Deep Learning with PyTorch

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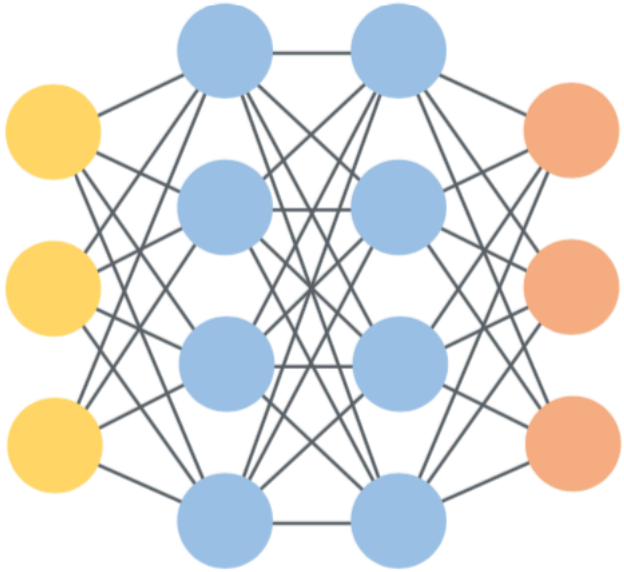
Outline

- PyTorch
- Tensor Manipulation
- Deep Neural Network Process
- Make Model with PyTorch

PyTorch

Deep Neural Network를 Numpy로 표현할 수 있을까?

- Deep Neural Network (DNN)



- 신경망이 깊어질수록 Numpy로 표현하는 것이 점점 더 어려워짐

  → 따라서 딥러닝 프레임워크를 통해 손쉽게 표현하고자 함

PyTorch

Facebook AI Research

Caffe2

PYTORCH

Yann LeCun

DIRECTOR OF AI RESEARCH

Facebook AI Research (FAIR)

Soumith Chintala

RESEARCH ENGINEER

Facebook AI Research (FAIR)

Tensor Manipulation

Numpy array → Torch tensor

- torch.Tensor - Constructs a tensor with data

```
10  ### torch.Tensor
11  array = np.array([[1,2,3,4], [5,6,7,8]])
12  tensor = torch.Tensor(array)
13  print(array)
14  print(tensor)
15  '''
16  [[1 2 3 4]
17   [5 6 7 8]]
18  tensor([[1., 2., 3., 4.],
19          [5., 6., 7., 8.]])
20  '''
21
22  array[0,0] = 10
23  print(array)
24  print(tensor)
25  '''
26  [[10  2  3  4]
27   [ 5  6  7  8]]
28  tensor([[1., 2., 3., 4.],
29          [5., 6., 7., 8.]])
30  '''
```

Tensor Manipulation

Numpy array → Torch tensor

- torch.from_numpy - Creates a Tensor from a numpy.ndarray

```
32  ### torch.from_numpy
33  array = np.array([[1,3,5,7], [9,11,13,15]])
34  tensor = torch.from_numpy(array)
35  print(array)
36  print(tensor)
37  '''
38  [[ 1  3  5  7]
39   [ 9 11 13 15]]
40  tensor([[ 1,  3,  5,  7],
41          [ 9, 11, 13, 15]])
42  '''
43
44  array[0][0] = 10
45  print(array)
46  print(tensor)
47  '''
48  [[10  3  5  7]
49   [ 9 11 13 15]]
50  tensor([[10,  3,  5,  7],
51          [ 9, 11, 13, 15]])
52  '''
```

Tensor Manipulation

Torch tensor → Numpy array

- numpy() - Returns self tensor as a numpy ndarray

```
58  tensor = torch.Tensor([[1,2,3,4], [5,6,7,8]])
59  array = tensor.numpy()
60  print(tensor)
61  print(array)
62  '''
63  tensor([[1., 2., 3., 4.],
64          [5., 6., 7., 8.]])
65  [[1. 2. 3. 4.]
66   [5. 6. 7. 8.]]
67  '''
```

Tensor Manipulation

Creating functions

- Zeros & Ones

```
73  ### Zeros & Ones
74  zeros = torch.zeros((2, 5))
75  print(zeros)
76  '''
77  tensor([[0., 0., 0., 0., 0.],
78          [0., 0., 0., 0., 0.]])
79  '''
80
81  ones = torch.ones((5, 2))
82  print(ones)
83  '''
84  tensor([[1., 1.],
85          [1., 1.],
86          [1., 1.],
87          [1., 1.],
88          [1., 1.]])
89  '''
```

Tensor Manipulation

Creating functions

- Something like

```
91  ### Something_like
92  tensor = torch.Tensor([[1,2,3,4], [5,6,7,8]])
93  zeros = torch.zeros_like(tensor)
94  print(zeros)
95  '''
96  tensor([[0., 0., 0., 0.],
97          [0., 0., 0., 0.]])
98  '''
```

Tensor Manipulation

Creating functions

- Rand - Uniform distribution over [0,1)

```
100   ### Rand - Uniform distribution over [0, 1)
101   rand_sampling = torch.rand(2,5)
102   print(rand_sampling)
103   '''
104   tensor([[0.1562, 0.7464, 0.0341, 0.1269, 0.7245],
105           [0.7135, 0.6891, 0.9348, 0.4983, 0.9259]])
106   '''
```

- Randn - Standard normal(gaussian) distribution of mean 0 and variance 1

```
108   ### Randn - Standard normal(gaussian) distribution of mean 0 and variance 1
109   randn_sampling = torch.randn(2,5)
110   print(randn_sampling)
111   '''
112   tensor([[ 0.4119, -1.1501, -0.4142,  0.9698, -0.9407],
113           [ 0.5520,  2.3532,  0.5251, -1.1743,  0.5667]])
114   '''
```

Tensor Manipulation

Operation functions

- Sum

```
120   ### Sum
121   tensor = torch.Tensor([[1,2,3,4], [5,6,7,8]])
122   sum_ = torch.sum(tensor)
123   sum_0 = torch.sum(tensor, dim=0)
124   sum_1 = torch.sum(tensor, dim=1)
125   print(sum_)
126   print(sum_0)
127   print(sum_1)
128   '''
129   tensor(36.)
130   tensor([ 6.,  8., 10., 12.])
131   tensor([10., 26.])
132   '''
```

Tensor Manipulation

Operation functions

- Max

```
134   ### Max
135   tensor = torch.Tensor([[1,2], [3,4], [5,6], [7,8]])
136
137   max_ = torch.max(tensor)
138   print(max_)
139   '''
140   tensor(8.)
141   '''
142
143   max_0 = torch.max(tensor, dim=0)
144   value, index = torch.max(tensor, dim=0)
145   max_0_0 = torch.max(tensor, dim=0)[0]
146   max_0_1 = torch.max(tensor, dim=0)[1]
147   print(max_0)
148   print(value)
149   print(index)
150   print(max_0_0)
151   print(max_0_1)
152   '''
153   (tensor([7., 8.]), tensor([3, 3]))
154   tensor([7., 8.])
155   tensor([3, 3])
156   tensor([7., 8.])
157   tensor([3, 3])
158   '''
```

```
160   max_1 = torch.max(tensor, dim=1)
161   value, index = torch.max(tensor, dim=1)
162   max_1_0 = torch.max(tensor, dim=1)[0]
163   max_1_1 = torch.max(tensor, dim=1)[1]
164   print(max_1)
165   print(value)
166   print(index)
167   print(max_1_0)
168   print(max_1_1)
169   '''
170   (tensor([2., 4., 6., 8.]), tensor([1, 1, 1, 1]))
171   tensor([2., 4., 6., 8.])
172   tensor([1, 1, 1, 1])
173   tensor([2., 4., 6., 8.])
174   tensor([1, 1, 1, 1])
175   '''
```

Tensor Manipulation

Operation functions

- Dot product(Inner product)

$$\langle [x_1, \dots, x_n], [y_1, \dots, y_n] \rangle = x^T y = \sum_{i=1}^{n} x_i y_i = x_1 y_1 + \cdots + x_n y_n$$

```
177   ### Dot product
178   tensor = torch.Tensor([1,2,3,4,5])
179   dot = torch.dot(tensor, tensor)
180   print(dot)
181   '''
182   tensor(55.)
183   '''
```

Tensor Manipulation

Operation functions

- Mathematical functions
  - torch.sqrt: $\sqrt{x}$
  - torch.exp: e^x
  - torch.log: $\log_e x$

```
185   ### Mathematical functions
186   tensor = torch.Tensor([[1,2,3,4], [5,6,7,8]])
187
188   sqrt = torch.sqrt(tensor)
189   exp = torch.exp(tensor)
190   log = torch.log(tensor)
191   print(sqrt)
192   print(exp)
193   print(log)
194   '''
195   tensor([[1.0000, 1.4142, 1.7321, 2.0000],
196           [2.2361, 2.4495, 2.6458, 2.8284]])
197   tensor([[   2.7183,    7.3891,   20.0855,   54.5982],
198           [ 148.4132,  403.4288, 1096.6332, 2980.9580]])
199   tensor([[0.0000, 0.6931, 1.0986, 1.3863],
200           [1.6094, 1.7918, 1.9459, 2.0794]])
201   '''
```

Tensor Manipulation

Operation functions

- Concatenate

```
203  ### Concatenate
204  tensor_a = torch.Tensor([[1,2,3,4], [5,6,7,8]])
205  tensor_b = torch.Tensor([[1,3,5,7], [2,4,6,8]])
206
207  cat = torch.cat([tensor_a, tensor_b]) # vstack
208  print(cat)
209  '''
210  tensor([[1., 2., 3., 4.],
211          [5., 6., 7., 8.],
212          [1., 3., 5., 7.],
213          [2., 4., 6., 8.]])
214  '''
215
216  cat_0 = torch.cat([tensor_a, tensor_b], dim=0) # vstack
217  print(cat_0)
218  '''
219  tensor([[1., 2., 3., 4.],
220          [5., 6., 7., 8.],
221          [1., 3., 5., 7.],
222          [2., 4., 6., 8.]])
223  '''
224
225  cat_1 = torch.cat([tensor_a, tensor_b], dim=1) # hstack
226  print(cat_1)
227  '''
228  tensor([[1., 2., 3., 4., 1., 3., 5., 7.],
229          [5., 6., 7., 8., 2., 4., 6., 8.]])
230  '''
```

Tensor Manipulation

Operation functions

- View

```
232  ### View
233  tensor_a = torch.Tensor([[1,3,5,7], [2,4,6,8]])
234
235  tensor_b = tensor_a.view(8)
236  print(tensor_b.shape)
237  '''
238  torch.Size([8])
239  '''
240
241  tensor_c = tensor_a.view(-1, 2)
242  print(tensor_c.shape)
243  '''
244  torch.Size([4, 2])
245  '''
246
247  tensor_d = tensor_a.view(-1)
248  print(tensor_d.shape)
249  '''
250  torch.Size([8])
251  '''
```

Tensor Manipulation

Operation functions

- Squeeze

```
253   ### Squeeze & Unsqueeze
254   tensor = torch.zeros(2, 1, 1, 5)
255
256   squ_0 = torch.squeeze(tensor)
257   print(squ_0.shape)
258   '''
259   torch.Size([2, 5])
260   '''
261
262   squ_1 = torch.squeeze(tensor, 1)
263   print(squ_1.shape)
264   print(tensor.squeeze(1).shape)
265   '''
266   torch.Size([2, 1, 5])
267   torch.Size([2, 1, 5])
268   '''
```

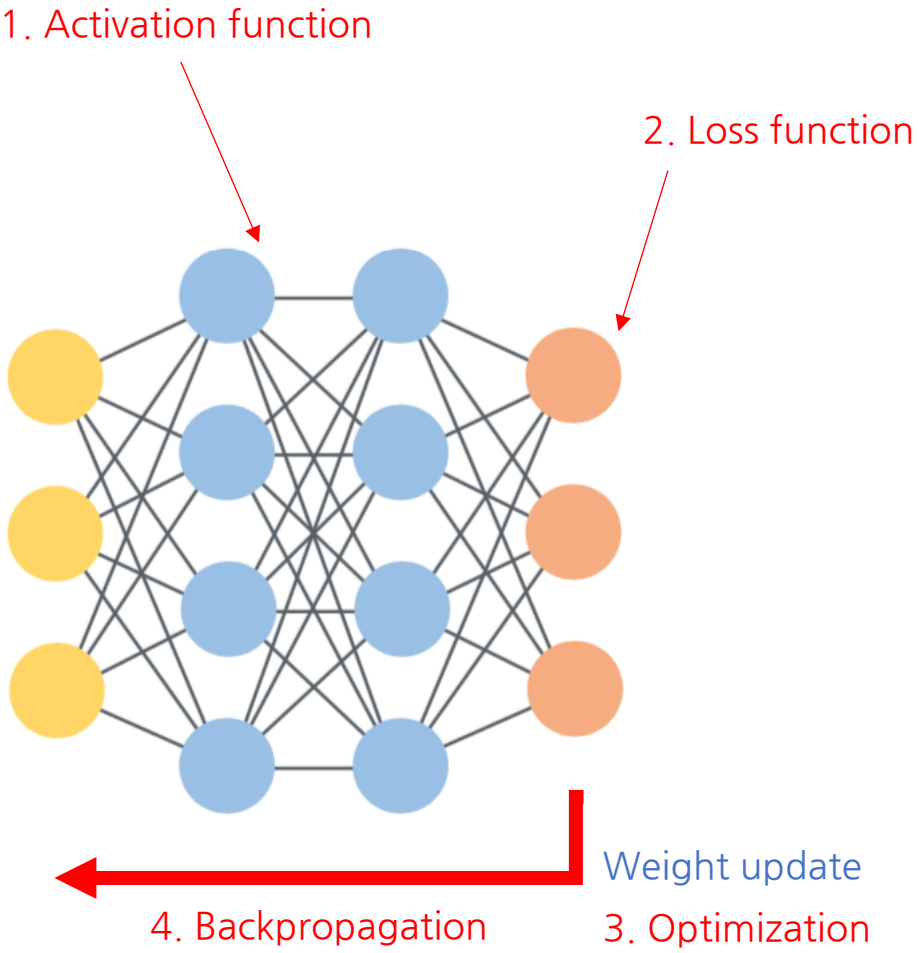
Tensor Manipulation

Operation functions

- Unsqueeze

```
270    unsqu_0 = torch.unsqueeze(tensor, 0)
271    print(unsqu_0.shape)
272    '''
273    torch.Size([1, 2, 1, 1, 5])
274    '''
275
276    unsqu_1 = torch.unsqueeze(tensor, 1)
277    print(unsqu_1.shape)
278    print(tensor.unsqueeze(1).shape)
279    '''
280    torch.Size([2, 1, 1, 1, 5])
281    torch.Size([2, 1, 1, 1, 5])
282    '''
```

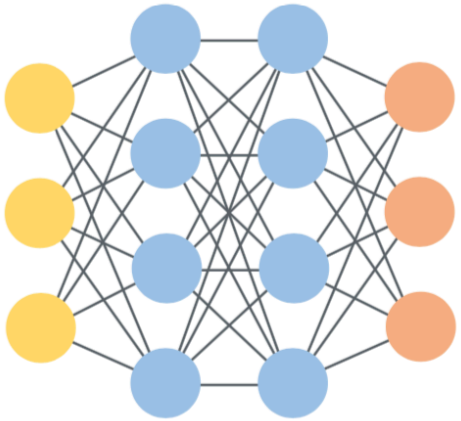
Deep Neural Network Process



Make Model with PyTorch

PyTorch example for Deep Neural Network process

```
294  import torch
295  import torch.nn as nn
296  import torch.optim as optim
297
298  class Net(nn.Module):
299      def __init__(self):
300          super(Net, self).__init__()
301          self.fc1 = nn.Linear(4, 64)
302          self.fc2 = nn.Linear(64, 64)
303          self.fc3 = nn.Linear(64, 2)
304
305      def forward(self, x):
306          x = torch.tanh(self.fc1(x))
307          x = torch.tanh(self.fc2(x))
308          x = self.fc3(x)
309          return x
```



$$o_1 = \sum_{i=1}^{p} w_i \phi \left(\sum_{j=1}^{p} w_j' \phi \left(\sum_{k=1}^{n} w_k'' x_k \right) \right)$$

Make Model with PyTorch

PyTorch example for Deep Neural Network process

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298  class Net(nn.Module):
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303          self.fc3 = nn.Linear(64, 2)
304
305      def forward(self, x):
306          x = torch.tanh(self.fc1(x))
307          x = torch.tanh(self.fc2(x))
308          x = self.fc3(x)
309          return x
```

```
311  net = Net()
312
313  # Define loss and optimizer
314  criterion = torch.nn.MSELoss()
315  optimizer = optim.Adam(net.parameters(), lr=0.001)
316
317
318  hypothesis = net(inputs)
319  loss = criterion(hypothesis, labels)
320
321  optimizer.zero_grad() # initialize gradient
322  loss.backward()       # compute gradient
323  optimizer.step()      # improve step
```

Make Model with PyTorch

Save & Load

```
329    ### save
330    torch.save(net.state_dict(), './save_model/model.pt')
331
332    ### load
333    net.load_state_dict(torch.load('./save_model/model.pt'))
```

Make Model with PyTorch

MNIST example

Thank You!

Any Questions?