Deep Learning Course

Picsart Academy

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Outline

Session 1

Deep Learning

What is Deep Learning?

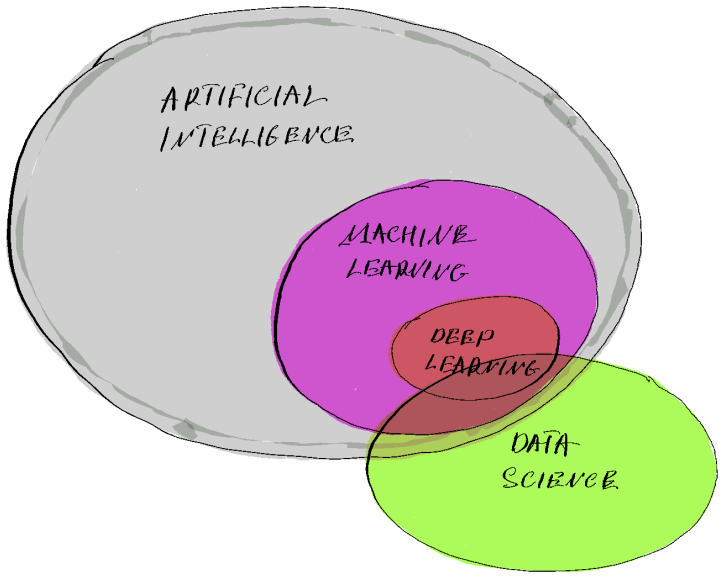


Figure 1: Where does Deep Learning stand in AI?

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."

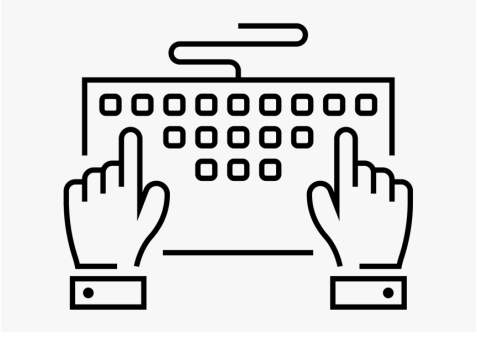
Source: PYTORCH: TENSORS

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!

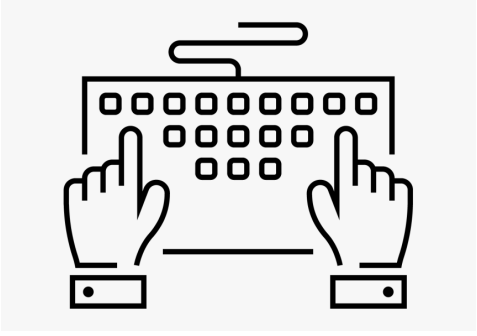
Session 2



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.

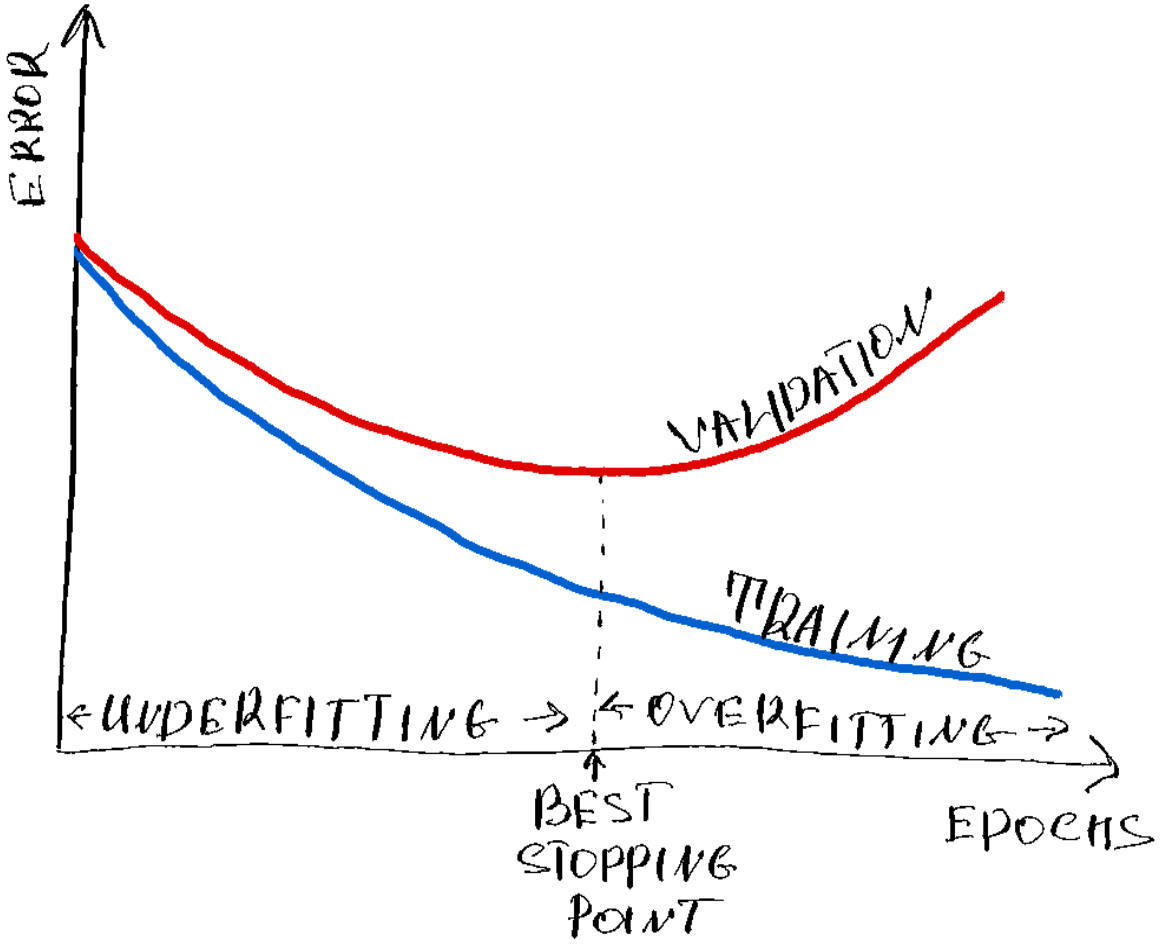


Figure 2: Training and Validation Losses of a NN

Session 6

Deep Neural Networks

What is *deep* in Deep Neural Network?

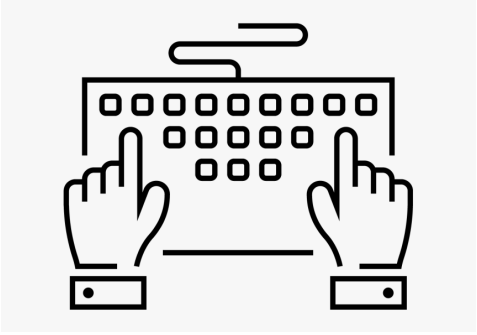
Let's recall "the ***deep*** in ***deep learning*** isn't a reference to any kind of deeper understanding achieved by the approach; rather, it stands for this idea of successive layers of representations."

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

Figure 3: Sample of 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

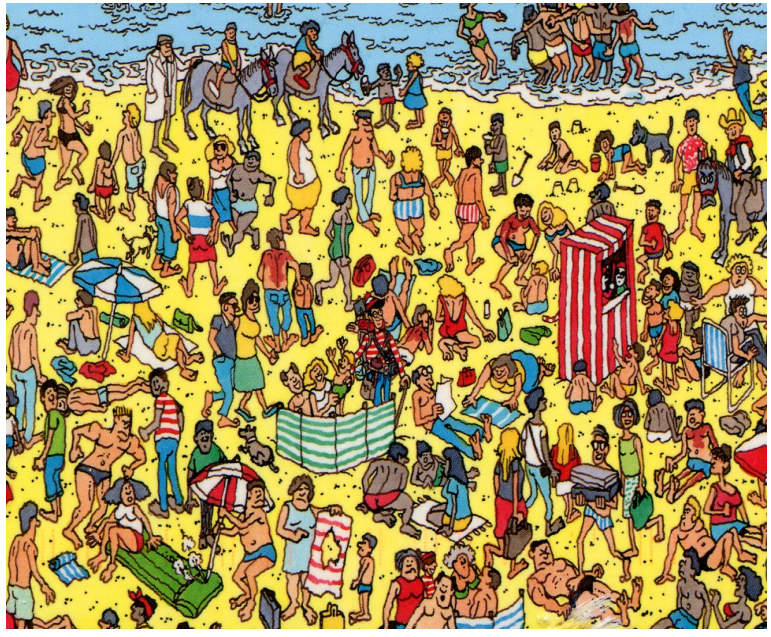


Figure 4: Where is Waldo?

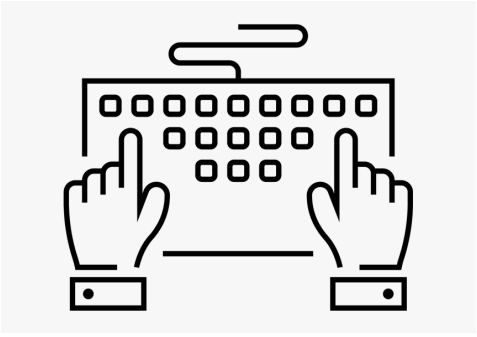
Session 9

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

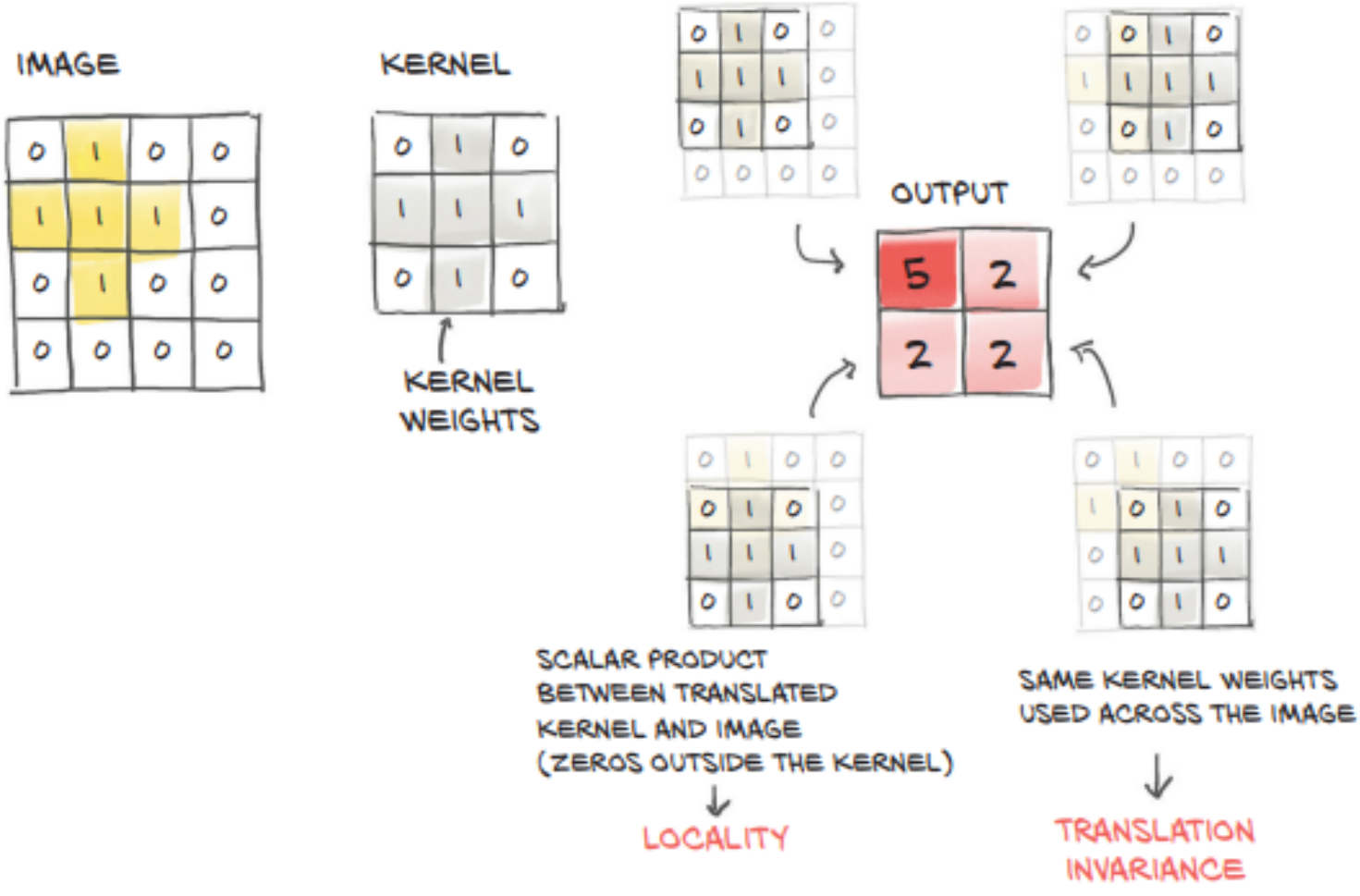
Session 11

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, 8 in Deep Learning with PyTorch by Eli Stevens et al.

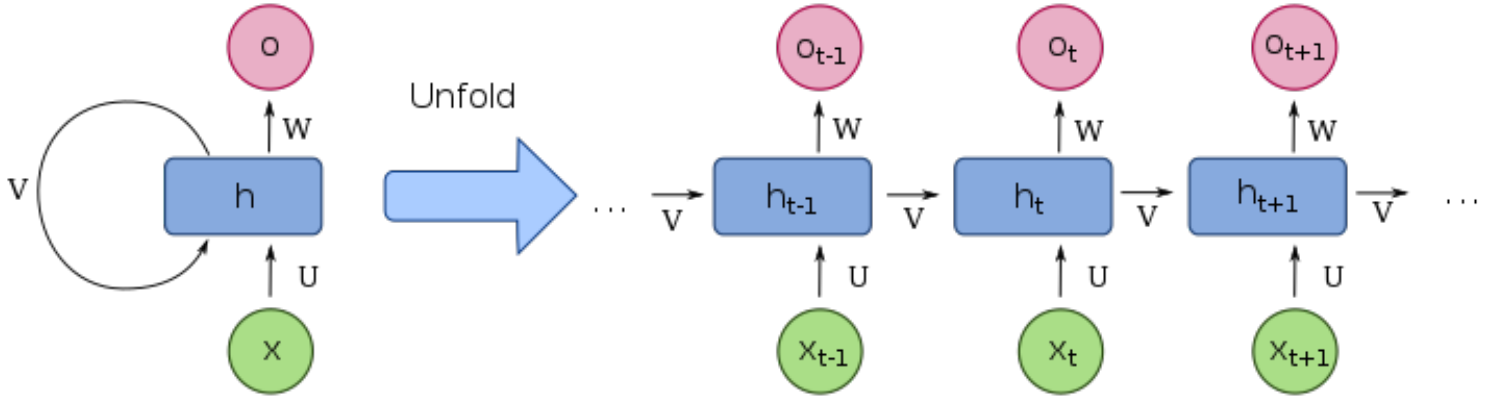


Session 12

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



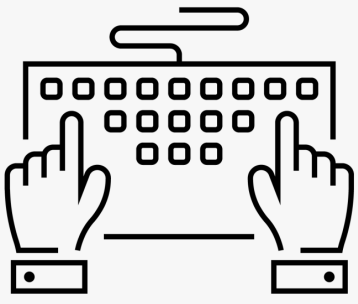
RNNs: Recommended Reading

- 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

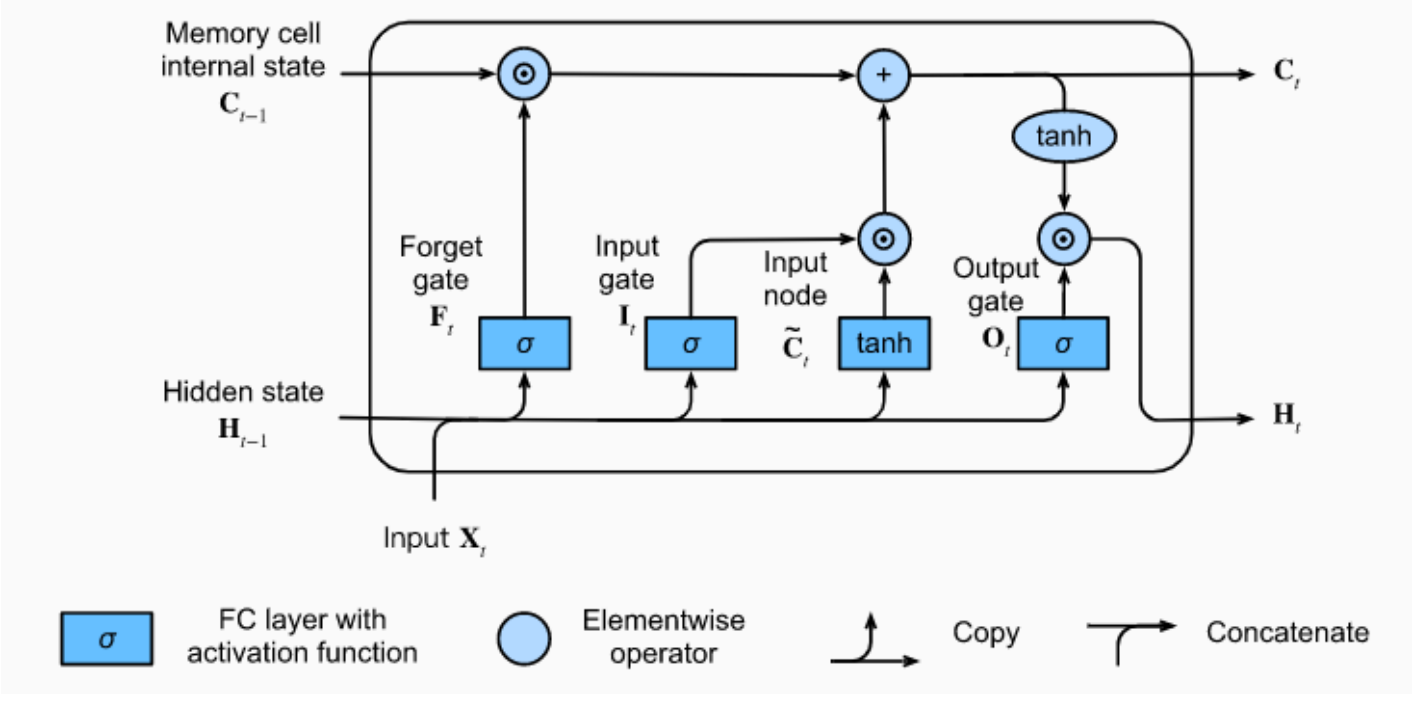


Figure 7: Memory Cell of LSTM