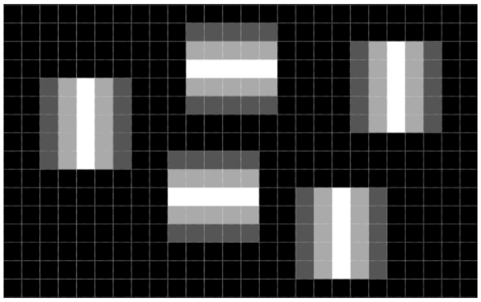
# Video Signals

Date: 16 June 2022



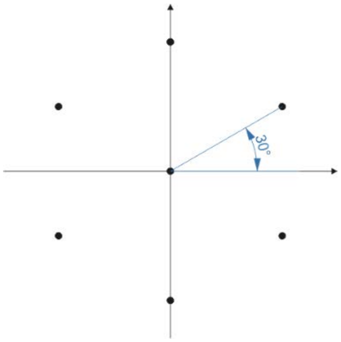
**Ex.1.[11 pts]** Given the 8 bit gray scale image on the right, some 5x5 wedges are present, where the intensities, e.g. for the vertical ones, are:

.

| | | | | |
|---|---|---|---|---|
| 85 | 170 | 255 | 170 | 85 |
| 85 | 170 | 255 | 170 | 85 |
| 85 | 170 | 255 | 170 | 85 |
| 85 | 170 | 255 | 170 | 85 |
| 85 | 170 | 255 | 170 | 85 |

The background is totally black (0) and for the horizontal wedges the matrix is simply transposed.
Define a proper Prewitt Filter to localize vertical wedges and differentiate them for horizontal ones, in particular: define the shape and the values of the filter, apply it to one vertical and one horizontal wedge and provide the intensities outcome. Provide a criterion to discriminate vertical and horizontal wedges and find the proper numerical values threshold adopted.

**Ex.2. [10 pts]** We have an image with the seven dots depicted below. Each dot, except the one in the origin, is equally spaced of 60° and their distance is 1 from the origin.




Using the Hough transform find the position of the 3 global maxima: what are their coordinates in the dual space?

What we can say about further non-global maxima?

**Ex. 3 is overleaf**

**Es.3. [12 pts to be done on the classroom PC using MATLAB]**

You want to solve the problem of counting and visually estimate the weight of newborn fishes in a fish breeding facility. You have built a system (Fig. 1) in which the camera is able to capture all the newborn fishes going through a water slide (a video frame is shown in Fig. 2). Assuming that the fishes do not overlap and they all have a dark color, while the background has a homogeneous light color, analyze the video frame shown in Fig. 2, in order to count the number of fishes and estimate their weight according to Eq. 1

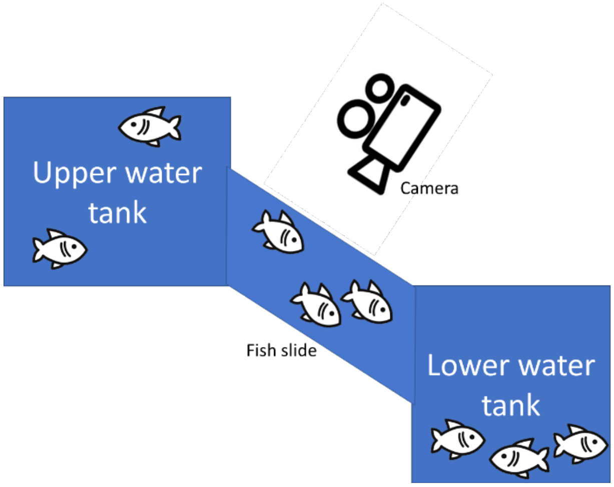



*Figure 1: Image aquisition system*

*Figure 2: Video Frame*

$$\text{Eq. 1:}\quad mass\ [g] = 8 + 0.02 \times area\ [pixel] - 0.05 \times perimeter\ [pixel]$$

Write a MATLAB script able to perform the following steps:

a) Read the 8-bit grayscale image (stored in the file *'video_frame.png'*) and visualize it.

b) Obtain a binary image using a threshold value of 100 (fishes must appear as white) and visualize the result.

c) Obtain a label image of connected components of the binary image (*hint: use the default 8-connectivity and remember that label 0 will be assigned to the background*).

d) Initialize the fish counter to zero and for each label in the label image (excluding the background) perform the following operations:

   I. Obtain a binary image specific to the considered label.

   II. Calculate the fish area (count the number of white pixels) and check if the area is greater than 100 (in order to exclude spurious white regions not related to any fish). Perform the following steps only if the previous condition is satisfied:

      i. Increase the fish counter by one.

      ii. Using a 3x3 8-connectivity structuring element, extract the boundary of the fish binary image and obtain the perimeter binary image.

      iii. Calculate the fish perimeter by counting the number of white pixels in the perimeter binary image.

      iv. Calculate the fish mass with Eq. 1

# Solutions

## *Es.1*

If we call W the wedges as the one described with the vertical edge and $W^T$ its transposed version, we can consider a Prewitt filter $p = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix}$.

Filtering a crop $C$ of the image with zero in the background and a wedge W at the center will give:

$$C = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 85 & 170 & 255 & 170 & 85 & 0 & 0 & 0 \\ 0 & 0 & 85 & 170 & 255 & 170 & 85 & 0 & 0 & 0 \\ 0 & 0 & 85 & 170 & 255 & 170 & 85 & 0 & 0 & 0 \\ 0 & 0 & 85 & 170 & 255 & 170 & 85 & 0 & 0 & 0 \\ 0 & 0 & 85 & 170 & 255 & 170 & 85 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

with the filter p will give:

$$C * p = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 85 & 255 & 510 & 595 & 510 & 255 & 85 & 0 & 0 & 0 \\ 0 & 0 & 85 & 255 & 510 & 595 & 510 & 255 & 85 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -85 & -255 & -510 & -595 & -510 & -255 & -85 & 0 & 0 & 0 \\ 0 & 0 & -85 & -255 & -510 & -595 & -510 & -255 & -85 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

While, if the wedge is horizontal:

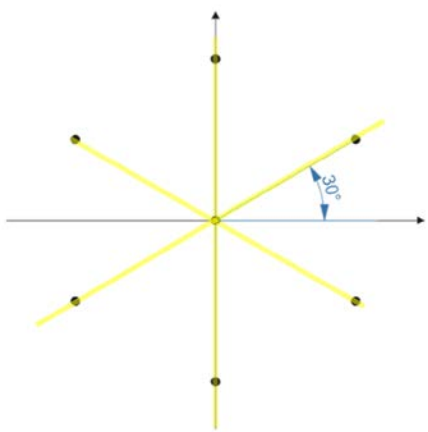
$$C^T = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 85 & 85 & 85 & 85 & 85 & 0 & 0 & 0 \\ 0 & 0 & 170 & 170 & 170 & 170 & 170 & 0 & 0 & 0 \\ 0 & 0 & 255 & 255 & 255 & 255 & 255 & 0 & 0 & 0 \\ 0 & 0 & 170 & 170 & 170 & 170 & 170 & 0 & 0 & 0 \\ 0 & 0 & 85 & 85 & 85 & 85 & 85 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$C^{\mathrm{T}} * p = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 85 & 170 & 255 & 255 & 255 & 170 & 85 & 0 & 0 & 0 \\ 0 & 0 & 170 & 340 & 510 & 510 & 510 & 340 & 170 & 0 & 0 & 0 \\ 0 & 0 & 170 & 340 & 510 & 510 & 510 & 340 & 170 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -170 & -340 & -510 & -510 & -510 & -340 & -170 & 0 & 0 & 0 \\ 0 & 0 & -170 & -340 & -510 & -510 & -510 & -340 & -170 & 0 & 0 & 0 \\ 0 & 0 & -85 & -170 & -255 & -255 & -255 & -170 & -85 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

A possible threshold to distinguish the two wedges is a value between 511 and 595 (considering the absolute values) that is present just in vertical wedges.

## *Es.2*

Considering all possible lines in the dual space of the Hough transform, you will get three global maxima (i.e. 3 points where 3 sinusoids will overlap) representing (in the direct space) the three yellow lines below:



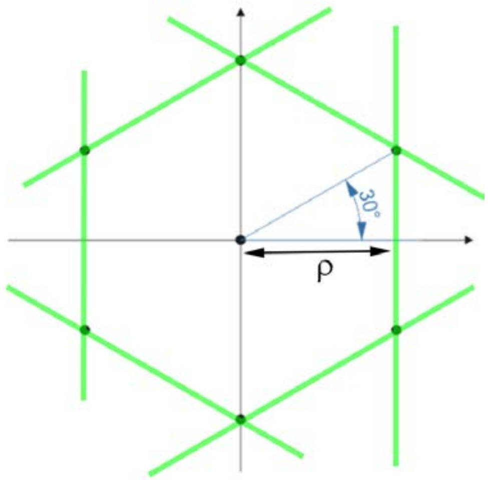

For each of them, according to the notation used in the lectures, we have:

$\rho = 0, \theta = 60°$

$\rho = 0, \theta = 0°$

$\rho = 0, \theta = -60°$

The other local and not global maxima will simply be represented by lines joining only 2 points as depitcted by the green lines below.




The six local maxima will then be:

$\rho = 1 \cdot \cos 30°, \theta = 0°$

$\rho = 1 \cdot \cos 30°, \theta = 60°$

$\rho = 1 \cdot \cos 30°, \theta = -60°$

$\rho = -1 \cdot \cos 30°, \theta = 0°$

$\rho = -1 \cdot \cos 30°, \theta = 60°$

$\rho = -1 \cdot \cos 30°, \theta = -60°$

## *Es.3*

```
clc
close all
clear all

%a)
I=imread('video_frame.png');
figure
imshow(I)

%b)
I_bw = I<100;
figure
imshow(I_bw)


%c)
L = bwlabel(I_bw);

%d)
min_area = 100;
count = 0;
for k=1:max(L(:))

    %d.1)
    mask = (L==k);

    %d.2)
    area = sum(mask(:));
    if(area>min_area)

        %d.2.i)
        count = count+1;
```

```
        %d.2.ii)
        B = strel('arbitrary', [1 1 1; 1 1 1; 1 1 1]);
        I_per = mask - imerode(mask, B);

        %d.2.iii)
        per = sum(I_per(:));

        %d.2.iv)
        mass = 0.02*area - 0.05*per + 8;

    end

end
```