# Machine Learning

## Lecture 5: Linear regression in PyTorch way

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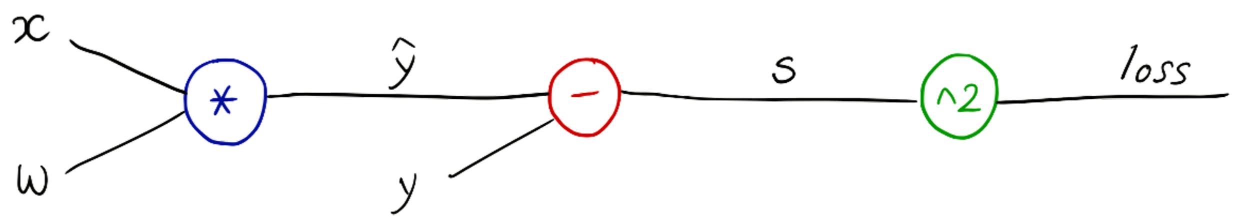
# PyTorch forward/backward

```python
w = Variable(torch.Tensor([1.0]),  requires_grad=True)  # Any random value

# our model forward pass
def forward(x):
   return x * w

# Loss function
def loss(x, y):
   y_pred = forward(x)
   return (y_pred - y) * (y_pred - y)

# Training loop
for epoch in range(10):
   for x_val, y_val in zip(x_data, y_data):
       l = loss(x_val, y_val)
       l.backward()
       print("\tgrad: ", x_val, y_val, w.grad.data[0])
       w.data = w.data - 0.01 * w.grad.data

       # Manually zero the gradients after updating weights
       w.grad.data.zero_()

   print("progress:", epoch, l.data[0])
```



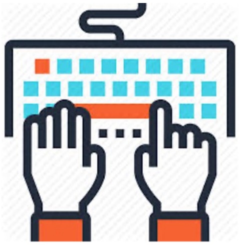
# PyTorch Rhythm

1. Design your model using class with Variables

2. Construct loss and optimizer
(select from PyTorch API)

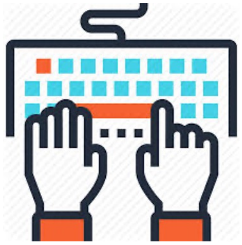
3. Training cycle
(forward, backward, update)

# Data definition



```
import torch
from torch.autograd import Variable

x_data = Variable(torch.Tensor([[1.0], [2.0], [3.0]]))
y_data = Variable(torch.Tensor([[2.0], [4.0], [6.0]]))
```

# 1 Model class in PyTorch way



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x_data = Variable(torch.Tensor([[1.0], [2.0], [3.0]]))
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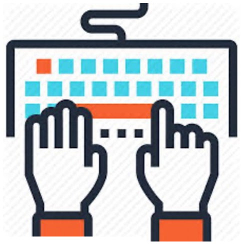
class Model(torch.nn.Module):
  def __init__(self):
    """
    In the constructor we instantiate two nn.Linear module
    """
    super(Model, self).__init__()
    self.linear = torch.nn.Linear(1, 1) # One in and one out

  def forward(self, x):
    """
    In the forward function we accept a Variable of input data and we must return
    a Variable of output data. We can use Modules defined in the constructor as
    well as arbitrary operators on Variables.
    """
    y_pred = self.linear(x)
    return y_pred

# our model
model = Model()
```

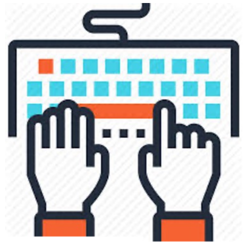
## ② Construct loss and optimizer



```
# Construct our loss function and an Optimizer. The call to model.parameters()
# in the SGD constructor will contain the learnable parameters of the two
# nn.Linear modules which are members of the model.
criterion = torch.nn.MSELoss(size_average=False)
optimizer = torch.optim.SGD(model.parameters(), lr=0.01)
```

https://github.com/jcjohnson/pytorch-examples

# ③ Training: forward, loss, backward, step



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criterion = torch.nn.MSELoss(size_average=False)
optimizer = torch.optim.SGD(model.parameters(), lr=0.01)

# Training loop
for epoch in range(500):
    # Forward pass: Compute predicted y by passing x to the model
    y_pred = model(x_data)

    # Compute and print loss
    loss = criterion(y_pred, y_data)
    print(epoch, loss.data[0])

    # Zero gradients, perform a backward pass, and update the weights.
    optimizer.zero_grad()
    loss.backward()
    optimizer.step()
```
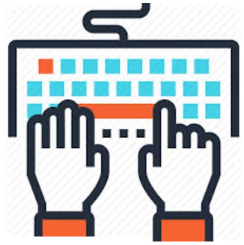

https://github.com/jcjohnson/pytorch-examples

# 3 Training: forward, loss, backward, step



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for x_val, y_val in zip(x_data, y_data):
    ...
    w.data = w.data - 0.01 * w.grad.data
```

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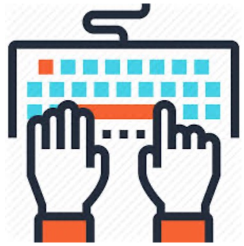
# Testing Model



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```
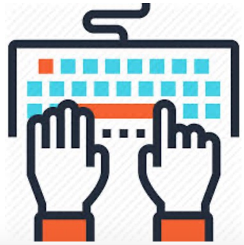

```python
# After training
hour_var = Variable(torch.Tensor([[4.0]]))
print("predict (after training)",  4, model.forward(hour_var).data[0][0])
```

https://github.com/jcjohnson/pytorch-examples

# Output



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```
470 1.52139027704834e-05
471 1.4996051504567731e-05
472 1.478133526688907 3e-05
473 1.4567947800969705e-05
474 1.4360077329911292e-05
475 1.4153701158647891e-05
476 1.3949686035630293e-05
477 1.3749523532169405e-05
478 1.3551662959798705e-05
479 1.3357152056414634e-05
480 1.3165942618797999e-05
481 1.2975904610357247e-05
482 1.2790364962711465e-05
483 1.2605956726474687e-05
484 1.2424526175891515e-05
485 1.2245835932844784e-05
486 1.2070459888491314e-05
487 1.1897350304934662e-05
488 1.1724299838533625e-05
489 1.155646714323666e-05
490 1.1392002306820359e-05
491 1.1226966307731345e-05
492 1.1066998922615312e-05
493 1.090722162189195e-05
494 1.0750130059022922e-05
495 1.0595314961392432e-05
496 1.0444626241223887e-05
497 1.029352642945014e-05
498 1.0146304703084752e-05
499 9.999960639106575e-06
predict (after training) 4 7.996364593505859
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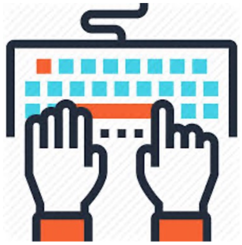

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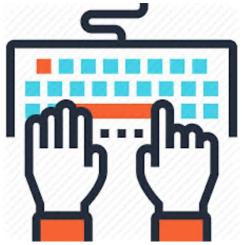

## 1 Design your model using class


## 2 Construct loss and optimizer (select from PyTorch API)

## 3 Training cycle (forward, backward, update)

# Training CIFAR10 Classifier

```python
##########################################################################
# 1. Define a Neural Network
# ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
# Copy the neural network from the Neural Networks section before and modify it to
# take 3-channel images (instead of 1-channel images as it was defined).

class Net(nn.Module):
    def __init__(self):
        super(Net, self).__init__()
        self.conv1 = nn.Conv2d(3, 6, 5)
        self.pool = nn.MaxPool2d(2, 2)
        self.conv2 = nn.Conv2d(6, 16, 5)
        self.fc1 = nn.Linear(16 * 5 * 5, 120)
        self.fc2 = nn.Linear(120, 84)
        self.fc3 = nn.Linear(84, 10)

    def forward(self, x):
        x = self.pool(F.relu(self.conv1(x)))
        x = self.pool(F.relu(self.conv2(x)))
        x = x.view(-1, 16 * 5 * 5)
        x = F.relu(self.fc1(x))
        x = F.relu(self.fc2(x))
        x = self.fc3(x)
        return x


net = Net()

##########################################################################
# 2. Define a Loss function and optimizer
# ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
# Let's use a Classification Cross-Entropy loss and SGD with momentum
criterion = nn.CrossEntropyLoss()
optimizer = optim.SGD(net.parameters(), lr=0.001, momentum=0.9)

##########################################################################
# 3. Train the network
# ^^^^^^^^^^^^^^^^^^^^
#
# This is when things start to get interesting.
# We simply have to loop over our data iterator, and feed the inputs to the
# network and optimize
for epoch in range(2):  # loop over the dataset multiple times

    running_loss = 0.0
    for i, data in enumerate(trainloader, 0):
        # get the inputs
        inputs, labels = data

        # wrap them in Variable
        inputs, labels = Variable(inputs), Variable(labels)

        # zero the parameter gradients
        optimizer.zero_grad()

        # forward + backward + optimize
        outputs = net(inputs)
        loss = criterion(outputs, labels)
        loss.backward()
        optimizer.step()

        # print statistics
        running_loss += loss.data[0]
        if i % 2000 == 1999:    # print every 2000 mini-batches
            print('[%d, %5d] loss: %.3f' %
                  (epoch + 1, i + 1, running_loss / 2000))
            running_loss = 0.0

print('Finished Training')
```


http://pytorch.org/tutorials/beginner/blitz/cifar10_tutorial.html

# Training CIFAR10 Classifier

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###############################################################################
# 1. Define a Neural Network
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        self.fc1 = nn.Linear(16 * 5 * 5, 120)
        self.fc2 = nn.Linear(120, 84)
        self.fc3 = nn.Linear(84, 10)

    def forward(self, x):
        x = self.pool(F.relu(self.conv1(x)))
        x = self.pool(F.relu(self.conv2(x)))
        x = x.view(-1, 16 * 5 * 5)
        x = F.relu(self.fc1(x))
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        x = self.fc3(x)
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        outputs = net(inputs)
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        loss.backward()
        optimizer.step()

        # print statistics
        running_loss += loss.data[0]
        if i % 2000 == 1999:    # print every 2000 mini-batches
            print('[%d, %5d] loss: %.3f' %
                  (epoch + 1, i + 1, running_loss / 2000))
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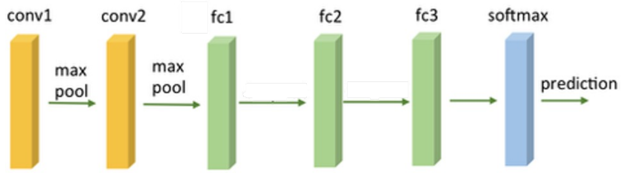
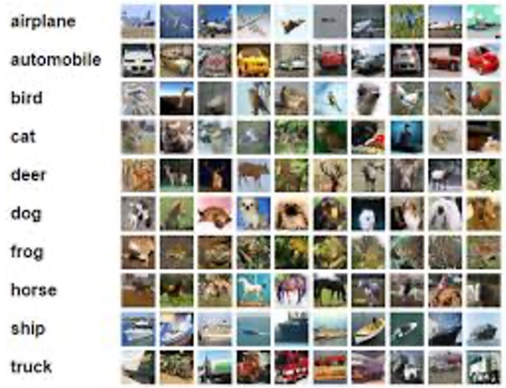
print('Finished Training')
```

**1** Design your model using class




**2** Construct loss and optimizer (select from PyTorch API)

**3** Training cycle (forward, backward, update)

http://pytorch.org/tutorials/beginner/blitz/cifar10_tutorial.html

# Exercise 5-1: Try other optimizers

- torch.optim.Adagrad
- torch.optim.Adam
- torch.optim.Adamax
- torch.optim.ASGD
- torch.optim.LBFGS
- torch.optim.RMSprop
- torch.optim.Rprop
- torch.optim.SGD

http://pytorch.org/docs/master/optim.html#algorithms

# Exercise 5-2: Read more PyTorch examples

- http://pytorch.org/tutorials/beginner/pytorch_with_examples.html

WHAT NEXT

# Lecture 6: Logistic regression