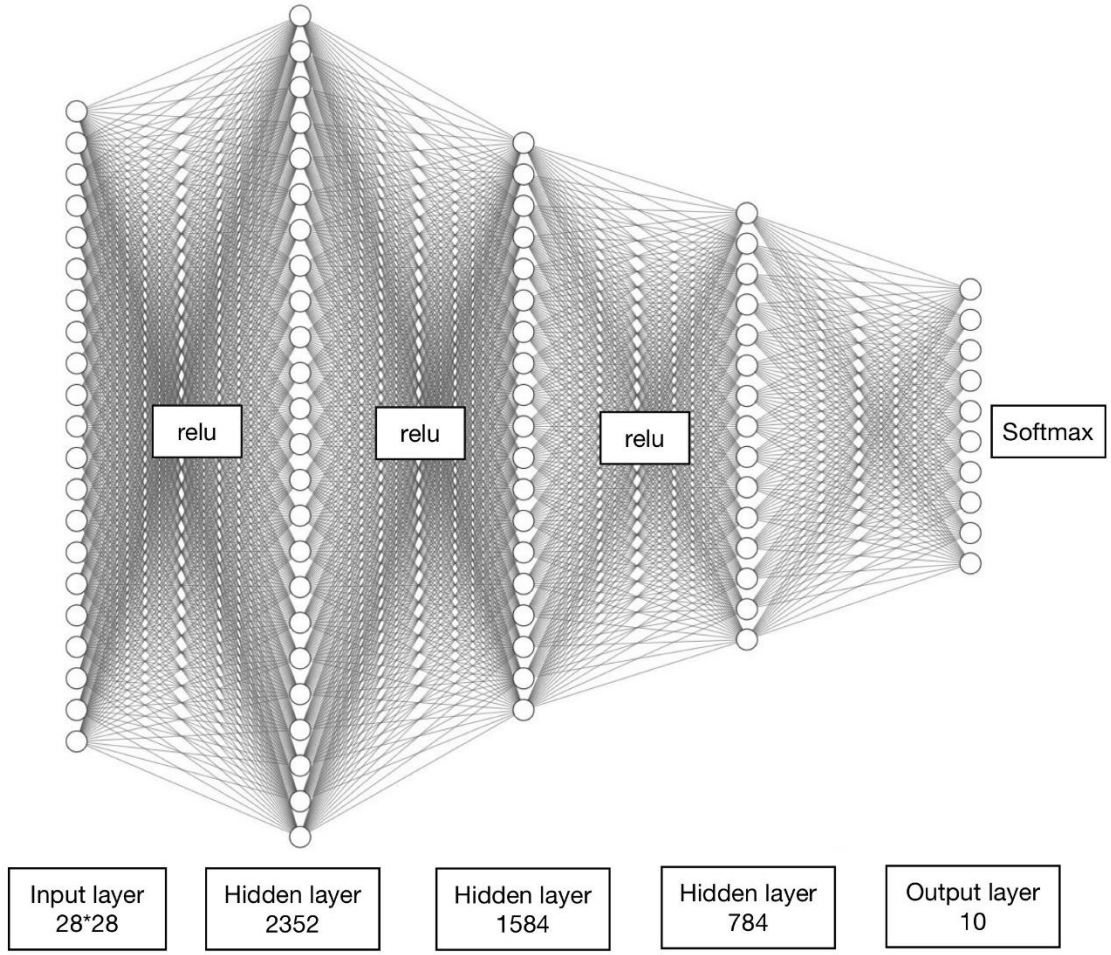
2024 DL Lab1 Backpropagation and Basic Pytorch

架構:



我使用的 network 是 4 層的 Fully Connected Layer，並使用 relu 當作我的 activation function，最後使用 softmax+crossEntropy 作為 loss function。

Network:

```
class Network(object):
    def __init__(self):

        ## by yourself .Finish your own NN framework
        ## Just an example.You can alter sample code anywhere.
        self.fc1 = FullyConnected(28*28, 2352) ## Just an example.You can alter sample code anywhere.
        self.relu1 = relu()
        self.fc2 = FullyConnected(2352, 1568)
        self.relu2 = relu()
        self.fc3 = FullyConnected(1568, 784)
        self.relu3 = relu()
        self.fc4 = FullyConnected(784, 10)
        # self.relu4 = relu()
        # self.fc5 = FullyConnected(64, 10)
        self.loss = SoftmaxWithloss()
```

我使用過 3 層 4 層 5 層的架構過。其實在 3 層時就有不錯的成績，Validation accuracy 就有達到 95%，而且訓練速度也很快。
但後續為了更好的 performance，嘗試開始使用 4 層 5 層，但發現並不是越深層 accuracy 會越好，4 層的 accuracy 皆會比 5 層還要準確一些，更重要的是跑完所有 epoch 所需的時間大大減少，因此開始往 4 層的架構去調整一些細節。

Loss function:

考慮這次是分 10 類的問題，因此使用 CrossEntropy loss，來決定屬於該類的機率。

Activation function:

所使用的是上課所推薦的 relu fuction，此種 activation function 收斂速度比 sigmoid 或 tanh 快很多。

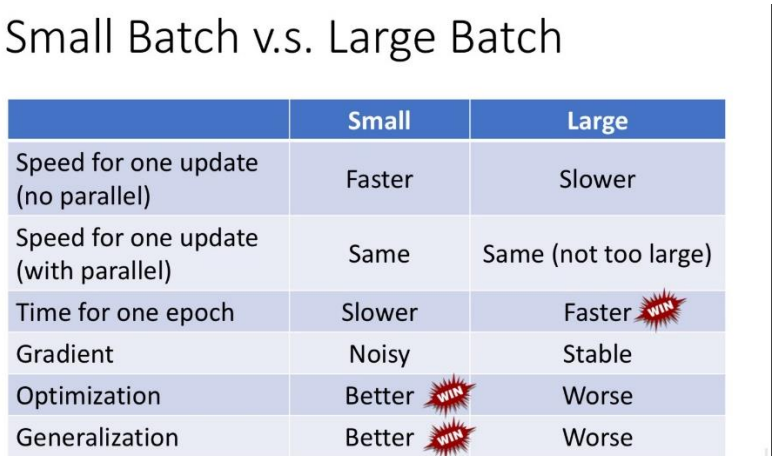
Hyperparameters function:

```
EPOCH = 30
Batch_size =  10# 10000 should be divisible by batch_size
Learning_rate = 0.005
```

EPOCH 選定 30 是我發現我大多架構下，跑到 20 幾時 Train loss 會為 0 且 Train accuracy 會達 100%，因此為了避免 overfitting，訂在合適的地方結束訓練。

Learning rate 上有試過使用隨著訓練而變動，當 epoch 數越高時，learning rate 開始遞減，我最後發現雖然有幫助，但效果不大。況且 learning rate 也不能太快降，要發現 error 在某一定值開始不動時再調整才是最優的。

Batch size 有試過 40 20 10，這對於結果皆有些許差異，最後決定使用最小的 10。小 batch size 在跑 one epoch 所花的時間會比較多是缺點外，在收斂速度以及避免困在 local minimum(noisy 的緣故)都有很好的效果。



(Source : small-gradient 李宏毅)

How to improve accuracy?

Validation set:

最後在拚 performance 時，我將 validation data set 設成 10，其他 data 都拿去訓練，這使我在成績上有不錯的進步。

Task1 Validation accuracy:

```
Task1  | Epoch:  1  |Train Loss:  0.3336  |Train Acc:89.5800  |Val Loss:  0.1709  |Val Acc:94.9900
Task1  | Epoch:  2  |Train Loss:  0.1037  |Train Acc:96.8680  |Val Loss:  0.1535  |Val Acc:95.4400
Task1  | Epoch:  3  |Train Loss:  0.0448  |Train Acc:98.6760  |Val Loss:  0.1623  |Val Acc:95.7700
Task1  | Epoch:  4  |Train Loss:  0.0323  |Train Acc:98.9880  |Val Loss:  0.1492  |Val Acc:96.2600
Task1  | Epoch:  5  |Train Loss:  0.0252  |Train Acc:99.2040  |Val Loss:  0.1497  |Val Acc:96.3000
Task1  | Epoch:  6  |Train Loss:  0.0214  |Train Acc:99.3380  |Val Loss:  0.1654  |Val Acc:96.3500
Task1  | Epoch:  7  |Train Loss:  0.0191  |Train Acc:99.4340  |Val Loss:  0.1624  |Val Acc:96.3000
Task1  | Epoch:  8  |Train Loss:  0.0129  |Train Acc:99.5820  |Val Loss:  0.1668  |Val Acc:96.1500
Task1  | Epoch:  9  |Train Loss:  0.0118  |Train Acc:99.6820  |Val Loss:  0.1457  |Val Acc:96.9400
Task1  | Epoch: 10  |Train Loss:  0.0083  |Train Acc:99.7880  |Val Loss:  0.1610  |Val Acc:96.6700
Task1  | Epoch: 11  |Train Loss:  0.0021  |Train Acc:99.9500  |Val Loss:  0.1685  |Val Acc:97.0900
Task1  | Epoch: 12  |Train Loss:  0.0017  |Train Acc:99.9620  |Val Loss:  0.1728  |Val Acc:97.0600
Task1  | Epoch: 13  |Train Loss:  0.0005  |Train Acc:99.9880  |Val Loss:  0.1630  |Val Acc:97.2400
Task1  | Epoch: 14  |Train Loss:  0.0001  |Train Acc:100.0000  |Val Loss:  0.1631  |Val Acc:97.2300
Task1  | Epoch: 15  |Train Loss:  0.0001  |Train Acc:100.0000  |Val Loss:  0.1648  |Val Acc:97.2500
Task1  | Epoch: 16  |Train Loss:  0.0000  |Train Acc:100.0000  |Val Loss:  0.1664  |Val Acc:97.2400
Task1  | Epoch: 17  |Train Loss:  0.0000  |Train Acc:100.0000  |Val Loss:  0.1677  |Val Acc:97.2400
Task1  | Epoch: 18  |Train Loss:  0.0000  |Train Acc:100.0000  |Val Loss:  0.1689  |Val Acc:97.2500
Task1  | Epoch: 19  |Train Loss:  0.0000  |Train Acc:100.0000  |Val Loss:  0.1700  |Val Acc:97.2400
Task1  | Epoch: 20  |Train Loss:  0.0000  |Train Acc:100.0000  |Val Loss:  0.1709  |Val Acc:97.2400
Task1  | Epoch: 21  |Train Loss:  0.0000  |Train Acc:100.0000  |Val Loss:  0.1718  |Val Acc:97.2400
Task1  | Epoch: 22  |Train Loss:  0.0000  |Train Acc:100.0000  |Val Loss:  0.1727  |Val Acc:97.2600
Task1  | Epoch: 23  |Train Loss:  0.0000  |Train Acc:100.0000  |Val Loss:  0.1734  |Val Acc:97.2600
Task1  | Epoch: 24  |Train Loss:  0.0000  |Train Acc:100.0000  |Val Loss:  0.1742  |Val Acc:97.2700
Task1  | Epoch: 25  |Train Loss:  0.0000  |Train Acc:100.0000  |Val Loss:  0.1749  |Val Acc:97.2800
...
Task1  | Epoch: 27  |Train Loss:  0.0000  |Train Acc:100.0000  |Val Loss:  0.1761  |Val Acc:97.2800
Task1  | Epoch: 28  |Train Loss:  0.0000  |Train Acc:100.0000  |Val Loss:  0.1767  |Val Acc:97.2800
Task1  | Epoch: 29  |Train Loss:  0.0000  |Train Acc:100.0000  |Val Loss:  0.1773  |Val Acc:97.2800
Task1  | Epoch: 30  |Train Loss:  0.0000  |Train Acc:100.0000  |Val Loss:  0.1778  |Val Acc:97.2800
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Task2 Validation accuracy:

```
Task2  | Epoch:  1  |Train Loss:  0.4737  |Train Acc:88.3020  |Val Loss:  0.2123  |Val Acc:93.6800
Task2  | Epoch:  2  |Train Loss:  0.1474  |Train Acc:95.4460  |Val Loss:  0.1944  |Val Acc:94.6200
Task2  | Epoch:  3  |Train Loss:  0.0873  |Train Acc:97.3000  |Val Loss:  0.2076  |Val Acc:94.7900
Task2  | Epoch:  4  |Train Loss:  0.0628  |Train Acc:98.1060  |Val Loss:  0.1900  |Val Acc:95.3700
Task2  | Epoch:  5  |Train Loss:  0.0641  |Train Acc:98.1680  |Val Loss:  0.2040  |Val Acc:95.0100
Task2  | Epoch:  6  |Train Loss:  0.0440  |Train Acc:98.7560  |Val Loss:  0.1829  |Val Acc:96.0400
Task2  | Epoch:  7  |Train Loss:  0.0454  |Train Acc:98.7620  |Val Loss:  0.2106  |Val Acc:95.5100
Task2  | Epoch:  8  |Train Loss:  0.0362  |Train Acc:99.0040  |Val Loss:  0.2036  |Val Acc:95.8800
Task2  | Epoch:  9  |Train Loss:  0.0302  |Train Acc:99.1840  |Val Loss:  0.1932  |Val Acc:96.1400
Task2  | Epoch: 10  |Train Loss:  0.0326  |Train Acc:99.1660  |Val Loss:  0.1838  |Val Acc:96.2300
Task2  | Epoch: 11  |Train Loss:  0.0261  |Train Acc:99.3460  |Val Loss:  0.1945  |Val Acc:96.3700
Task2  | Epoch: 12  |Train Loss:  0.0370  |Train Acc:99.0640  |Val Loss:  0.2389  |Val Acc:95.7900
Task2  | Epoch: 13  |Train Loss:  0.0236  |Train Acc:99.4200  |Val Loss:  0.2279  |Val Acc:96.2000
Task2  | Epoch: 14  |Train Loss:  0.0277  |Train Acc:99.2960  |Val Loss:  0.2863  |Val Acc:95.3100
Task2  | Epoch: 15  |Train Loss:  0.0205  |Train Acc:99.5860  |Val Loss:  0.2057  |Val Acc:96.3400
Task2  | Epoch: 16  |Train Loss:  0.0203  |Train Acc:99.4500  |Val Loss:  0.2336  |Val Acc:96.5200
Task2  | Epoch: 17  |Train Loss:  0.0209  |Train Acc:99.5020  |Val Loss:  0.2269  |Val Acc:96.3500
Task2  | Epoch: 18  |Train Loss:  0.0270  |Train Acc:99.3380  |Val Loss:  0.2446  |Val Acc:96.2700
Task2  | Epoch: 19  |Train Loss:  0.0271  |Train Acc:99.3780  |Val Loss:  0.2251  |Val Acc:96.3000
Task2  | Epoch: 20  |Train Loss:  0.0100  |Train Acc:99.7560  |Val Loss:  0.2081  |Val Acc:96.7000
Task2  | Epoch: 21  |Train Loss:  0.0068  |Train Acc:99.8340  |Val Loss:  0.2297  |Val Acc:96.6500
Task2  | Epoch: 22  |Train Loss:  0.0062  |Train Acc:99.8400  |Val Loss:  0.2645  |Val Acc:96.5300
Task2  | Epoch: 23  |Train Loss:  0.0141  |Train Acc:99.6620  |Val Loss:  0.3069  |Val Acc:95.8900
Task2  | Epoch: 24  |Train Loss:  0.0159  |Train Acc:99.6220  |Val Loss:  0.2571  |Val Acc:96.5800
Task2  | Epoch: 25  |Train Loss:  0.0153  |Train Acc:99.6860  |Val Loss:  0.2668  |Val Acc:95.9600
...
Task2  | Epoch: 27  |Train Loss:  0.0184  |Train Acc:99.6200  |Val Loss:  0.2465  |Val Acc:96.6900
Task2  | Epoch: 28  |Train Loss:  0.0135  |Train Acc:99.7080  |Val Loss:  0.2840  |Val Acc:96.3300
Task2  | Epoch: 29  |Train Loss:  0.0165  |Train Acc:99.6900  |Val Loss:  0.2384  |Val Acc:96.5400
Task2  | Epoch: 30  |Train Loss:  0.0094  |Train Acc:99.7620  |Val Loss:  0.2472  |Val Acc:96.6800
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