# 图解机器学习 MATLAB程序集

# p.24

clear all

n=50; N=1000;

x=linspace(-3,3,n)'; X=linspace(-3,3,N)';

pix=pi\*x;

y=sin(pix)./(pix)+0.1\*x+0.05\*randn(n,1);

p(:,1)=ones(n,1); P(:,1)=ones(N,1);

for j=1:15

p(:,2\*j)=sin(j/2\*x); p(:,2\*j+1)=cos(j/2\*x);

P(:,2\*j)=sin(j/2\*X); P(:,2\*j+1)=cos(j/2\*X);

end

t=p\y;

F=P\*t;

figure(1);clf;hold on; axis([-2.8,2.8,-0.5,1.2]);

plot(X,F,'r-');plot(x,y,'bo');

# p.24 修正

clear all

n=50; N=1000;

x=linspace(-3,3,n)'; X=linspace(-3,3,N)';

pix=pi\*x;

y=sin(pix)./(pix)+0.1\*x+0.05\*randn(n,1);

p(:,1)=ones(n,1); P(:,1)=ones(N,1);

for j=1:4

p(:,2\*j)=sin(j/2\*x); p(:,2\*j+1)=cos(j/2\*x);

P(:,2\*j)=sin(j/2\*X); P(:,2\*j+1)=cos(j/2\*X);

end

t=p\y;

F=P\*t;

figure(1);clf;hold on; axis([-2.8,2.8,-0.5,1.2]);

plot(X,F,'r-');plot(x,y,'bo');

e=p\y-inv(p'\*p)\*p'\*y;

ME=sum(abs(e)/n);

disp('mean of absolute errors = '); disp(ME)

# p.24 幂律基

clear all

n=50; N=1000;

x=linspace(-3,3,n)'; X=linspace(-3,3,N)';

pix=pi\*x;

y=log(pix)./(pix)+0.1\*x+0.05\*randn(n,1);

p(:,1)=ones(n,1); P(:,1)=ones(N,1);

for j=1:10

p(:,j)=x.^j; P(:,j)=X.^j;

end

t=p\y;

F=P\*t;

figure(1);clf;hold on; axis([-2.8,2.8,-0.5,1.2]);

plot(X,F,'r-');plot(x,y,'bo');

## p.30

n=50; N=1000;

x=linspace(-3,3,n)'; X=linspace(-3,3,N)';

pix=pi\*x;

y=sin(pix)./(pix)+0.1\*x+0.05\*randn(n,1);

hh=2\*0.3^2;

t0=randn(n,1);e=0.1;

for o=1:n\*1000

i=ceil(rand\*n);

ki=exp(-(x-x(i)).^2/hh);t=t0-e\*ki\*(ki'\*t0-y(i));

if norm(t-t0)<0.000001,break,end

t0=t;

end

K=exp(-(repmat(X.^2,1,n)+repmat(x.^2',N,1)-2\*X\*x')/hh);

F=K\*t;

figure(1);clf;hold on; axis([-2.8,2.8,-0.5,1.2]);

plot(X,F,'g-');plot(x,y,'bo');

## p.33

clear all

n=50; N=1000;

x=linspace(-3,3,n)'; X=linspace(-3,3,N)';

pix=pi\*x;

y=sin(pix)./(pix)+0.1\*x+0.05\*randn(n,1);

p(:,1)=ones(n,1); P(:,1)=ones(N,1);

for j=1:15

p(:,2\*j)=sin(j/2\*x); p(:,2\*j+1)=cos(j/2\*x);

P(:,2\*j)=sin(j/2\*X); P(:,2\*j+1)=cos(j/2\*X);

end

t1=p\y;

F1=P\*t1;

t2=(p\*diag([ones(1,11) zeros(1,20)]))\y;

F2=P\*t2;

figure(1); clf; hold on; axis([-2.8,2.8,-0.5,1.2]);

plot(X,F1,'g-'); plot(X,F2,'r--'); plot(x,y,'bo');

legend('LS','Subspace-Constraineed LS');

## p.36

clear all

n=50; N=1000;

x=linspace(-3,3,n)'; X=linspace(-3,3,N)';

pix=pi\*x; piX=pi\*X;

y=sin(pix)./(pix)+0.1\*x+0.1\*randn(n,1);

Y=sin(piX)./(piX)+0.1\*X+0.05\*randn(N,1);

x2=x.^2; X2=X.^2;

hh=2\*0.3^2;

l=0.1;

k=exp(-(repmat(x2,1,n)+repmat(x2',n,1)-2\*(x\*x'))/hh);

K=exp(-(repmat(X2,1,N)+repmat(X2',N,1)-2\*(X\*X'))/hh);

t1=k\y;

F1=k\*t1;

t2=(K^2+l\*eye(N))\(K\*Y);

F2=K\*t2;

figure(1); clf; hold on; axis([-2.8,2.8,-0.5,1.2]);

plot(x,F1,'g-'); plot(X,F2,'r--'); plot(x,y,'bx');

legend('LS','L2-Constraineed LS');

## MLp42

clear all

n=50; N=1000;

x=linspace(-3,3,n)'; X=linspace(-3,3,N)';

pix=pi\*x; piX=pi\*X;

y=sin(pix)./(pix)+0.1\*x+0.1\*randn(n,1);

x2=x.^2; xx=repmat(x2,1,n)+repmat(x2',n,1)-2\*x\*x';

hhs=2\*[0.03 0.3 3].^2;ls=[0.0001 0.1 100];

m=5;u=floor(m\*[0:n-1]/n)+1;u=u(randperm(n));

for hk=1:length(hhs)

hh=hhs(hk);k=exp(-xx/hh);

for i=1:m

ki=k(u~=i,:);kc=k(u==i,:);yi=y(u~=i);yc=y(u==i);

for lk=1:length(ls)

l=ls(lk);t=(ki'\*ki+l\*eye(n))\(ki'\*yi);fc=kc\*t;

g(hk,lk,i)=mean((fc-yc).^2);

end,end,end

[gl,ggl]=min(mean(g,3),[],2);[ghl,gghl]=min(gl);

L=ls(ggl(gghl));HH=hhs(gghl);

K=exp(-(repmat(X.^2,1,n)+repmat(x2',N,1)-2\*X\*x')/HH);

k=exp(-xx/HH);t=(k^2+L\*eye(n))\(k\*y);F=K\*t;

figure(1); clf; hold on; axis([-2.8,2.8,-0.7,1.7]);

plot(X,F,'g-'); plot(x,y,'bo');

## MLp.49

clear all

n=50; N=1000;

x=linspace(-3,3,n)'; X=linspace(-3,3,N)';

pix=pi\*x;

y=sin(pix)./(pix)+0.1\*x+0.2\*randn(n,1);

hh=2\*0.3^2; l=0.1;

t0=randn(n,1); x2=x.^2;

k=exp(-(repmat(x2,1,n)+repmat(x2',n,1)-2\*x\*x')/hh);

k2=k^2;ky=k\*y;

for o=1:1000

t=(k2+l\*pinv(diag(abs(t0))))\ky;

if norm(t-t0)<0.001,break, end

t0=t;

end

K=exp(-(repmat(X.^2,1,n)+repmat(x2',N,1)-2\*X\*x')/hh);

F=K\*t;

figure(1); clf; hold on; axis([-2.8,2.8,-1,1.5]);

plot(X,F,'g-'); plot(x,y,'bo');

## MLp62

clear all

n=10; N=1000;

x=linspace(-3,3,n)'; X=linspace(-4,4,N)';

y=x+0.2\*randn(n,1);

y(n)=-4;

p(:,1)=ones(n,1); p(:,2)=x;

t0=p\y;e=1;

for o=1:1000

r=abs(p\*t0-y);w=ones(n,1);w(r>e)=e./r(r>e);

t=(p'\*(repmat(w,1,2).\*p))\(p'\*(w.\*y));

if norm(t-t0)<0.001,break, end

t0=t;

end

P(:,1)=ones(N,1);P(:,2)=X;

F=P\*t;

figure(1); clf; hold on; axis([-4,4,-4.5,3.5]);

plot(X,F,'g-'); plot(x,y,'bo');

## MLp68

clear all

n=50; N=1000;

x=linspace(-3,3,n)'; X=linspace(-3,3,N)';

pix=pi\*x;

y=sin(pix)./(pix)+0.1\*x+0.1\*randn(n,1);

y(n/2)=-0.5;

hh=2\*0.3^2;

l=0.1;

e=0.1;

t0=randn(n,1);

x2=x.^2;

k=exp(-(repmat(x2,1,n)+repmat(x2',n,1)-2\*(x\*x'))/hh);

for o=1:1000

r=abs(k\*t0-y);w=ones(n,1);w(r>e)=e./r(r>e);

Z=k\*(repmat(w,1,n).\*k)+l\*pinv(diag(abs(t0)));

t=(Z+0.000001\*eye(n))\(k\*(w.\*y));

if norm(t-t0)<0.001,break, end

t0=t;

end

K=exp(-(repmat(X.^2,1,n)+repmat(x2',N,1)-2\*(X\*x'))/hh);

F=K\*t;

figure(1); clf; hold on; axis([-2.8,2.8,-1,1.5]);

plot(X,F,'g-'); plot(x,y,'bo');

## MLp72

clear all

n=800;

a=linspace(0,4\*pi,n/2);

l=1;

u=[a.\*cos(a),(a+pi).\*cos(a)]'+l\*rand(n,1);

v=[a.\*sin(a),(a+pi).\*sin(a)]'+l\*rand(n,1);

x=[u,v];

y=[ones(1,n/2),-ones(1,n/2)]';

x2=sum(x.^2,2);

hh=2\*1^2;

l=0.01;

k=exp(-(repmat(x2,1,n)+repmat(x2',n,1)-2\*(x\*x'))/hh);

t=(k^2+1\*eye(n))\(k\*y);

m=100;

X=linspace(-15,15,m)';

X2=X.^2;

U=exp(-(repmat(u.^2,1,m)+repmat(X2',n,1)-2\*u\*X')/hh);

V=exp(-(repmat(v.^2,1,m)+repmat(X2',n,1)-2\*v\*X')/hh);

figure(1); clf; hold on; axis([-15,15,-15,15]);

contourf(X,X,sign(V'\*(U.\*repmat(t,1,m))));

plot(x(y==1,1),x(y==1,2),'bo');

plot(x(y==-1,1),x(y==-1,2),'rx');

colormap([1,0.7,1;0.7,1,1]);

## ML97

clear all

n=40;x=[randn(1,n/2)-15,randn(1,n/2)-5;randn(1,n)]';

y=[ones(n/2,1);-ones(n/2,1)];

x(1:2,1)=x(1:2,1)+60;x(:,3)=1;

l=0.01;e=0.01;t0=zeros(3,1);

for o=1:1000

m=(x\*t0).\*y;v=m+min(1,max(0,1-m));

a=abs(v-m);w=ones(size(y));w(a>e)=e./a(a>e);

t=(x'\*(repmat(w,1,3).\*x)+l\*eye(3))\(x'\*(w.\*v.\*y));

if norm(t-t0)<0.001,break, end

t0=t;

end

figure(1); clf; hold on; z=[-20 50];axis([z,-2,2]);

plot(x(y==1,1),x(y==1,2),'bo');

plot(x(y==-1,1),x(y==-1,2),'rx');

plot(z,-(t(3)+z\*t(1))/t(2),'k-');

## ML101

clear all

x=randn(50,2);y=2\*(x(:,1)>x(:,2))>-1;

X0=linspace(-3,3,50);[X(:,:,1),X(:,:,2)]=meshgrid(X0);

d=ceil(2\*rand);[xs,xi]=sort(x(:,d));

el=cumsum(y(xi));eu=cumsum(y(xi(end:-1:1)));

e=eu(end-1:-1:1)-el(1:end-1);

[em,ei]=max(abs(e));c=mean(xs(ei:ei+1));s=sign(e(ei));

Y=sign(s\*(X(:,:,d)-c));

figure(1);clf; hold on; axis([-3,3,-3,3]);

colormap([1,0.7,1;0.7,1,1]);

contourf(X0,X0,Y);

plot(x(y==1,1),x(y==1,2),'bo');

plot(x(y==-1,1),x(y==-1,2),'rx');

## MLp.104

clear all

n=50;

x=randn(n,2); y=2\*(x(:,1)>x(:,2))-1; b=5000;

a=50;

Y=zeros(a,a);

X0=linspace(-3,3,a);

[X(:,:,1),X(:,:,2)]=meshgrid(X0);

for j=1:b

db=ceil(2\*rand); r=ceil(n\*rand(n,1));

xb=x(r,:);yb=y(r);[xs,xi]=sort(xb(:,db));

el=cumsum(yb(xi)); eu=cumsum(yb(xi(end:-1:1)));

e=eu(end-1:-1:1)-el(1:end-1);

[em,ei]=max(abs(e)); c=mean(xs(ei:ei+1)); s=sign(e(ei));

Y=Y+sign(s\*(X(:,:,db)-c))/b;

end

figure(1); clf; hold on; axis([-3,3,-3,3]);

colormap([1,0.7,1;0.7,1,1]);

contourf(X0,X0,sign(Y));

plot(x(y==1,1),x(y==1,2),'bo');

plot(x(y==-1,1),x(y==-1,2),'rx');

## MLp.108

clear all

n=50;

x=randn(n,2); y=2\*(x(:,1)>x(:,2))-1; b=5000;

a=50;

Y=zeros(a,a);yy=zeros(size(y)); w=ones(n,1)/n;

X0=linspace(-3,3,a);

[X(:,:,1),X(:,:,2)]=meshgrid(X0);

for j=1:b

wy=w.\*y; d=ceil(2\*rand); [xs,xi]=sort(x(:,d));

el=cumsum(wy(xi)); eu=cumsum(wy(xi(end:-1:1)));

e=eu(end-1:-1:1)-el(1:end-1);

[em,ei]=max(abs(e)); c=mean(xs(ei:ei+1)); s=sign(e(ei));

yh=sign(s\*(x(:,d)-c)); R=w'\*(1-yh.\*y)/2;

t=log((1-R)/R)/2; yy=yy+yh\*t; w=exp(-yy.\*y); w=w/sum(w);

Y=Y+sign(s\*(X(:,:,d)-c))\*t;

end

figure(1); clf; hold on; axis([-3,3,-3,3]);

colormap([1,0.7,1;0.7,1,1]);

contourf(X0,X0,sign(Y));

plot(x(y==1,1),x(y==1,2),'bo');

plot(x(y==-1,1),x(y==-1,2),'rx');

## MLp115

clear all

n=90;c=3; y=ones(n/c,1)\*[1:c]; y=y(:);

x=randn(n/c,c)+repmat(linspace(-3,3,c),n/c,1);x=x(:);

hh=2\*1^2; t0=randn(n,c);

for o=1:n\*1000

i=ceil(rand\*n);yi=y(i);ki=exp(-(x-x(i)).^2/hh);

ci=exp(ki'\*t0);t=t0-0.1\*(ki-ci)/(1+sum(ci));

t(:,yi)=t(:,yi)+0.1\*ki;

if norm(t-t0)<0.001,break, end

t0=t;

end

N=100;

X=linspace(-5,5,N)';

K=exp(-(repmat(X.^2,1,n)+repmat(x.^2',N,1)-2\*X\*x')/hh);

figure(1); clf; hold on; axis([-5,5,-0.3,1.8]);

C=exp(K\*t);C=C./repmat(sum(C,2),1,c);

plot(X,C(:,1),'b-');

plot(X,C(:,2),'r--');

plot(X,C(:,3),'g:');

plot(x(y==1),-0.1\*ones(n/c,1),'bo');

plot(x(y==2),-0.2\*ones(n/c,1),'rx');

plot(x(y==3),-0.1\*ones(n/c,1),'gv');

legend('q(y=1|x)','q(y=2|x)','q(y=3|x)')

## MLp119

clear all

n=90;c=3; y=ones(n/c,1)\*[1:c]; y=y(:);

x=randn(n/c,c)+repmat(linspace(-3,3,c),n/c,1);

x=x(:);

hh=2\*1^2; x2=x.^2; l=0.1;

N=100;

X=linspace(-5,5,N)';

k=exp(-(repmat(x2,1,n)+repmat(x2',n,1)-2\*x\*x')/hh);

K=exp(-(repmat(X.^2,1,n)+repmat(x2',N,1)-2\*X\*x')/hh);

for yy=1:c

yk=(y==yy); ky=k(:,yk);

ty=(ky'\*ky+1\*eye(sum(yk)))\(ky'\*yk);

Kt(:,yy)=max(0,K(:,yk)\*ty);

end

ph=Kt./repmat(sum(Kt,2),1,c);

figure(1); clf; hold on; axis([-5,5,-0.3,1.8]);

plot(X,ph(:,1),'b-');

plot(X,ph(:,2),'r--');

plot(X,ph(:,3),'g:');

plot(x(y==1),-0.1\*ones(n/c,1),'bo');

plot(x(y==2),-0.2\*ones(n/c,1),'rx');

plot(x(y==3),-0.1\*ones(n/c,1),'gv');

legend('p(y=1|x)','p(y=2|x)','p(y=3|x)')

# p.134

clear all

n=100;x=[(rand(n/2,2)-0.5)\*20;randn(n/2,2)];x(n,1)=14;

k=3;x2=sum(x.^2,2);

[s,t]=sort(sqrt(repmat(x2,1,n)+repmat(x2',n,1)-2\*x\*x'),2);

for i=1:k+1

for j=1:k

RD(:,j)=max(s(t(t(:,i),j+1),k),s(t(:,i),j+1));

end

LRD(:,i)=1./mean(RD,2);

end

LOF=mean(LRD(:,2:k+1),2)./LRD(:,1);

figure(1); clf; hold on;

plot(x(:,1),x(:,2),'rx');

for i=1:n

plot(x(:,1),x(:,2),'bo','MarkerSize',LOF(i)\*10);

end

# p.142\*

clear all

n=100;x=randn(n,1);y=randn(n,1);y(n)=5;

hhs=2\*[1 5 10].^2;m=5;

x2=x.^2; xx=repmat(x2,1,n)+repmat(x2',n,1)-2\*x\*x';

y2=y.^2; yx=repmat(y2,1,n)+repmat(x2',n,1)-2\*y\*x';

u=floor(m\*[0:n-1]/n)+1;u=u(randperm(n));

for hk=1:length(hhs)

hh=hhs(hk);k=exp(-xx/hh);r=exp(-yx/hh);

for i=1:m

g(hk,i)=mean(k(u==i,:)\*KLIEP(k(u~=i,:),r));

end

end

[gh,ggh]=max(mean(g,2));HH=hhs(ggh);

k=exp(-xx/HH);r=exp(-yx/HH);s=r\*KLIEP(k,r);

figure(1); clf; hold on;

plot(y,s,'rx');

function a=KLIEP(k,r)

a0=rand(size(k,2),1);b=mean(r)’;c=sum(b.^2);

for o=1:n\*1000

a=a0+0.01\*k’\*(1./k\*a0);a=a+b\*(1-sum(b.\*a))/c;

a=max(0,a);

a=a/sum(b.\*a);

[d,y]=min(repmat(m2,1,n)+repmat(x2',c,1)-2\*m\*x');

if norm(a-a0)<0.001,break, end

a0=a;

end

## p.148

clear all

n=100;

x=[2\*randn(n,1),randn(n,1)];

%x=[2\*randn(n,1),2\*round(randn(n,1))-1+randn(n,1)/3];

x=x-repmat(mean(x),[n,1]);

[t,v]=eigs(x'\*x,1);

figure(1); clf; hold on;

plot(x(:,1),x(:,2),'rx');

plot(9\*[-t(1),t(1)],9\*[-t(2),t(2)]);

## p.151

clear all

n=100;

x=[2\*randn(n,1),randn(n,1)];

%x=[2\*randn(n,1),2\*round(randn(n,1))-1+randn(n,1)/3];

x=x-repmat(mean(x),[n,1]);

x2=sum(x.^2,2);

W=exp(-(repmat(x2,1,n)+repmat(x2',n,1)-2\*x\*x'));

D=diag(sum(W,2));L=D-W;z=x'\*D\*x;z=(z+z')/2;

[t,v]=eigs(x'\*L\*x,z,1,'sm');

figure(1); clf; hold on;

plot(x(:,1),x(:,2),'rx');

plot(9\*[-t(1),t(1)],9\*[-t(2),t(2)]);

## p.156

clear all

n=1000;k=10;a=3\*pi\*rand(n,1);

x=[a.\*cos(a),30\*rand(n,1),a.\*sin(a)];

x=x-repmat(mean(x),[n,1]);x2=sum(x.^2,2);

d=repmat(x2,1,n)+repmat(x2',n,1)-2\*x\*x';

[p,i]=sort(d);

W=sparse(d<=ones(n,1)\*p(k+1,:));W=(W+W'~=0);

D=diag(sum(W,2));L=D-W;

[z,v]=eigs(L,D,3,'sm');

figure(1); clf; hold on; view([15,10]);

scatter3(x(:,1),x(:,2),x(:,3),40,a,'o');

figure(2); clf; hold on;

scatter(z(:,2),z(:,1),40,a,'o');

# p.160

clear all

n=300;c=3;

t=randperm(n);

x=[randn(1,n/3)-2 randn(1,n/3) randn(1,n/3)+2

randn(1,n/3) randn(1,n/3)+4 randn(1,n/3)]';

m=x(t(1:c),:); x2=sum(x.^2,2); s0(1:c,1)=inf;

for o=1:n\*1000

m2=sum(m.^2,2);

[d,y]=min(repmat(m2,1,n)+repmat(x2',c,1)-2\*m\*x');

for t=1:c

m(t,:)=mean(x(y==t,:)); s(t,1)=mean(d(y==t));

end

if norm(s-s0)<0.001,break, end

s0=s;

end

figure(1); clf; hold on;

plot(x(y==1,1),x(y==1,2),'bo');

plot(x(y==2,1),x(y==2,2),'rx');

plot(x(y==3,1),x(y==3,2),'gv');

legend('q(y=1|x)','q(y=2|x)','q(y=3|x)')

# p.163

clear all

n=500;c=2; k=10;

t=randperm(n); a=linspace(0,2\*pi,n/2)';

x=[a.\*cos(a),a.\*sin(a);(a+pi).\*cos(a),(a+pi).\*sin(a)];

x=x+rand(n,2);x=x-repmat(mean(x),[n,1]); x2=sum(x.^2,2);

d=repmat(x2,1,n)+repmat(x2',n,1)-2\*x\*x';[p,i]=sort(d);

W=sparse(d<=ones(n,1)\*p(k+1,:));

W=(W+W'~=0);

D=diag(sum(W,2));L=D-W; [z,v]=eigs(L,D,c-1,'sm');

m=z(t(1:c),:); s0(1:c,1)=inf; z2=sum(z.^2,2);

for o=1:n\*1000

m2=sum(m.^2,2);

[u,y]=min(repmat(m2,1,n)+repmat(x2',c,1)-2\*m\*z');

for t=1:c

m(t,:)=mean(z(y==t,:)); s(t,1)=mean(d(y==t));

end

if norm(s-s0)<0.001,break, end

s0=s;

end

figure(1); clf; hold on; axis([-10,10,-10,10])

plot(x(y==1,1),x(y==1,2),'bo');

plot(x(y==2),x(y==2,2),'rx');

# p.167

clear all

n=50;a=linspace(0,2\*pi,n/2)';

x=[a.\*cos(a),a.\*sin(a);(a+pi).\*cos(a),(a+pi).\*sin(a)];

x=x+rand(n,2);

x=x-repmat(mean(x),[n,1]);

x2=sum(x.^2,2);

y=[ones(1,n/2),zeros(1,n/2)];

d=repmat(x2,1,n)+repmat(x2',n,1)-2\*x\*x';

hhs=2\*[0.5,1,2].^2;ls=10.^[-5,-4,-3];m=5;

u=floor(m\*[0:n-1]/n)+1;u=u(randperm(n));

g=zeros(length(hhs),length(ls),m);

for hk=1:length(hhs)

hh=hhs(hk);k=exp(-d/hh);

for j=unique(y),for i=1:m

ki=k(u~=i,y==j);kc=k(u==i,y==j);

Gi=ki'\*ki\*sum(u~=i&y==j)/(sum(u~=i)^2);

Gc=kc'\*kc\*sum(u==i&y==j)/(sum(u==i)^2);

hi=sum(k(u~=i&y==j,y==j),1)'/sum(u~=i);

hc=sum(k(u==i&y==j,y==j),1)'/sum(u==i);

for lk=1:length(ls)

l=ls(lk);a=(Gi+l\*eye(sum(y==j)))\hi;

g(hk,lk,i)=g(hk,lk,i)+a'\*Gc\*a/2-hc'\*a;

end, end, end, end

g=mean(g,3);[gl,ggl]=min(g,[],2);[ghl,gghl]=min(gl);

L=ls(ggl(gghl));HH=hhs(gghl);s=-1/2;

for j=unique(y)

k=exp(-d(:,y==j)/HH);h=sum(k(y==j,:),2)/n;t=sum(y==j);

s=s+h'\*((k'\*k\*t/(n^2)+L\*eye(t))\h)/2;

end

disp(sprintf('Information=%g',s));