# Deep Learning Course

*Picsart Academy*

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# Outline

# Session 1

# Deep Learning

## What is Deep Learning?

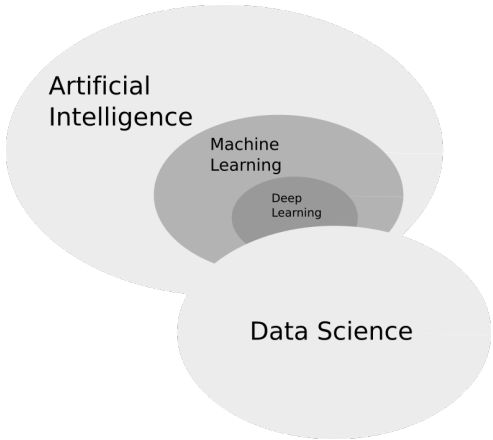



Figure 1: Where does Deep Learning stand in AI?

"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."

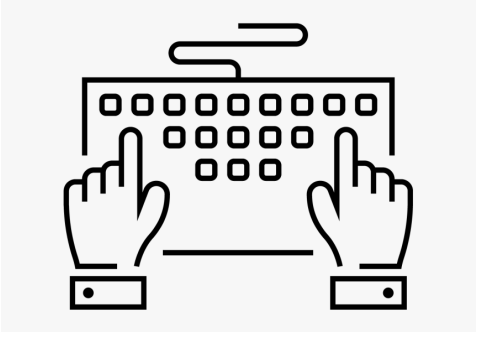
*Source: PYTORCH: TENSORS*

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!*

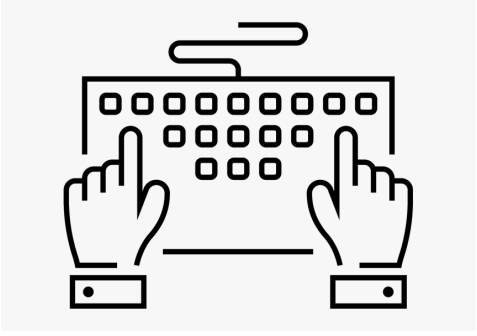
# Session 2



# 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

# Neural Networks: Recommended Reading

- Chapter 5 in Deep Learning with PyTorch by Eli Stevens et al.

# Session 6

# Deep Neural Networks

What is *deep* in Deep Neural Network?

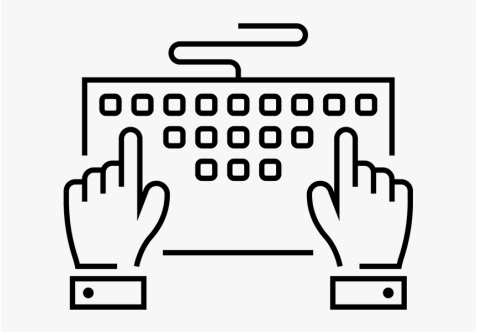
Let's recall that `"the deep in 'deep learning' isn't a reference to any kind of deeper understanding achieved by the approach; rather, it stands for this idea of successive layers of representations."`

*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

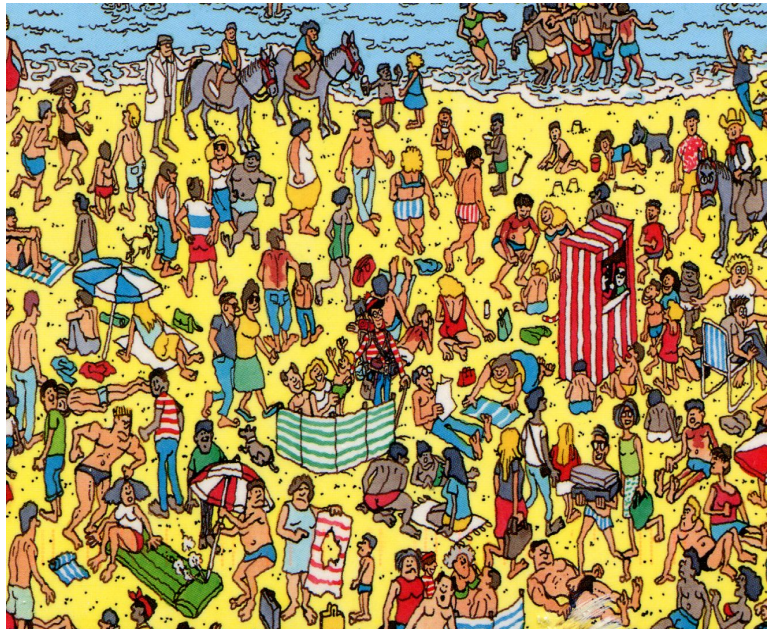


Figure 2: Where is Waldo?

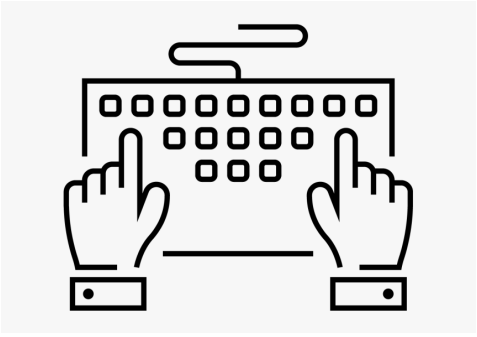
# Session 9

# 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

# Session 11

# Advances in Deep Learning & Big CNN Models

- 1995: LeNet
- Advances in GPU
  - GPU is good for massively parallel processing for repeatable, identical computations
  - CPU is good for processing multiple, more complex computations at the same time
- ***2012***: AlexNet
- 2013: NiN
- 2014: VGG
- 2014: GoogLeNet
- 2015: Batch Normalization and 2016: Layer Normalization
- 2016: ResNet and 2017: ResNeXt
- 2017: DenseNet
- 2018: Neural Architecture Search (NAS) and 2019: EfficientNets
- 2020: RegNet

# Convolutional Neural Networks: Recommended Reading

- Chapter 7, 8 in Dive into Deep Learning by Zhang Aston et al.
- Chapter 7, and 8 in Deep Learning with PyTorch by Eli Stevens et al.

# Session 12

# Recurrent Neural Networks (RNNs): Introduction

What is a Sequence?

- Autoregressive Models
- Sequence Models
- Markov Models
  - Conditional Probability
- Time Series
- Language Models
- RNN: A Visual Explanation
- The Vanishing Gradient problem

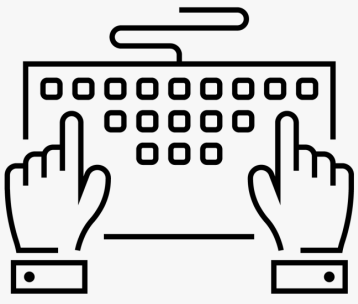
# RNNs: Recommended Reading

- Chapter 13 (up to 13.2.1) in Pattern Recognition and Machine Learning by Christopher Bishop
- Chapter 9 in Dive into Deep Learning by Zhang Aston et al.

# Session 13

# RNN: Implementations

- PyTorch's RNN module
- Classifying Names with a Character-level RNN



RNN from scratch

GitHub

# Session 14

# More Efficient RNN Variants

- Long Short-Term Memory (LSTM)
  - PyTorch's LSTM module
- Gated Recurrent Units (GRU)
  - PyTorch's GRU module
- LSTM and GRU: A Visual Explanation