- exercise-02

September 17, 2020

[3]:
```
%matplotlib inline
```

[8]:
```
conda install pytorch torchvision -c pytorch
```

```
Collecting package metadata (current_repodata.json): done
Solving environment: failed with initial frozen solve. Retrying with flexible
solve.
Solving environment: failed with repodata from current_repodata.json, will retry
with next repodata source.
Collecting package metadata (repodata.json): done
Solving environment: done

## Package Plan ##

  environment location: /Users/jason/opt/anaconda3

  added / updated specs:
    - pytorch
    - torchvision


The following packages will be downloaded:

    package                    |            build
    ---------------------------|-----------------
    conda-4.8.4                |           py37_0         2.9 MB
    ninja-1.9.0                |   py37h04f5b5a_0          90 KB
    pytorch-1.6.0              |         py3.7_0        54.5 MB  pytorch
    torchvision-0.7.0          |        py37_cpu         5.8 MB  pytorch
    ------------------------------------------------------------
                                           Total:        63.2 MB

The following NEW packages will be INSTALLED:

  ninja              pkgs/main/osx-64::ninja-1.9.0-py37h04f5b5a_0
  pytorch            pytorch/osx-64::pytorch-1.6.0-py3.7_0
  torchvision        pytorch/osx-64::torchvision-0.7.0-py37_cpu
```

```
The following packages will be UPDATED:

  conda                                       4.8.3-py37_0 --> 4.8.4-py37_0


Downloading and Extracting Packages
torchvision-0.7.0    | 5.8 MB    | ##################################### | 100%
pytorch-1.6.0        | 54.5 MB   | ##################################### | 100%
conda-4.8.4          | 2.9 MB    | ##################################### | 100%
ninja-1.9.0          | 90 KB     | ##################################### | 100%

InvalidArchiveError('Error with archive
/Users/jason/opt/anaconda3/pkgs/pytorch-1.6.0-py3.7_0.tar.bz2.  You probably
need to delete and re-download or re-create this file.  Message from libarchive
was:\n\ntruncated bzip2 input')


Note: you may need to restart the kernel to use updated packages.
```

1 What is PyTorch?

It's a Python-based scientific computing package targeted at two sets of audiences:

- A replacement for NumPy to use the power of GPUs
- a deep learning research platform that provides maximum flexibility and speed

1.1 Getting Started

Tensors are similar to NumPy's ndarrays, with the addition being that Tensors can also be used on a GPU to accelerate computing.

[7]:
```
from __future__ import print_function
import torch
```

```
␣
↪---------------------------------------------------------------------------

ModuleNotFoundError                       Traceback (most recent call␣
↪last)

<ipython-input-7-c92f3ea41741> in <module>
  1 from __future__ import print_function
----> 2 import torch


ModuleNotFoundError: No module named 'torch'
```

Note

An uninitialized matrix is declared, but does not contain definite known values before it is used. When an uninitialized matrix is created, whatever values were in the allocated memory at the time will appear as the initial values.

Construct a 5x3 matrix, uninitialized:

[ ]:
```
x = torch.empty(5, 3)
print(x)
```

Construct a randomly initialized matrix:

[ ]:
```
x = torch.rand(5, 3)
print(x)
```

Construct a matrix filled zeros and of dtype long:

[ ]:
```
x = torch.zeros(5, 3, dtype=torch.long)
print(x)
```

Construct a tensor directly from data:

[ ]:
```
x = torch.tensor([5.5, 3])
print(x)
```

or create a tensor based on an existing tensor. These methods will reuse properties of the input tensor, e.g. dtype, unless new values are provided by user

[ ]:
```
x = x.new_ones(5, 3, dtype=torch.double)      # new_* methods take in sizes
print(x)

x = torch.randn_like(x, dtype=torch.float)    # override dtype!
print(x)                                      # result has the same size
```

Get its size:

[ ]:
```
print(x.size())
```

Note

`torch.Size` is in fact a tuple, so it supports all tuple operations.

Operations

There are multiple syntaxes for operations. In the following example, we will take a look at the addition operation.

Addition: syntax 1

[ ]:
```
y = torch.rand(5, 3)
print(x + y)
```

Addition: syntax 2

[ ]:
```
print(torch.add(x, y))
```

Addition: providing an output tensor as argument

[ ]:
```
result = torch.empty(5, 3)
torch.add(x, y, out=result)
print(result)
```

Addition: in-place

[ ]:
```
# adds x to y
y.add_(x)
print(y)
```

Note

Any operation that mutates a tensor in-place is post-fixed with an `_`. For example: `x.copy_(y)`, `x.t_()`, will change `x`.

You can use standard NumPy-like indexing with all bells and whistles!

[ ]:
```
print(x[:, 1])
```

Resizing: If you want to resize/reshape tensor, you can use `torch.view`:

[ ]:
```
x = torch.randn(4, 4)
y = x.view(16)
z = x.view(-1, 8)  # the size -1 is inferred from other dimensions
print(x.size(), y.size(), z.size())
```

If you have a one element tensor, use `.item()` to get the value as a Python number

[ ]:
```
x = torch.randn(1)
print(x)
print(x.item())
```

Slicing

[ ]:
```
x = torch.rand((4,5))

print("x = {}".format(x))
print("x[1] = {}".format(x[1]))
print("x[2,3] = {}".format(x[2,3]))
print("x[0, 1:4] = {}".format(x[0,1:4]))
```

Multiplication

1) Elementwise multiplication

```
[ ]: x = torch.tensor((1,2,3))
     y = torch.tensor((4,5,6))

     z = torch.mul(x,y) # same as x * y

     print(z)
```

2) Dot product

```
[ ]: x = torch.tensor([1,2,3])
     y = torch.tensor([4,5,6])

     z = torch.dot(x,y)
     print(z)
```

3) Matrix multiplication

```
[ ]: x = torch.tensor([[1,1],[2,2],[3,3]])
     y = torch.tensor([[6,5],[4,3]])

     z = torch.matmul(x,y)
     print("x.size() = {}".format(x.shape))
     print("y.size() = {}".format(y.shape))
     print("z.size() = {}".format(z.shape))

     print("z = {}" .format(z))
```

Transpose

'torch.transpose' returns a tensor that is a transposed version of input.

The given dimension dim0 and dim1 are swapped.

```
[ ]: x = torch.rand((4,2))
     print("x.size() = {}".format(x.shape))

     y = x.T
     print("y.size() = {}".format(y.shape))

     a = torch.rand((1,2,3,4))
     print("a.size() = {}".format(a.shape))

     b = torch.transpose(a, dim0=1, dim1=2)
     print("b.size() = {}".format(b.shape))
```

Squeeze, Unsqueenze

'torch.squeeze' returns a tensor with all the dimensions of input of size 1 removed.

'torch.unsqueeze' returns a tensor with a dimension of size one inserted at the specified position.

[ ]:
```
x = torch.rand(1,2,3,1,4)
y = torch.unsqueeze(x, dim=1)
print("x.size() = {}".format(x.shape))
print("y.size() = {}".format(y.shape))

z = torch.squeeze(x)
print("z.size() = {}".format(z.shape))
```

Cat

Concatenates the given sequence of seq tensors in the given dimensions.

[ ]:
```
x = torch.rand(2,3)
print(x)
print("x.size() = {}".format(x.shape))

y = torch.cat((x,x), dim=0)
print(y)
print("y.size() = {}".format(y.shape))

z = torch.cat((x,x), dim=1)
print(z)
print("z.size() = {}".format(z.shape))
```

Read later:

100+ Tensor operations, including transposing, indexing, slicing, mathematical operations, linear algebra, random numbers, etc., are described `here <https://pytorch.org/docs/torch>`_.

1.2 NumPy Bridge

Converting a Torch Tensor to a NumPy array and vice versa is a breeze.

The Torch Tensor and NumPy array will share their underlying memory locations (if the Torch Tensor is on CPU), and changing one will change the other.

Converting a Torch Tensor to a NumPy Array

[ ]:
```
a = torch.ones(5)
print(a)
```

[ ]:
```
b = a.numpy()
print(b)
```

See how the numpy array changed in value.

[ ]:
```
a.add_(1)
print(a)
print(b)
```

Converting NumPy Array to Torch Tensor ~~~~~~ See how changing the np array changed the Torch Tensor automatically

```
[ ]: import numpy as np
a = np.ones(5)
b = torch.from_numpy(a)
np.add(a, 1, out=a)
print(a)
print(b)
```

All the Tensors on the CPU except a CharTensor support converting to NumPy and back.

1.3 CUDA Tensors

Tensors can be moved onto any device using the `.to` method.

```
[ ]: # let us run this cell only if CUDA is available
# We will use ``torch.device`` objects to move tensors in and out of GPU
if torch.cuda.is_available():
    device = torch.device("cuda")          # a CUDA device object
    y = torch.ones_like(x, device=device)  # directly create a tensor on GPU
    x = x.to(device)                       # or just use strings ``.to("cuda")``
    z = x + y
    print(z)
    print(z.to("cpu", torch.double))       # ``.to`` can also change dtype␣
 ↪together!
```