EIE4512 - Digital Image Processing – Homework #3

Instructor: Prof. Zhen Li

Due on 05/18/2019 17:00 pm

Written exercises

Problem 1

The arithmetic decoding process is the reverse of the encoding procedure. Decode the message 0.23355 given the coding model

Symbol	Probability
a	0.2
e	0.3
i	0.1
o	0.2
u	0.1
!	0.1

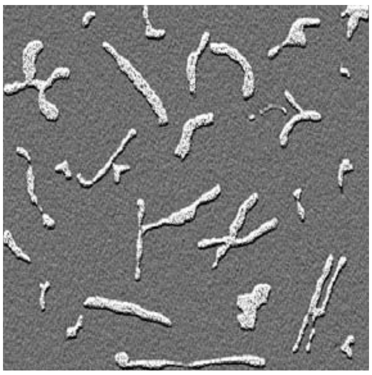
Problem 2

a. Use the LZW coding algorithm to encode the 7-bit ASCII string "aaaaaaaaaaa".

b. Devise an algorithm for decoding the LZW encoded output of Example 8.7 on textbook page 552. Since the dictionary that was used during the encoding is not available, the code book must be reproduced as the output is decoded.

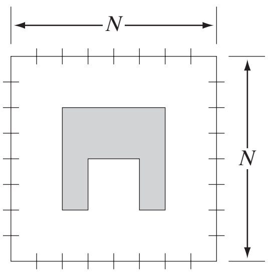
Problem 3

The objects and background in the image shown have a mean intensity of 170 and 60, respectively, on a [0, 255] scale. The image is corrupted by Gaussian noise with 0 mean and a standard deviation of 10 intensity levels. Propose a thresholding method capable of yielding a correct segmentation rate of 90% or higher. (Recall that 99.7% of the area of a Gaussian curve lies in $\pm 3\sigma$ interval about the mean, where σ is the standard deviation.)



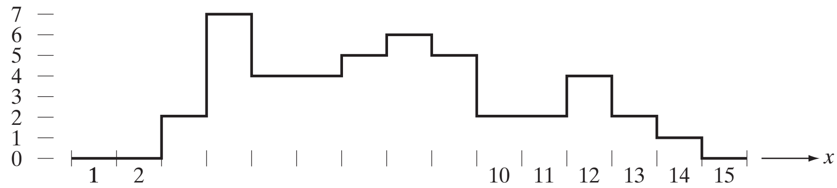
Problem 4

Segment the image shown by using the split and merge procedure discussed in class. Let $Q(R_i)$ = TRUE if all pixels in R_i have the same intensity. Show the quadtree corresponding to your segmentation.



Problem 5

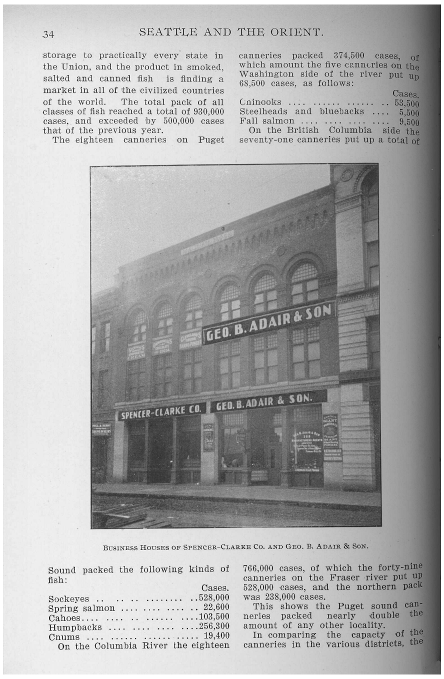
Give a step-by-step implementation of the dam-building procedure for the one-dimensional intensity cross section shown. Show a drawing of the cross section at each step, showing "water" levels and dams constructed.



Matlab exercises

Problem 1 Binarization of Scanned Book Pages

Services like the Guttenberg Project and 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 images pro1_page1.jpg and pro1_page2.jpg, which are available in the figs folder.



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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	103,500
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:

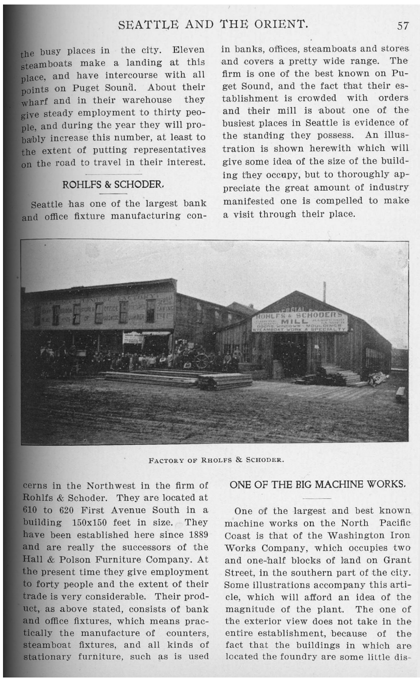
	Cases.
Chinooks	53,500
Steelheads and bluebacks	5,500
Fall salmon	9,500

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 RHOLFS & 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-

pro1_page1.jpg pro1_page2.jpg

(a) For each image, generate a binary image by performing global thresholding. Use a threshold chosen by Otsu's method (function: `graythresh`). Submit the binary image. Also, submit a histogram of the original image's gray values and clearly mark the threshold of Otsu's method on this histogram. Comment on the quality of the binary image.

(b) Now, perform locally adaptive thresholding. Treat uniform and non-uniform regions differently based on the local variance. Submit the binary image. Comment on the quality of the binary image compared to the result from part (a).

(c) Apply locally adaptive thresholding[1] to binarize the image pro1_page3.png, so that the text appears as black pixels and the blank space on the page appears as white pixels. Report the block size you select for locally adaptive thresholding. Submit the binarized image.

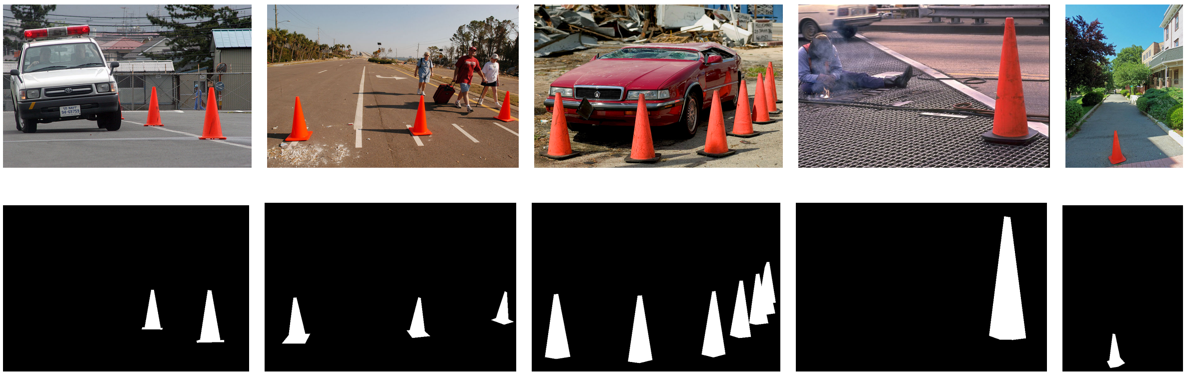
Note: Please attach relevant MATLAB code.

[1] https://www.mathworks.com/matlabcentral/fileexchange/8647-local-adaptive-thresholding

Problem 2 Traffic Cone Detection

Traffic cones are set up by law enforcement and construction workers to block a portion of the road. Unlike more permanent road signs whose locations are indexed in digital maps and hence available to navigation systems on automobiles, traffic cones are missing from the digital maps and must be dynamically detected. Please see the following images in the figs folder:

- pro2_cone_training_{1,2,3,4,5}.jpg: RGB images for training
- pro2_cone_training_map_{1,2,3,4,5}.png: binary masks of cones in the training images
- pro2_cone_testing_{1,2}.jpg: RGB images for testing



(a) Using the 5 training images, generate and submit a 3-d scatterplot in RGB space of a small randomly chosen subset of the training RGB samples, where the cone and non-cone RGB samples are plotted with different markers (function: `scatter3`). Comment on how effectively cone and non-cone samples are separated in RGB space.

(b) Using the 5 training images, train a multidimensional MAP detector[1] in RGB space for distinguishing between traffic cones and other parts of the image. Assuming RGB values lie in the range [0,255], use 16x16x16 uniformly spaced bins for the RGB values. Report the fraction of bins in the 16x16x16 grid which are labeled as belonging to the cone class.

(c) Use the multidimensional MAP detector to classify pixels in each testing image as “cone” or “non-cone”. After MAP classification, you can also perform any post-processing (e.g., small region removal) to make the final result more accurate. For each testing image, submit a binary image where the “cone” pixels are shown as white and the “non-cone” pixels are shown as black.

Note: Please attach relevant MATLAB code.

[1]Week13_basic_image_segmentation slide page 81

Problem 3 Image Compression

In this problem you will implement the main part of the JPEG compression algorithm work on pro3_compression.jpg. The image needs to be split into 8x8 blocks and DCT must be performed on each of them. The coefficients are then quantized using a quantization matrix. The result is finally losslessly compressed using entropy encoding.

(a) Use the provided function `quantization_matrix` to generate different quantization matrices[1]. The function accepts an argument on the interval [1, 100] which can be interpreted as the output image quality. How does the matrix change with different inputs?

(b) Split your input image into 8x8 blocks. Take care to pad the input image if its dimensions are not divisible by 8 (you can use the function `padarray`).

For each of the blocks, do:

- Subtract 128 (take care of the data type)
- Calculate the 2D DCT
- Perform element-wise division by the quantization matrix Q
- Round the coefficients to quantize them
- Do element-wise multiplication with Q.
- Save the quantized coefficients in a separate matrix
- Calculate the 2D IDCT
- Add 128

Display the image reconstructed from quantized blocks. Display the difference to the original. Comment on the distribution of the differences and the reduction in image quality (try different levels of quantization).

(c) Use the provided function `norm2huff` to compress the entire matrix of quantized coeffieient. Comment on the compression ratio for different levels of quantization.
Question: Why can quantized images be stored using less space?

Note: Please attach relevant MATLAB code.

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[1] https://stackoverflow.com/questions/29215879/how-can-i-generalize-the-quantization-matrix-in-jpeg-compression