General Course Info

Basic Image Processing Algorithms
Fall 2024

Times, rooms, teachers, website

Group 0IP & 0IPL:
    Wednesday, 8:15-10:00
    222 PC lab
    practice leader: Bódis Balázs Márk
    Email:
    bodis.balazs.mark@hallgato.ppke.hu

Group 01 & 01L:
    Wednesday 8:15-10:00
    322 PC lab
    practice leader: Pálffy Balázs
    Email: palffy.balazs@itk.ppke.hu

Group 02 & 02L:
    Wednesday 8:15-10:00
    422 PC lab
    practice leader: Kövendi József
    Email: kovendi.jozsef@itk.ppke.hu

You should regularly check the Moodle page of this course:

https://moodle.ppke.hu/course/view.php?id=1687

Rules

- On each lab some programming tasks will be given to you. ***You have to work on the tasks during lab-time and follow the instructions of the practice leader*** in order to solve the exercises. ***You have to understand the code and be able to explain it.***

- The lab exercises will be written in MATLAB. Your uploaded Lab-solutions and Assignment-files should be able to run in version R2018b or higher without error.

- ***Using someone else's code is strictly forbidden!*** Code plagiarism instantly leads to denial of the Teacher's signature.

- ***Usage of online material is allowed, but citation is needed!***

Requirements

- ***The exercises of the Labs have to be solved and submitted on the lab-day.*** The deadlines are clearly indicated in the Moodle system.

- ***There will be two Assignments that have to be solved and submitted within 7 days*** (there is no exception in case of autumn break).

There will be a total of 11 Labs and 2 Assignments.
- In order to get the Teacher's signature the Student must collect
  - at least 6 points from the Lab submissions (maximum 11);
  - accomplish at least 50-50% points on the Assignments
- Your final score on the labs is the sum of your Assignment points (the assignment-performance will contribute in your final score).
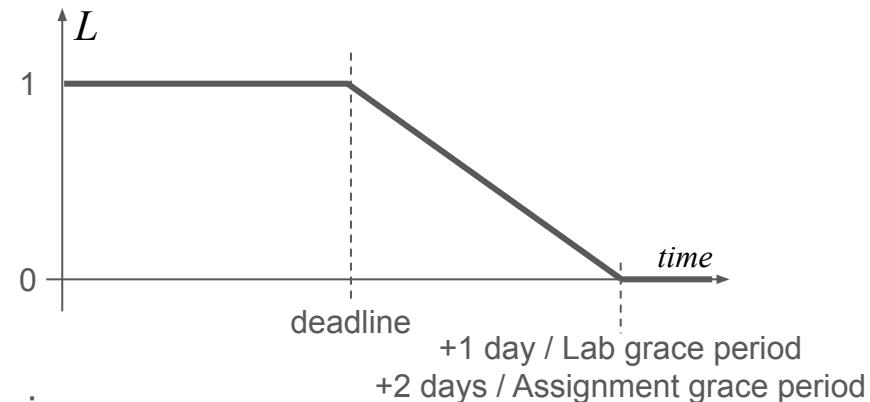
Grading

For each Lab:
- The grade of a submission is from the set $\{-1\} \cup [0,1]$.
- The grade is –1 if the submission is missing or the code throws a serious error (e.g. `MATLAB:UndefinedFunction`, `MATLAB:badsubscript`, `MATLAB:TooManyInputs` etc.).
- Otherwise, the Lab's grade is a number from the [0,1] interval depending on how well the required functions were implemented.
- In case of a late submission the [0,1] range is scaled down by a factor L which depends on the date of submission.
- Each task can be submitted only once!

For each Assignment:
- Its individual weight in the 'lab score' will be defined later.
- Points are scaled down in case of late submission.
- Each assignment can be submitted only once.

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Lab 01

Basic Image Processing Algorithms
Fall 2024

Data in MATLAB

22	12	42	32
62	52	72	92

11
33

- how to create a matrix:
  - `m1 = [22 12 42 32; 62 52 72 92];`
  - `m2 = [11; 33];`

11	33

- transpose: `m2t = m2';`

22	12	42	32	11
62	52	72	92	33

- concatenate: `m3 = [m1, m2];`
- indexing:
  - **index itself starts from 1!**
  - single element: `element = m1(2, 1)`

62

`m1(1, end) = 77`

22	12	42	77
62	52	72	92

special keyword

7

Data in MATLAB

m3:
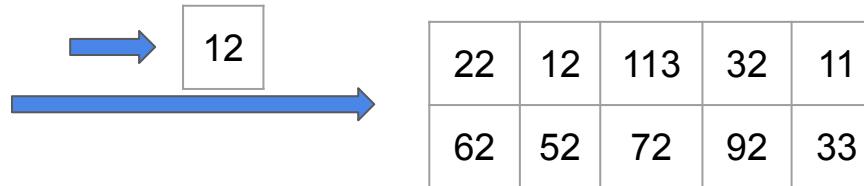
| 22	12	42	32	11
62	52	72	92	33

- indexing:
  - linear indexing:
    - in the background, your ND array stored as a 1D column vector
    - with one index only (regardless the number of dimensions) you can refer to any of your element
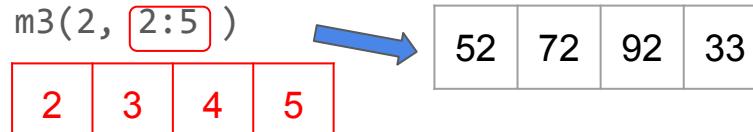
      `element = m3(3)` → 12

      `m3(5) = 113`

22	12	113	32	11
62	52	72	92	33
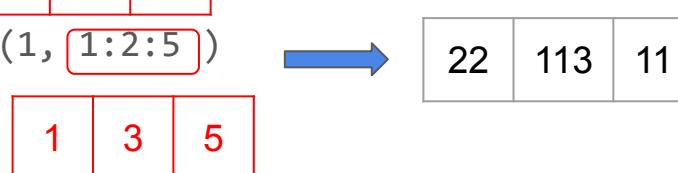
  - accessing multiple elements aka. *indexing with vectors/matrices*:
    - consecutively: `mp1 = m3(2, 2:5 )`

2	3	4	5

      → | 52 | 72 | 92 | 33 |
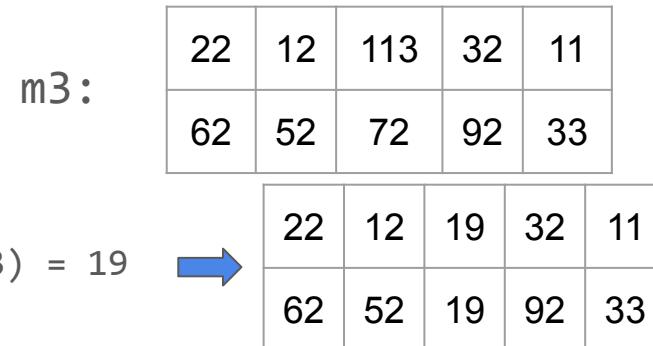
    - non-consecutively: `mp2 = m3(1, 1:2:5 )`

1	3	5

      → | 22 | 113 | 11 |

Data in MATLAB

m3:

22	12	113	32	11
62	52	72	92	33

- *indexing / acc. mult. elements continued:*
  - along a whole dimension/direction: `m3(:, 3) = 19`
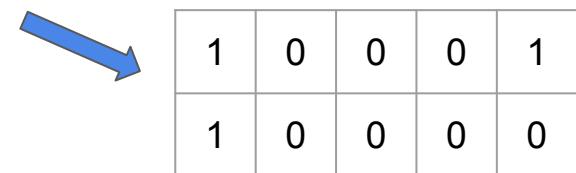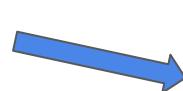
22	12	19	32	11
62	52	19	92	33

  - with logical array / expression:
    ```
    idxs = logical([1 0 0 0 1; 1 0 0 0 0])
    m3(idxs)
    ```

22
62
11

1	0	0	0	1
1	0	0	0	0
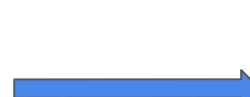
22
32
33

    ```
    idxs2 = m3>20 & m3<40
    m3(idxs2)
    ```

1	0	0	1	0
0	0	0	0	1
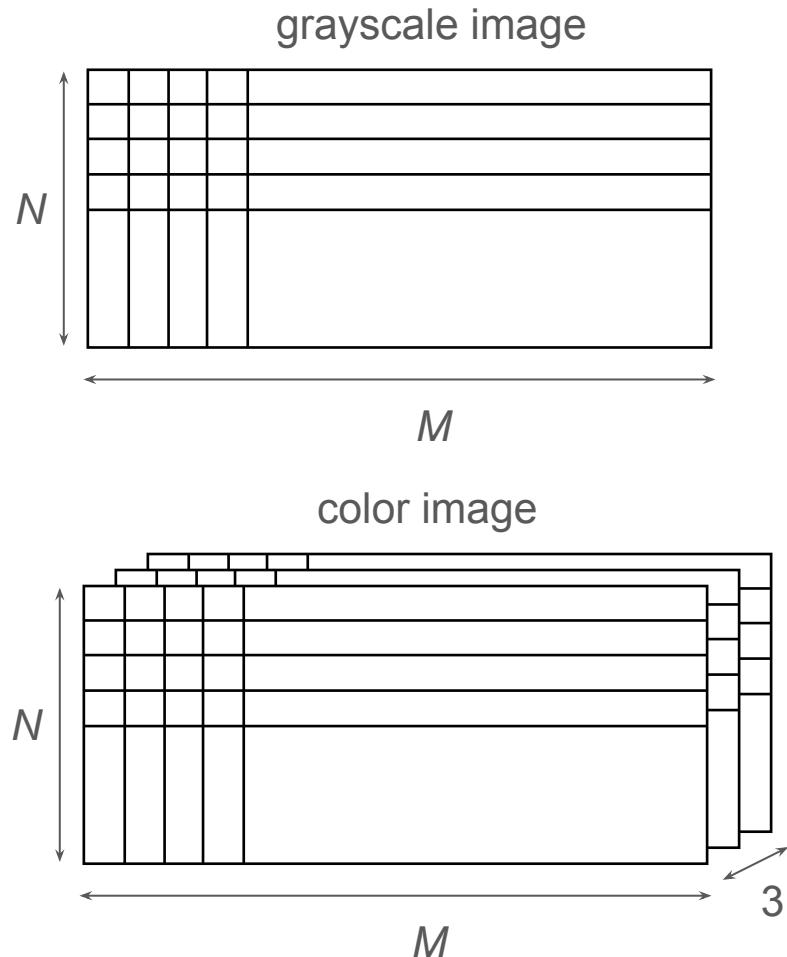
- `size, squeeze, reshape` (please recap from MATLAB Help these & the chapter Matrix Indexing)

Image data in MATLAB

- **Picture elements (pixels) have a location** (vertical, horizontal, (and channel) coordinates) **and an intensity value.**
- role of the type of the data
  - `uint8` → range: [0, 255]
  - `double` → range: [0, 1]
    `double` is the default type of every number in MATLAB
- number of dimensions of the array
  - 2 → grayscale or BW image
  - 3 → color image (channels 'r', 'g', 'b')

grayscale image

N

M

color image

N

M

3

Script   vs.   Function

- **no formal constraint** on the syntax
- the **workspace is shared** with other, individual commands typed in the Command Window

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- **syntax constraints**:
  first line:
  [*out_args*] = function fname(*in_args*)
  last line:
  end
  the fname should match the name of the m-file
- the **workspace is individual**:
  - when terminates, all the variables are destroyed except return values
  - during execution, the outer workspace is unreachable

You will have to hand in <u>functions only!</u>

For every Lab task you can download a "code package" containing all the necessary test images, scripts and empty functions.

Your task is to implement the functions as described in the "slides" of the Lab.

After implementation, you should run the scripts, understand the whole project.

Finally, you have to upload the implemented function files only!
(I.e. no test images, scripts, results, reports etc. are needed).

But today is somewhat special :P

Now please

download the 'Lab 01' code package

from

https://moodle.ppke.hu/course/view.php?id=1687

Exercise 1

Create a script (`script1.m`) in which:

- Using `imread()`, load the file 'AlfredoBorba_TuscanLandscape.jpg'
- Using `imshow()`, display the loaded image
- Create a logical variable which tells whether the image is color
  - Name the variable `isColor`
  - Check if the number of channels is exactly 3. For this you can use `size()`.
- If `isColor`, use `rgb2gray()` to convert the image to grayscale
- Using `imshow()`, display the grayscale image
- Using `imwrite()`, save the grayscale image into the output folder. Name it 'AlfredoBorba_TuscanLandscape_GRAY.jpg'

Run this script and examine the results.

Exercise 2a

Create a script (`script2.m`) in which:

- Using `imread()`, load the file 'AlfredoBorba_TuscanLandscape.jpg'
- Call the function `flip_and_rotate()`
  - Check the empty function file to know the input and output arguments
  - In Exercise 2b you have to implement this function
- Using `subplot()` and `imshow()`, display the three returned images side by side.

After implementing the function, run this script and examine the results.

Exercise 2b

Implement the function `flip_and_rotate()` **in which:**

- The first returned value `VER` have to be the vertically flipped input image. Use `flipud()`.
- The second returned value `HOR` have to be the horizontally flipped input image. Use `fliplr()`.
- The third returned value `ROT` have to be the input image rotated by 45 degrees clockwise. Use `imrotate()`.

Exercise 3

Implement the function `swap_RB_dumb()` **in which:**
- In the returned image `BGR` the red and blue channels of the input image have to be swapped.
- **You have to carry out the operation pixel by pixel,** using a `for` loop.

Implement the function `swap_RB_smart()` **in which:**
- In the returned image `BGR` the red and blue channels of the input image have to be swapped.
- **You have to carry out the operation using array indexing,** without any loops.

Run the script `script3.m` **to test your functions, measure the runtimes and visualize the result.** Compare the runtimes. *Remember, that doing matrix operations using loops is usually slower than using smart indexing!*

Dumb: 0.011179 seconds

Smart: 0.000878 seconds
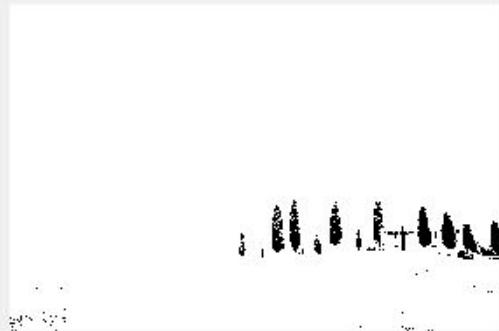
Exercise 4

Implement the function `threshold()` in which:
- Check if the input image `IMG` is grayscale (has only one channel). If not:
  - display a warning (use `warning()`),and
  - convert the input to grayscale (use `rgb2gray()`).
- The returned value `TH` should be a black-and-white image {0, 255} where all the pixels below the parameter `level` are black, the others are white.
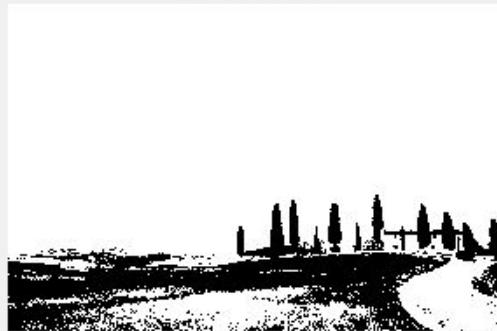
Run the script `script4.m` to test your function and visualize the results of different threshold levels.

level = 50   level = 100   level = 150
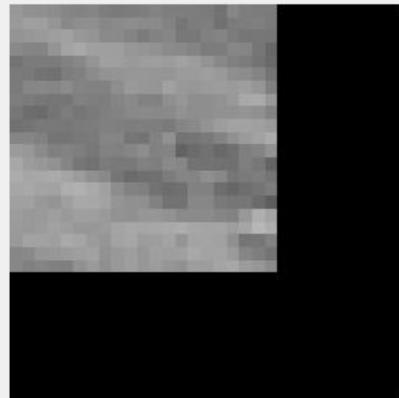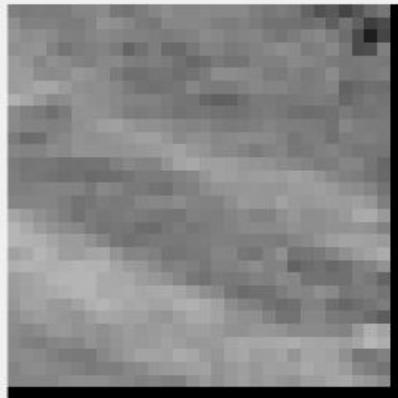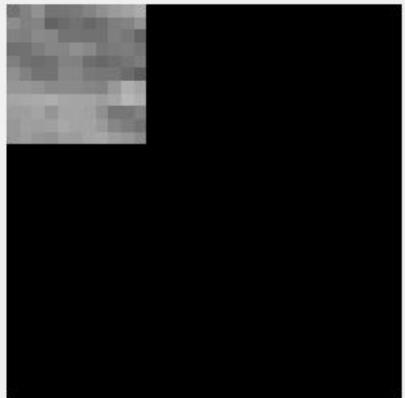
Exercise 5

Implement the function `pad_image()` in which:
- The function should work with 1 or 2 input arguments.
  - Use `varargin`.
  - The first input is always the input image `IMG`.
  - If given, the second one is the border size (`border_size`).
  - If there is no second argument, the border size should be 10.
- Check if the input image `IMG` is grayscale (has only one channel). If not:
  - display a warning (use `warning()`),and
  - convert the input to grayscale (use `rgb2gray()`).
- The returned value `PAD` should be the grayscale image surrounded by zeros.
  - It's advised to create a bigger matrix filled with zeros and copy `IMG` in the center.

**Run the script `script5.m` to test your function and visualize the results.**
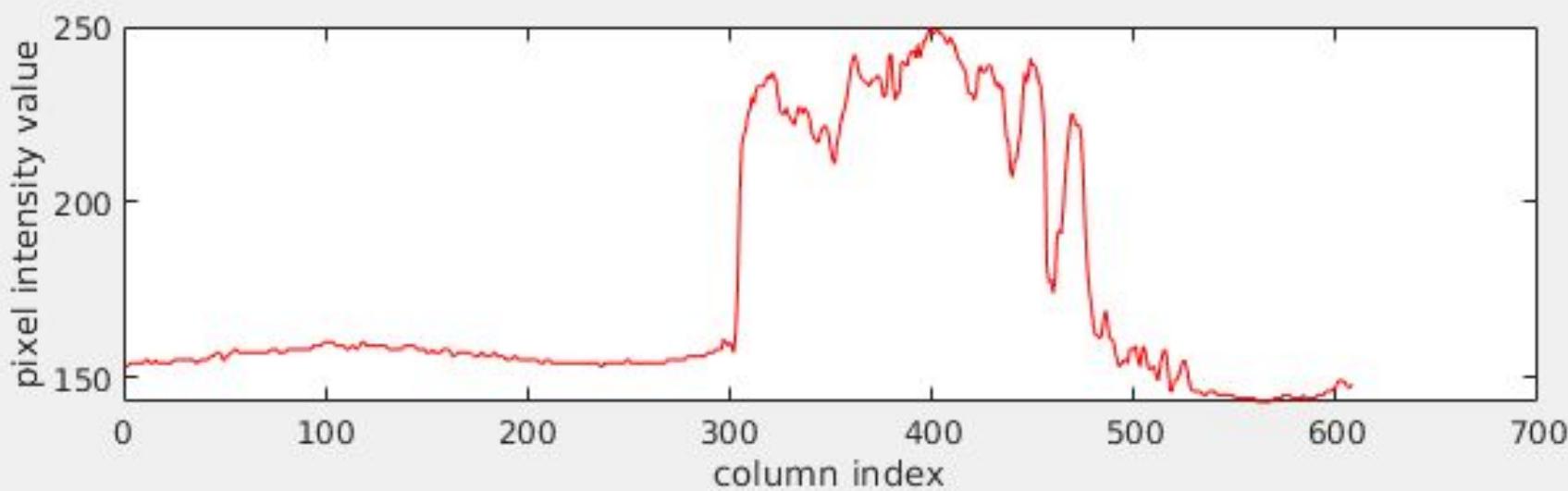
Exercise 6

Create a script `script6.m` **in which:**
- You should load the file 'AlfredoBorba_TuscanLandscape.jpg' and convert it to grayscale.
- Define a variable (`row`) and set its value to 150.
- Raise a new figure, display two subplots:
  - In the top, show the grayscale image.
  - On the grayscale image, plot a line according to the row number.
  - In the bottom, plot the pixel intensity levels in the selected row as a function of the column index.
  - Set the axis labels as seen in the next slide.

Run the script, visualize the result, play with the value of `row`**.**

THE END