Machine Learning

Pytorch Tutorial 2

Example of Using Pytorch

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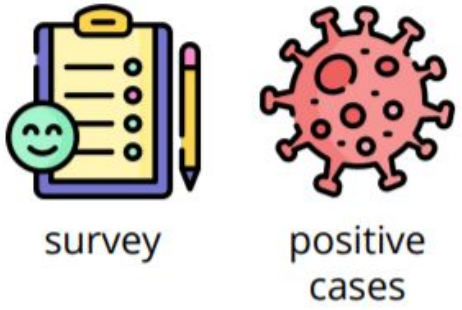
Task Description

- Given survey results in the past 5 days in a specific state in U.S., then predict the percentage of new tested positive cases in the 5th day.



Day1&2&3&4

Day5

Data

- In this case, data is included in a .csv file
- Each row represents a sample of data, containing 118 feature (id + 37 states + 16 features * 5 days)
- the last element of a row is its label

id	AL	AK	AZ	AR	CA	CO
0	0	0	0	0	0	0
1	0	0	0	0	0	1
2	0	0	0	0	0	0
3	0	0	0	0	0	0

...

smoothed_worried_finances	smoothed_tested_positive_14d
37.3295118	7.4561538
32.5088806	8.010957
36.7455876	2.9069774
38.6801619	12.5758159

Load data / Preprocessing

Load data: You can use **pandas** to load a csv file.

```
train_data = pd.read_csv('./covid.train.csv').drop(columns=['date']).values
```

Preprocessing: Get model inputs and labels.

```
x_train, y_train = train_data[:,:-1], train_data[:,-1]
```

```
print(x_train.shape)
print(y_train.shape)
```

```
(2699, 117)
(2699,)
```

Dataset

- __init__: Read data and preprocess
- __getitem__: Return one sample at a time. In this case, one sample includes a 117 dimensional feature and a label
- __len__: Return the size of the dataset. In this case, it is 2699

```
class COVID19Dataset(Dataset):
    '''
    x: Features.
    y: Targets, if none, do prediction.
    '''
    def __init__(self, x, y=None):
        if y is None:
            self.y = y
        else:
            self.y = torch.FloatTensor(y)
        self.x = torch.FloatTensor(x)

    def __getitem__(self, idx):
        if self.y is None:
            return self.x[idx]
        else:
            return self.x[idx], self.y[idx]

    def __len__(self):
        return len(self.x)
```

```
train_dataset = COVID19Dataset(x_train, y_train)
```

Dataloader

```
train_loader = DataLoader(train_dataset, batch_size=32, shuffle=True, pin_memory=True)
```

- Group data into batches
- If you set **shuffle=True**, dataloader will permutes the indices of all samples automatically.
- We often set **shuffle=True** during training
- You can check this page Advantage to shuffle a dataset if you are curious about why we should shuffle the data during training

Model

- The input dimension of our model will be 117
- The output of our model will be a scalar, which represents the predicting value of the percentage of new tested positive cases in the 5th day

```
class My_model(nn.Module):
    def __init__(self, input_dim):
        super(My_model, self).__init__()
        # TODO: modify model's structure, be aware of dimension.
        self.layers = nn.Sequential(
            nn.Linear(input_dim, 64),
            nn.ReLU(),
            nn.Linear(64, 32),
            nn.ReLU(),
            nn.Linear(32, 1)
        )

    def forward(self, x):
        x = self.layers(x)
        x = x.squeeze(1) # (B, 1) -> (B)
        return x
```

```
model = My_Model(input_dim=x_train.shape[1]).to('cuda')
```

Criterion

We are doing a regression task, choosing mean square error as our loss function would be a good idea !

```
criterion = torch.nn.MSELoss(reduction='mean')
```

More choices! : pytorch documentation: torch.nn

Optimizer

We need to declare a optimizer that adjust network parameters in order to reduce error.

Here we choose stochastic gradient descent as our optimization algorithm.

```
optimizer = torch.optim.SGD(model.parameters(), lr=1e-5, momentum=0.9)
```

Training loop

```
for epoch in range(3000):
        model.train() # Set your model to train mode.
        # tqdm is a package to visualize your training progress.
        train_pbar = tqdm(train_loader, position=0, leave=True)
        for x, y in train_pbar:
            x, y = x.to('cuda'), y.to('cuda')   # Move your data to device.
            pred = model(x)
            loss = criterion(pred, y)
            loss.backward()                 # Compute gradient(backpropagation).
            optimizer.step()                        # Update parameters.
            optimizer.zero_grad()                   # Set gradient to zero.
```

Get model prediction, compute gradient, update parameters and reset the gradient of model parameters.

Note !

- The example code in this pytorch tutorial is slightly different from the sample code of hw1 for explanation convenience.
- Please refer to the sample code of hw1. 請以hw1的sample code為準。

Any Question?

Machine Learning

Pytorch Tutorial 3

Documentation and Common Errors

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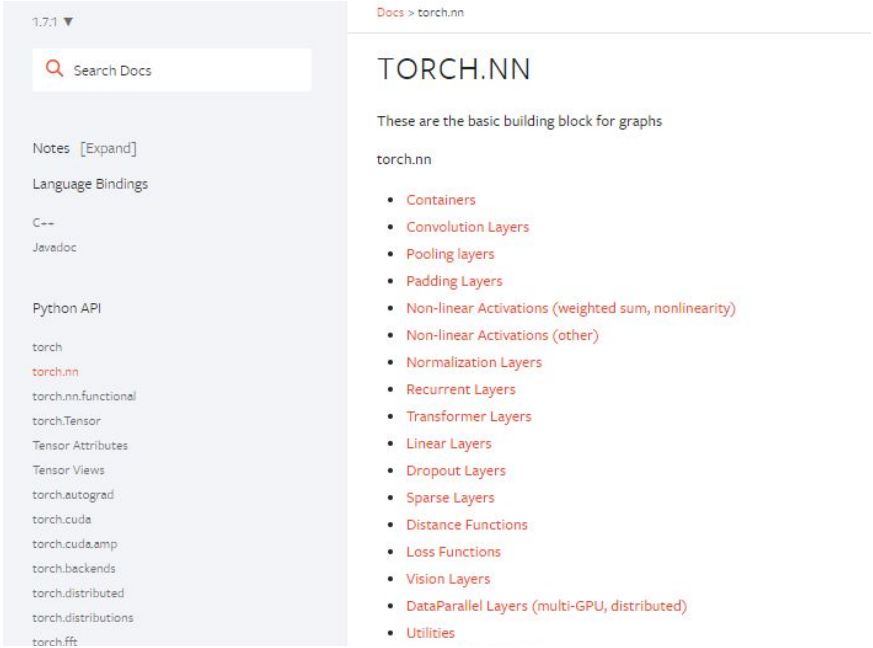
PyTorch Documentation

https://pytorch.org/docs/stable/

torch.nn -> neural network

torch.optim -> optimization algorithms

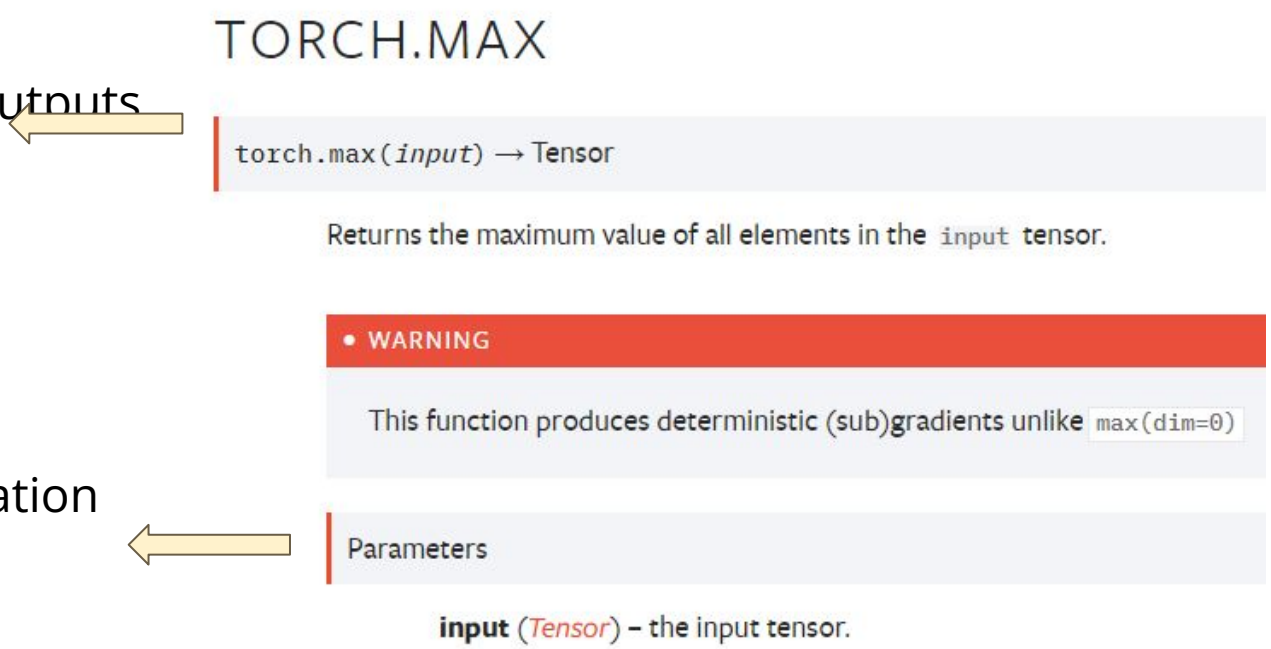
torch.utils.data -> dataset, dataloader



PyTorch Documentation Example

Function inputs and outputs

Data type and explanation of each input



TORCH.MAX

`torch.max(input)` → Tensor

Returns the maximum value of all elements in the `input` tensor.

• WARNING

This function produces deterministic (sub)gradients unlike `max(dim=0)`

Parameters

input (*Tensor*) – the input tensor.

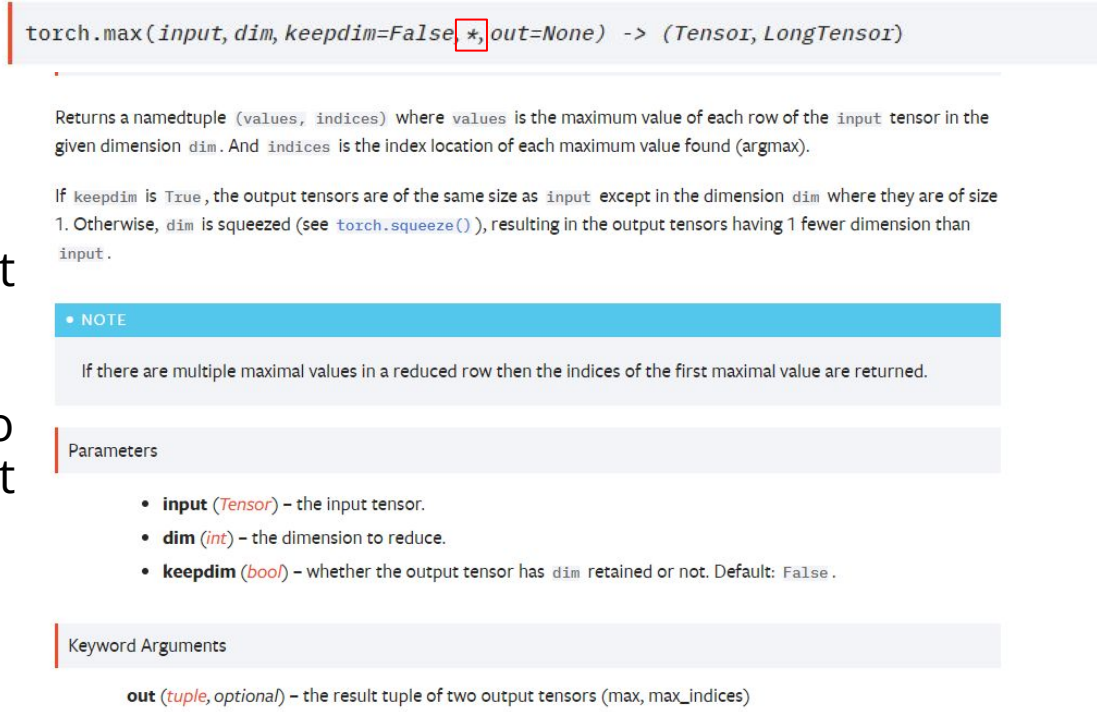
PyTorch Documentation Example

Some functions behave differently with different inputs

Parameters : You don't need to specify the name of the argument (Positional Arguments)

Keyword Arguments : You have to specify the name of the argument

*They are separated by **



```
torch.max(input, dim, keepdim=False, *, out=None) -> (Tensor, LongTensor)
```

Returns a namedtuple `(values, indices)` where `values` is the maximum value of each row of the `input` tensor in the given dimension `dim`. And `indices` is the index location of each maximum value found (argmax).

If `keepdim` is `True`, the output tensors are of the same size as `input` except in the dimension `dim` where they are of size 1. Otherwise, `dim` is squeezed (see `torch.squeeze()`), resulting in the output tensors having 1 fewer dimension than `input`.

• NOTE

If there are multiple maximal values in a reduced row then the indices of the first maximal value are returned.

Parameters

- **input** (*Tensor*) – the input tensor.
- **dim** (*int*) – the dimension to reduce.
- **keepdim** (*bool*) – whether the output tensor has `dim` retained or not. Default: `False`.

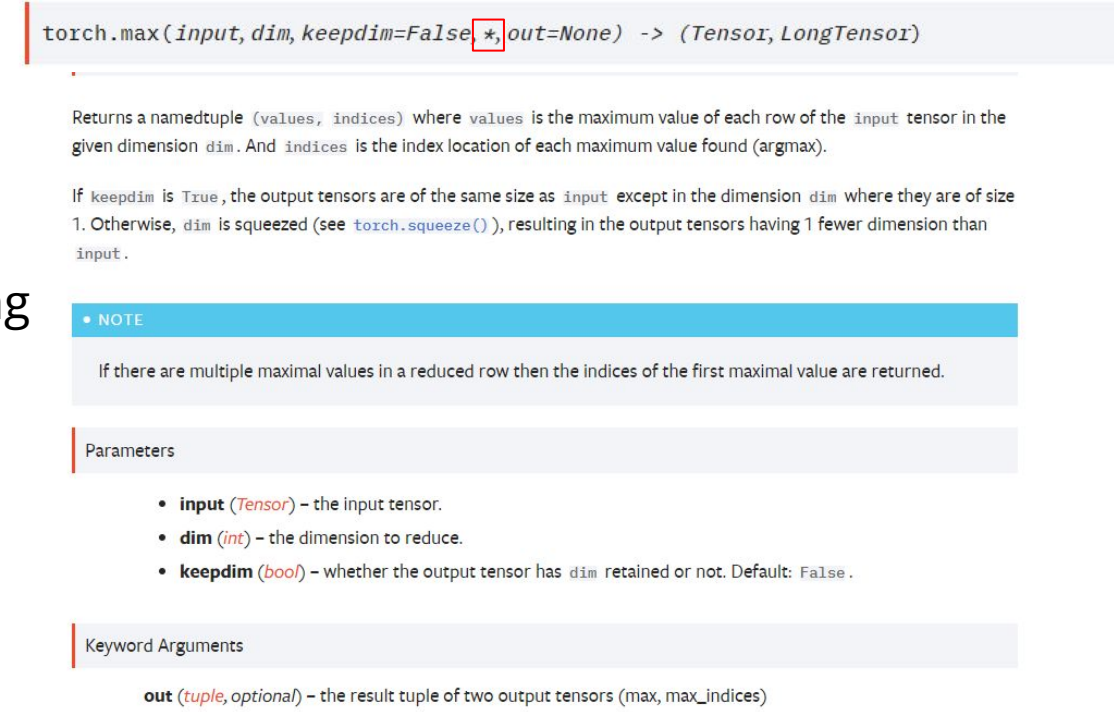
Keyword Arguments

out (*tuple, optional*) – the result tuple of two output tensors (max, max_indices)

PyTorch Documentation Example

Some functions behave differently with different inputs

Arguments with default value : Some arguments have a default value (keepdim=False), so passing a value of this argument is optional



```
torch.max(input, dim, keepdim=False, *, out=None) -> (Tensor, LongTensor)
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Parameters

- **input** (*Tensor*) – the input tensor.
- **dim** (*int*) – the dimension to reduce.
- **keepdim** (*bool*) – whether the output tensor has `dim` retained or not. Default: `False`.

Keyword Arguments

out (*tuple, optional*) – the result tuple of two output tensors (max, max_indices)

PyTorch Documentation Example

Three Kinds of torch.max

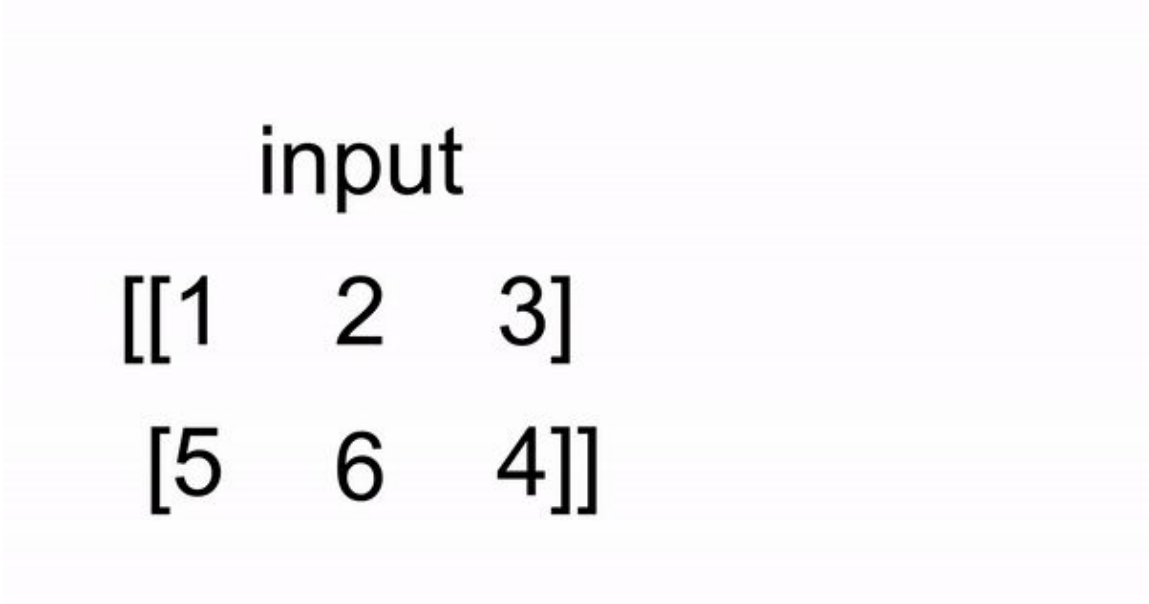
1. **`torch.max(input) → Tensor`**
2. **`torch.max(input, dim, keepdim=False, *, out=None) → (Tensor, LongTensor)`**
3. **`torch.max(input, other, *, out=None) → Tensor`**

```
input : Tensor, dim : int, keepdim : bool
other : Tensor
```

PyTorch Documentation Example

`1.torch.max(input)` → `Tensor`

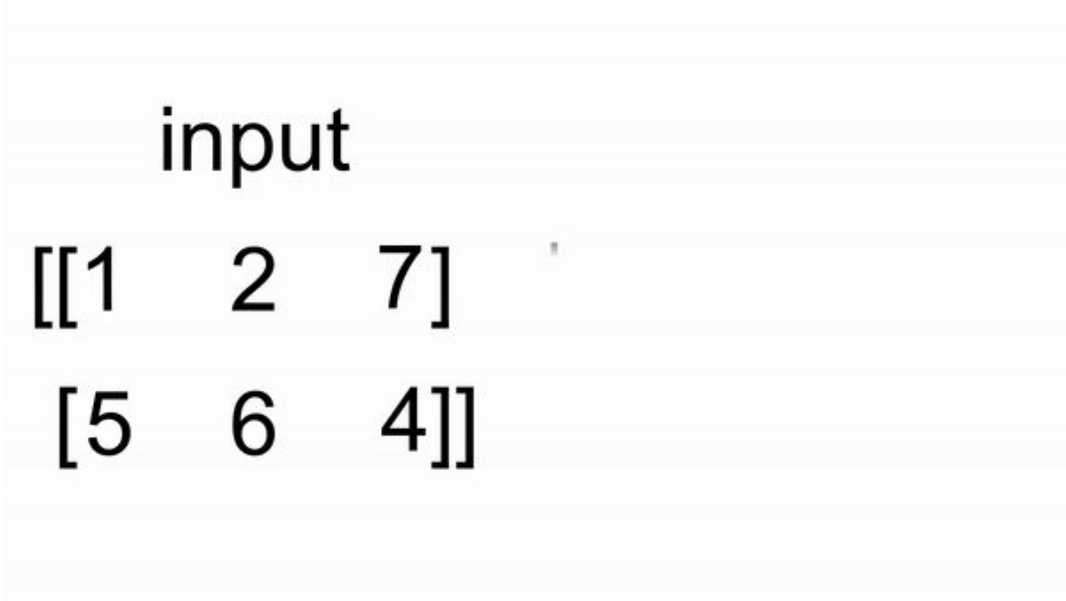
Find the maximum value of a tensor, and return that value.



PyTorch Documentation Example

`2. torch.max(input, dim, keepdim=False, *, out=None) → (Tensor, LongTensor)`

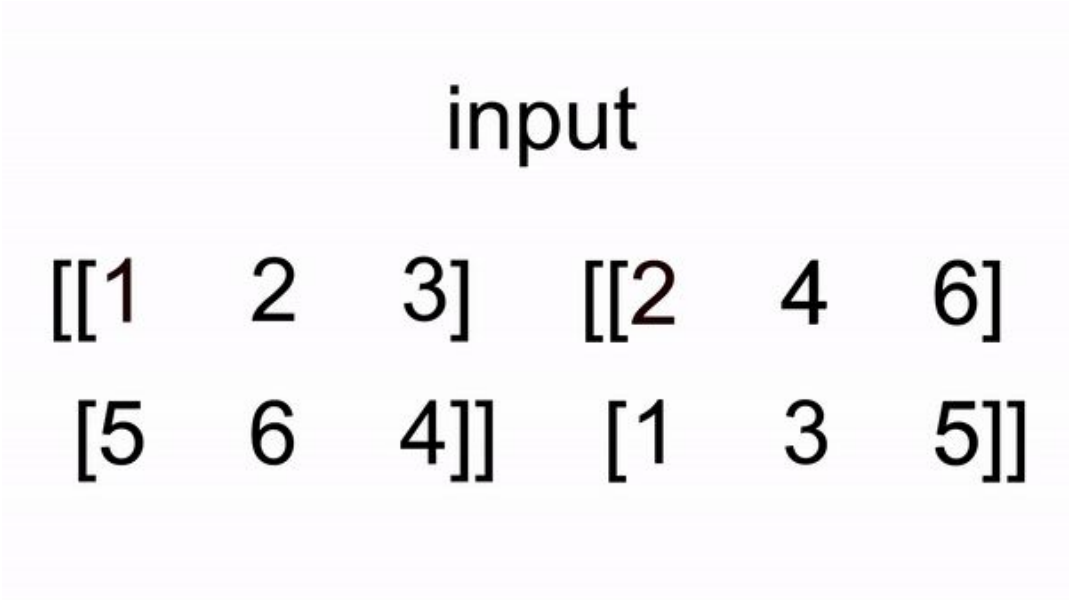
Find the maximum value of a tensor along a dimension, and return that value, along with the index corresponding to that value.



PyTorch Documentation Example

`3.torch.max(input, other) → Tensor`

Perform element-wise comparison between two tensors of the same size, and select the maximum of the two to construct a tensor with the same size.



PyTorch Documentation Example (Colab)

Three Kinds of torch.max

1. `torch.max(input) → Tensor`
2. `torch.max(input, dim, keepdim=False, *, out=None) → (Tensor, LongTensor)`
3. `torch.max(input, other, *, out=None) → Tensor`

```
input : Tensor
dim : int
keepdim : bool
other : Tensor
```

Colab code

```
x = torch.randn(4,5)
y = torch.randn(4,5)
1.  m = torch.max(x)
2.  m, idx = torch.max(x,0)→O
    m, idx = torch.max(input = x,dim=0)→O
    m, idx = torch.max(x,0,False)→O
    m, idx = torch.max(x,0,keepdim=True)→O
    m, idx = torch.max(x,0,False,out=p)→O
    m, idx = torch.max(x,0,False,p)→x
        *out is a keyword argument
    m, idx = torch.max(x,True)→x
        *did not specify dim
3.  t = torch.max(x,y)
```

Common Errors -- Tensor on Different Device to Model

```
model = torch.nn.Linear(5,1).to("cuda:0")
x = torch.randn(5).to("cpu")
y = model(x)
```

Tensor for * is on CPU, but expected them to be on GPU

=> send the tensor to GPU

```
x = torch.randn(5).to("cuda:0")
y = model(x)
print(y.shape)
```

Common Errors -- Mismatched Dimensions

```
x = torch.randn(4,5)
y = torch.randn(5,4)
z = x + y
```

The size of tensor a (5) must match the size of tensor b (4) at non-singleton dimension 1

=> the shape of a tensor is incorrect, use **`transpose`**, **`squeeze`**, **`unsqueeze`** to align the dimensions

```
y = y.transpose(0,1)
z = x + y
print(z.shape)
```

Common Errors -- Cuda Out of Memory

```
import torch
import torchvision.models as models
resnet18 = models.resnet18().to("cuda:0") # Neural Networks for Image Recognition
data = torch.randn(512,3,244,244) # Create fake data (512 images)
out = resnet18(data.to("cuda:0")) # Use Data as Input and Feed to Model
print(out.shape)
```

CUDA out of memory. Tried to allocate 350.00 MiB (GPU 0; 14.76 GiB total capacity; 11.94 GiB already allocated; 123.75 MiB free; 13.71 GiB reserved in total by PyTorch)

=> The batch size of data is too large to fit in the GPU. Reduce the batch size.

Common Errors -- Cuda Out of Memory

If the data is iterated (batch size = 1), the problem will be solved. You can also use DataLoader

```
for d in data:
 out = resnet18(d.to("cuda:0").unsqueeze(0))
print(out.shape)
```

Common Errors -- Mismatched Tensor Type

```
import torch.nn as nn
L = nn.CrossEntropyLoss()
outs = torch.randn(5,5)
labels = torch.Tensor([1,2,3,4,0])
lossval = L(outs,labels) # Calculate CrossEntropyLoss between outs and labels
```

expected scalar type Long but found Float

=> labels must be long tensors, cast it to type “Long” to fix this issue

```
labels = labels.long()
lossval = L(outs,labels)
print(lossval)
```

Any Question?