Deep Learning Course

Picsart Academy

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Outline

Session 1

Deep Learning

What is Deep Learning?

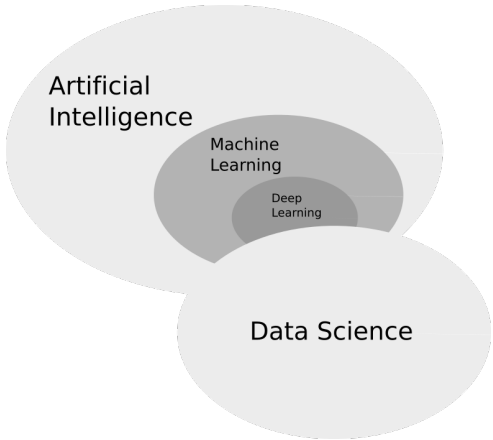


Figure 1: Where does Deep Learning stand in AI?

"Deep learning is a specific subfield of machine learning: a new take on learning representations from data that puts an emphasis on learning successive layers of increasingly meaningful representations. The "deep" in "deep learning" isn't a reference to any kind of deeper understanding achieved by the approach; rather, it stands for this idea of successive layers of representations."

François Chollet in Deep Learning with Python, Second Edition

Frameworks

What is Deep Learning Framework?

"Deep learning (DL) frameworks offer building blocks for designing, training, and validating deep neural networks through a high-level programming interface."

Nvidia

Most popular:

- PyTorch <– gaining momentum
- TensorFlow and Keras
- MXNet
- JAX <– gaining momentum

Introduction: Recommended Material

- Chapter 1, Deep Learning with Python, Second Edition by François Chollet
- Chapter 1, Dive into Deep Learning by Zhang A. et al.
- YouTube: INTRODUCTION TO PYTORCH
- Chapter 1, Neural Networks and Deep Learning by Michael Nielsen
- Introduction, Deep Learning by Yoshua Bengio, Ian Goodfellow and Aaron Courville
- GitHub: Awesome Deep Learning
- Chapter 1, Deep Learning with PyTorch: A practical approach to building neural network models using PyTorch by Vishnu Subramanian
- Chapter 1, Deep Learning with PyTorch: Build, Train, and Tune Neural Networks Using Python Tools by Eli Stevens, Luca Antiga, Thomas Viehmann

What is PyTorch?

"An open source machine learning framework that accelerates the path from research prototyping to production deployment"

PyTorch Webpage

- Tensors
- Datasets, Dataloaders and Transforms
- Autograd
- Vectorisation
- Computational Graph

PyTorch Ecosystem Tools

- Python API
- Ecosystem Tools
  - Lightning: Simplified PyTorch for Research
  - pyro and numpyro: Deep Universal Probabilistic Programming
  - BoTorch: Bayesian Optimization in PyTorch
  - fastai: fastai simplifies training fast and accurate neural nets using modern best practices
  - ONNX Runtime: Cross-platform inference and training machine-learning accelerator
  - Transformers by HuggingFace
  - Ray: A unified framework for scaling AI and Python applications
  - PyTorch NLP: NLP library in Python
  - detectron2: State-of-the-art object detection and segmentation algorithms
  - Optuna: Hyperparameter optimization framework

PyTorch Ecosystem Libraries

- torchaudio: audio and signal processing
- torchvision: popular datasets, model architectures, and common image transformations for computer vision
- torchtext: data processing utilities and popular datasets for NLP
- torchserve: model serving

Introduction to PyTorch, tensors, and operations

What is Tensor?

"A PyTorch Tensor is basically the same as a numpy array: it does not know anything about deep learning or computational graphs or gradients, and is just a generic n-dimensional array to be used for arbitrary numeric computation."

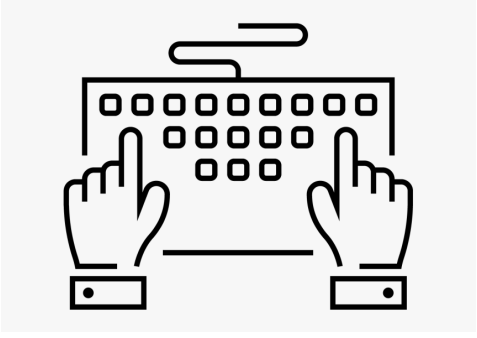
Source: PYTORCH: TENSORS

Torch tensor:

- Runs on either CPU or GPU
  - For GPU, cast tensor to a cuda datatype
  - More info on cuda python and accelerated computing
- Optimised for automatic differentiation; `grad_fn` property references the backward propagation function

Get used to numpy library and numpy array before moving on!

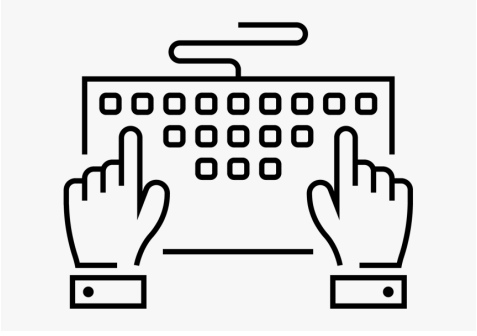
Session 2



Tensors and Operations

GitHub: tensors

Session 3



Autograd and Vectorisation

GitHub

- autograd
- vectorisation

Session 4 and 5

Linear and Logistic Regressions as Neural Nets

Steps to build a Neural Net:

- Model
- Loss function
- Optimiser
- Training

Hyperparameters for training:

- **Number of Epochs** - the number times to iterate over the dataset
- **Batch Size** - the number of data samples propagated through the network before the parameters are updated
- **Learning Rate** - how much to update models parameters at each batch/epoch (SGD for Linear Regression at MLU)

Implementations:

- Linear Regression
- Logistic Regression

Session 6

Deep Neural Networks

What is *deep* in Deep Neural Network?

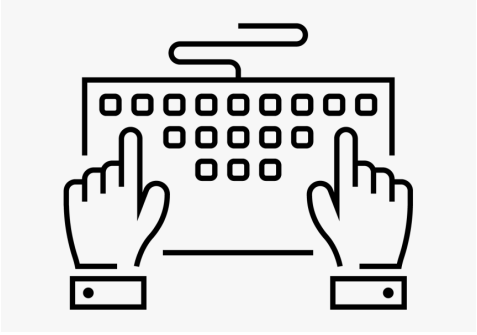
Let's recall that `"the deep in 'deep learning' isn't a reference to any kind of deeper understanding achieved by the approach; rather, it stands for this idea of successive layers of representations."`

François Chollet in Deep Learning with Python, Second Edition

Ingredients of common deep NN:

- Hidden Layers
- Activation Functions
  - Sigmoid
  - ReLU
  - Tanh

Session 7



Deep Neural Networks

- GitHub: Multiclass Classification
- Mathematics of Deep Neural Networks
- Element-wise Activation Functions
- Row-wise Activation Functions
- Normalization Layers
- Dropout Layers

Homework 1

Build a simple neural network using PyTorch to classify MNIST digits

Session 8

Convolutional Neural Network (CNN)

What is a convolution?

- Translation Invariance
- Locality
- Convolution Kernel (Filter) and Cross-Correlation Operation
- Edge Detector
- Padding and Strided Convolutions

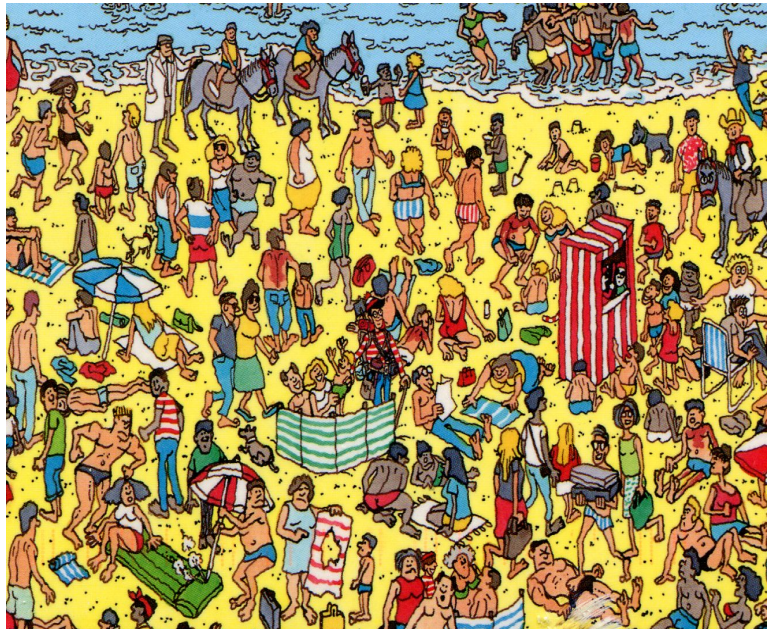


Figure 2: Where is Waldo?

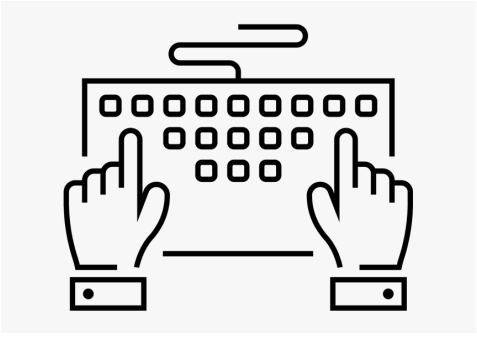
Session 9

Channels in CNN

What is a channel?

- Colour image input data might be a 3-dimensional tensor representing an image with *height*, *width*, and *colour*. The amount of red, green, and blue present is represented by the RGB colour channels that's why the image has a shape $3xhxw$
- Filters are applied to each channel separately
- Filters are designed to learn different features in the image
- Resulting outputs are combined to form the output of the convolutional layer
- Channels of an image are typically processed in parallel by different filters
- Multiple Input Channels
- Multiple Output Channels

Session 10



CNN

- torchvision
  - Datasets
- Open-CV
- MNIST
- GitHub

Transfer Learning and Fine-tuning Pre-trained Models

Object Detection and Instance Segmentation with PyTorch

Homework 2

- Use a pre-trained model to classify images from the CIFAR-10 dataset
- Use a pre-trained model to detect and classify objects in an image

Convolutional Neural Networks: Recommended Reading

- Deep Learning with PyTorch: A practical approach to building neural networks, Chapter 3
- PyTorch for Deep Learning and Computer Vision, Chapter 4
- Hands-On Computer Vision with PyTorch, Chapter 3

Natural Language Processing

Introduction to Word Embeddings and Language Modelling

Sequence labeling and text classification with PyTorch

Machine translation and generation with PyTorch

Homework 3

- Use a pre-trained word embedding model to classify sentences
- Use a pre-trained machine translation model to translate a sentence from English to Armenian

Natural Language Processing: Recommended Reading

- Deep Learning with PyTorch: A practical approach to building neural networks, Chapter 4
- Natural Language Processing with PyTorch, Chapter 2
- Deep Learning with PyTorch, Chapter 5

Recurrent Neural Networks

Introduction to Word Embeddings and Language Modelling

Sequence labeling and text classification with PyTorch

Machine translation and generation with PyTorch

Homework 4

- Use a pre-trained model to generate text based on a given prompt

Recurrent Neural Networks: Recommended Reading

- Deep Learning with PyTorch: A practical approach to building neural networks, Chapter 5
- PyTorch for Deep Learning and Computer Vision, Chapter 5
- Hands-On Computer Vision with PyTorch, Chapter 4

JAX and Distributed Training

Introduction to JAX and its differences from PyTorch

Distributed training with PyTorch and JAX

JAX best practices and advanced techniques

Homework 5

- Use JAX to train a simple neural network on the MNIST dataset

JAX and Distributed Training: Recommended Reading

- Deep Learning with PyTorch: A practical approach to building neural networks, Chapter 6
- JAX: High-performance machine learning with NumPy-style functions, Chapter 3
- Deep Learning with PyTorch, Chapter 6