Dpto. Ingeniería de Sistemas y Automática
Universidad de Málaga

COMPUTER VISION

EXERCISE 5a: REGION DESCRIPTORS

Concepts: Hu moments

1. **Central moments:** Implement a function that computes the central moments (until order 3) of a grayscale image *I*. The function prototype must be as follows: *Note: it really helps if you implement another function to compute the non-central, or raw moments, and you use it to retrieve the central ones. If not, you can use the expression below.*

```
[mu00,mu10,mu01,mu11,mu20,mu02,mu21,mu12,mu30,mu03]=momentos_centrales(I)
```

Central moments expression:

$$\mu_{ij} = \sum_{y=1}^{N} \sum_{x=1}^{N} (x-\mu_x)^i (y-\mu_y)^j \, f(x,y)$$

To test your code, if you run the function with the *'botella_A_1.bmp'* as argument, you have to obtain the following results:

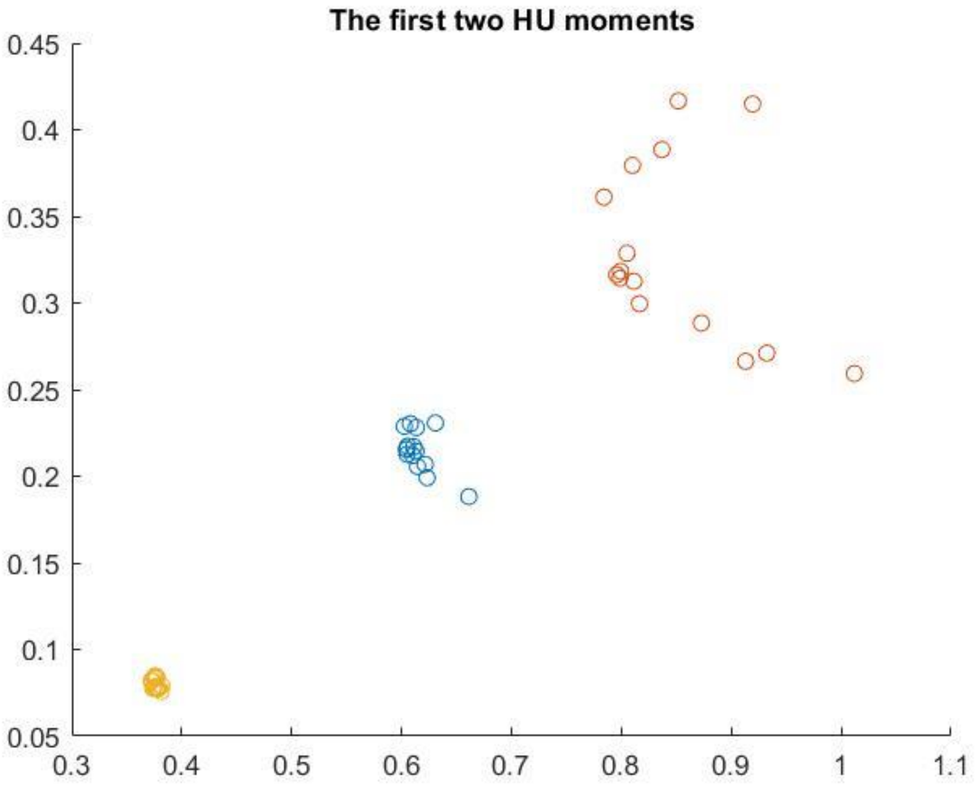
mu00	1148052	**mu10**	0	**mu01**	0
mu11	-4.3331e+06	**mu20**	-2.6373e+06	**mu02**	-7.1258e+06
mu21	1.0521e+07	**mu12**	1.9549e+07	**mu30**	5.1157e+06
mu03	3.4196e+07				

```
[m00,m10,m01,m11,m20,m02,m21,m12,m30,m03]=momentos_no_centrales(I);
xm=m10/m00;
ym=m01/m00;
u=m00;
mu00=m00;
mu01=0;
mu10=0;
mu20=m20-u*xm^2;
mu11=m11-u*ym*xm;
mu02=m02-u*ym^2;
mu30=m30-3*m20*xm+2*m10*xm^2;
mu21=m21-2*m11*xm-m20*ym+2*m01*xm^2;
mu12=m12-2*m11*ym-m02*xm+2*m10*ym^2;
mu03=m03-3*m02*ym+2*m01*ym^2;

function
[m00,m10,m01,m11,m20,m02,m21,m12,m30,m03]=momentos_no_centrales(I)
m00=moment_no_central(0,0,I);
m01=moment_no_central(0,1,I);
m10=moment_no_central(1,0,I);
m20=moment_no_central(2,0,I);
m11=moment_no_central(1,1,I);
m02=moment_no_central(0,2,I);
m03=moment_no_central(0,3,I);
m12=moment_no_central(1,2,I);
m21=moment_no_central(2,1,I);
m30=moment_no_central(3,0,I);

function y=moment_no_central(i,j,I)
[M,N]=size(I);
ax=(1:N).^i; ay=(1:M).^j;
y=ax*I'*ay';
```

2. **Hu moments:** For the grayscale images attached, corresponding to 3 different types of bottles, do the following: *Note: use only the first 15 images of each type.*
    a. Compute the Hu moments employing the *"momentos_Hu"* function included below. This functions relies on the *"momentos_centrales"* function implemented in the previous point.
    b. Graphically represent the values of the two first Hu moments. You should employ a different color for each bottle type.

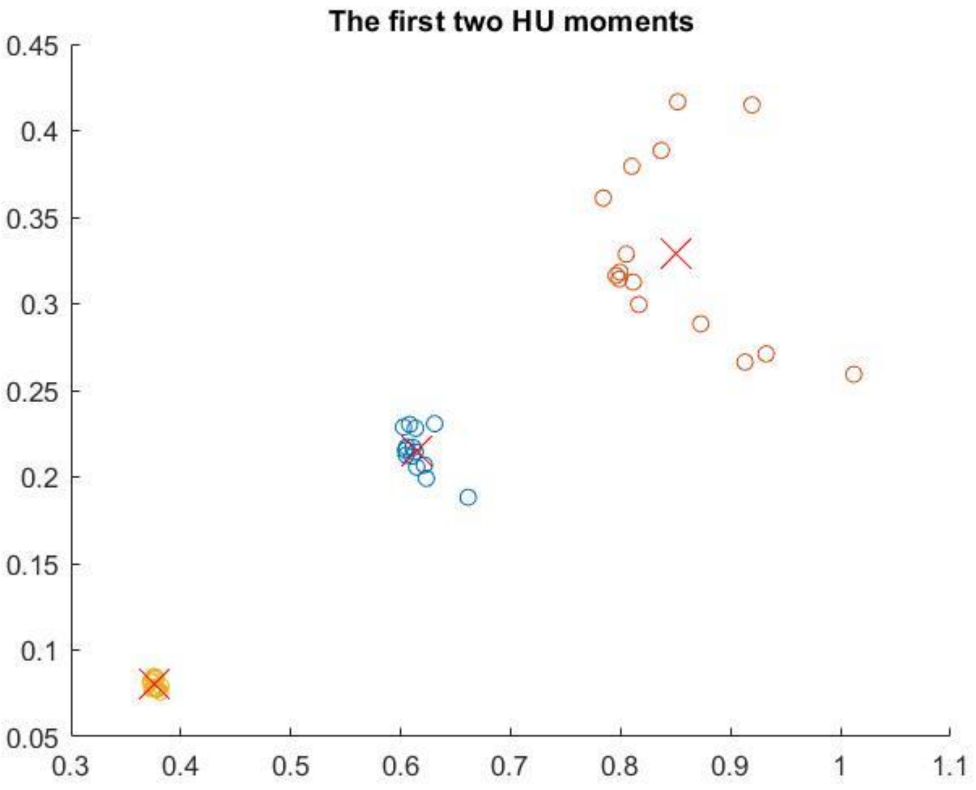


Plot 1

As we see in the plot, we can distinguish three different group, which are the different type of bottles we have. From this we could analyse a picture and say which type of bottle is it, but it is difficult to do it.

3. **Centroid:** Compute the centroid (center of mass) of the first two Hu moments of each bottle type and display them in the previous figure. Employ a different mark to distinguish them from the other points.

```
im=['A','B','C'];
centroid=zeros(2,3);
for i=1:length(im)
    l=im(i);
    hu=zeros(7,15);
    for j=1:15
        hu(:,j)=
        momentos_Hu(imread(sprintf('botella_%s_%d.bmp',l,j));
    end
    scatter(hu(1,:),hu(2,:));
    centroid(1,i)=mean(hu(1,:));
    centroid(2,i)=mean(hu(2,:));
end
scatter(centroid(1,:),centroid(2,:),250,'rx');
title('The first two HU moments');
```



Plot 2

As we see in the plot, we can distinguish three different group, which are the different type of bottles we have. Furthermore, this group have each one a centre which we could use to classify an image into the three types of bottle. This time s more simple because we could use the minimum distance between them.

4. **Euclidean classifier:** Implement a Matlab script that:
   a. Asks for the name of an image through the keyboard and read it.
   ```
   str_im = input('Introduce the image name of the bottle\n');
   ```
   b. Computes the two first Hu moments of that image. This will be the descriptors vector.
   ```
   im_hu = momentos_Hu(im);
   ```
   c. Compares such a vector with the center of mass of each bottle type retrieved in the previous point. *Note: to compare two vectors employ the Euclidean distance.*
   ```
   for i=1:length(im_type)
       ( … )
       d(i)=pdist2(centroid,im_hu(1:2),'euclidean');
   end
   ```
   d. Shows in the screen the type of the bottle in the image.
   ```
   [~,point] = min(d);
   fprintf('The image corresponds to a %s type bottle\n',im_type(point));
   ```

Function "momentos_Hu"

```
function HM=momentos_Hu(I)
% Calcula los momentos de Hu invariantes de una imagen (I) en niveles de gris
% Si se desea obtener la descripción de momentos de un único objeto de la
% imagen, el resto hay que ponerlos a cero.
%
% Entrada: Imagen I en niveles de gris
% Salida:  Vector HM (7x1) de momentos de Hu (invariantes)
%
% Fecha: 2009-2012 Javier Gonzalez

    I=double(I)/255;

    % Momentos centrales
    [mu00,mu10,mu01,mu11,mu20,mu02,mu21,mu12,mu30,mu03] = momentos_centrales(I);

    %Momentos normalizados
    u002 = mu00*mu00;
    u0025 = mu00^2.5;
    %u0015 = mu00^1.5
    n02 = mu02/u002;
    n20 = mu20/u002;
    n11 = mu11/u002;
    n12 = mu12/u0025;
    n21 = mu21/u0025;
    n03 = mu03/u0025;
    n30 = mu30/u0025;

    %Momentos invariantes de Hu
    f1 = n20+n02;
    f2 = (n20-n02)^2 + 4*n11^2;
    f3 = (n30-3*n12)^2+(3*n21-n03)^2;
    f4 = (n30+n12)^2+(n21+n03)^2;
    f5 = (n30-3*n12)*(n30+n12)*((n30+n12)^2 - 3*(n21+n03)^2) + (3*n21-
n03)*(n21+n03)*(3*(n30+n12)^2 - (n21+n03)^2);
    f6 = (n20-n02)*((n30+n12)^2 - (n21+n03)^2) + 4*n11*(n30+n12)*(n21+n03);
    f7 = (3*n21-n03)*(n30+n12)*((n30+n12)^2 - 3*(n21+n03)^2) - (n30-
3*n12)*(n21+n03)*(3*(n30+n12)^2 - (n21+n03)^2);

    HM = [f1 f2 f3 f4 f5 f6 f7];

return;
```

OPTIONAL! EXERCISE 5b: Centroid and principal directions

Concepts: Centroid and principal direction. Eigenvalue and eigenvector of a dispersion matrix.

Write a function that computes and draws the centroid and principal direction of the segmented region, given by a binary image (input argument to the function) where the background has a value of 0 and the segmented region a value of 1. *Note: for the segmentation step you can use the region growing algorithm.*

```
function Centroid_and_principal_direction(I)
global center;
[mu00,~,~,mu11,mu20,mu02,~,~,~,~]=momentos_centrales(I);
plot(center(1),center(2),'r+');
Cov=1/mu00.*[mu20 mu11;mu11 mu02];
[V,D]=eig(Cov);
V1=V(:,1); V2=V(:,2);
a1=D(1,1); a2=D(2,2);
x0=center(1); y0=center(2);
x1=V1(1)*a1+x0; y1=V1(2)*a1+y0;
line ([x0,x1],[y0,y1], 'LineWidth',1, 'Color',[0 0 1]);
x1=V2(1)*a2+x0; y1=V2(2)*a2+y0;
line ([x0,x1],[y0,y1], 'LineWidth',1, 'Color',[0 0 1]);
end
```

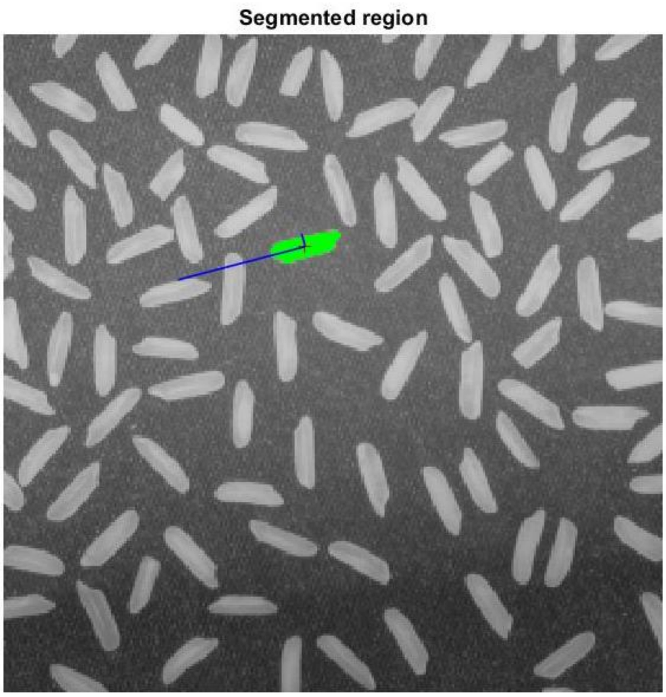


Image 1

As we see in the image, the vector indicates the orientation of the segmented region and the intensity of each orientation from the base x=(1,0) y=(0,1). The one who have the major intensity indicate the predominant orientation.