Homework 6

`Image Processing`

Modification

1. All your modifications must be between the markers:
   `#DO_NOT_EDIT_ANYTHING_ABOVE_THIS_LINE`
   `#DO_NOT_EDIT_ANYTHING_BELOW_THIS_LINE`
   All changes in other places will be lost.
2. If you modify/delete the markers, we will not be able to extract your answer, and you may receive zero.
   SO, DON'T TOUCH THE MARKERS.

Description

In this homework, you will implement a small image processing application with various functionality. You will need to implement 6 functions that will be explained in more detail later in this document.

Your Task

Outline of the task (each one of these 5 tasks will amount to 20 points, to a total of 100):

- You will need to implement two functions `read_imagefile(f)` and `write_imagefile(f, img_matrix)` that will allow you to read and write `.pgm` image file format (more on that later).
  - If you want to see your results, you can view `.pgm` image files using the free software GIMP or following website online: PGMViewer.
- You will need to implement `misalign(img_matrix)` function. This function should reverse odd numbered columns in the given image.
- You will need to implement `sort_columns(img_matrix)` function. This function should sort every column of the given image in ascending order from top the bottom.
- You will need to implement `sort_rows_border(img_matrix)` function. This function should sort every row in ascending order from left to right. However, sorting should be done independently respecting the borders (see the detailed explanation below).
- You will need to implement `convolution(img_matrix, kernel)` function. This function should apply the convolution operation to the `img_matrix` using the 3x3 `kernel` (see the detailed explanation below).

Input

User will provide three words separated by single whitespaces in the form
`<INPUT_FILE> <COMMAND> <OUTPUT_FILE>`

Input taking part is already handled:

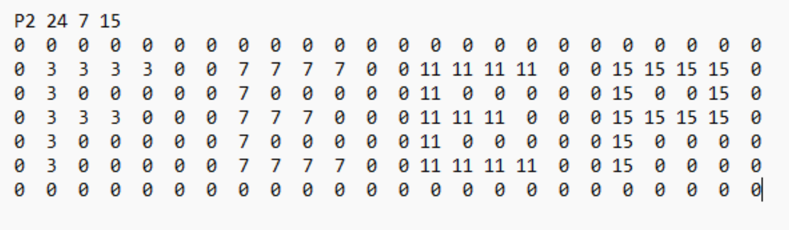
- Variable `inp_filename` : non-empty word `<INPUT_FILE>` . Name of the input image file. Always will be a `.pgm` file.
- Variable `operation` : non-empty word `<COMMAND>` . Name of the command. Possible values: `misalign` , `sort_columns` , `sort_rows_border` , `highpass`
- Variable `out_filename` : non-empty word `<OUTPUT_FILE>` . Name of the output image file. Always will be a `.pgm` file.

Provided Code

When you look at the provided code, you will see that we are already taking the input from the user and also at the bottom of the page we are already calling the related functions on given commands. It would be beneficial to investigate these parts as it will give a clue on how the program supposed to work.

.pgm Image File Format

We will be dealing with grayscale images (no colors). Following is an example `.pgm` file content.



```
P2 24 7 15
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  3  3  3  3  0  0  7  7  7  7  0  0 11 11 11 11  0  0 15 15 15 15  0
0  3  0  0  0  0  0  7  0  0  0  0  0 11  0  0  0  0  0 15  0  0 15  0
0  3  3  3  0  0  0  7  7  7  0  0  0 11 11 11  0  0  0 15 15 15 15  0
0  3  0  0  0  0  0  7  0  0  0  0  0 11  0  0  0  0  0 15  0  0  0  0
0  3  0  0  0  0  0  7  7  7  7  0  0 11 11 11 11  0  0 15  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
```

First line is composed of 4 parts as: `<CODE> <WIDTH> <HEIGHT> <MAX_LEVEL>`

- `<CODE>` will always be `P2`
- `<WIDTH>` is the width of the image in pixels (positive integer).
- `<HEIGHT>` is the height of the image in pixels (positive integer).

- `<MAX_LEVEL>` is the value that corresponds to pure white color. In our examples, this will always be 255. This means that 0 means pure black and 255 means pure white whereas all the numbers in between are shades of gray linearly.

Remaining lines contain the image data. From top left corner to bottom right corner, every value corresponds to the color of a pixel at its corresponding position. Data will always be whitespace separated. Note that there are no extra whitespaces at the end of the lines. Following is the image depicted by the example file given above (magnified):

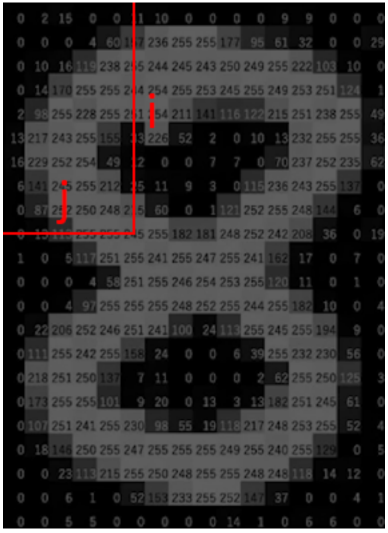
Function Definitions

read_imagefile(f)

This function should assume `f` is an already opened `.pgm` image file following the format described above (check the first three lines under the `# DO_NOT_EDIT_ANYTHING_BELOW_THIS_LINE`). It should read this file and convert it into a 2-D list of lists (of integers). Return value, let's say `img_matrix` should be this list. Given `i` and `j`, value of the `img_matrix[i][j]` should correspond to the **color value of the pixel** at the `i` 'th row and `j` 'th column of the image. This means that:

- If `i` is 0, we are referring to the first horizontal line of pixels (top part) of the image whereas if `i` is `<HEIGHT> - 1`. We are referring to the last horizontal line of pixels (bottom part) in the image.
- If `j` is 0, we are referring to the first vertical line of pixels (left part) of the image whereas if `j` is `<WIDTH> - 1`. We are referring to the last vertical line of pixels (right part) in the image.

Following is a short description of the content of `img_matrix`:

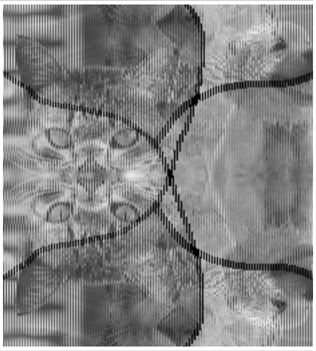


write_imagefile(f, img_matrix)

This function should assume f is an already opened `.pgm` file (opened in "w" mode) (check the last 3 lines of provided code). It should write to this file in such a way that it becomes a proper `.pgm` image file that contains the image described by `img_matrix`. It should follow the format of `.pgm` above.

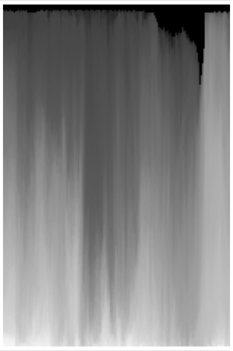
misalign(img_matrix)

This function should modify the `img_matrix` in such a way that the "odd numbered" columns of the image are reversed from top to bottom. It should return this resulting `img_matrix` after modification. Example:

Input	animals.pgm	animals_misalign.pgm
`animals.pgm misalign animals_misalign.pgm`		

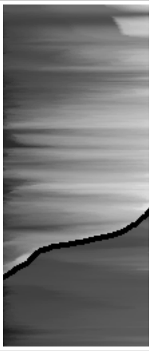
sort_columns(img_matrix)

This function should modify the `img_matrix` in such a way that the columns of the image are sorted from top to bottom, in ascending order. It should return this resulting `img_matrix` after modification. Example:

Input	animals.pgm	animals_sort_columns.p
animals.pgm sort_columns animals_sort_columns.pgm		

sort_rows_border(img_matrix)

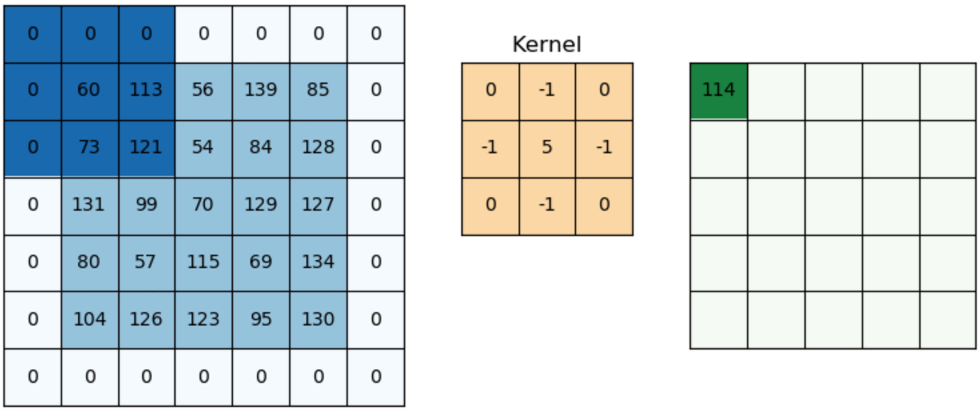
This function should modify the `img_matrix` in such a way that the rows of the image are sorted from left to right, in ascending order. However with one caveat, it should respect the borders. A border is a pure black (color value 0) separator between parts of the image. In the cases this function will be called, you can assume the only parts of the image that have the value 0 will be the borders. Borders does not have to be 1 pixel thick. They can be wider than that. If there are no borders in the image, this is almost the same task as previous one, with rows instead of columns. It should return this resulting `img_matrix` after modification. Example:

Input	animals.pgm	animals_sort_r
animals.pgm sort_rows_border animals_sort_rows_border.pgm		

convolution(img_matrix, kernel)

This function should return the result of the convolution with zero padding between `img_matrix` and a 3 by 3 kernel `kernel`. It will be called when the `highpass` command is entered by the user. It will be called using a specific kernel (check the provided code relating to the `highpass` command.)

What is convolution?



0	0	0	0	0	0	0
0	60	113	56	139	85	0
0	73	121	54	84	128	0
0	131	99	70	129	127	0
0	80	57	115	69	134	0
0	104	126	123	95	130	0
0	0	0	0	0	0	0

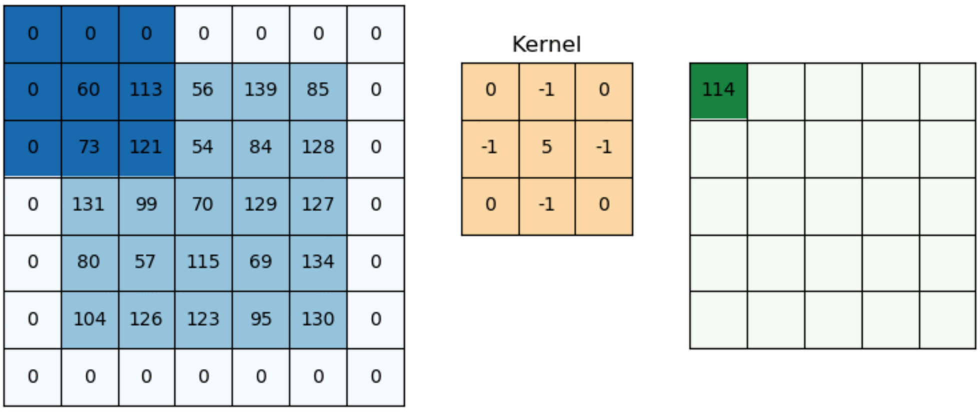
Kernel

0	-1	0
-1	5	-1
0	-1	0

114				

(GIF by Dharmaraj D)
Imagine the **light blue** part is the `img_matrix` and it is extended by zeroes. Operationally, imagine that you are moving the kernel on this new extended matrix. As the kernel is moving (**region in dark blue**) you

element-wise multiply the kernel and the values in **dark blue** region then sum all these values up. Result of this summation is the new value in your resulting matrix. For example, focus on the first frame:



0	0	0	0	0	0	0
0	60	113	56	139	85	0
0	73	121	54	84	128	0
0	131	99	70	129	127	0
0	80	57	115	69	134	0
0	104	126	123	95	130	0
0	0	0	0	0	0	0

Kernel

0	-1	0
-1	5	-1
0	-1	0

114				

This frame shows the calculation of the value in `[0][0]` position of the resulting matrix. When we element-wise multiply the kernel and the **dark blue** region and sum the values we get the expression

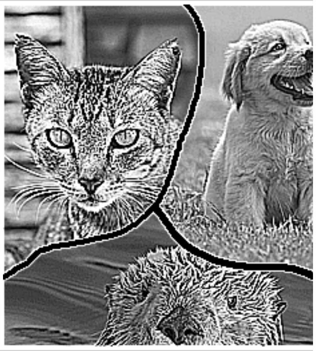
`(0 * 0) + (0 * -1) + (0 * 0) + (0 * -1) + (60 * 5) + (113 * -1) + (0 * 0) + (73 * -1) + (121 *`

Which is equal to `114`. This means the value at `[0][0]` position of the resulting matrix should be `114`.

Some notes:

- At each position, if the resulting value is bigger than 255, you should set it to 255.
- At each position, if the resulting value is less than 0, you should set it to 0.
- If you make changes on `img_matrix` while you are still applying the convolution operation, results will be altered. Therefore, you should create a new matrix and fill it with the values you are calculating while not touching the `img_matrix` itself.

It should return this resulting matrix after modification. Example:

Input	**animals.pgm**	**animals_highpass.pgm**
`animals.pgm highpass animals_highpass.pgm`		

Notes:

You will not be provided a `Tester.py` as with other homeworks. However, you are provided two example images and resulting images after each separate command. These will be in the same folder as `Main.py`. To check your results, you can open these image files in text editor and see the values. Also you should check them by eye, using an image viewer tool that was suggested in the **Your Task** section.

Check the examples for further clarification. Keep in mind that we will be grading your code not just based on these examples, but other cases as well, so try to write code which can handle all possible cases.

Warning: You are not allowed to use any imports.