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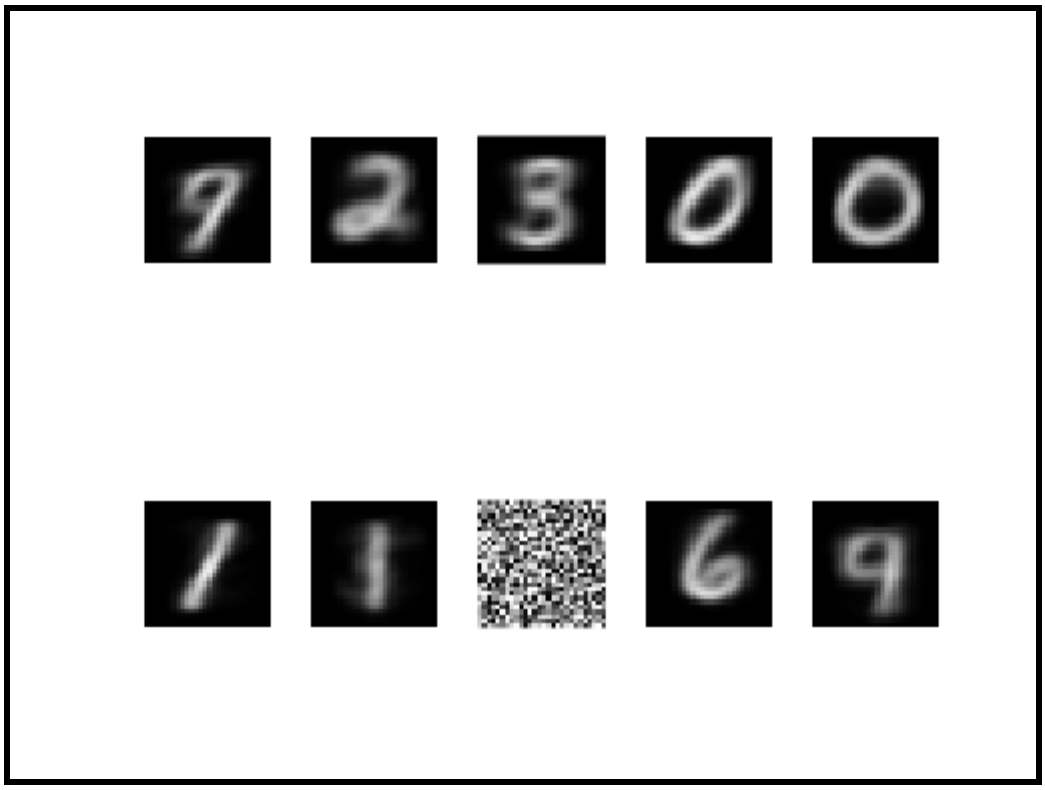
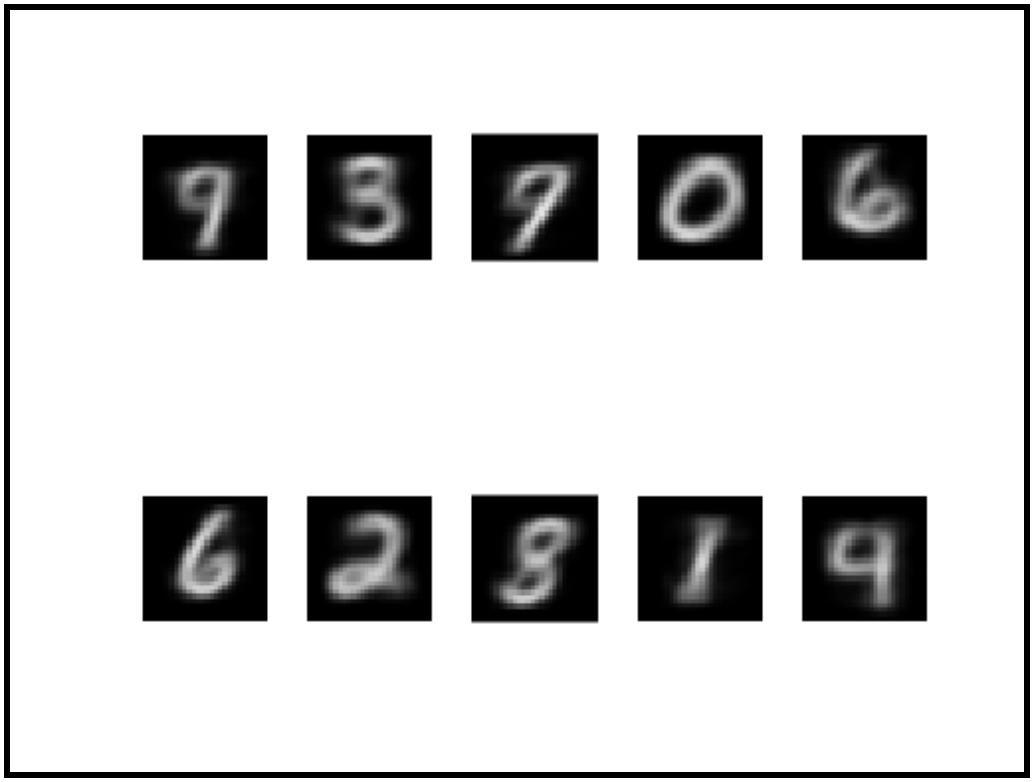
**ECE175**

**HW5**

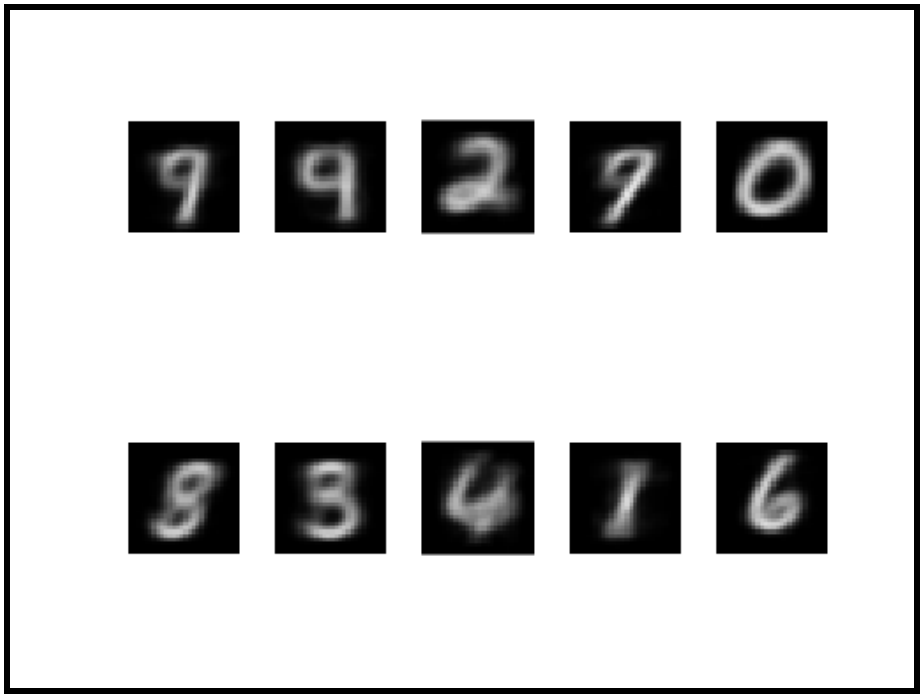
**(1)**



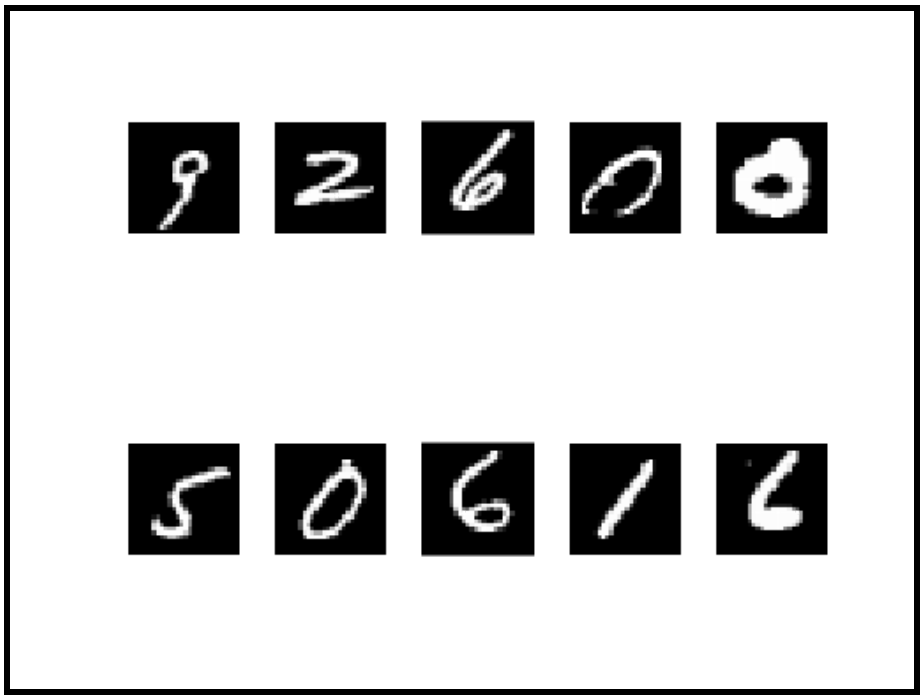


For random initiations, there are sometimes showing up random images for the mean (the first image). This is because some initiations are not at the closest distance to any images in the training set. So there are no images being assigned to that cluster. It remains unchanged. To tackle this problem, we can keep re-initializing means until all each mean has a cluster belonging to it (the second image).

(2)

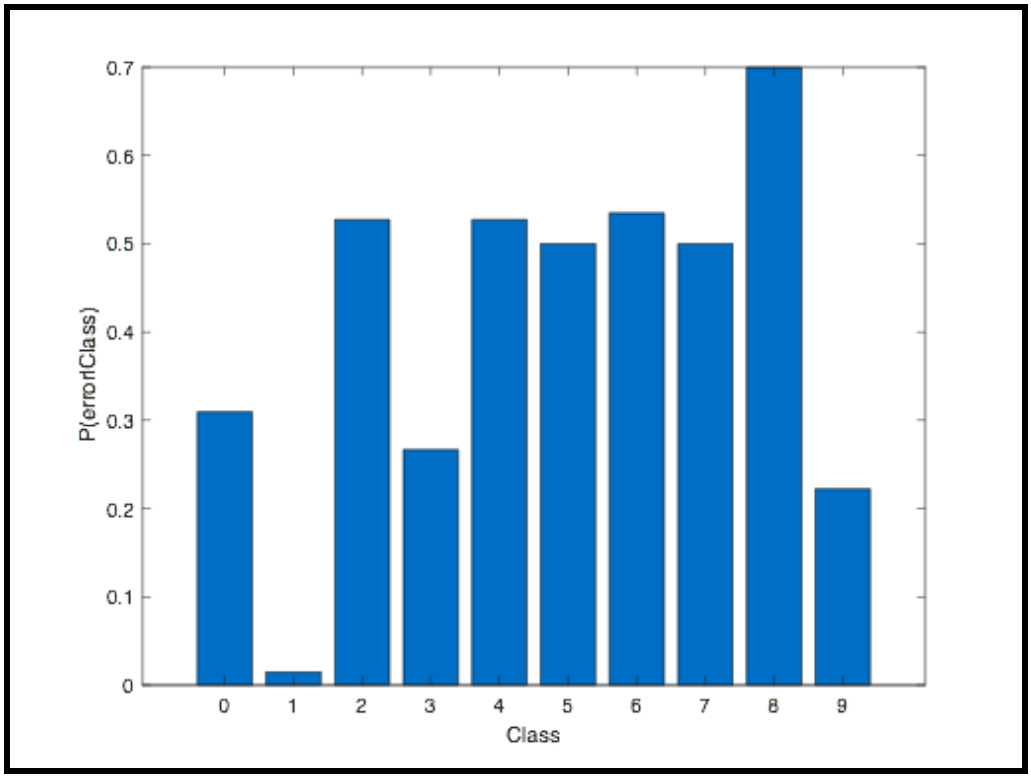


**Means after running the K-means algorithm**



**Means chose for initiation**

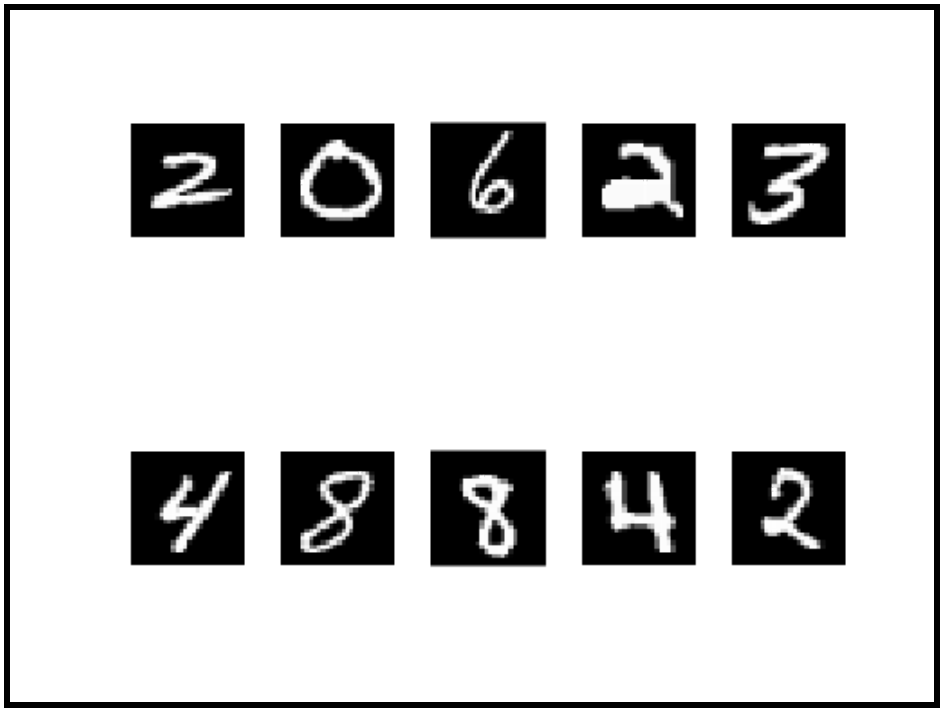
**(3)**



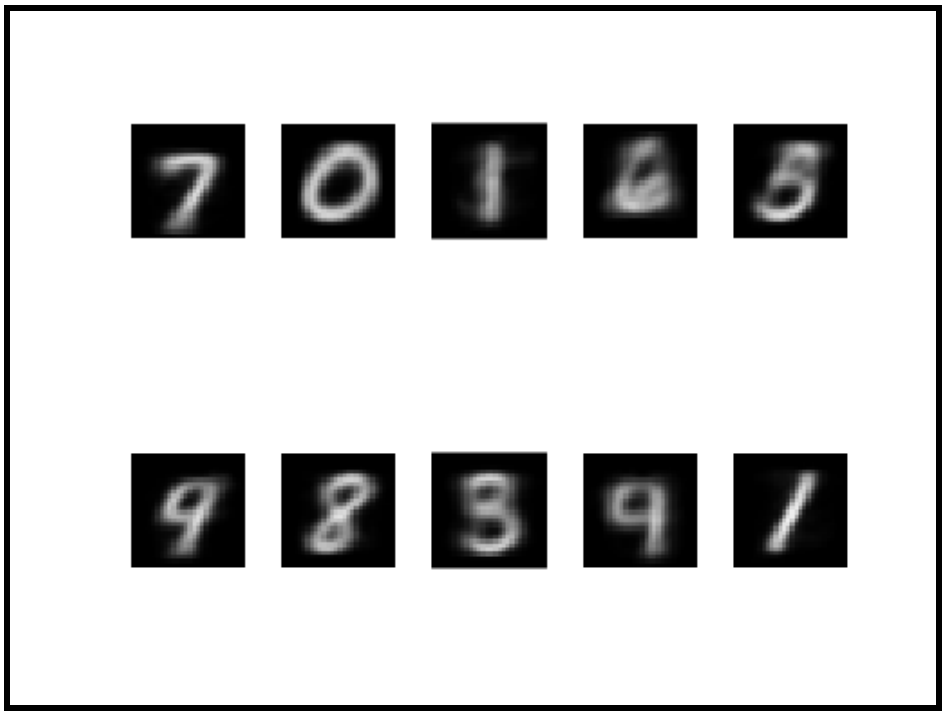

```
total_error_rate =

    0.3930
```

**(4)**



**Means chose for initiation**



**Means after running the K-means algorithm**

The means are different from the ones I obtained above. The final means are very sensitive to the initialization because different initial means can lead to different final means.

(1)

```
mu=zeros(28,28,10);
mu_old=zeros(28,28,10);
mu(:,:,1)=randi(256,28,28);
mu(:,:,2)=randi(256,28,28);
mu(:,:,3)=randi(256,28,28);
mu(:,:,4)=randi(256,28,28);
mu(:,:,5)=randi(256,28,28);
mu(:,:,6)=randi(256,28,28);
mu(:,:,7)=randi(256,28,28);
mu(:,:,8)=randi(256,28,28);
mu(:,:,9)=randi(256,28,28);
mu(:,:,10)=randi(256,28,28);
d=zeros(10,5000);
e=0.0002;
while sqrt(sum(sum((mu(:,:,1)-mu_old(:,:,1)).^2)))>e ||
sqrt(sum(sum((mu(:,:,2)-mu_old(:,:,2)).^2)))>e || sqrt(sum(sum((mu(:,:,3)-
mu_old(:,:,3)).^2)))>e ||sqrt(sum(sum((mu(:,:,4)-mu_old(:,:,4)).^2)))>e||
sqrt(sum(sum((mu(:,:,5)-mu_old(:,:,5)).^2)))>e ||sqrt(sum(sum((mu(:,:,6)-
mu_old(:,:,6)).^2)))>e|| sqrt(sum(sum((mu(:,:,7)-
mu_old(:,:,7)).^2)))>e||sqrt(sum(sum((mu(:,:,8)-
mu_old(:,:,8)).^2)))>e||sqrt(sum(sum((mu(:,:,9)-
mu_old(:,:,9)).^2)))>e||sqrt(sum(sum((mu(:,:,10)-mu_old(:,:,10)).^2)))>e
for i=1:5000
    for j=1:10
    d(j,i)=sqrt(sum(sum((imageTrain(:,:,i)-mu(:,:,j)).^2)));
    end
end
class=zeros(5000,1);
for k=1:5000
[minval,index]=min(d(:,k));
class(k)=index-1;
end
mu_old=mu;
for i=0:9
   imagetotal=zeros(28,28);
   a=find(class==i);
   b=size(a);
   for j=1:b(1)
      imagetotal=imagetotal+imageTrain(:,:,a(j));
      mu(:,:,i+1)=imagetotal/b(1);
   end
end
end
figure;
```

```
for i=1:10
    subplot(2,5,i);
    imshow(uint8(mu(:,:,i)));
end
```

(2)(3)

```
mu=zeros(28,28,10);
mu_old=zeros(28,28,10);
mu(:,:,1)=imageTrain(:,:,20);
mu(:,:,2)=imageTrain(:,:,200);
mu(:,:,3)=imageTrain(:,:,1000);
mu(:,:,4)=imageTrain(:,:,1050);
mu(:,:,5)=imageTrain(:,:,2000);
mu(:,:,6)=imageTrain(:,:,2050);
mu(:,:,7)=imageTrain(:,:,3050);
mu(:,:,8)=imageTrain(:,:,4000);
mu(:,:,9)=imageTrain(:,:,4050);
mu(:,:,10)=imageTrain(:,:,4060);
figure;
for i=1:10
  subplot(2,5,i);
  imshow(uint8(mu(:,:,i)));
end
d=zeros(10,5000);
e=0.0002;
while sqrt(sum(sum((mu(:,:,1)-mu_old(:,:,1)).^2)))>e ||
sqrt(sum(sum((mu(:,:,2)-mu_old(:,:,2)).^2)))>e || sqrt(sum(sum((mu(:,:,3)-
mu_old(:,:,3)).^2)))>e ||sqrt(sum(sum((mu(:,:,4)-mu_old(:,:,4)).^2)))>e||
sqrt(sum(sum((mu(:,:,5)-mu_old(:,:,5)).^2)))>e ||sqrt(sum(sum((mu(:,:,6)-
mu_old(:,:,6)).^2)))>e|| sqrt(sum(sum((mu(:,:,7)-mu_old(:,:,7)).^2)))>e ||
sqrt(sum(sum((mu(:,:,8)-mu_old(:,:,8)).^2)))>e||sqrt(sum(sum((mu(:,:,9)-
mu_old(:,:,9)).^2)))>e||sqrt(sum(sum((mu(:,:,10)-mu_old(:,:,10)).^2)))>e
    for i=1:5000
    for j=1:10
    d(j,i)=sqrt(sum(sum((imageTrain(:,:,i)-mu(:,:,j)).^2)));
    end
end
class=zeros(5000,1);
for k=1:5000
[minval,index]=min(d(:,k));
class(k)=index-1;
end
mu_old=mu;
for i=0:9
   imagetotal=zeros(28,28);
   a=find(class==i);
   b=size(a);
   for j=1:b(1)
```

```
        imagetotal=imagetotal+imageTrain(:,:,a(j));
        mu(:,:,i+1)=imagetotal/b(1);
    end
end
end
figure;
for i=1:10
  subplot(2,5,i);
  imshow(uint8(mu(:,:,i)));
end
mu_test=zeros(784,8);
mu_test(:,1)=reshape(mu(:,:,1),[784,1]);
mu_test(:,2)=reshape(mu(:,:,3),[784,1]);
mu_test(:,3)=reshape(mu(:,:,5),[784,1]);
mu_test(:,4)=reshape(mu(:,:,6),[784,1]);
mu_test(:,5)=reshape(mu(:,:,7),[784,1]);
mu_test(:,6)=reshape(mu(:,:,8),[784,1]);
mu_test(:,7)=reshape(mu(:,:,9),[784,1]);
mu_test(:,8)=reshape(mu(:,:,10),[784,1]);
d=zeros(8,500);
for i=1:8
    for j=1:500
        d(i,j)=-0.5*(TestStack(:,j)-mu_test(:,i))'*(TestStack(:,j)-
mu_test(:,i));
    end
end
class=zeros(500,1);
for i=1:500
 [M,I]=max(d(:,i));
 class(i)=I;
end
for i=1:500
    if class(i)==1
        class(i)=9;
    elseif class(i)==2
        class(i)=2;
    elseif class(i)==3
        class(i)=0;
    elseif class(i)==4
        class(i)=8;
    elseif class(i)==5
        class(i)=3;
    elseif class(i)==6
        class(i)=4;
    elseif class(i)==7
        class(i)=1;
    else
        class(i)=6;
    end
```

```
end
errorrate=zeros(1,10);
error=zeros(1,10);
for c=0:9
x=find(labelTest==c);
for j=1:length(x)
   if class(x(j))~=labelTest(x(j))
    error(c+1)=error(c+1)+1;
   end
end
 errorrate(c+1)=error(c+1)/length(x);
 if errorrate(c+1)==1
    errorrate(c+1)=0.5;
 end
end
total_error=0;
error(6)=length(find(labelTest==5))*0.5;
error(8)=length(find(labelTest==7))*0.5;
for i=1:10
    total_error=error(i)+total_error;
end
total_error_rate=total_error/500
figure;
bar(0:9,errorrate)
xlabel('Class');
ylabel('P(error|Class)');
```

(4)

```
mu=zeros(28,28,10);
mu_old=zeros(28,28,10);
mu(:,:,1)=imageTrain(:,:,200);
mu(:,:,2)=imageTrain(:,:,250);
mu(:,:,3)=imageTrain(:,:,1780);
mu(:,:,4)=imageTrain(:,:,2005);
mu(:,:,5)=imageTrain(:,:,2490);
mu(:,:,6)=imageTrain(:,:,2342);
mu(:,:,7)=imageTrain(:,:,3094);
mu(:,:,8)=imageTrain(:,:,4385);
mu(:,:,9)=imageTrain(:,:,4782);
mu(:,:,10)=imageTrain(:,:,5000);
d=zeros(10,5000);
e=0.0002;
```

```
while sqrt(sum(sum((mu(:,:,1)-mu_old(:,:,1)).^2)))>e ||
sqrt(sum(sum((mu(:,:,2)-mu_old(:,:,2)).^2)))>e || sqrt(sum(sum((mu(:,:,3)-
mu_old(:,:,3)).^2)))>e ||sqrt(sum(sum((mu(:,:,4)-mu_old(:,:,4)).^2)))>e||
sqrt(sum(sum((mu(:,:,5)-mu_old(:,:,5)).^2)))>e ||sqrt(sum(sum((mu(:,:,6)-
mu_old(:,:,6)).^2)))>e|| sqrt(sum(sum((mu(:,:,7)-mu_old(:,:,7)).^2)))>e
||sqrt(sum(sum((mu(:,:,7)-mu_old(:,:,7)).^2)))>e
||sqrt(sum(sum((mu(:,:,8)-mu_old(:,:,8)).^2)))>e||sqrt(sum(sum((mu(:,:,9)-
mu_old(:,:,9)).^2)))>e||sqrt(sum(sum((mu(:,:,10)-mu_old(:,:,10)).^2)))>e
for i=1:5000
    for j=1:10
    d(j,i)=sqrt(sum(sum((imageTrain(:,:,i)-mu(:,:,j)).^2)));
    end
end
class=zeros(5000,1);
for k=1:5000
[minval,index]=min(d(:,k));
class(k)=index-1;
end
mu_old=mu;
for i=0:9
   imagetotal=zeros(28,28);
   a=find(class==i);
   b=size(a);
   for j=1:b(1)
      imagetotal=imagetotal+imageTrain(:,:,a(j));
      mu(:,:,i+1)=imagetotal/b(1);
   end
end
end
figure;
for i=1:10
    subplot(2,5,i);
    imshow(uint8(mu(:,:,i)));
end
```