Test with Iris dataset and Test and train split function

```
In [50]: from sklearn.datasets import load_iris
         from sklearn.model_selection import train_test_split
         #loading dataset
         iris = load_iris()
         X, y = iris.data, iris.target
         X_train,X_test,y_train,y_test=train_test_split(X,y,test_size=0.2,random_state=1)
         print(X_train.shape)
         print(y_train.shape)
         print(X_test.shape)
         print(y_test.shape)
```

```
(120, 4)
(120,)
(30, 4)
(30,)
```

Architecture definition

```
In [51]: import torch.nn as nn

         class ANN(nn.Module) :
             def __init__(self, num_classes=3):
                 super(self.__class__, self).__init__()

                 self.fullyConnected = nn.Sequential(
                     nn.Linear(in_features=4, out_features=10), #out_features are the same in_features in next nn.Linear
                     nn.ReLU(),
                     nn.Linear(in_features=10, out_features=20),
                     nn.ReLU(),
                     nn.Linear(in_features=20, out_features=num_classes),
                 )

             def forward(self, x, debug=False):
                 if debug : print('input',x.shape)
                 y = self.fullyConnected(x)
                 if debug : print('output',y.shape)
                 return y
```

Model analysis

```
In [52]: import torch

         if torch.cuda.is_available():
             my_device = torch.device("cuda:0")
             print("Running on CUDA.")
         else:
             my_device = torch.device("cpu")
             print("No Cuda Available")

         net = ANN( num_classes=3 )

         net = net.to(my_device)

         a = torch.rand( (1, 4) )
         a = a.to(my_device)
         b = net( a , debug=True )

         del a, b, net
```

```
Running on CUDA.
input torch.Size([1, 4])
output torch.Size([1, 3])
```

```
In [53]: from torchsummary import summary

         net = ANN( num_classes=3 )

         net = net.to(my_device)
         #calcular quantidade de parametros
         summary(net, input_size=(120, 4), batch_size=1)

         del net
```

```
=================================================================
Layer (type:depth-idx)                   Param #
=================================================================
├─Sequential: 1-1                        --
|    └─Linear: 2-1                       50
|    └─ReLU: 2-2                         --
|    └─Linear: 2-3                       220
|    └─ReLU: 2-4                         --
|    └─Linear: 2-5                       63
=================================================================
Total params: 333
Trainable params: 333
Non-trainable params: 0
=================================================================
```

Training functions - Batch based learning steps

```
In [54]: from sklearn.model_selection import train_test_split
         from datetime import datetime

         from torch.utils.tensorboard import SummaryWriter

         import matplotlib.pyplot as plt
         import copy
         from tqdm import tqdm

         from torch.utils.data import DataLoader, TensorDataset

         import numpy as np

         def train_batch ( dataset, prefix=None, upper_bound=101.0, save=False, epochs=100,
                    lr=1e-1, device='cpu', debug=False, layers2tensorboard=True, lambda_reg=0, batch_size=32 ) :

             num_classes = 3

             tensorboard_path = 'logs/' # Setar o caminho para salvar o log para o TensorBoard

             net = ANN( num_classes )
             net.to(device)

             optimizer = torch.optim.SGD(net.parameters(), lr=lr, weight_decay=lambda_reg)
             criterion = nn.CrossEntropyLoss()

             now = datetime.now()
             suffix = now.strftime("%Y%m%d_%H%M%S")
             prefix = suffix if prefix is None else prefix + '-' + suffix

             writer = SummaryWriter( log_dir=tensorboard_path+prefix )

             accuracies = []
             max_accuracy = -1.0
             smallest_loss = float('inf')

             # Present the data to the model
             data_loader = train_test_split( dataset.data,
                                             dataset.target,
                                             test_size=0.2,
                                             random_state=1 )

             train_x,test_x,train_label,test_label = data_loader

             train_x = torch.from_numpy(train_x).float()
             train_x = train_x.to(device)
             train_label = torch.from_numpy(train_label).float()
             train_label = train_label.to(device)

             test_x = torch.from_numpy(test_x).float()
             test_x = test_x.to(device)
             test_label = torch.from_numpy(test_label).float()
             test_label = test_label.to(device)

             #Split the data into batches
             #train_set = TensorDataset(train_x, train_label)
             #train_loader = DataLoader(train_set, batch_size=batch_size, shuffle=True)
             num_batches =  int(np.ceil(len(train_x) / batch_size))
             train_loader = []
             for i in range(0, num_batches):
                 batch_x = train_x[(i * batch_size): ((i+1) * batch_size)]
                 batch_label = train_label[(i * batch_size): ((i+1) * batch_size)]
                 train_loader.append((batch_x, batch_label))



             writer.add_graph(net, train_x)

             for epoch in tqdm( range(epochs) , desc='Training epochs...' ) :

                 net.train()
                 epoch_loss = 0

                 #For each batch of the data
                 for batch_x, batch_label in train_loader:
                     optimizer.zero_grad() #reset gradients of all the parameters to zero before computing the gradients
                     #for the next batch

                     #For each sample of the batch, calculate the loss
                     predict_y = net(batch_x.to(device))
                     error = criterion(predict_y, batch_label.to(device).long())

                     # Back propagation
                     error.backward()
                     optimizer.step()

                     epoch_loss += error.item()
                 #calculate the full loss
                 full_loss = epoch_loss / len(train_loader)

                 accuracy_test = validate(net, test_x, test_label, device=device)
                 accuracies.append(accuracy_test)

                 writer.add_scalar( 'Loss/train', full_loss, epoch )
                 writer.add_scalar( 'Accuracy/train', accuracy_test, epoch )
                 writer.add_scalar( 'Accuracy/test', accuracy_test, epoch )
                 if layers2tensorboard :
                    plot_layers( net, writer, epoch )

                 #Test Model
                 if accuracy_test > max_accuracy:
                     best_model = copy.deepcopy(net)
                     max_accuracy = accuracies[-1]
                     print(f'Saving the best model at epoch {epoch+1:3d} ' +
                             f'with Accuracy: {max_accuracy:8.4f}%')


                 if debug : print( f'Epoch: {epoch+1:3d} |'
                                 + f'Accuracy Test: {accuracy_test:3.4f}%' )

                 if accuracy_test > upper_bound :
                     break

             if save :
                 models_path = '' # Setar o caminho para salvar o modelo final
                 path = f'{models_path}ANN-iris-{max_accuracy:.2f}.pkl'
                 torch.save( best_model, path )
                 print( f'Model saved in: {path}' )

             plt.figure(figsize=(16, 8))
             plt.plot(accuracies)

             writer.flush()
             writer.close()

             return best_model
```

Training functions

```
In [55]: from sklearn.model_selection import train_test_split
         from datetime import datetime

         from torch.utils.tensorboard import SummaryWriter

         import matplotlib.pyplot as plt
         import copy
         from tqdm import tqdm

         def train ( dataset, prefix=None, upper_bound=101.0, save=False, epochs=100,
                    lr=1e-1, device='cpu', debug=False, layers2tensorboard=True, lambda_reg=0, batch_size = 30 ) :

             num_classes = 3

             tensorboard_path = 'logs/' # Setar o caminho para salvar o log para o TensorBoard

             net = ANN( num_classes )
             net.to(device)

             optimizer = torch.optim.SGD(net.parameters(), lr=lr, weight_decay=lambda_reg)
             criterion = nn.CrossEntropyLoss()

             now = datetime.now()
             suffix = now.strftime("%Y%m%d_%H%M%S")
             prefix = suffix if prefix is None else prefix + '-batch-' + suffix

             writer = SummaryWriter( log_dir=tensorboard_path+prefix )

             accuracies = []
             max_accuracy = -1.0
             #1. Present the data to the model
             data_loader = train_test_split( dataset.data,
                                             dataset.target,
                                             test_size=0.2,
                                             random_state=1 )

             train_x,test_x,train_label,test_label = data_loader

             train_x = torch.from_numpy(train_x).float()
             train_x = train_x.to(device)
             train_label = torch.from_numpy(train_label).float()
             train_label = train_label.to(device)

             test_x = torch.from_numpy(test_x).float()
             test_x = test_x.to(device)
             test_label = torch.from_numpy(test_label).float()
             test_label = test_label.to(device)

             writer.add_graph(net, train_x)

             for epoch in tqdm( range(epochs) , desc='Training epochs...' ) :

                 # Set Pytorch variables
                 net.train()
                 optimizer.zero_grad()

                 # Forward step
                 predict_y = net( train_x )

                 # Loss
                 error = criterion( predict_y , train_label.long() )

                 # Back propagation
                 error.backward()
                 optimizer.step()

                 # Accuracies:
                 predict_ys = torch.max( predict_y, axis=1 )[1]
                 correct    = torch.sum( predict_ys == train_label )
                 accuracy_train = correct/train_x.size(0)

                 accuracy_test = validate(net, test_x, test_label, device=device)
                 accuracies.append(accuracy_test)

                 # Tensor board writing
                 writer.add_scalar( 'Loss/train', error.item(), epoch )
                 writer.add_scalar( 'Accuracy/train', accuracy_train, epoch )
                 writer.add_scalar( 'Accuracy/test', accuracy_test, epoch )

                 if layers2tensorboard :
                     plot_layers( net, writer, epoch )

                 # Test model
                 if accuracy_test > max_accuracy:
                     best_model = copy.deepcopy(net)
                     max_accuracy = accuracy_test
                     print(f'Saving the best model at epoch {epoch+1:3d} ' +
                             f'with Accuracy: {accuracy_test:8.4f}%')

                 if debug : print( f'Epoch: {epoch+1:3d} |'
                                 + f'Accuracy Test: {accuracy_test:3.4f}%' )

                 if accuracy_test > upper_bound :
                     break

             if save :
                 models_path = '' # Setar o caminho para salvar o modelo final
                 path = f'{models_path}ANN-iris-{max_accuracy:.2f}.pkl'
                 torch.save( best_model, path )
                 print( f'Model saved in: {path}' )

             plt.figure(figsize=(16, 8))
             plt.plot(accuracies)

             writer.flush()
             writer.close()

             return best_model
```

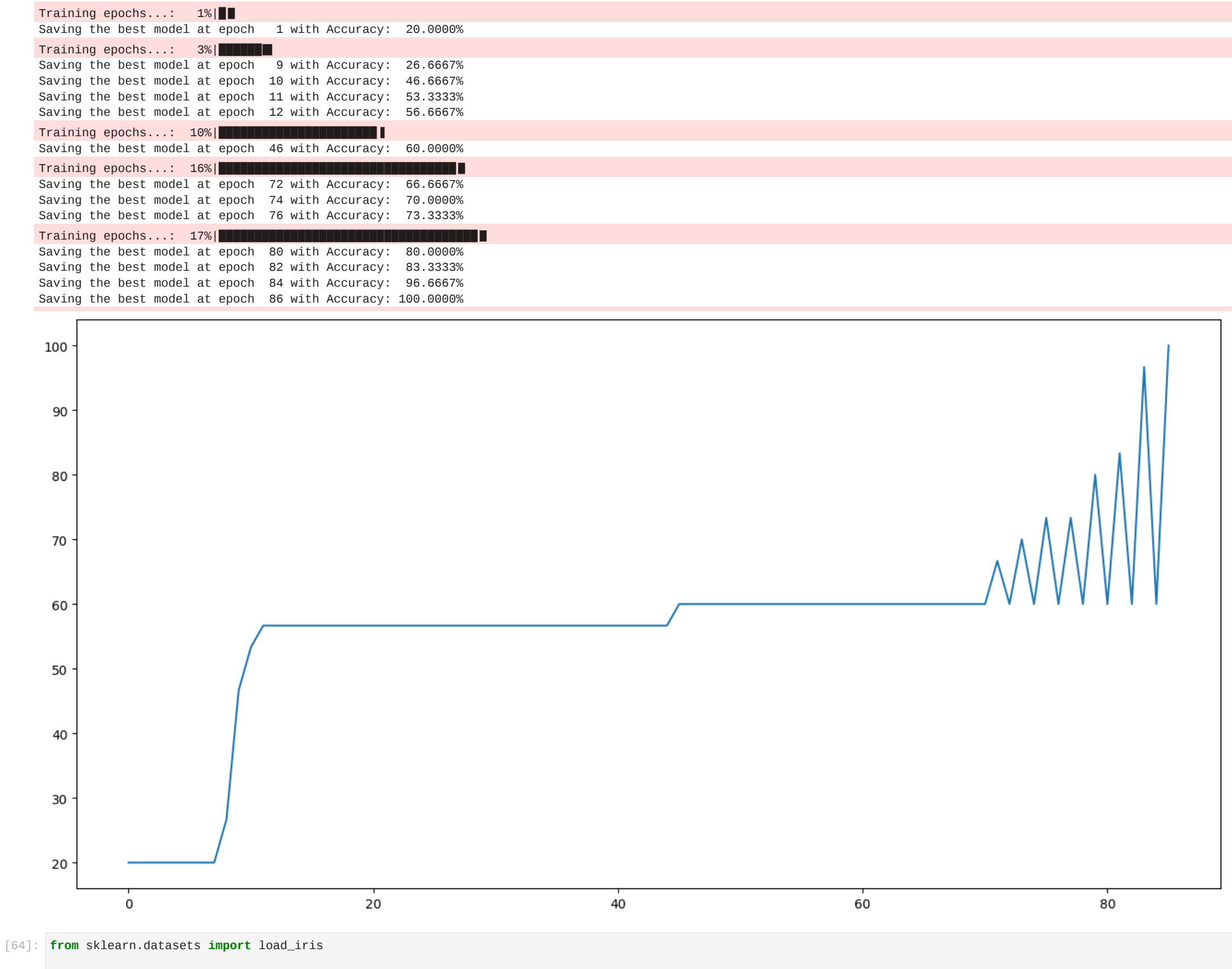
```
In [56]: def validate ( model , test_x, test_label , device='cpu') :

             model.eval()

             correct = 0
             sum = 0

             predict_y = model( test_x ).detach()
             predict_ys = torch.max( predict_y, axis=1 )[1]
             sum = sum + test_x.size(0)
             correct = correct + torch.sum(predict_ys == test_label)

             return correct.to('cpu').numpy()*100./sum
```

```
In [57]: def plot_layers ( net , writer, epoch ) :
             layers = list(net.fullyConnected.modules())

             layer_id = 1
             for layer in layers:
                 if isinstance(layer, nn.Linear) :
                     writer.add_histogram(f'Bias/linear-{layer_id}', layer.bias, epoch )
                     writer.add_histogram(f'Weight/linear-{layer_id}', layer.weight, epoch )
                     writer.add_histogram(f'Grad/linear-{layer_id}', layer.weight.grad, epoch )
                     layer_id += 1
```

Run the training phase

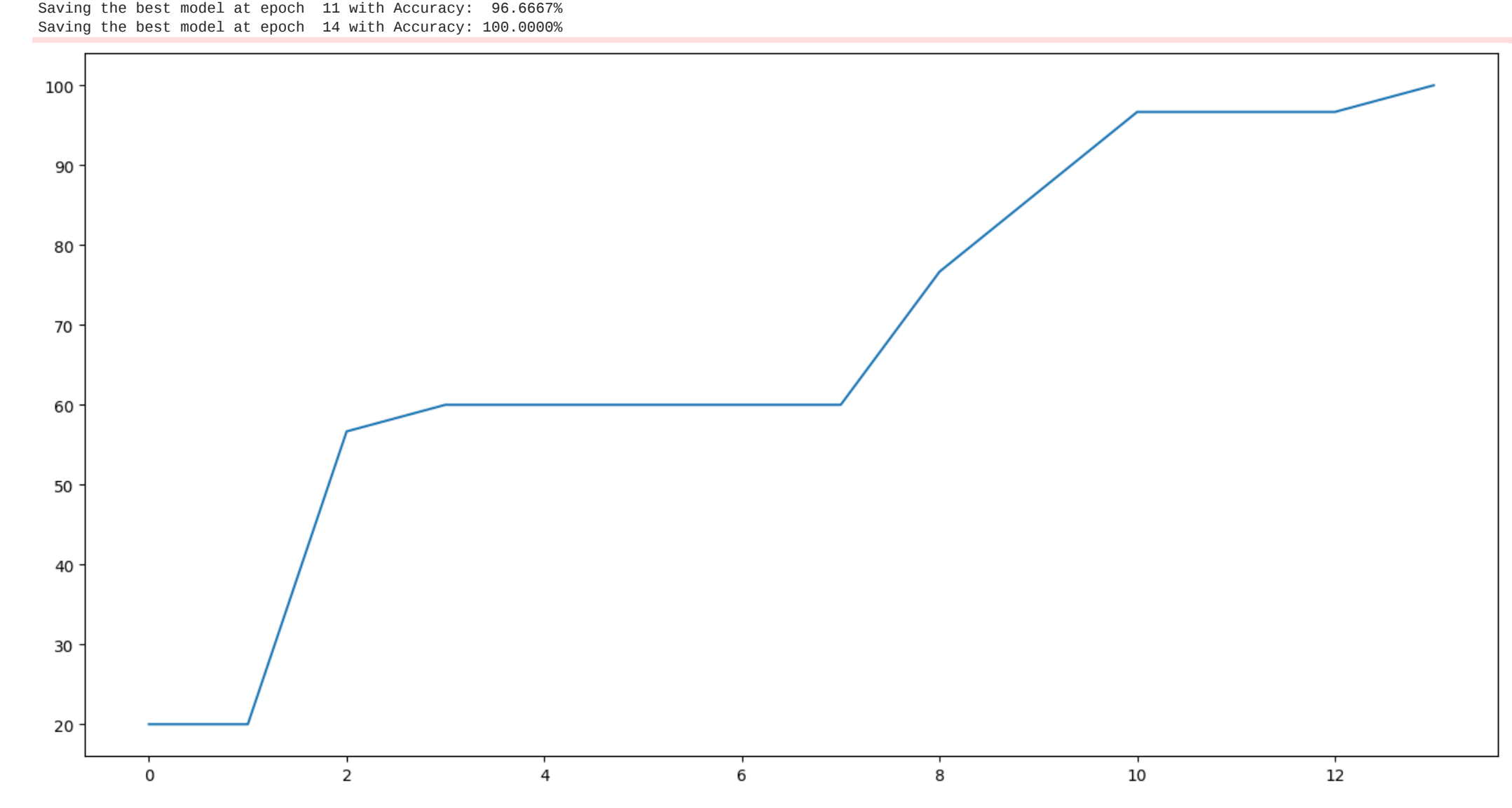
```
In [63]: from sklearn.datasets import load_iris

         if torch.cuda.is_available():
             my_device = torch.device("cuda:0")
             print("Running on CUDA.")
         else:
             my_device = torch.device("cpu")
             print("No Cuda Available")

         dataset = 'Iris'
         epochs = 500
         lr = 1e-1
         lambda_reg = 1e-1
         prefix = 'ANN-{}-e-{}-lr-{}'.format(dataset, epochs, lr)

         iris = load_iris()
         dataset = iris

         net = train( dataset=dataset, epochs=epochs, device=my_device,
                     upper_bound=99.9, lr=lr, lambda_reg=lambda_reg,
                     layers2tensorboard=True, save=False, prefix=prefix
                    )
         #Era a versão do numpy que deu problema que te perguntei em sala, abaixei para a versão 1.20.0 e foi
```

```
Running on CUDA.
Training epochs...:   1%|██                                                         | 4/500 [00:00<00:14, 34.39it/s]
Saving the best model at epoch   1 with Accuracy:  20.0000%
Training epochs...:   3%|██████▌                                                    | 16/500 [00:00<00:13, 35.62it/s]
Saving the best model at epoch   9 with Accuracy:  26.6667%
Saving the best model at epoch  10 with Accuracy:  46.6667%
Saving the best model at epoch  11 with Accuracy:  53.3333%
Saving the best model at epoch  12 with Accuracy:  56.6667%
Training epochs...:  10%|████████████████████▌                                     | 52/500 [00:01<00:12, 34.92it/s]
Saving the best model at epoch  46 with Accuracy:  60.0000%
Training epochs...:  16%|████████████████████████████████▌                         | 78/500 [00:02<00:10, 39.54it/s]
Saving the best model at epoch  72 with Accuracy:  66.6667%
Saving the best model at epoch  74 with Accuracy:  70.0000%
Saving the best model at epoch  76 with Accuracy:  73.3333%
Training epochs...:  17%|██████████████████████████████████▌                       | 85/500 [00:02<00:11, 35.84it/s]
Saving the best model at epoch  80 with Accuracy:  80.0000%
Saving the best model at epoch  82 with Accuracy:  83.3333%
Saving the best model at epoch  84 with Accuracy:  96.6667%
Saving the best model at epoch  86 with Accuracy: 100.0000%
```



```
In [64]: from sklearn.datasets import load_iris

         if torch.cuda.is_available():
             my_device = torch.device("cuda:0")
             print("Running on CUDA.")
         else:
             my_device = torch.device("cpu")
             print("No Cuda Available")

         dataset = 'Iris'
         epochs = 500
         lr = 1e-1
         lambda_reg = 1e-1
         prefix = 'ANN-{}-e-{}-lr-{}'.format(dataset, epochs, lr)

         iris = load_iris()
         dataset = iris


         net = train_batch( dataset=dataset, epochs=epochs, device=my_device,
                         upper_bound=99.9, lr=lr, lambda_reg=lambda_reg,
                         layers2tensorboard=True, save=False, prefix=prefix, batch_size = 30
                        )
```

```
Running on CUDA.
Training epochs...:   1%|█▍                                                         | 3/500 [00:00<00:19, 25.58it/s]
Saving the best model at epoch   1 with Accuracy:  20.0000%
Saving the best model at epoch   3 with Accuracy:  56.6667%
Saving the best model at epoch   4 with Accuracy:  60.0000%
Training epochs...:   3%|█████                                                     | 13/500 [00:00<00:17, 27.54it/s]
Saving the best model at epoch   9 with Accuracy:  76.6667%
Saving the best model at epoch  10 with Accuracy:  86.6667%
Saving the best model at epoch  11 with Accuracy:  96.6667%
Saving the best model at epoch  14 with Accuracy: 100.0000%
```



Conclusion

In conclusion, we achieved 100% accuracy in both batch size learning and all-at-once training methods. However, with a batch size of 30, we achieved this accuracy faster, reaching it in epoch 14, compared to epoch 86 in the all-at-once method. This demonstrates the efficiency of using batch size learning in training models.

```
In [13]: import numpy
         print(numpy.__version__)
```

```python
print(torch.__version__)
```

```
1.20.0
1.12.1+cu113
```