HOMEWORK #3
Geometrical Modification, Texture Analysis and Document Processing

Homework Instructions:
This document and all the mentioned files are posted on Sakai. Images are in the **raw** file format. The size and format information of these images are listed in the appendix. Your report should include your findings from your own created testing images. You should use AIGC (AI Generated Content) tools to create your own testing images for each exercise and document what you find after applying your code for processing. Please include your created image and the processed results in your report with detailed explanation and discussion for each question.

Problem 1: Geometric Modification (30%)

(a) Special Effect via Compound Linear Geometric Modification
We would like to create a special effect that consists of the compound operations of minification, rotation and translation as specified below.

1. Both minification and rotational operations use the center of the image as its pivot.
2. For the minification effect, the height and the width of the image shrink *s*% per second.
3. For the rotational effect, the image rotates θ degree clock-wise per second.
4. For the translational effect, the image moves towards the south-east direction at the speed of *m* pixels per second.

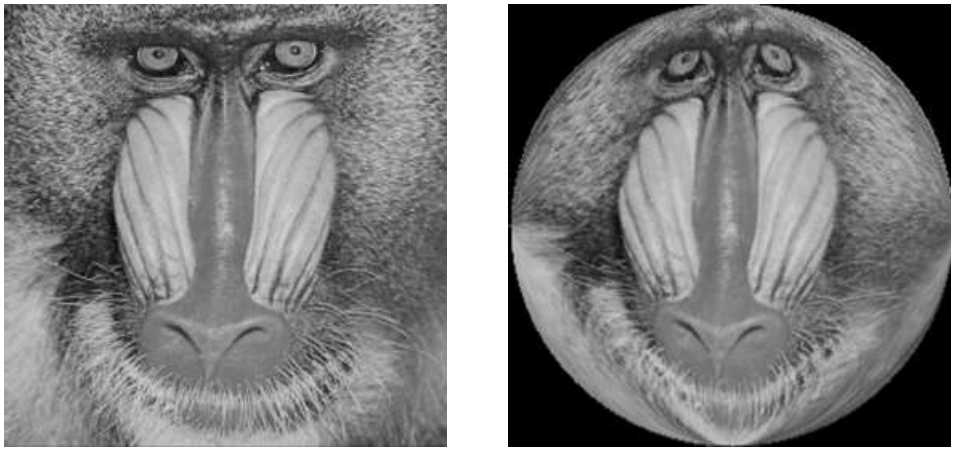
The output image sequence is a function of time *t*.
Please derive the reverse address mapping function of each individual effect, described above with respect to *s*, θ, *m* and *t*, mathematically and implement the effect. Use Fig 1 as the input to your program and report the result at t = 5 and 20 given m = 2, θ = *5, s = 3.*

(a) Original image
Figure 1. Geometric Modificatio

(b) Spatial warping techniques

1. Apply the spatial warping technique to obtain a disk image from a square image as shown in Fig. 2. (The disk image shown is an example and it is not provided in the homework package.) Please describe your approach as clearly as possible. Note that the pixels on the boundaries of square image should be on the boundaries of disk image after warping.

2. Apply inverse warping to get the square image from the disk image. Please describe your approach clearly. Is there any difference between the original square image and the square image after the forward warping and inverse warping? If so, explain the source of difference.



(a) Original baboon image (b) Warped disk image

Fig.2 Image Warping

Problem 2: Texture Analysis and Segmentation (35%)

(a) Texture Classification

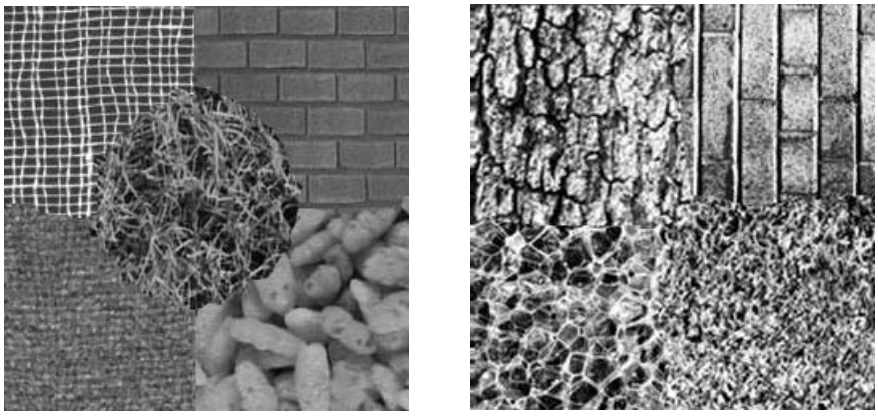
Fifteen sample images, sample1.raw to sample15.raw (size 64x64) are provided for the texture classification exercise. Please categorize them into five different texture types, where each type contains three images.

(b) Texture Segmentation

In Fig. 3(a) and Fig. 3(b), there are several different textures. However, the boundaries between textures may not be straight. Please implement the texture segmentation algorithm as follows.

1. Feature Extraction: Use the Law's filter to obtain features.
2. Segmentation: Use the k-means algorithm to perform segmentation on the two composite texture images given in Fig. 3. Assuming that there are *K* textures in the image, your output image will be of *K* gray levels, each level represents one type. For example, there are five textures in Fig 3(a), there will also be five gray levels as (0, 63, 127, 191, 255) in the output image.

The input of your program consists of the input image mosaic and the K value. Please report your classification result using K=5 for Fig 3(a), and K=4 for Fig 3(b). To further improve the result, you may take advantage of the fact that each texture is contained in one connected area.



(a) comb1.raw (b) comb2.raw

Figure 3. Two composite textured images.

Problem 3: Document Processing (Optical Character Recognition – OCR) (35%)

The image "training.raw" contains 12 symbols, including ten numeric numbers (0-9) and two arithmetic symbols. All these symbols are of the Verdana font and of the same size. These symbol images will be used as the training data for the feature extraction of your OCR program that can recognize patterns of similar shapes in document images.

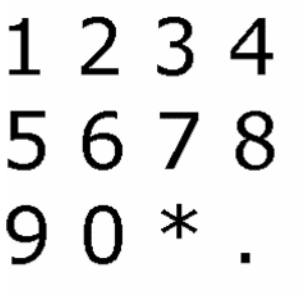


Figure 4: OCR training set "training.raw".

(a) Write an OCR program using training symbols of "training.raw", and use the OCR program to recognize two test document images ("test1.raw" and "test2.raw"). Since each document image contains multiple symbols of different formats and different sizes, you may have to perform a primitive segmentation to separate each symbol in the images. Note: segmentation of the image should be done automatically using your own program. Here are some properties taught in class or described in the textbook. You may use these properties as the features.

[1] Area. [2] Perimeter. [3] Euler Number. [4] Circularity. [5] Spatial Moment. [6] Symmetry. [7] Aspect Ratio.

Your OCR program should show the classified symbol(s) as the final result. Please describe the features of your choice, and discuss the effect of the features on your OCR performance. Please also illustrate your decision tree of classification in the report.

(b) Perform the same OCR of (a) over another test document image "test3.raw" which has some alphabet symbols not included in the original OCR training set "training.raw". Instead of declaring "unclassifiable", your OCR program should recognize the alphabet symbols as any of the numeric and arithmetic symbols of the training set that share some common features. Please justify your OCR output by discussing what features act on the alphabet symbols and how they finally lead to your recognition output.

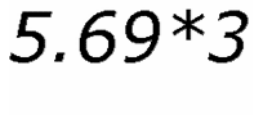


Figure 5: test1.raw.

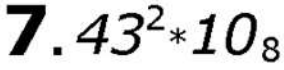


Figure 6: test2.raw.

Figure 7: test3.raw.

Appendix: Image files and sample code used in this project

Problem 1: Geometric Modification

barbara.raw	Fig.1	256 × 256	gray-scale
baboon.raw	Fig. 2(a)	512 × 512	gray-scale

Problem 2: Texture Analysis and Segmentation

sample01.raw~sample15.raw		64 × 64	gray-scale
comb1.raw	Fig 3(a)	256 × 256	gray-scale
comb2.raw	Fig 3(b)	256 × 256	gray-scale

Problem 3: Document Processing

training.raw	Fig. 4	256 × 256 × 3
test1.raw	Fig. 5	256 × 256 × 3
test2.raw	Fig. 6	256 × 256 × 3
test3.raw	Fig. 7	256 × 256 × 3

Sample Code: KMEANS.C for Problem 2