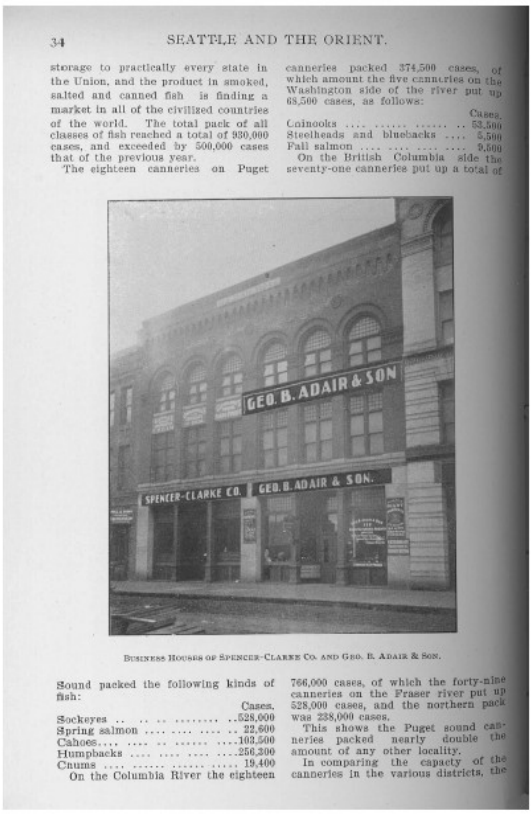
Sequence 5 exercises

1. Binarization of some scanned book pages (Homework)

Services like Internet Archive have digitized large collections of books. First, the book pages are scanned. Then, the scanned images are binarized and processed through an optical character recognition (OCR) engine. For modern books, the book spine can be removed to separate the book pages for more efficient scanning. For vintage books, however, destroying the original binding of the book is often undesirable. If a book is scanned with its spine left intact, the curvature of the pages causes uneven illumination in the resulting images. This effect can be observed in the following images.



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storage to practically every state in the Union, and the product in smoked, salted and canned fish is finding a market in all of the civilized countries of the world. The total pack of all classes of fish reached a total of 930,000 cases, and exceeded by 500,000 cases that of the previous year.

The eighteen canneries on Puget Sound packed the following kinds of fish:

	Cases.
Sockeyes	528,000
Spring salmon	22,600
Cahoes	102,500
Humpbacks	256,300
Chums	19,400

On the Columbia River the eighteen canneries packed 374,500 cases, of which amount the five canneries on the Washington side of the river put up 68,500 cases, as follows:

	Cases.
Coinooks	53,500
Steelheads and bluebacks	5,500
Fall salmon	9,500

On the British Columbia side the seventy-one canneries put up a total of 766,000 cases, of which the forty-nine canneries on the Fraser river put up 528,000 cases, and the northern pack was 238,000 cases.

This shows the Puget sound canneries packed nearly double the amount of any other locality.

In comparing the capacty of the canneries in the various districts, the

BUSINESS HOUSES OF SPENCER-CLARKE CO. AND GEO. B. ADAIR & SON.

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the busy places in the city. Eleven steamboats make a landing at this place, and have intercourse with all points on Puget Sound. About their wharf and in their warehouse they give steady employment to thirty people, and during the year they will probably increase this number, at least to the extent of putting representatives on the road to travel in their interest.

ROHLFS & SCHODER.

Seattle has one of the largest bank and office fixture manufacturing concerns in the Northwest in the firm of Rohlfs & Schoder. They are located at 610 to 620 First Avenue South in a building 150x150 feet in size. They have been established here since 1889 and are really the successors of the Hall & Polson Furniture Company. At the present time they give employment to forty people and the extent of their trade is very considerable. Their product, as above stated, consists of bank and office fixtures, which means practically the manufacture of counters, steamboat fixtures, and all kinds of stationary furniture, such as is used in banks, offices, steamboats and stores and covers a pretty wide range. The firm is one of the best known on Puget Sound, and the fact that their establishment is crowded with orders and their mill is about one of the busiest places in Seattle is evidence of the standing they possess. An illustration is shown herewith which will give some idea of the size of the building they occupy, but to thoroughly appreciate the great amount of industry manifested one is compelled to make a visit through their place.

FACTORY OF ROHLFS & SCHODER.

ONE OF THE BIG MACHINE WORKS.

One of the largest and best known machine works on the North Pacific Coast is that of the Washington Iron Works Company, which occupies two and one-half blocks of land on Grant Street, in the southern part of the city. Some illustrations accompany this article, which will afford an idea of the magnitude of the plant. The one of the exterior view does not take in the entire establishment, because of the fact that the buildings in which are located the foundry are some little dis-

Both images (*book_page_1.jpg* and *book_page_2.jpg*) are available in the *images* directory. Download the file *Sequence5_part1_code.py*.

(a) For each image, generate a binary image by performing a global thresholding. Use a threshold chosen by Otsu's method (cf. *threshold_otsu()* function). Display the binary image. Also, display the histogram of the original image and clearly mark the threshold of Otsu's method on this histogram. Comment on the quality of the binary image for text reading (do not take attention to the figures). What is the problem?

(b) Propose and implement a solution in order to improve the binarized image. Display the binary image by explaining your method to obtain it. Comment on the quality of the binary image for text reading compared to the result from part (a).

2. Kmean clustering (Classwork)

Download the file *Sequence5_part2_code.py*.

2.1 Kmean clustering based on luminance information

Proceed to the kmean segmentation of images *toyobjects.png*, *bacteria.tif* and *leopard.jpg*. In each case, guess the optimal number of clusters. Rmk: for the *bacteria.tif* image, we suppose there are two clusters only: bacteria and background.
Comment the obtained segmentations. Explain in each case why the kmean algorithm is efficient or not.
In order to post process the segmented image, apply some morphological operations. Explain your process.

2.2 Kmean clustering based on Gabor features

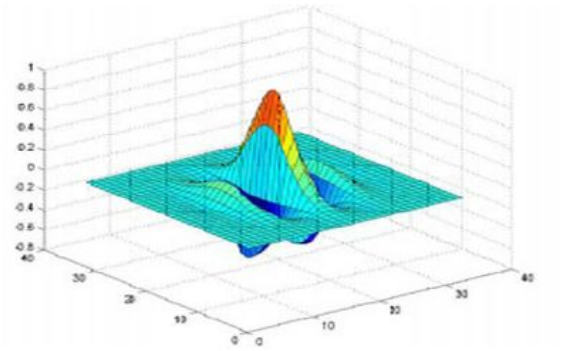
In order to improve the segmentation especially for the *leopard.jpg* image, let us consider Gabor filters. Gabor filters are filters sensitive to both frequency and orientation. They emphasize frequencies in a given orientation. Such a filter is defined by:

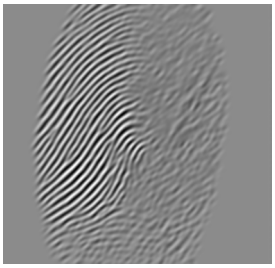
$$g_{\theta,f}(x,y) = \exp\left[-\frac{1}{2}\left(\frac{{x_\theta}^2}{\sigma_x^2} + \frac{{y_\theta}^2}{\sigma_y^2}\right)\right]\cos\left(2\pi f x_\theta\right)$$

$$g_{\theta,f}(x,y) = \exp\left[-\frac{1}{2}\left(\frac{{x_\theta}^2}{\sigma_x^2} + \frac{{y_\theta}^2}{\sigma_y^2}\right)\right]\cos\left(2\pi f\left(x\sin\theta + y\cos\theta\right)\right)$$

$$\begin{bmatrix} x_\theta \\ y_\theta \end{bmatrix} = \begin{bmatrix} \cos(90°-\theta) & \sin(90°-\theta) \\ -\sin(90°-\theta) & \cos(90°-\theta) \end{bmatrix}\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} \sin\theta & \cos\theta \\ -\cos\theta & \sin\theta \end{bmatrix}\begin{bmatrix} x \\ y \end{bmatrix}$$

Where: θ is the filter orientation, *f*: is the sine filter frequency, σ_x, σ_y are the standard deviations of the exponential envelop.
Rmk: theoretically, the full expression of Gabor filter introduces also a complex term in the expression which is i*sin(…) (exp[…] * (cos(…) + i*sin(…)) but here we have written the real part of the answer only.
The following figure presents an example of Gabor filter transfer function with the exponential envelop and the sine evolution. The figure shows the effect of such a filter tuned on 45° on a fingerprint image. It appears that the lines in the 45° orientation are highlighted.





Implement the Gabor filtering (cf. *skimage.filters* module) of the image to be segmented by considering the frequency=0.5 and 8 orientations (0, pi/8, pi/4, …, 7pi/8). Filter the *leopard.jpg* image with the 8 oriented filters and compute the magnitude of the Gabor filter answer for each orientation. Before displaying the results, smooth each answer by applying a Gaussian filter with sigma = 3 on each magnitude map.

In order to improve the segmentation result, the idea is to apply the kmean algorithm on the best Gabor map instead on the luminance map. If necessary, tune the Gabor filters parameters in order to obtain the best Gabor map (define first what a good Gabor map is in your opinion). Display the obtained segmentation.

In order to post process the segmented image, apply some morphological operations. Explain your process.