

# Introduction to Computer Vision (ECSE 415)

## Assignment 3

Due: November 2<sup>nd</sup>, 11:59PM

Please submit your assignment solutions electronically via the myCourses assignment dropbox. Attempt all parts of this assignment. The assignment will be graded out of total of **33 points**. Students are expected to write their own code. (Academic integrity guidelines can be found at <https://www.mcgill.ca/students/srr/academicrights/integrity>). Assignments received up to 24 hours late will be penalized by 30%. Assignments received more than 24 hours late will not be graded.

### Submission Instructions

1. Prepare and submit **two separate Google Colab** notebooks for the two questions.
2. Comment your code appropriately.
3. Do not submit input/output images. Assume image folders are kept in a same directory as the codes.
4. Make sure that the submitted code is running without error. Add a README file if required.
5. Answers to reasoning questions should be comprehensive but concise.
6. Submissions that do not follow the format will be penalized 10%.

Note that you can use any of the OpenCV, sklearn, skimage and Pytorch functions shown during the tutorial sessions.

## 1 Image Classification using RF and SVM

For this task, you are given a dataset of flower images<sup>1</sup>. The dataset contains images of **9 types of flowers**. You can read the images and the corresponding labels as follows.

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<sup>1</sup>The dataset is derived from the 102-Category Flower dataset[1].

```

train_images = np.load('flower_subset.npz')['train_images']
train_labels = np.load('flower_subset.npz')['train_labels']
test_images = np.load('flower_subset.npz')['test_images']
test_labels = np.load('flower_subset.npz')['test_labels']

```

The arrays `train_images` and `test_images` are stacks of 1556 and 90 gray-scale images of size  $128 \times 128$ , respectively.

- Resize the train/test images to  $64 \times 64$  and compute HoG features using cells of  $8 \times 8$  pixels, blocks of  $4 \times 4$  cells and 4 bins. This should yield a feature vector of size 1600 per image. (3 points)  
(Suggestion: Make a function which takes list of images as arguments and delivers list of HoG features as output. The same function can be used for train and test set.)
- Fit a **non-linear SVM classifier** (use **RBF kernel** with **gamma='auto'** and **C=1**) on the features and the class labels of the training images. (1 points)
- Predict labels of the test images by feeding the test features to the trained classifier and calculate classification accuracy. (2 points)
- Tune values of hyperparameters 'gamma' and 'C' to achieve test accuracy greater than 50%. (2 points)
- Fit a Random Forest(RF) classifier (set `n_estimators=10`, `max_depth=5` and `criterion='entropy'`) on the features and the class labels of the training images. (1 points)
- Predict labels of the test images by feeding the test features to the trained classifier and calculate classification accuracy. (2 points)
- Tune values of hyperparameters 'n\_estimators' and 'max\_depth' to achieve test accuracy greater than 50%. (2 points)
- Compare results of SVM and RF classifiers. Which one provides better results? Experiment training both classifiers with a range of random states (try different random values for the argument 'random\_state') and measure classification accuracy of the test set. Which classifier is more stable or robust to the change in random state? (3 points)

## 2 Image Classification with Convolution Neural Network (CNN).

In this part, you will classify MNIST digits [2] into 10 categories using a CNN. You may chose to run the code on GPU.

1. Use Pytorch class `torchvision.datasets.MNIST` to (down)load the dataset. Use batch size of 32. **(3 points)**
2. Implement a CNN with the layers mentioned below. **(5 points)**
  - A convolution layer with 32 kernels of size  $3 \times 3$ .
  - A ReLU activation.
  - A convolution layer with 64 kernels of size  $3 \times 3$ .
  - A ReLU activation.
  - A maxpool layer with kernels of size  $2 \times 2$ .
  - A convolution layer with 64 kernels of size  $3 \times 3$ .
  - A ReLU activation.
  - A convolution layer with 64 kernels of size  $3 \times 3$ .
  - A ReLU activation.
  - A flattening layer. (This layer resizes 2D feature map to a feature vector. The length of this feature vector should be 4096.)
  - A Linear layer with output size of 10.

*(Suggestion: you can start with the code from Tutorial 6 and adapt it for the current problem.)*
3. Create an instance of SGD optimizer with learning rate of 0.001. Use the default setting for rest of the hyperparameters. Create an instance of categorical cross entropy criterion. **(1 point)**
4. Train the CNN for 10 epochs. **(5 points)**
5. Predicts labels of the test images using the above trained CNN. Measure and display classification accuracy. **(3 points)**

## References

- [1] Nilsback, Maria-Elena, and Andrew Zisserman. "Automated flower classification over a large number of classes." 2008 Sixth Indian Conference on Computer Vision, Graphics & Image Processing. IEEE, 2008.
- [2] Y. LeCun, L. Bottou, Y. Bengio, and P. Haffner. "Gradient-based learning applied to document recognition." Proceedings of the IEEE, 86(11):2278-2324, November 1998.