

# APAI Lab1

## DNN Definition & Training

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### **How to deliver the assignment:**

**DEADLINE:** 4/10/2024 (midnight)

#### **Instructions:**

- Use Virtuale platform to load your file: [link](#)
- update only the .ipynb file, named as follows: LAB1\_APAI\_yourname.ipynb

**Important:** the notebook must be pre-run by you. Outputs must be correct and visible when you download it

### **Links to COLAB exercise:**

#### **GitHub:**

<https://github.com/EEESlab/APAI24-LAB01-DNN-definition-and-training/blob/master/APAI24-LAB1-DNN-definition-and-training.ipynb>

Solution is coming after the deadline

### **Lab session summary:**

1. PyTorch definition of a NN model;
2. Count network's parameters and MAC operations;
3. Data loader for Fashion-MNIST;
4. Code for testing a neural network on Fashion MNIST dataset;
5. Code for training a neural network on Fashion MNIST;
6. Save and load model's trained weights;

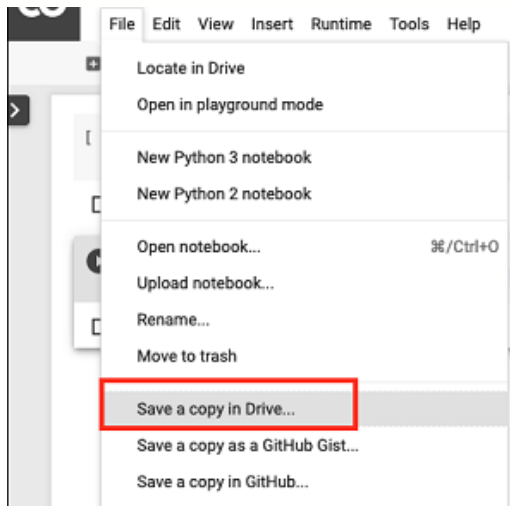
## Setup:

0. Open the link to launch [COLAB](#) from the [GitHub repository](#)



1. Create your own [COLAB](#) copy of the notebook!

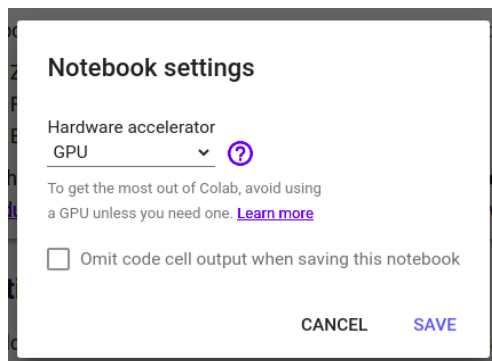
- In Google Colab, use the menu: *File > Save a copy in Drive*



Note: in case you don't complete the assignment, Colab keeps your file in your Google Drive!

2. Activate/deactivate GPU: *Runtime -> Change runtime type*

- **Note:** *If you use for too much time the GPU, your account will be limited to CPU for 24h.*



## Task 1: CNN topology definition (PyTorch)

Resources: [official PyTorch tutorials and documentation](#), [Pytorch tutorial: how to define a NN](#)

Description: PyTorch definition of a CNN topology, following [Figure 1](#).

Output: Code of a NN definition, following [Code 1](#) structure.

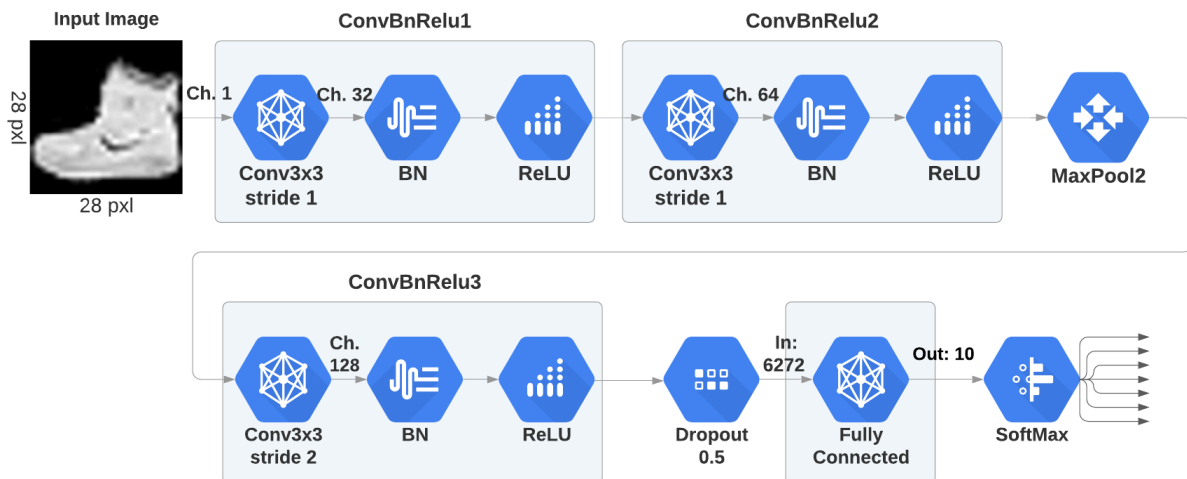


Figure 1: The Custom CNN topology.

```
class CNN(nn.Module):
    def __init__(self):
        super(CNN, self).__init__()
        conv1 = ...
        conv2 = ...
    def forward(self, x):
        ...
        return output

net = CNN.to(device)
```

Code 1.

## Task 2: Count network's parameters and MAC operations

Resources: [PyTorch Info](#), [PyTorch Operations counter](#), [PyTorch FLOPs counter](#)

Description: calculate the number of model's parameters. Calculate the Multiply-Add-Operations (MACs). You can use some external pre-implemented functions from github (see refs).

Output: model size and MAC operations of the NN defined.

## Task 3: Define dataset loaders

Resources: [quickstart pytorch training](#), [data\\_tutorial](#)

*Description:* create dataset and dataloader for Fashion-Mnist for both training and validation sets. We will use these in the training loop. Make use of torchvision.datasets and torch-utils.data.DataLoader

*Output:* a dataset loader for training and validation sets of Fashion-MNIST.

*Sub-Tasks:*

1. download fashion mnist with torchvision with torchvision.datasets
2. define 2 transformations that we will apply to the dataset: transform data to tensor, and normalization of input pixel data
3. define the dataset object
4. define the dataset loader with torch.utils.data.DataLoader. batch=128.
5. Sanity check: you must get 60 k training images, and 10 k validation images

## Task 4: Testing a neural network in PyTorch

*Resources:* [quickstart PyTorch](#),

*Description:* build a testing loop in order to calculate accuracy of our NN

*Output:* Code of the testing loop (following Code 3 structure)

*Sub-tasks:*

- Define an accuracy metric as (num\_correct\_predictions/total\_n\_predictions)
- write testing loop, following Code 3 structure.
- Note: Remember to set network to evaluating with net.eval()

*Example:*

```
def validate(net, dataloader, accuracy_function, loss_function):
    n_images = len(dataloader.dataset)
    num_batches = len(dataloader)
    net.eval() # set network to eval mode
    test_loss, correct = 0, 0
    with torch.no_grad():
        for batch_idx, data in dataloader:
            inputs, labels = data[0].to(device), data[1].to(device)

            # Compute prediction (forward input in the model)
            ...
            # calculate accuracy
            ...
            # calculate testing loss
            ...

    # print accuracy and loss
    print(f"Test Error: \n Accuracy: {(100*correct)>0.1f}%, Avg loss: {test_loss:>8f} \n")
```

## Task 5: Training a neural network in PyTorch

Resources: [quickstart pytorch training](#), [Learning pytorch with examples](#)

Description: training a neural network on MNIST dataset

Output: Code of a training loop, following Code 2 structure

Sub-tasks:

- Define a Cross Entropy [Loss Function](#)
- define an SGD [optimizer](#)
- write the training loop function, which takes the arguments listed in Code 2
- plot training and validation loss over epochs. this is a good practice to track the training process.

Tips:

- use `.to(device)` on both model and inputs, in order to use the GPU at training time. This will be much faster than using CPU!
- Use `net.train()` to set network to training mode before starting the main loop

Example:

```
def train(net, dataloader, loss_fn, optimizer):
    net.train()
    for epoch in range(epochs):
        for batch_n, (input, label) in enumerate(dataloader):
            size = len(dataloader.dataset)
            X, y = X.to(device), y.to(device)

            # Compute prediction (forward input in the model)
            ...
            # Compute prediction error with the loss function
            ...
            # Backpropagation
            optimizer.zero_grad()
            ...
            # optimizer step
            ...
        # print: training loss and accuracy
        ...
        # Test network on validation set
        ...
        # print: validation accuracy, validation loss
        ...
```

## Task 6: Save and load model's trained weights

Resources: [save and load PyTorch model](#)

*Description:* You must be able to save and load correctly your model, as you will use it for future LAB sessions.

*Output:* model size and MAC operations of the NN defined

Sub-tasks:

- Save current model weights
- Load pre-trained weights to a non-initialized NN definition.
- Use the Testing function previously defined to test the new model with pre-trained weights, and get ~90% accuracy.