PyTorch Quick Reference

Tensors, autograd, neural networks, and training

Tensors

Creating Tensors

```
import torch
a = torch.tensor([1, 2, 3])
b = torch.zeros(2, 3)
c = torch.ones(3, 3)
d = torch.randn(2, 4)  # normal dist
```

Tensor Constructors

`torch.zeros(m, n)`	All zeros, shape (m, n)
`torch.ones(m, n)`	All ones, shape (m, n)
`torch.randn(m, n)`	Standard normal random
`torch.arange(start, end, step)`	Evenly spaced values
`torch.linspace(start, end, steps)`	Fixed number of points
`torch.eye(n)`	Identity matrix
`torch.empty(m, n)`	Uninitialized memory

NumPy Interop

```
t = torch.from_numpy(np_array)
arr = tensor.numpy()  # shares memory
t = torch.as_tensor(np_array)
```

Autograd

Tracking Gradients

```
x = torch.tensor([2.0, 3.0],
    requires_grad=True)
y = (x ** 2).sum()
y.backward()
print(x.grad)  # tensor([4., 6.])
```

Disabling Gradient Tracking

```
with torch.no_grad():
    pred = model(x)  # inference only
x_det = x.detach()  # detach from graph
```

Gradient Control

`x.requires_grad_(True)`	Enable grad tracking in-place
`x.grad.zero_()`	Reset accumulated gradients
`x.detach()`	New tensor without grad history
`x.grad`	Access stored gradients

Neural Networks

Define a Model

```
import torch.nn as nn
class Net(nn.Module):
    def __init__(self):
        super().__init__()
        self.fc1 = nn.Linear(784, 128)
        self.fc2 = nn.Linear(128, 10)
    def forward(self, x):
        x = torch.relu(self.fc1(x))
        return self.fc2(x)
```

Sequential Model

```
model = nn.Sequential(
    nn.Linear(784, 256),
    nn.ReLU(),
    nn.Dropout(0.2),
    nn.Linear(256, 10))
```

Common Layers

`nn.Linear(in, out)`	Fully connected layer
`nn.Conv2d(c_in, c_out, k)`	2D convolution, kernel size k
`nn.BatchNorm2d(n)`	Batch normalization
`nn.LSTM(in, hidden)`	LSTM recurrent layer
`nn.Dropout(p)`	Dropout with probability p
`nn.Embedding(vocab, dim)`	Embedding lookup table

Data Loading

Custom Dataset

```
from torch.utils.data import Dataset, DataLoader
class MyData(Dataset):
    def __init__(self, X, y):
        self.X, self.y = X, y
    def __len__(self): return len(self.X)
    def __getitem__(self, i):
        return self.X[i], self.y[i]
```

DataLoader

```
loader = DataLoader(dataset, batch_size=32,
    shuffle=True, num_workers=2)
for batch_x, batch_y in loader:
    output = model(batch_x)
```

Built-in Datasets

```
from torchvision import datasets, transforms
t = transforms.Compose([
    transforms.ToTensor(),
    transforms.Normalize((0.5,), (0.5,))])
data = datasets.MNIST("data", train=True,
    download=True, transform=t)
```

Training Loop

Standard Training Loop

```
model.train()
for epoch in range(num_epochs):
    for X, y in train_loader:
        optimizer.zero_grad()
        loss = criterion(model(X), y)
        loss.backward()
        optimizer.step()
```

Evaluation

```
model.eval()
with torch.no_grad():
    correct = 0
    for X, y in test_loader:
        pred = model(X).argmax(dim=1)
        correct += (pred == y).sum().item()
```

Training Checklist

`model.train()`	Enable dropout / batch norm training
`model.eval()`	Switch to inference mode
`optimizer.zero_grad()`	Clear gradients before backward
`loss.backward()`	Compute gradients
`optimizer.step()`	Update parameters

Optimizers

Common Optimizers

```
import torch.optim as optim
opt = optim.SGD(model.parameters(), lr=0.01,
    momentum=0.9)
opt = optim.Adam(model.parameters(), lr=1e-3)
opt = optim.AdamW(model.parameters(), lr=1e-3,
    weight_decay=0.01)
```

Learning Rate Scheduler

```
sched = optim.lr_scheduler.StepLR(
    opt, step_size=10, gamma=0.1)
# in loop: sched.step() after each epoch
```

Optimizer Comparison

`SGD`	Simple, needs tuning, good with momentum
`Adam`	Adaptive LR, fast convergence, default
`AdamW`	Adam with decoupled weight decay
`RMSprop`	Adaptive, good for RNNs

Loss Functions

Common Loss Functions

`nn.CrossEntropyLoss()`	Classification (logits, no softmax)
`nn.BCEWithLogitsLoss()`	Binary classification (logits)
`nn.MSELoss()`	Regression (mean squared error)
`nn.L1Loss()`	Regression (mean absolute error)
`nn.NLLLoss()`	Negative log-likelihood (after log_softmax)
`nn.HuberLoss()`	Robust regression (less outlier-sensitive)

Usage

```
criterion = nn.CrossEntropyLoss()
loss = criterion(logits, targets)
# logits: (batch, classes), targets: (batch,)
```

Custom Loss

```
def focal_loss(pred, target, gamma=2.0):
    ce = nn.functional.cross_entropy(
        pred, target, reduction="none")
    pt = torch.exp(-ce)
    return ((1 - pt) ** gamma * ce).mean()
```

Saving & Loading

Save / Load State Dict (Recommended)

```
torch.save(model.state_dict(), "model.pt")
model = Net()
model.load_state_dict(
    torch.load("model.pt", weights_only=True))
```

Save Full Checkpoint

```
torch.save({
    "epoch": epoch,
    "model": model.state_dict(),
    "optimizer": opt.state_dict(),
    "loss": loss}, "checkpoint.pt")
```

Load Checkpoint

```
ckpt = torch.load("checkpoint.pt",
    weights_only=False)
model.load_state_dict(ckpt["model"])
opt.load_state_dict(ckpt["optimizer"])
```

GPU

Device Management

```
device = torch.device(
    "cuda" if torch.cuda.is_available()
    else "cpu")
model = model.to(device)
x = x.to(device)
```

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GPU Utilities

`torch.cuda.is_available()`	Check if CUDA is available
`torch.cuda.device_count()`	Number of GPUs
`torch.cuda.memory_allocated()`	Current GPU memory usage (bytes)
`torch.cuda.empty_cache()`	Free unused cached memory

Multi-GPU

```
if torch.cuda.device_count() > 1:
    model = nn.DataParallel(model)
model = model.to(device)
```

Common Patterns

Weight Initialization

```
def init_weights(m):
    if isinstance(m, nn.Linear):
        nn.init.xavier_uniform_(m.weight)
        m.bias.data.fill_(0.01)
model.apply(init_weights)
```

Gradient Clipping

```
torch.nn.utils.clip_grad_norm_(
    model.parameters(), max_norm=1.0)
```

Freeze Layers

```
for param in model.fc1.parameters():
    param.requires_grad = False
```

Model Summary

```
total = sum(p.numel()
    for p in model.parameters())
trainable = sum(p.numel()
    for p in model.parameters()
    if p.requires_grad)
```