Assignment 1

Basic Image Processing Algorithms
Fall 2024

General rules

This is the first assignment. There will be one more assignment during the semester.

Point value: **20 points**, which is 50% of the total assignment points.
Criteria: **At least 10 points must be reached on this assignment in order to pass.**
Deadline: **October 16, 2022 23:59:59** (late submission until Oct. 18)
This is a not-guided exercise. The description of this assignment is general and does not focus on the details as in case of the Lab exercises.

The main task is to provide a good, reasonable solution. You may code “freely” (only minimal restrictions on file names and outputs are given).

Problem formulation

You have to write a custom data processing (optical pattern / data recognition) program that can straighten a rotated page of text, can identify optical markers in the page and can digitize the handwritten data

Input: an image showing a possibly rotated page of a questionnaire

Output: the digitized data

Tasks to do

Write a script that…

1. loops through the input folder and processes each image as follows:
2. applies histogram operations (e.g. stretching) to enhance quality
3. applies Fourier transform to get the phase and magnitude matrices
4. uses the frequency domain data to restore the rotation of the image
5. applies a Hough-like transformation to find the circles in the image
6. examines the histogram inside the circles
7. decides for each circle whether it contains a cross (an X) or not
8. stores the digitized value in an accumulator (an array)
9. after each image is processed, returns the statistics of the votes.

Key results to be presented:

You may code freely, as there are not so many restrictions on what to use.

However, please create the followings:

1.) A function named `processor` which takes and argument (image matrix) and returns the digitized data (a 4×2 matrix containing ones at places where the corresponding circles contained an X)

2.) A script that iterates through all images in the `input` folder, applies the processor function to each of them and summarizes the results.

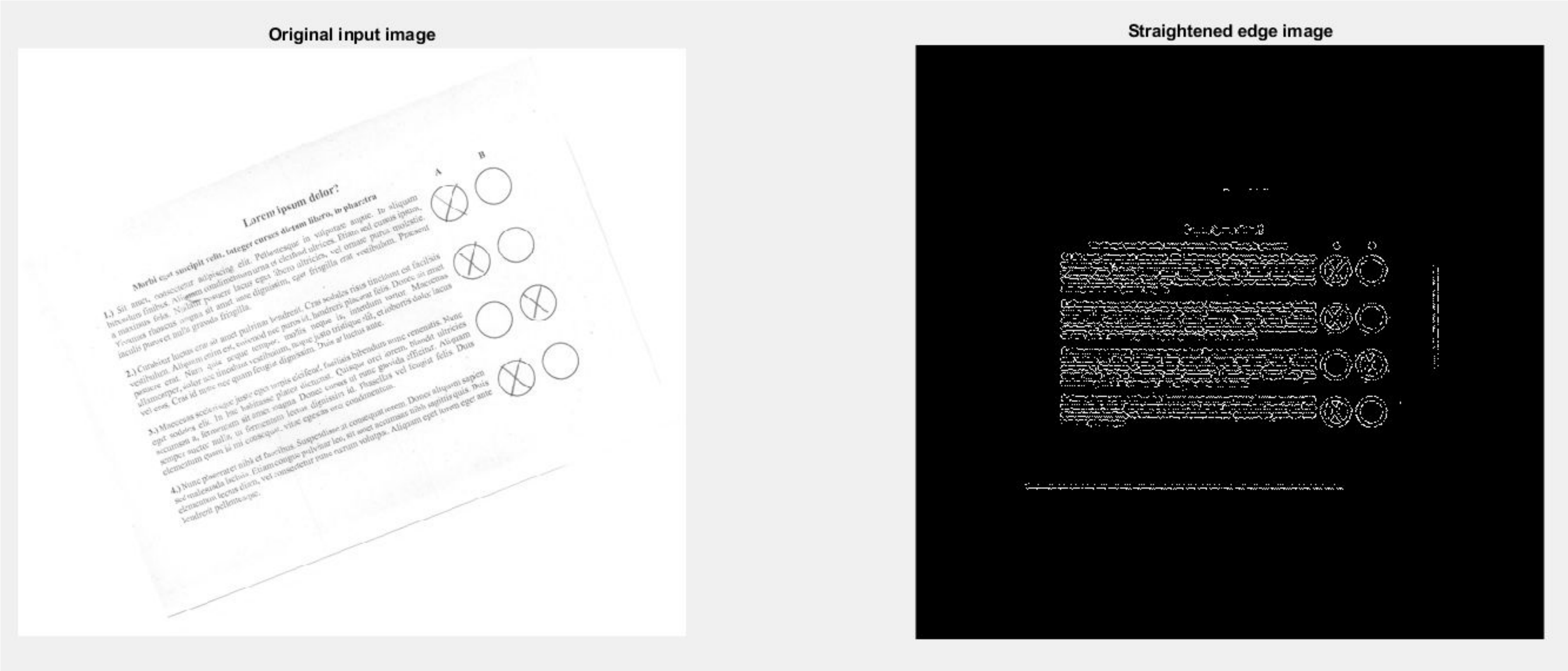
Key results to be presented:

Further details of the `processor` function:

It should have an optional second argument (`verbose`) which is False by default. If set to True, the function should raise 3 figures as follows:

Figure 1	shows the input image and the rotated, binarized, “edge” one
Figure 2	shows the found circles and the corresponding Hough space
Figure 3	shows the cropped image of every circle with a title saying whether this circle contains a cross or not

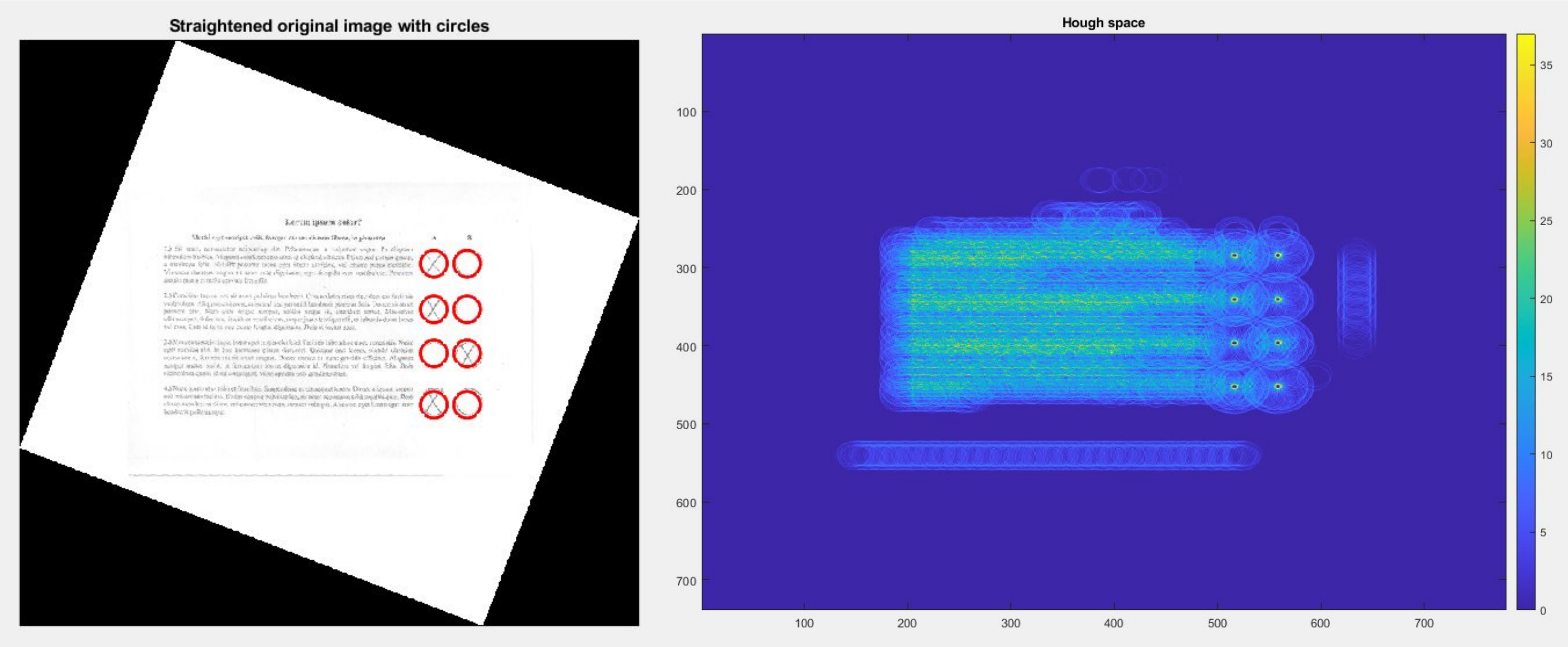
Figure 1



Original input image

Straightened edge image

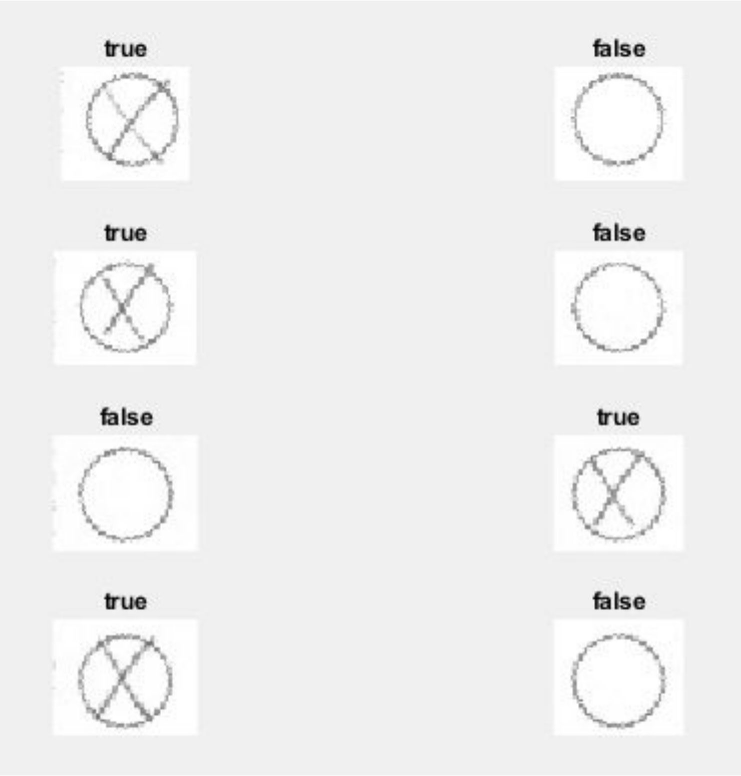
Figure 2



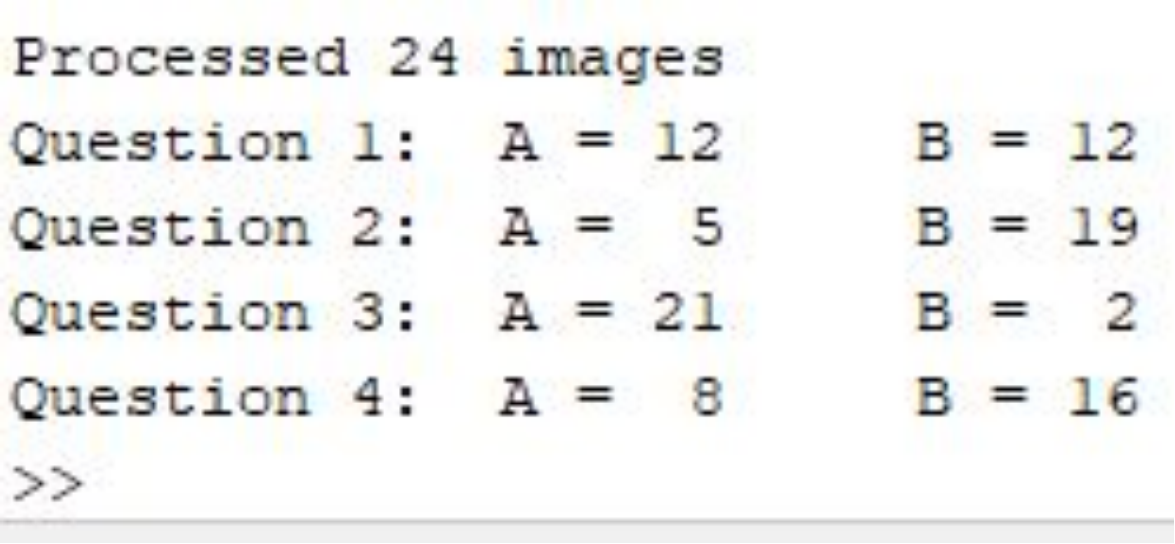
Straightened original image with circles

Hough space

Figure 3



Console output after the processing is complete



```
Processed 24 images
Question 1:  A = 12     B = 12
Question 2:  A =  5     B = 19
Question 3:  A = 21     B =  2
Question 4:  A =  8     B = 16
>>
```

There is no code package for this assignment.

All scripts and functions must be written entirely by you.

Submission & hints

You should create a script named `a01_NEPTUN.m` where the NEPTUN part is your Neptun ID. This has to be the main script; running that must be able to solve the problem. Please also create the `processor.m` function.

You are allowed to create other files (e.g. additional functions) too, if necessary.

Please submit ALL files (including the input folder as well) in a **ZIP** file via the Moodle system.

Check the upcoming slides for hints!

Hint 1

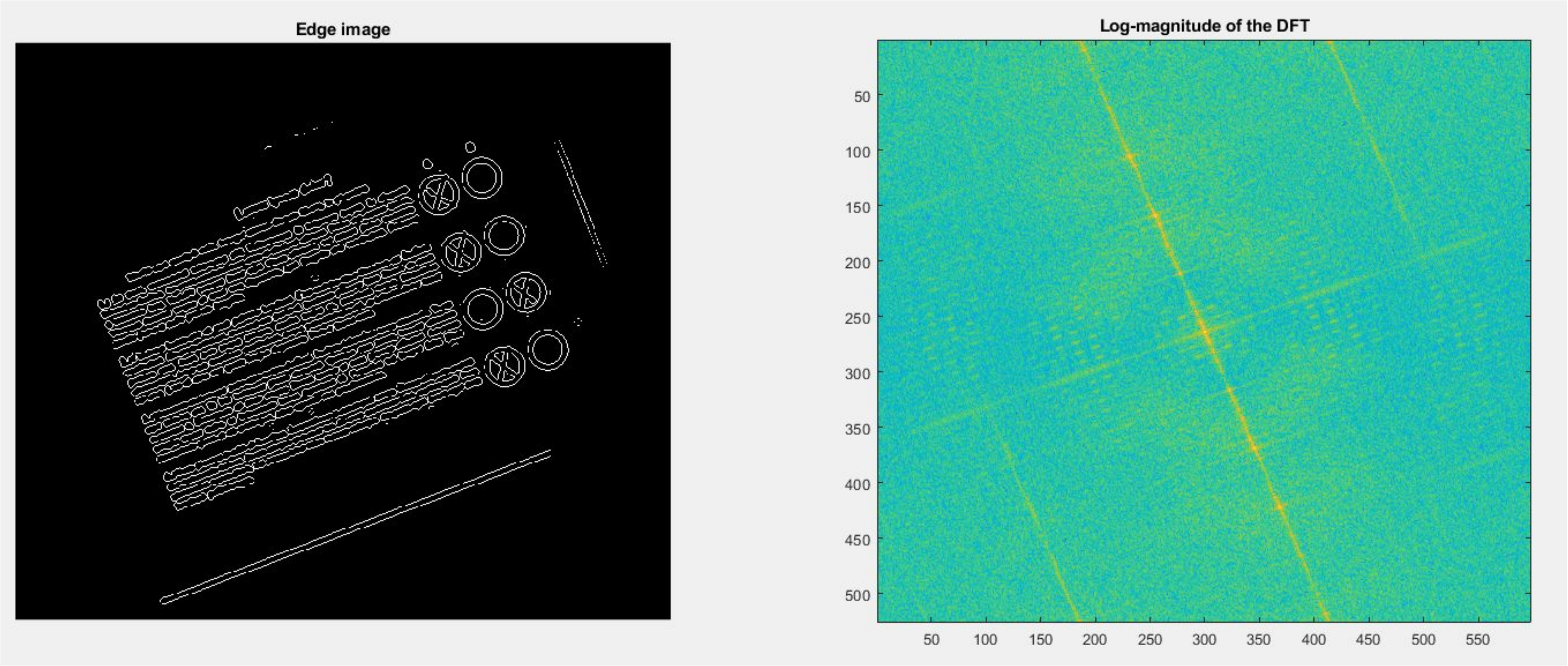
Start by applying an RGB to grayscale operation and then an edge finding operation. You may consider using the built-in `edge` function with an appropriate method and additional parameters.

To straighten the image you may use the magnitude of the DFT of this edge-image which has maxima values along a line crossing the center.

The angle of this line is the same as the rotation of the image.

See the figure in the next slide!

Hint 1


Edge image
Log-magnitude of the DFT
50
100
150
200
250
300
350
400
450
500
50
100
150
200
250
300
350
400
450
500
550

Hint 2

The Hough method can be modified in order to find circles instead of lines.

Use the equation of the circle:

$$(x-a)^2+(y-b)^2=r^2$$

Also, it might be beneficial to read the following article: https://en.wikipedia.org/wiki/Circle_Hough_Transform

In this Assignment, the radius of the circle can be considered known, so the Hough space can (and should) be 2D.

Hint 3

Identify the relationship between the circles by the position of their centers.

Use this info to identify which circle corresponds to which answer option.

To detect the cross in the circle you may use the histogram of the cropped circle and / or anything else that comes to your mind.

E.g. a Laws-like filter (or a simple convolution) can be used to detect whether the content looks like an X or not. Any other methods (e.g. Fourier based) can be good too.

Grading

The final score of this assignment is the sum of the following points:

The script filename is correct, it’s a script, function exists, name is correct	2 points
Script processes all images in the input folder	1 point
Edge finding exists, chosen method and its parameters are OK	1 point
FFT of the edge image exists, maxima values are used for rotation angle	2 points
Image is straightened using the angle in the previous point, Fig.1 exists	1 point
Hough space exists, has correct dimensions and type	2 points
Hough algorithm is for circles, it works as expected, Fig.2 exists and looks good	2 points
Found circles are cropped as requested, exactly 8 circles are found	2 points
Cross detection works as expected, Fig.3 exists and looks good	2 points
Function returns a 4×2 boolean matrix, values are OK, accumulation is OK	2 points
The script shows a summary after the processing is done	1 point
Code quality (readability, understandability, good comments and structure)	2 points

Contact

If you have any further questions regarding this assignment, contact

Lab leaders

via **Teams** (in private chat) or write an email to

kovendi.jozsef@itk.ppke.hu

bodis.balazs.mark@itk.ppke.hu

palffy.balazs.1@itk.ppke.hu

THE END