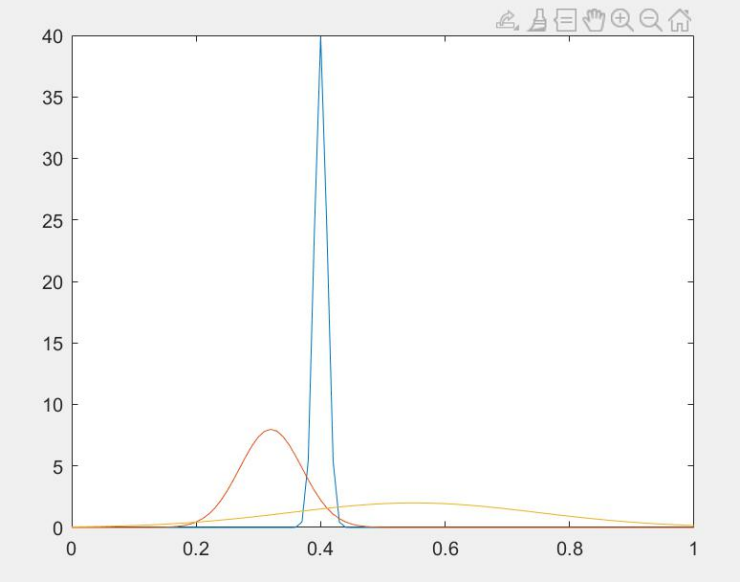
0.3247 class 2. 0.3360 class 2. 0.2974 class 2.

0.4443 class 1.(wrong) 0.5505 class 3. 0.6469 class 3

So in the total 9 testing values, 8 of 9 are correctly classified.

3.2

pdf



For x=0.4003, the highest value of the three pdf function is in class 1(blue) so class 1(right).
x= 0.3802, this measurement is classified as class 1, but it is in class 2(wrong).
For all the other data, the results of gaussian classification are right.

4 Classification

P1=0.25*e *(1-e)^3
P2=0.5*e^3*(1-e)
P3=0.25*e^2*(1-e)^2

a) e=0.1
p1=0.018225
p2=0.00045
p3=0.002025
p=p1+p2+p3=0.0207
P1=0.018225/0.0207=0.8804 MAP
P2=0.00045/0.0207=0.0217
P3=0.002025/0.0207=0.0978

b) e=0.4
p1=0.0216
p2=0.0192
p3=0.0144
p=p1+p2+p3=0.0552
P1=0.0216/0.0552=0.3913 MAP
P2=0.0192/0.0552=0.3478
P3=0.0144/0.0552=0.2609

5 Classification

A priori probabilities:
p1=0.3 p2=0.2 p3=0.2 p4=0.3
P(line1)=0.3*(1-e)^4*{(1-e)^2*e^2}^3=0.3*0.8^10*0.2^6=0.00000206

P(line2)=0.2*(1-e)^8*{(1-e)^2*e^2}^2=0.2*0.8^12*0.2^4=0.00002199
P(line3)=0.2*(1-e)^4*{(1-e)^2*e^2}^3=0.2*0.8^10*0.2^6=0.00000137
P(line4)=0.3*{(1-e)^2*e^2}^4=0.3*0.8^8*0.2^8=0.0000001289
e=0.2
P=p1+p2+p3+p4=0.000025549
a posteriori probabilities:
P1=0.0806
P2=0.8607 most probable image MAP
P3=0.0536
P4=0.0050

6 Classification

A priori probabilities:
P(B)=0.35 P(0)=0.4 P(8)=0.25
A priori probabilities:
p(x|B)*p(B)=0.2^5*0.7^5*0.8^5*0.35=6.1682e-06
p(x|0)*p(0)=0.2^5*0.7^5*0.8^3*0.3^2*0.4=9.9132e-07
p(x|8)*p(8)=0.2^3*0.3*0.7^7*0.8^4*0.25=2.0240e-05
P(x)= p(x|B)*p(B)+ p(x|0)*p(0)+ p(x|8)*p(8)= 2.7400e-05
P(B|x)=p(x|B)*p(B)/p(x)= 0.2251
P(0|x)=p(x|0)*p(0)/p(x)= 0.0362
P(8|x)=p(x|8)*p(8)/p(x)= 0.7387 MAP
8 is the most probable image.

7 The OCR system - part 2 - Feature extraction

Features:
Euler Number: Number of objects in the region minus the number of holes in those objects:
The Centroid of the holes of the digit: return the x-coordinate and y-coordinate of the center of holes.
Extent: Ratio of pixels in the region to pixels in the total bounding box
Perimeter: Distance around the boundary of the region
Eccentricity: The eccentricity is the ratio of the distance between the foci of the ellipse and its major axis length. The value is between 0 and 1.
Extent: Ratio of pixels in the region to pixels in the total bounding box.

```
function features = segment2features(I)
BW = I;
[row,col] = find(BW);
rowmin = min(row);
rowmax = max(row);
colmin = min(col);
colmax = max(col);
si = BW(rowmin:rowmax,colmin-1:colmax+1);
si = imresize(si, [23, 18]);
```

```
m = size(si,1);
n = size(si,2);
for i=1:m
    for j=1:n
        if si(i,j)>1
           si(i,j)=1;
        end
    end
end

fill = imfill(si,8,'holes');
hole = fill - si;
if hole == 0
 s(1) = 0;
 s(2) = 0;
else
o = ones(m,1)*[1:n];
p = [1:m]'*ones(1,n);
area = sum(sum(hole));
meanx = sum(sum(hole.*o))/area;
meany = sum(sum(hole.*p))/area;
s(1) = meanx/10;
s(2) = meany/10;
end
a1 = regionprops(si,'Perimeter');
s(8) = (cat(1,a1.Perimeter))/100;
a2 = regionprops(si,'EulerNumber');
%s(2) = cat(1,a2.EulerNumber);
a3 = regionprops(si,'Eccentricity');
s(3) = cat(1,a3.Eccentricity);
a4 = regionprops(si,'Extent');
s(4) = cat(1,a4.Extent);
a5 = regionprops(si,'FilledArea');
s(5) = (cat(1,a5.FilledArea))/100;
a6 = regionprops(si,'Centroid');
s(6:7) = (cat(1,a6.Centroid))/10;
a7 = regionprops(si,'Extrema');
%s(3:18) = (cat(1,a7.Extrema))/10;
features = s';
end
```

Results:

Studying the character 0

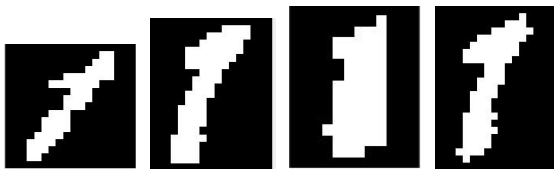
There are 3 examples in the database.

The feature vectors for these are:

ans = 

0.9520	0.9846	0.9508
1.1937	1.1701	1.2150
0.8543	0.8667	0.8238
0.2018	0.2731	0.3114
0.4600	1.3700	0.7100
0.9239	1.0237	0.9704
1.1761	1.1712	1.1239
0.1910	0.4590	0.0619

Studying the character 1
There are 4 examples in the database.
The feature vectors for these are:

ans = 

0.8969	0.9526	0.9560	0.8037
1.0935	0.9589	1.1322	1.1139
0.9811	0.9717	0.9386	0.9643
0.2456	0.3158	0.5294	0.2450
0.5900	0.7200	0.8200	0.6000
0.9536	0.9227	0.8792	0.8898
1.1286	1.1015	1.2611	1.0980
0.2192	0.5602	0.4679	0.5299

Studying the character 2
There are 4 examples in the database.
The feature vectors for these are:

ans =

1.1121	0.9556	1.0337	1.0202
1.0898	1.2420	1.1638	0.7926
0.9558	0.9065	0.8612	0.9150
0.2143	0.2833	0.2963	0.2982

0.5400	0.7500	0.7600	0.7600
1.0000	0.9426	1.0500	1.0029
1.3815	1.3059	1.2016	1.2279
0.2559	0.8099	0.6924	0.2171

Studying the character 3
There are 5 examples in the database.
The feature vectors for these are:

ans =

0.9853	1.0994	0.9402	0.9620	0.9120
1.1541	0.8567	1.2477	1.2173	1.2849
0.8965	0.9085	0.8994	0.9190	0.8767
0.2105	0.3114	0.3445	0.3202	0.2588
0.4800	0.7900	0.8100	0.8700	0.5900
0.9938	0.9662	1.0292	1.0466	1.0220
1.1896	1.2394	1.2556	1.1740	0.9983
0.1845	0.7888	0.6767	0.6126	0.0441

Studying the character 4
There are 5 examples in the database.
The feature vectors for these are:

ans =

0.9267	0.9459	0.9042	0.9107	0.8662
1.0007	1.1628	1.2711	1.1142	1.1433
0.8332	0.8043	0.8615	0.8339	0.8713
0.3923	0.2456	0.2165	0.3493	0.3611
1.1700	0.7100	0.5900	1.1500	1.2000
0.9951	0.9732	0.8500	0.9973	0.9282
1.1317	1.2018	1.1600	1.0986	1.2718
0.4766	0.5883	0.5721	0.4748	0.4628

Studying the character 5
There are 9 examples in the database.
The feature vectors for these are:

ans =

0	1.0191	0.9169	0.9283	0.8339	0.8928	0.9390	0.9324	0.9541
0	1.0460	1.2087	1.2282	1.1285	1.1194	1.1304	1.2773	1.1483
0.8787	0.9505	0.8332	0.9331	0.8632	0.9565	0.9566	0.9245	0.8793

0.4127	0.1759	0.3509	0.3254	0.3532	0.2421	0.1579	0.2579	0.2810
1.0400	0.3900	0.8700	0.8200	1.0900	0.6900	0.3700	0.7500	0.6200
1.0308	0.9132	0.9525	0.9061	0.9101	0.9049	0.8806	0.9769	0.9305
1.0635	1.2868	1.1625	1.1183	1.1483	1.0262	1.2528	1.1954	1.1017
0.7385	0.2632	0.8282	0.2446	0.8669	0.1350	0.1499	0.7437	0.7290

Studying the character 6
There are 3 examples in the database.
The feature vectors for these are:

ans =

0.9142	0.8647	0.9193
1.6253	1.5927	1.6168
0.8179	0.8872	0.8214
0.2488	0.2456	0.2987
0.6500	0.9500	0.7800
0.8500	0.9482	0.8884
1.4615	1.2589	1.1783
0.4298	0.5693	0.7858

Studying the character 7
There are 2 examples in the database.
The feature vectors for these are:

ans =

0.8461	0.8227
1.1558	1.0758
0.9080	0.9236
0.1930	0.2222
0.4700	0.6200
0.8682	0.9304
0.9273	0.9125
0.2786	0.6077

Studying the character 8
There are 7 examples in the database.
The feature vectors for these are:

ans =

0.8558	0.9080	0.9729	0.9278	0.8698	0.9652	0.9802
1.3250	1.2571	1.2722	1.2208	1.1663	1.2928	1.2964

0.9082	0.9050	0.8041	0.9121	0.8204	0.8141	0.8168
0.3421	0.3509	0.4329	0.3114	0.4498	0.3772	0.4474
0.9000	1.3000	1.8600	0.9200	1.5700	1.1800	1.3500
0.8821	0.9488	0.9830	0.9141	0.8809	1.0081	0.9480
1.1359	1.1650	1.2010	1.1268	1.1777	1.1605	1.1931
0.6914	0.5159	0.5365	0.6849	0.5506	0.6885	0.5640

Studying the character 9
There are 8 examples in the database.
The feature vectors for these are:

ans =

0.9312	0.9168	0.9919	0.8492	0.8593	0.9428	0.9403	1.0193
0.8367	0.7696	0.9418	0.8883	0.9251	0.8296	0.8510	0.8763
0.7789	0.7507	0.8859	0.9162	0.8845	0.8463	0.8346	0.9125
0.3158	0.3202	0.2963	0.3651	0.3056	0.3550	0.3463	0.3211
1.3400	1.1800	0.9900	1.0100	1.1100	0.7800	1.4500	0.9900
0.9514	0.9493	0.9672	0.9630	0.9403	0.9338	1.0500	0.9328
1.1375	0.9932	1.0938	1.0500	1.0117	1.0521	1.0662	1.0803
0.5647	0.5121	0.0937	0.5957	0.5721	0.2929	0.5523	0.4747