ML HW3 Report

學號：b07902040 | 系級：資工二 | 姓名：吳承軒

1. 請說明你實作的 CNN 模型(best model)，其模型架構、訓練參數量和準確率為何？(1%)

對vgg16架構略做修改:

模型架構:

```
self.cnn = nn.Sequential(
            nn.Conv2d(3, 64, 3, 1, 1),  # [64, 128, 128]
            nn.BatchNorm2d(64),
            nn.ReLU(),
            nn.Conv2d(64, 64, 3, 1, 1),
            nn.BatchNorm2d(64),
            nn.ReLU(),
            nn.MaxPool2d(2, 2, 0),      # [64, 64, 64]

            nn.Conv2d(64, 128, 3, 1, 1), # [64, 64, 64]
            nn.BatchNorm2d(128),
            nn.ReLU(),
            nn.Conv2d(128, 128, 3, 1, 1),
            nn.BatchNorm2d(128),
            nn.ReLU(),
            nn.MaxPool2d(2, 2, 0),      # [128, 32, 32]

            nn.Conv2d(128, 256, 3, 1, 1), # [128, 32, 32]
            nn.BatchNorm2d(256),
            nn.ReLU(),
            nn.Conv2d(256, 256, 3, 1, 1),
            nn.BatchNorm2d(256),
            nn.ReLU(),
            nn.Conv2d(256, 256, 3, 1, 1),
            nn.BatchNorm2d(256),
            nn.ReLU(),
            nn.MaxPool2d(2, 2, 0),      # [256, 16, 16]

            nn.Conv2d(256, 512, 3, 1, 1), # [256, 16, 16]
            nn.BatchNorm2d(512),
            nn.ReLU(),
            nn.Conv2d(512, 512, 3, 1, 1),
            nn.BatchNorm2d(512),
            nn.ReLU(),
            nn.Conv2d(512, 512, 3, 1, 1),
            nn.BatchNorm2d(512),
            nn.ReLU(),
            nn.MaxPool2d(2, 2, 0),       # [512, 8, 8]

            nn.Conv2d(512, 512, 3, 1, 1), # [512, 8, 8]
            nn.BatchNorm2d(512),
            nn.ReLU(),
```

```
            nn.Conv2d(512, 512, 3, 1, 1), # [512, 8, 8]
            nn.BatchNorm2d(512),
            nn.ReLU(),
            nn.Conv2d(512, 512, 3, 1, 1), # [512, 8, 8]
            nn.BatchNorm2d(512),
            nn.ReLU(),
            nn.MaxPool2d(2, 2, 0),       # [512, 4, 4]
        )
        self.fc = nn.Sequential(
            nn.Linear(512*4*4, 4096),
            nn.Dropout(0.5),
            nn.ReLU(),
            nn.Linear(4096, 2048),
            nn.Dropout(0.5),
            nn.ReLU(),
            nn.Linear(2048, 512),
            nn.Dropout(0.5),
            nn.ReLU(),
            nn.Linear(512, 11)
        )
```

參數:

```
batch_size = 128
learning_rate = 0.001
num_epoch = 200
input_size = 3*128*128
```

訓練參數量: 57,707,715 parameters

```
INPUT: [128x128x3] weights: 0
CONV3-64: [128x128x64] weights: (3*3*3)*64 = 1,728
CONV3-64: [128x128x64] weights: (3*3*64)*64 = 36,864
POOL2: [64x64x64] weights: 0
CONV3-128: [64x64x128] weights: (3*3*64)*128 = 73,728
CONV3-128: [64x64x128] weights: (3*3*128)*128 = 147,456
POOL2: [32x32x128] weights: 0
CONV3-256: [32x32x256] weights: (3*3*128)*256 = 294,912
CONV3-256: [32x32x256] weights: (3*3*256)*256 = 589,824
CONV3-256: [32x32x256] weights: (3*3*256)*256 = 589,824
POOL2: [16x16x256] weights: 0
CONV3-512: [16x16x512] weights: (3*3*256)*512 = 1,179,648
CONV3-512: [16x16x512] weights: (3*3*512)*512 = 2,359,296
CONV3-512: [16x16x512] weights: (3*3*512)*512 = 2,359,296
POOL2: [8x8x512] weights: 0
CONV3-512: [8x8x512] weights: (3*3*512)*512 = 2,359,296
CONV3-512: [8x8x512] weights: (3*3*512)*512 = 2,359,296
CONV3-512: [8x8x512] weights: (3*3*512)*512 = 2,359,296
POOL2: [4x4x512] weights: 0
FC: [1x1x4096] weights: 4*4*512*4096 = 33,554,432
FC: [1x1x2048] weights: 4096*2048 = 8,388,608
FC: [1x1x512] weights: 2048*512 = 1,048,579
FC: [1x1x11] weights: 512*11 = 5632
Total = 以上總和 = 57,707,715
```

正確率

在kaggle public上的準確率為84.518%

2. 請實作與第一題接近的參數量，但 CNN 深度（CNN 層數）減半的模型，並說明其模型架構、訓練參數量和準確率為何？(1%)

模型架構:

```
self.cnn = nn.Sequential(
            nn.Conv2d(3, 64, 3, 1, 1),  # [64, 128, 128]
            nn.BatchNorm2d(64),
            nn.ReLU(),
            nn.MaxPool2d(2, 2, 0),      # [64, 64, 64]

            nn.Conv2d(64, 128, 3, 1, 1), # [64, 64, 64]
            nn.BatchNorm2d(128),
            nn.ReLU(),
            nn.Conv2d(128, 128, 3, 1, 1),
            nn.BatchNorm2d(128),
            nn.ReLU(),
            nn.MaxPool2d(2, 2, 0),      # [128, 32, 32]

            nn.Conv2d(128, 256, 3, 1, 1), # [128, 32, 32]
            nn.BatchNorm2d(256),
            nn.ReLU(),
            nn.MaxPool2d(2, 2, 0),      # [256, 16, 16]

            nn.Conv2d(256, 512, 3, 1, 1), # [256, 16, 16]
            nn.BatchNorm2d(512),
            nn.ReLU(),
            nn.MaxPool2d(2, 2, 0),       # [512, 8, 8]

            nn.Conv2d(512, 512, 3, 1, 1), # [512, 8, 8]
            nn.BatchNorm2d(512),
            nn.ReLU(),
            nn.MaxPool2d(2, 2, 0),       # [512, 4, 4]
        )
        self.fc = nn.Sequential(
            nn.Linear(512*4*4, 4096),
            nn.Dropout(0.5),
            nn.ReLU(),
            nn.Linear(4096, 2048),
            nn.Dropout(0.5),
            nn.ReLU(),
            nn.Linear(2048, 512),
            nn.Dropout(0.5),
            nn.ReLU(),
            nn.Linear(512, 11)
        )
```

參數:

```
batch_size = 128
learning_rate = 0.001
num_epoch = 200
input_size = 3*128*128
```

訓練參數量: 55,274,649 parameters

```
INPUT: [128x128x3] weights: 0
CONV3-64: [128x128x64] weights: (3*3*3)*64 = 1,728
POOL2: [64x64x64] weights: 0
CONV3-128: [64x64x128] weights: (3*3*64)*128 = 73,728
CONV3-128: [64x64x128] weights: (3*3*128)*128 = 147,456
POOL2: [32x32x128] weights: 0
CONV3-256: [32x32x256] weights: (3*3*128)*256 = 294,912
POOL2: [16x16x256] weights: 0
CONV3-512: [16x16x512] weights: (3*3*256)*512 = 1,179,648
POOL2: [8x8x512] weights: 0
CONV3-512: [8x8x512] weights: (3*3*512)*512 = 2,359,296
POOL2: [4x4x512] weights: 0
FC: [1x1x4096] weights: 4*4*512*4096 = 33,554,432
FC: [1x1x4096] weights: 4096*4096 = 16,777,216
FC: [1x1x512] weights: 4096*512 = 2,097,158
FC: [1x1x11] weights: 512*11 = 5632
Total = 以上總和 = 55,274,694
```

正確率

在kaggle public上的準確率為80.394%

3. 請實作與第一題接近的參數量，簡單的 DNN 模型，同時也說明其模型架構、訓練參數和準確率為何？(1%)

模型架構:

```
self.cnn = nn.Sequential(
            nn.MaxPool2d(2, 2, 0)
        )
        self.fc = nn.Sequential(
            nn.Linear(3*64*64, 4096),
            nn.Dropout(0.5),
            nn.ReLU(),
            nn.Linear(4096, 2048),
            nn.Dropout(0.5),
            nn.ReLU(),
            nn.Linear(2048, 512),
            nn.Dropout(0.5),
            nn.ReLU(),
            nn.Linear(512, 11)
        )
```

參數:

```
batch_size = 128
learning_rate = 0.001
num_epoch = 200
input_size = 3*128*128
```

訓練參數量: 59,774,476 parameters

```
INPUT: [128x128x3] weights: 0
POOL2: [64x64x3] weights: 0
FC: [1x1x4096] weights: 3*64*64*4096 = 50,331,648
FC: [1x1x2048] weights: 4096*2048 = 8,388,608
FC: [1x1x512] weights: 2048*512 = 1,048,579
FC: [1x1x11] weights: 512*11 = 5632
Total = 以上總和 = 59,774,476
```

正確率

在kaggle public上的準確率為22.414%

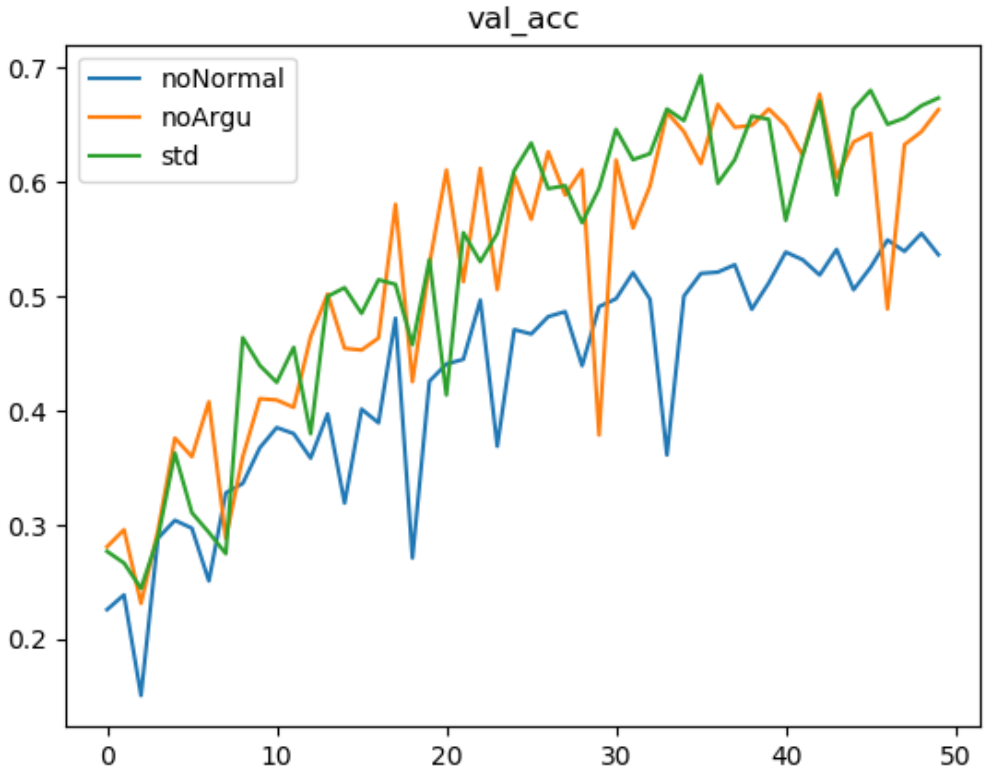
4. 請說明由 1 ~ 3 題的實驗中你觀察到了什麼？(1%)

可以發現在此題在參數量接近時，細長的架構(layer多，每層layer小)通常會比粗短(layer少，每層layer大)的來的好，尤其在圖片分類的訓練中，找出2D中的特徵特別重要。第3題只使用DNN的做法完全忽略了2D上的分布，將圖片直接拉為一直線，所以正確率相當低。

5. 請嘗試 data normalization 及 data augmentation，說明實作方法並且說明實行前後對準確率有什麼樣的影響？(1%)

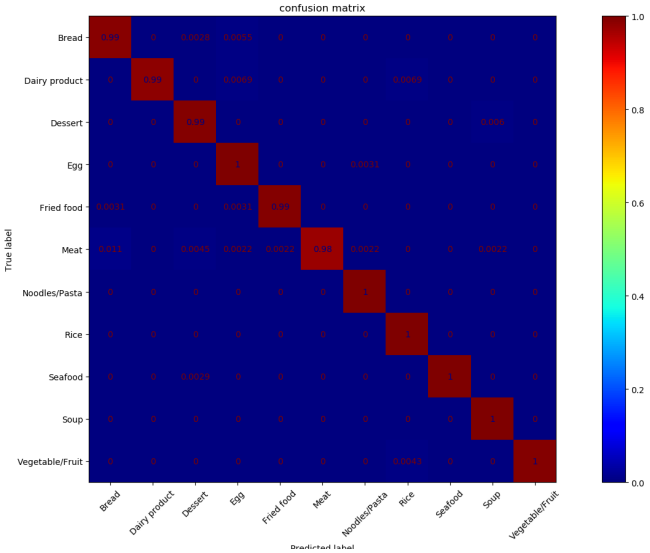
data normalization實行方法:由於transforms.ToTensor()會自動做normalization，所以由是否對每個x乘255控制。 data augmentation實行方法:由是否加入以下兩行控制。

```
transforms.RandomHorizontalFlip(), # 隨機將圖片水平翻轉
transforms.RandomRotation(15), # 隨機旋轉圖片
```



std為data normalization和data augmentation都有做 可以發現 1.取消normalize之後，其正確率顯著地較另外兩個case低，可能是因為取消normalize後，其loss function的空間較為崎嶇，gradient descent的過程較長且彎曲。 2.取消augmentation之後的波動較大，可能是因為其model學習到了在training data上順序的pattern，而這種pattern對val來說是毫無道理的，從而導致over fitting，在val上的表現較std差。

6. 觀察答錯的圖片中，哪些 class 彼此間容易用混？[繪出 confusion matrix 分析] (1%)



這是在val上的confusion matrix。 由於我在訓練時為了增加資料量，把val併入了train一起訓練，所以這些val都是model看過的樣本，所以正確率才這麼高，但仍看得出來哪些class之間較易弄混。 最常出錯的是誤認Dairy product為Egg和Rice。 次為誤認Bread為Egg