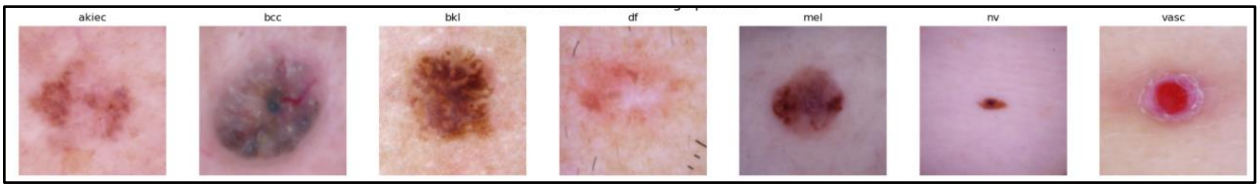
Fall 2024 |DATA 255 |Homework # 2
Deadline – 11.59 PM – 10/10/2024
20 Points

Problem 1: Apply the following models on the **DermaMNIST** Dataset. Train the model with the training data and evaluate the model with the test data. Minimum number of epochs should be 50 and include early stopping criteria as callbacks - for questions a-d.

Download the dataset from - Canvas/Files/HW2/dermamnist_128.npz

The DermaMNIST dataset is a part of the MedMNIST collection, consisting of pre-processed 2D images for skin lesion classification tasks.



a. **CNN model from scratch:** Develop a CNN model with 3 convolutional layers (with kernel size= 3, stride =1, padding = "same", activation function = "relu") with following MaxPooling layer (Size= 2) and 3 fully connected layer (including one output layer). After each of the Convolutional layer apply Batch Normalization. In the fully connected layer apply dropout (rate 0.50). Show the learning curve. Report performance evaluation on the test data. **3 pts**

b. Apply grid search on the CNN model (from a) to find the optimal set of hyperparameters that produce the max performance on the test data. You must train the model using the training data and evaluate model performance using the test dataset. Use grid search for hyperparameter tuning with the following: **3 pts**

Hyperparameters	values
Activation function for Hidden Layer	ReLU
optimizer	Adam
Mini-batch size	16,32
Learning rate	0.001, 0.0001

You should not use any inbuilt package (like gridsearch) for grid search hyperparameter tuning. Write a for loop and find all possible combinations results. Your output should look like below. Include the output and mention the optimal hyperparameters.

Hyperparameter Combinations ("Activation function for Hidden Layer", "optimizer", "mini-batch size", "learning rate")	Test Accuracy
ReLU, Adam, 16, 0.001	
…….	

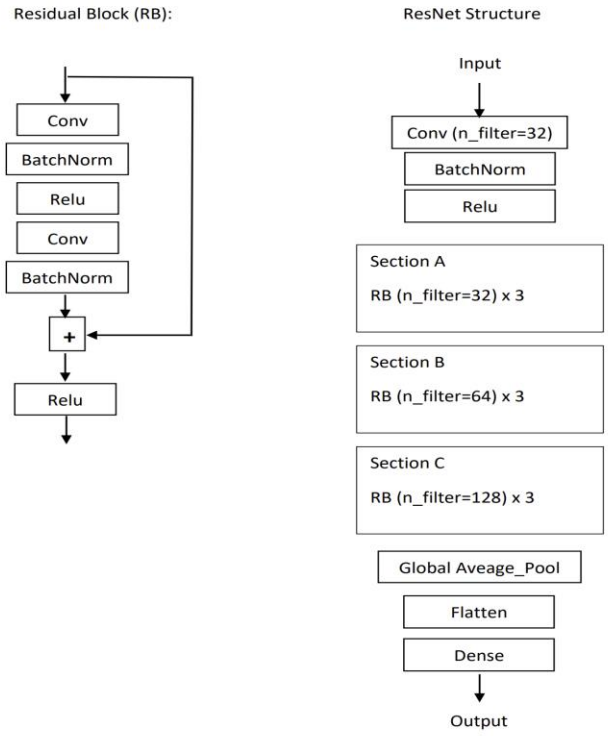
c. **Data Augmentation:** Apply three different image augmentation techniques on the train data to augment it and then apply the previously designed (from a) model on it. Report performance evaluation on the test data. **2 pts**

d. **Transfer Learning:** Load the VGG-19 model. Drop after final pooling layer and on top of it add one **global average pooling** layer and one fully connected layer, and one final output layer. Keep the base model layers (VGG19) freeze. Apply this model on the **DermaMNIST** Dataset. Report performance evaluation on the test data. **2 pts**

e. Use **Grad-CAM (Gradient-weighted Class Activation Mapping)** to create visual explanations for CNN's decisions on the DermatMNIST dataset. Use the developed CNN from question a. Generate heatmaps for 5 images from each class to highlight the key regions influencing the model's classifications and explain. **2pts**

Problem 2 **(8 pts):** Developing ResNet model from scratch using CIFAR10 dataset.

Apply a residual network specified in the following architecture. All convolutional layers use kernel size 3, stride = 1, and padding = "same", minimum number of epochs 20.



Save the trained model after training. Your code should not train the model from scratch and return the model. Rather, the code should load a trained model from a model file and return it.

You should not upload the .h5 file of the trained model to Canvas. Instead, you should share it in your google drive and put the share link in a comment line at the beginning of your code. Before submission, make sure people other than yourself can download the model file using the link. Your code should work when your code and the model file are in the same directory.

Useful link-

Data Download:

DermaMinist: https://zenodo.org/records/10519652

CIFAR10: Keras: https://keras.io/api/datasets/cifar10/

Pytorch: https://pytorch.org/vision/stable/generated/torchvision.datasets.CIFAR10.html

Layer concatenation: https://keras.io/api/layers/merging_layers/concatenate/

Model save in keras: https://www.tensorflow.org/guide/keras/save_and_serialize

You are required to submit:

1. An MS/PDF/Scanned document:
    a. Include all the steps of your calculations.
    b. Attach screenshots of the code output.
    c. Include the summary of the model
    d. Include a Table - Mention all the hyperparameters you selected: activation function in hidden layer and output layer, weight initializer, number of hidden layers, neurons in hidden layers, loss function, optimizer, number of epochs, batch size, learning rate, evaluation metric
2. Source code:
    a. Python (Jupyter Notebook)
    b. Ensure it is well-organized with comments and proper indentation.

- Failure to submit the source code will result in a deduction of 5 points.
- Format your filenames as follows: "your_last_name_HW2.pdf" for the document and "your_last_name_HW2_source_code.ipynb" for the source code.
- Before submitting the source code, please double-check that it runs without any errors.
- Must submit the files separately.
- Do not compress into a zip file.
- HW submitted more than 24 hours late will not be accepted for credit.