Machine Learning HW3

ML TAs
ntu-ml-2022-spring-ta@googlegroups.com

Objective - Image Classification

1. Solve image classification with **convolutional neural networks**.
2. Improve the performance with **data augmentations**.
3. Understand popular image model techniques such as **residual**.

Task Introduction - Food Classification

- The images are collected from the food-11 dataset classified into 11 classes.
- Training set: 9866 labeled images
- Validation set: 3430 labeled images
- Testing set: 3347 images

Rules

- DO NOT attempt to find the original labels of the testing set.
- DO NOT use any external datasets.
- **DO NOT use any pretrained models.**
  - Also, do not attempt to “test how effective pretraining is” by submitting to kaggle. Pretraining is very effective and you may test it after the competition ends.
- You may use any publicly available packages/code
  - But make sure you do not use pretrained models. Most code use those.
  - You may not upload your code/checkpoints to be publicly available during the timespan of this homework.

Baseline

Simple : 0.50099

Medium : 0.73207 Training Augmentation + Train Longer

Strong : 0.81872 Training Augmentation + Model Design + Train Looonger (+ Cross Validation + Ensemble)

Boss : 0.88446 Training Augmentation + Model Design +Test Time Augmentation + Train Looonger (+ Cross Validation + Ensemble)

Submission Format

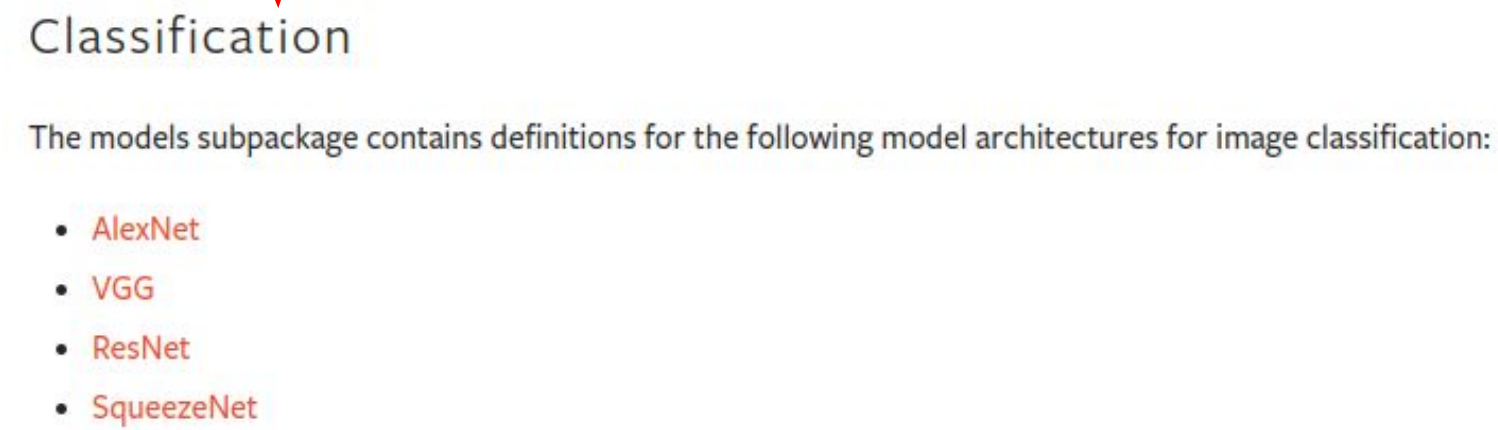
The file should contain a header and have the following format:

```
Id,Category
0001,1
```

Both type should be strings. Id corresponds to the jpg filenames in test. Follow the sample code if you have trouble with formatting.

Model Selection

- Visit torchvision.models for a list of model structures, or go to timm for the latest model structures.
- Pretrained weights are not allowed, specifically set pretrained=False to ensure that the guideline is met.



Classification

The models subpackage contains definitions for the following model architectures for image classification:

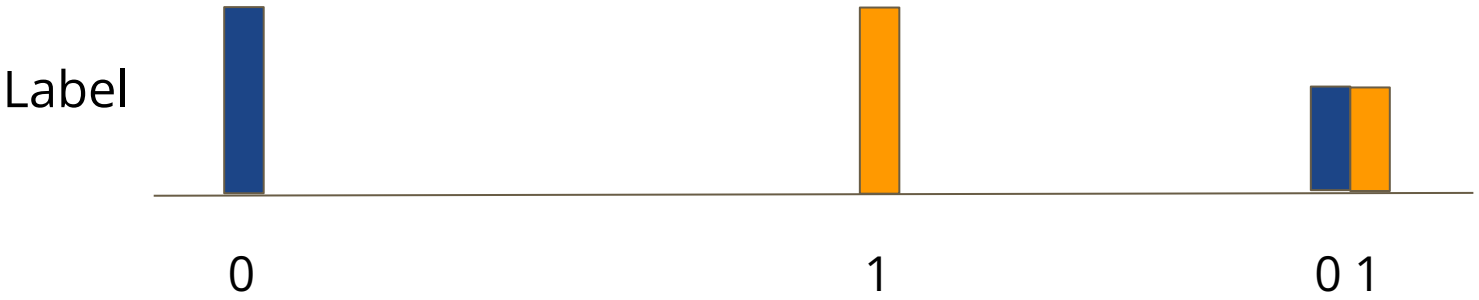
- AlexNet
- VGG
- ResNet
- SqueezeNet

Data Augmentation

- Modify the image data so non-identical inputs are given to the model each epoch, to prevent overfitting of the model
- Visit torchvision.transforms for a list of choices and their corresponding effect. Diversity is encouraged! Usually, stacking multiple transformations leads to better results.
- Coding : fill in `train_tfm` to gain this effect

Advanced Data Augmentation - mixup

0.5*  + 0.5 *  = 

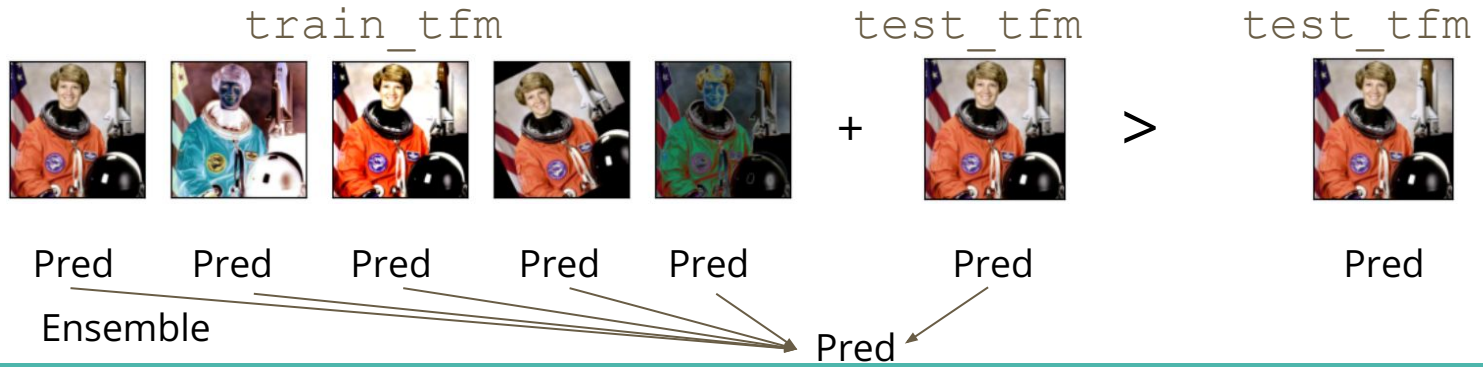


Advanced Data Augmentation - mixup

- Coding :
- In your `torch.utils.Dataset`, `__getitem__()` needs to return an image that is the linear combination of two images.
- In your `torch.utils.Dataset`, `__getitem__()` needs to return a label that is a vector, to assign probabilities to each class.
- You need to explicitly code out the math formula of the cross entropy loss, as `CrossEntropyLoss` does not support multiple labels.

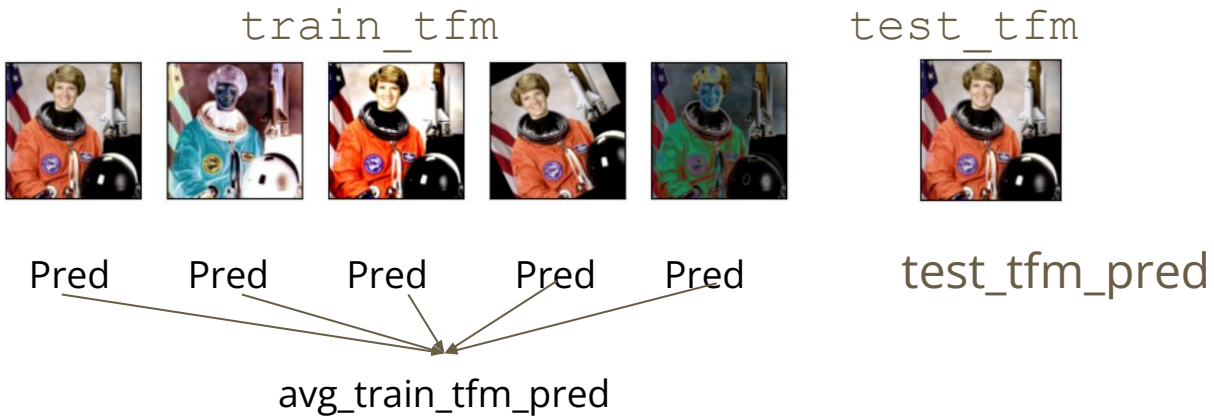
Test Time Augmentation

- The sample code tests images using a deterministic “test transformation”
- You may using the train transformation for a more diversified representation of the images, and predict with multiple variants of the test images.
- Coding : You need to fill in `train_tfm`, change the augmentation method for test_dataset, and modify prediction code to gain this effect



Test Time Augmentation

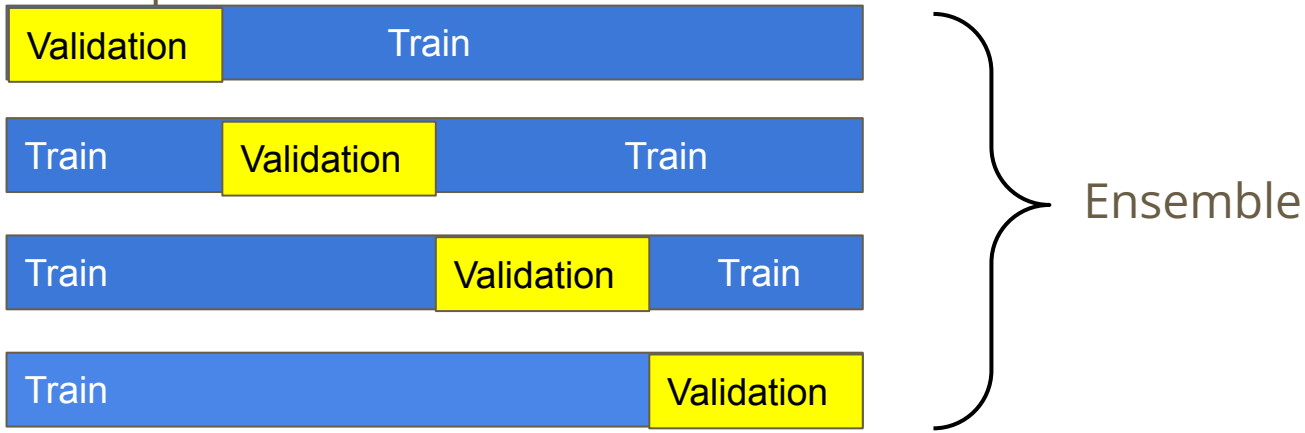
- Usually, test_tfm will produce images that are more identifiable, so you can assign a larger weight to test_tfm results for better performance.



- Ex : Final Prediction = avg_train_tfm_pred * **0.5** + test_tfm_pred* **0.5**

Cross Validation

- Cross-validation is a resampling method that uses different portions of the data to validate and train a model on different iterations. Ensembling multiple results lead to better performance.
- Coding : You need to merge the current train and validation paths, and resample form those to form new train and validation sets.



Cross Validation

- Even if you don’t do cross validation, you are encouraged to resplit the train/validation set to suitable proportions.
  - Currently, train : validation ~ 3 : 1, more training data could be valuable.

Ensemble

- Average of logits or probability : Need to save verbose output, less ambiguous
- Voting : Easier to implement, need to break ties

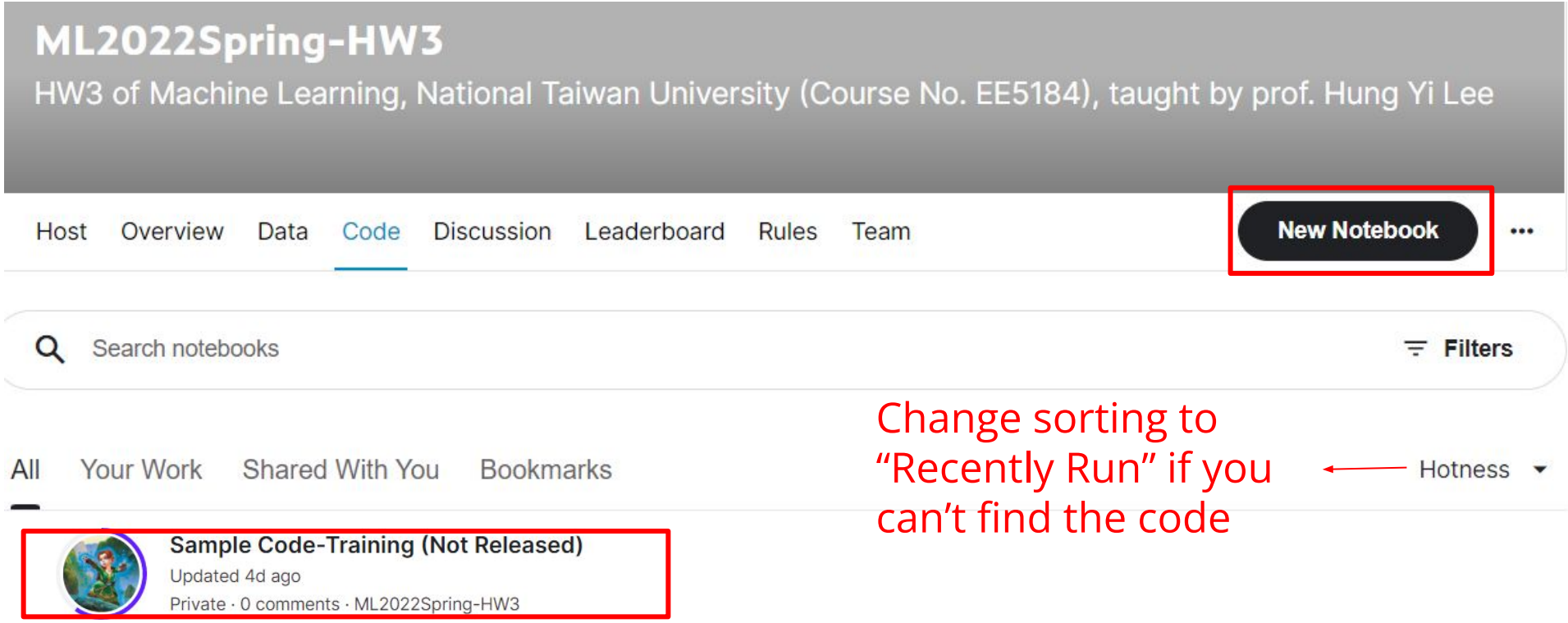
- Coding : basic math operations with numpy or torch

Kaggle Tutorial

Kaggle Introduction

- Kaggle GPU : 16G NVIDIA TESLA P100
  - https://www.kaggle.com/docs/efficient-gpu-usage
- Faster data IO
- Easier checkpoint reusing
- Limited to 30+ hrs/week depending on usage.
- Limited to 12hrs/run
- We strongly recommend that you run with Kaggle for this homework

How to run



Change sorting to "Recently Run" if you can't find the code

How to get data : In the input section, there should already be data titled “ml2022spring-hw3”

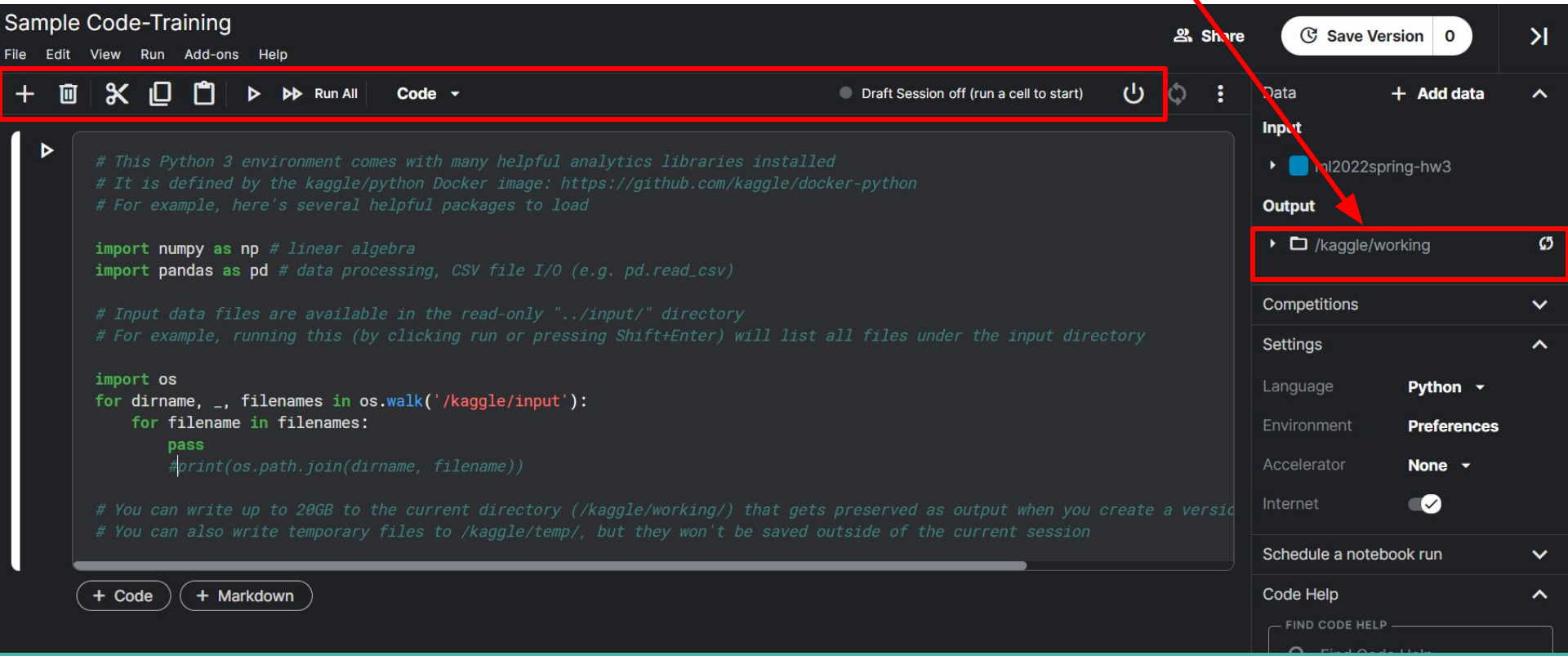
If there isn’t, click on Add data and find “ml2022spring-hw3”

How to use gpu : Change accelerator to “gpu” when you run your code.

Since GPU time is limited, It is advised to NOT utilize GPU while debugging

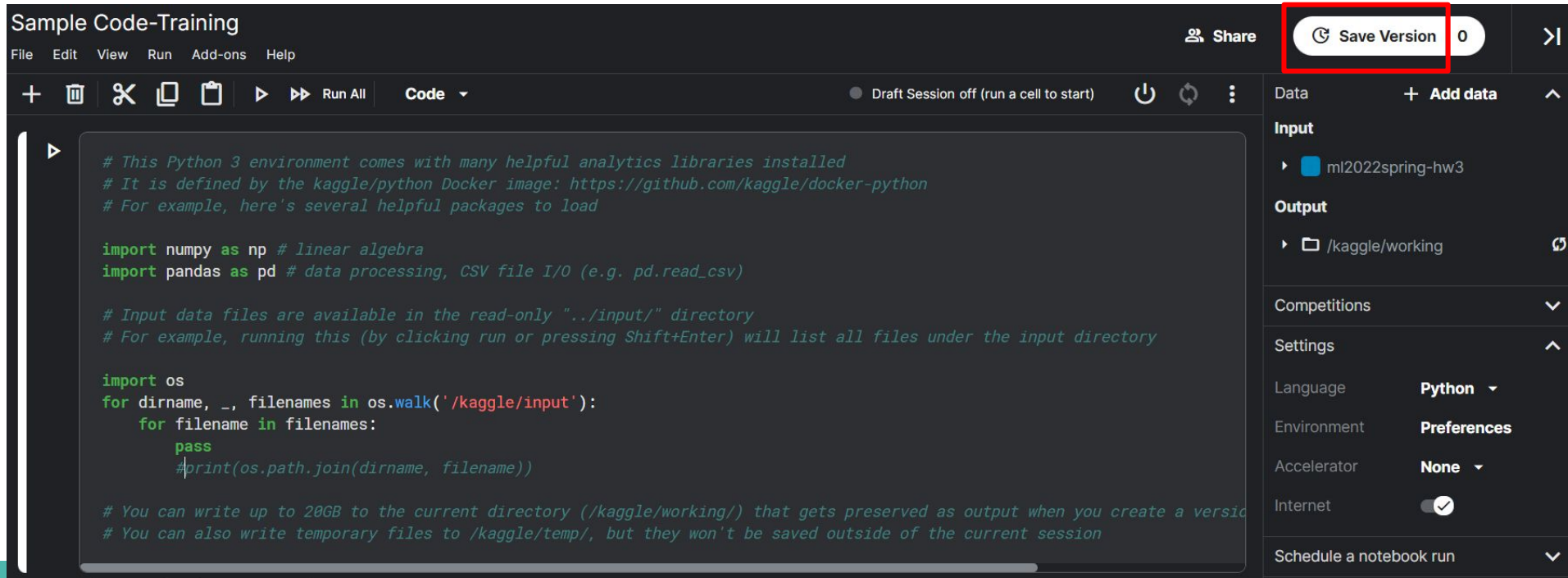
How to Run interactively : The commands are very similar to google colab

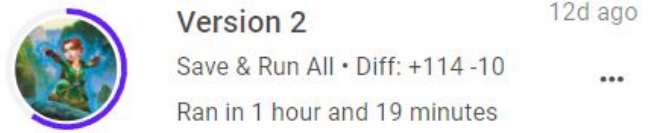
Any output writing to ./ will end up here, you can download it



How to Run in background: Execute code from start to end, all results would be save **permanently.** (Output is limited to 20G, max run time = 12hrs)

Make sure your code is bug free, as any error in any code block would result in early stopping

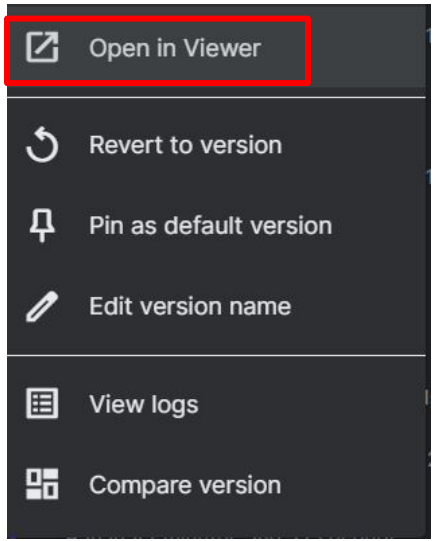




How to view “Run in background” results

You can view your results this way

Don’t worry if your run is “cancelled”, the output will still be saved.



How to utilize your results

SPLEND1DCHAN (燦爛) +3 · 11D AGO · 47 VIEWS · PRIVATE

0 Edit

run_classification_best

Python · Food-11

Script Data Logs Comments (0) Settings

- boss_14_0.61137.ckpt
- boss_15_0.65539.ckpt
- boss_1_0.51341.ckpt
- boss_2_0.53557.ckpt
- boss_3_0.51808.ckpt
- boss_4_0.57318.ckpt
- boss_5_0.58163.ckpt
- boss_6_0.57114.ckpt
- boss_7_0.56327.ckpt
- boss_8_0.60758.ckpt
- boss_9_0.59971.ckpt
- boss_best.ckpt

Download All

+ New Version

+ New Notebook

Upload your model to become kaggle dataset + New Dataset

Create a new notebook with the output as input

How to train and predict

1. Run your code in background
2. Find the output data “./submission.csv” and upload it to the submission page

How to retrain from a checkpoint

1. Run your code in background
2. Find the output model and save it as a dataset
3. Import your dataset into the notebook via “Add data”
4. **Modify your code to load your checkpoint**
5. Run your code in background
6. Find the output data “./submission.csv” and upload it to the submission page

Tips and tricks

Time management

- Kaggle will allocate more time for those who have utilized GPU resources in the past week. Time resets every Saturday at 08:00, Taipei Time.

=> Run any code with GPU on kaggle today (3/4) to get (possible) extra time next week.

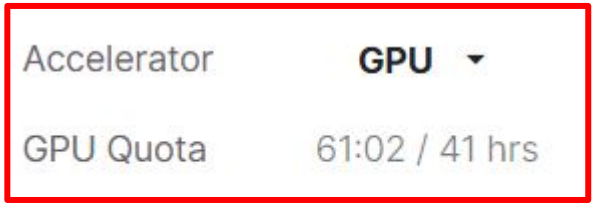
- Time consumption is the sum of notebooks running interactively with gpu and running in background with gpu.
- Please start early

Time management

- You can go over the time limit moderately. Kaggle will not interrupt your code in the background if it is already running. If your time limit is reached, you cannot run any code with GPU.

=> 時間快用完的時候在背景跑一隻程式，等於多12小時runtime

=> 時間快用完的時候在背景跑兩隻程式，等於多24小時runtime

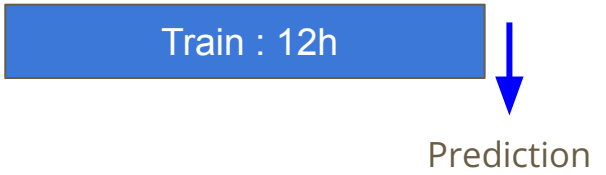


Time management - Parallelization

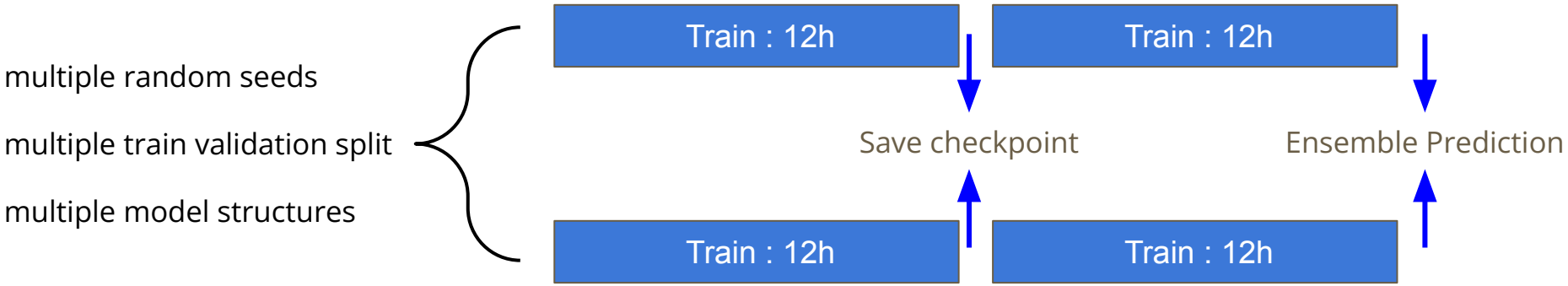
- You can run **two** codes in the background
- If you are satisfied with your code, utilize this to run **multiple random seeds/multiple train validation split/multiple model structures**, so you can ensemble

A sample procedure for beating the boss baseline

The boss baseline could be beaten with a single model trained on kaggle for 12hrs



Your procedure can be ensemble of models with parallelization



Experimental Tips

- **Augmentation** is a must to prevent overfitting. A good augmentation can carry on to the testing phase with **Test Time Augmentation.**
- If you build your own network structure and have implemented augmentation, don’t be afraid to scale up your model. (Many predefined models structure are huge and perform great)
- In TA’s experiment, model structures with **downsampling** work better, simply choosing the best performing models on ImageNet according to websites is not always a good idea because pretrained weights are not allowed.

Other tricks.....

- on Classification
  - Label Smoothing Cross Entropy Loss
  - FocalLoss
- on Optimization
  - Dropout
  - Gradient Accumulation
  - BatchNorm
  - Image Normalization

Running with Google Colab

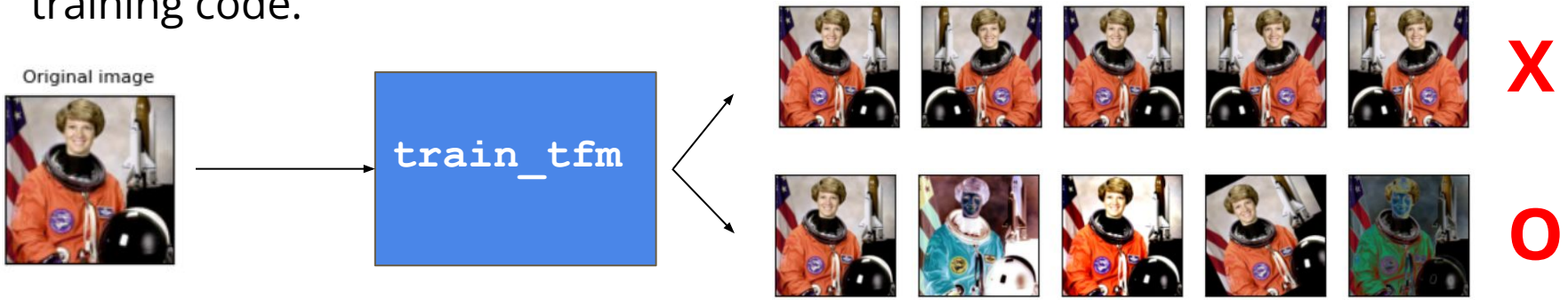
- We strongly recommend that you run with Kaggle for this homework
- If you would like to use colab, DO NOT store data in your drive and load from there, the input/output is very slow. (store at ./ instead)
- If you mount your google drive in colab : G-suite google drive now has a storage limit. Since models and data can be large, keep an eye on your used space to prevent your account being suspended.

Report Questions

Q1. Augmentation Implementation (2%)

Implement augmentation by finishing **`train_tfm`** in the code with image size of your choice. Copy your **`train_tfm`** code and paste it onto the GradeScope.

- Your **`train_tfm`** must be capable of producing 5+ different results when given an identical image multiple times.
- Your **`train_tfm`** in the report can be different from **`train_tfm`** in your training code.



Q2. Residual Connection Implementation (2%)

Residual Connection is widely used in CNNs such as Deep Residual Learning for Image Recognition. Residual is demonstrated in the following graph.

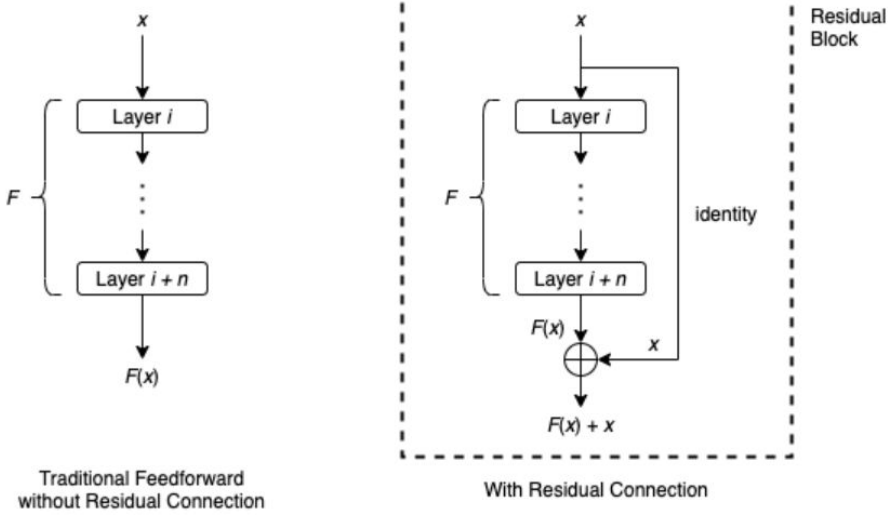
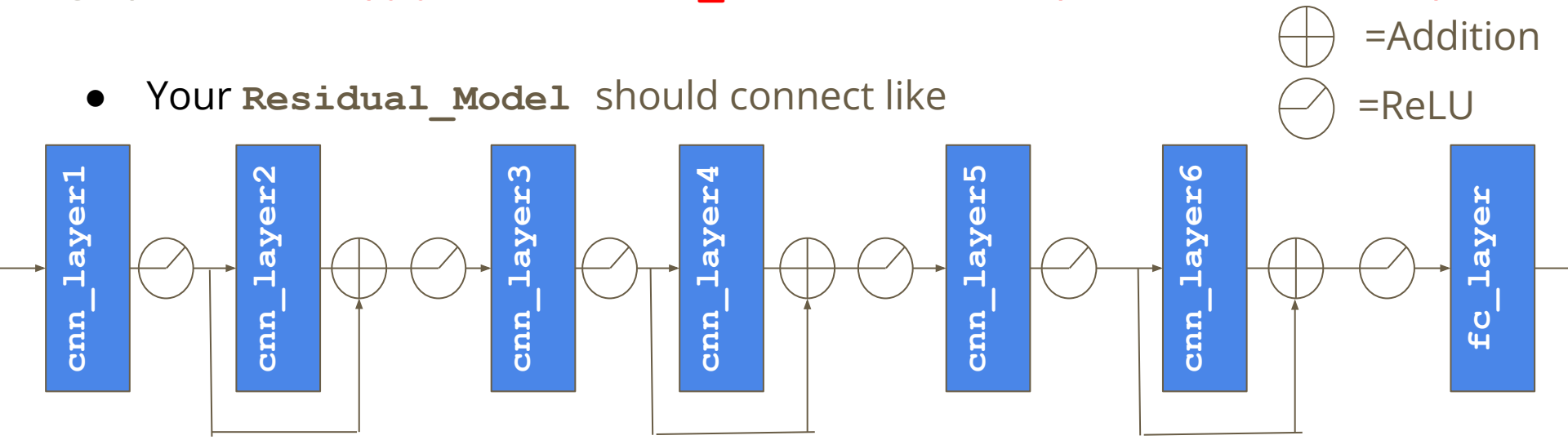


Image Source : https://towardsdatascience.com/what-is-residual-connection-efb07cab0d55

Q2. Residual Connection Implementation (2%)

Implement Residual Connections in the **`Residual_Model`**, following the graph below. Copy your **`Residual_Model`** code and paste it on Gradescope.



- Your **`Residual_Model`** should connect like

- You should only modify the `forward` part of the model

Submission Format

- **`train_tfm`** and **`Residual_Model`** are present in colab (scroll to bottom) and kaggle (ML2022HW3 - Report Questions), you only need to modify from our sample code.

```
train_tfm = transforms.Compose([
    # Resize the image into a fixed shape (height = width = 128)
    transforms.Resize((128, 128)),
    # You need to add some transforms here.
    transforms.ToTensor(),
])
```

```
from torch import nn
class Residual_Network(nn.Module):
    def __init__(self):
        super(Residual_Network, self).__init__()

        self.cnn_layer1 = nn.Sequential(
            nn.Conv2d(3, 64, 3, 1, 1),
            nn.BatchNorm2d(64),
        )

        self.cnn_layer2 = nn.Sequential(
            nn.Conv2d(64, 64, 3, 1, 1),
            nn.BatchNorm2d(64),
        )

        self.cnn_layer3 = nn.Sequential(
            nn.Conv2d(64, 128, 3, 2, 1),
            nn.BatchNorm2d(128),
        )
```

Regulations and Grading Policy

Grading

simple	(public)	+0.5 pts
simple	(private)	+0.5 pts
medium	(public)	+0.5 pts
medium	(private)	+0.5 pts
strong	(public)	+0.5 pts
strong	(private)	+0.5 pts
boss	(public)	+0.5 pts
boss	(private)	+0.5 pts
code submission		+2 pts
report		+4 pts

Total : 10 pts

Code Submission

- NTU COOL
  - Compress your code and pack them into **.zip file**

<student_ID>_hw3.zip

- Your **.zip** file should include only
  - **Code**: either .py or .ipynb
- **Do not submit models and data**
- **File Size Limit : 25MB**
- **Submit the code that corresponds to your chosen submission in Kaggle (One of the best)**

Report Submission

Answer the questions on GradeScope

Deadlines

- Kaggle, Code (NTU COOL), Report (GradeScope)

2022/03/25 23:59 (UTC+8)

Rules

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- DO NOT use any external datasets.
- **DO NOT use any pretrained models.**
  - Also, do not attempt to “test how effective pretraining is” by submitting to kaggle. Pretraining is very effective and you may test it after the competition ends.
- You may use any publicly available packages/code
  - But make sure you do not use pretrained models. Most code use those.
  - You may not upload your code/checkpoints to be publicly available during the timespan of this homework.

Rules

- You should finish your homework on your own.
- You should not modify your prediction files manually
- Do not share codes or prediction files with any living creatures.
- Do not use any approaches to submit your results more than **5 times** a day.
- Your **final grade x 0.9 and 0 pt for this HW** if you violate any of the above rules, **final grade = Fail** for repeat offenders
- Prof. Lee & TAs preserve the rights to change the rules & grades.

Links

Kaggle : https://www.kaggle.com/c/ml2022spring-hw3b

Kaggle code (join competition first) :
https://www.kaggle.com/c/ml2022spring-hw3b/code?competitionId=34954&sortBy=dateRun

Colab :
https://colab.research.google.com/drive/15hMu9YiYjE_6HY99UXon2vKGk2KwugWu

Contact us if you have problems...

- **Kaggle Discussion** (Recommended for this HW)
- NTU COOL
- Email
  - mlta-2022-spring@googlegroups.com
  - The title should begin with “[hw3]”