ASSIGNMENT 1
CS5187 VISION AND IMAGE

You are required to complete both written and programming tasks in this assignment.

PART-1: PROOF

A. Show that a 2D Gaussian filter is separable into two 1D Gaussian filters.　　　(5%)

B. Derive the 1st derivative of 2D Gaussian filter.　　　(5%)

C. Derive the 2nd derivative of 2D Gaussian filter.　　　(5%)

D. Derive the Laplacian of Gaussian (LoG) filter.　　　(5%)

PART-2: CONVOLUTION

Following below to generate a filter bank of 48 image filters, each with size 32×32 pixels:

- 4 Gaussian filters with $\sigma = \{1, \sqrt{2}, 2, 2\sqrt{2}\}$.
- 8 LOG (Laplacian of Gaussian) filters with $\sigma = \{\sqrt{2}, 2, 2\sqrt{2}, 4, 3\sqrt{2}, 6, 6\sqrt{2}, 12\}$.
- 18 x-directional first derivation of Gaussian filters with $\sigma_x = \sigma$ and $\sigma_y = 3\sigma$ in three different scales $\sigma = \{1, \sqrt{2}, 2\}$ and six rotation orientations $\theta = \{0, \frac{\pi}{6}, \frac{\pi}{3}, \frac{\pi}{2}, \frac{2\pi}{3}, \frac{5\pi}{6}\}$.
- 18 x-directional second derivation of Gaussian filters with $\sigma_x = \sigma$ and $\sigma_y = 3\sigma$ in three different scales $\sigma = \{1, \sqrt{2}, 2\}$ and six rotation orientations $\theta = \{0, \frac{\pi}{6}, \frac{\pi}{3}, \frac{\pi}{2}, \frac{2\pi}{3}, \frac{5\pi}{6}\}$.

A. Display the 48 image filters in the report.　　　(5%)

B. Display the 48 image responses of the images "leapord.jpg" and "panda.jpg" after performing convolution with the filter bank.　　　(5%)

C. Compute the mean and variance of each image response to form a vector of length 96 elements. Write down the filter that gives the largest value of mean and the filter that gives the largest value of variance for "leapord.jpg" and "panda.jpg" in the report.

　　　(5%)

PART-3: IMAGE RANKING

You are given a collection of 2,000 images and 5 query images (in the canvas). You need to extract visual features from these images by performing convolution with the 48 filters Your task is: For each query, retrieve the five most similar images from the collection of 2,000 images. Show the five most similar images of each query in the report.   (15%)

The similarity between two images can be based on any distance or similarity function:

Euclidean distance between query $Q = [q_1, q_2 \cdots q_n]$ and image $F = [f_1, f_2 \cdots f_n]$:

$$Distance(Q, F) = \sqrt{\sum_{i=1}^{n} (q_i - f_i)^2}$$

Cosine similarity between query $Q = [q_1, q_2 \cdots q_n]$ and image $F = [f_1, f_2 \cdots f_n]$:

$$Similarity(Q, F) = \frac{\sum_{i=1}^{n} q_i f_i}{\sqrt{\sum_{i=1}^{n} q_i^2} \sqrt{\sum_{i=1}^{n} f_i^2}}$$

PART-4: METHOD COMPARISON

A. Implement any two feature extraction methods that you know (e.g., color histogram, LBP, SIFT, deep learning) to extract features for 2,000 images in Part-3. Show the five most similar images of each query for each method.   (10%)

B. Compare the retrieval result with the performance obtained in Part-3.   (5%)

C. Propose a method to fuse (or combine) the results in Part-3 and Part-4. Show the five most similar images of each query.   (5%)

PART-5: COMPETITION

Now you should have results for the following four methods:

-   Part-3: Filter bank
-   Part-4: Method (1), Method (2), fusion

Select one method that you are most confident with, and list its retrieval result (a rank list of 2,000 images in descending order of similarity) for the 5 queries in a text file: rankList.txt (see submission guideline in the next page). *State clearly which method you choose.*

The mark will be allocated based on the retrieval performance of your method.   (30%)

SUBMISSION

Note: 10 marks will be deducted if (1) the results are not presented properly in the report, (2) rank list is not in the required format, (3) python program is difficult to understand.

Please zip the followings and submit to Canvas:

- ✓ *Computer program*: You MUST use Python 2.
- ✓ *Report*
- ✓ *Rank list*: A text file showing the descending order of the images. Sample text file:

```
Q1: 7 12 214 350 ...
Q2: 301 501 1990 2 ...
Q3: 288 345 389 1290 ...
Q4: 248 293 1098 2000 ...
Q5: 380 287 392 478 222 ...
```

Remark: 5 rows only; Each row should list the names of the 2, 000 images (named in number) in descending order of their similarities to a query.

DEADLINE

The submission should be done before 28-Feb, 11:59pm.

Penalty on late submission: 20% of marks will be deducted per day. No submission will be allowed after five days from the deadline. *Do NOT copy code from the internet and do not borrow other people's code. Remember that PLAGIARISM is a serious offense for which you may fail the class or even be expelled from the university.*

CONTACT PERSON

Please email Teaching Assistant Qi ZHANG (Email: qzhang364-c@my.cityu.edu.hk) for technical question.