Deep Learning with Keras and TensorFlow

Introduction to Deep Learning

Learning Objectives

By the end of this lesson, you will be able to:

- Explore the factors contributing to the achievements of Deep Learning in the past decade
- Understand the applications and challenges of Deep Learning
- Evaluate various frameworks that facilitate the development of deep learning models, including their features and uses
- Engage in the end-to-end process of a deep learning project, from planning and data collection to training, evaluation, deployment, and monitoring

Business Scenario

A retail company wants to enhance its customer experience by implementing Deep Learning techniques. They plan to analyze customer data, including purchase history, browsing behavior, and demographic information, to gain insights and make personalized product recommendations. By using Deep Learning algorithms, they aim to identify complex patterns and correlations in the data to understand customer preferences better.

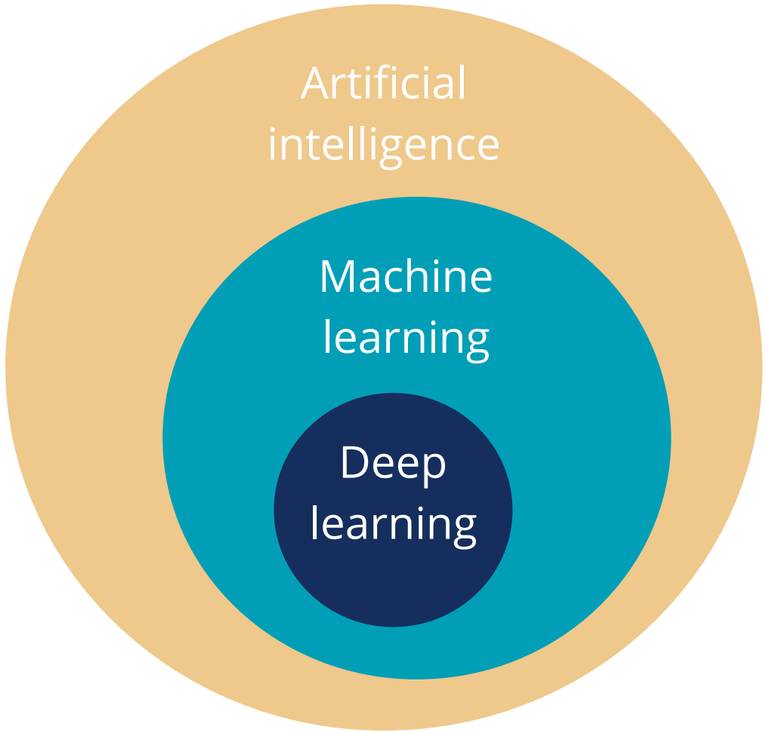
Approach:

To accomplish this, the company collects and preprocesses a large customer dataset, utilizes significant computational resources for deep neural network training, and deploys the trained model to provide real-time recommendations. This leads to increased customer satisfaction, higher sales, and improved marketing effectiveness.

Brief History of AI

Artificial Intelligence

Artificial Intelligence (AI) is the field of study focused on creating machines capable of performing tasks that would typically require human intelligence



Deep Learning is a subset of Machine Learning, which in itself is a subset of Artificial Intelligence, each representing a narrowing specialization within the field.

Evolution of AI

1940 to 1950

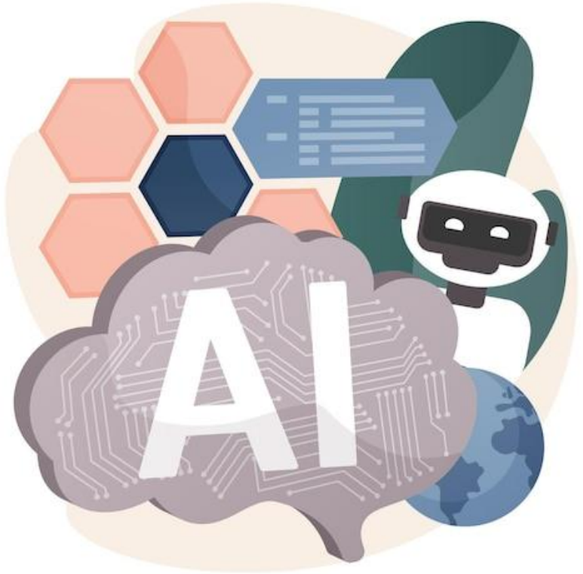
Warren McCulloch and Walter Pits proposed a model of artificial neurons in 1943.

Alan Turing proposed a test, called Turing Test to check a machine's ability.

Evolution of AI

1940 to 1950

1950s



The word **Artificial Intelligence** was coined.

Perceptron was invented in 1957.

High-level programming languages like COBOL, FORTRAN, and LISP were invented.

Evolution of AI

1940 to 1950

1950s

1960s

Researchers solved mathematical problems using AI.

Joseph Weizenbaum invented the first chatbot, ELIZA, in 1966.

Evolution of AI

1940 to 1950 → 1950s → 1960s → 1970 to 1980

Interest in AI research dropped significantly.

Funding for AI projects from the government was insufficient.

Evolution of AI

1940 to 1950 | 1950s | 1960s | 1970 to 1980 | 1980 to 1987

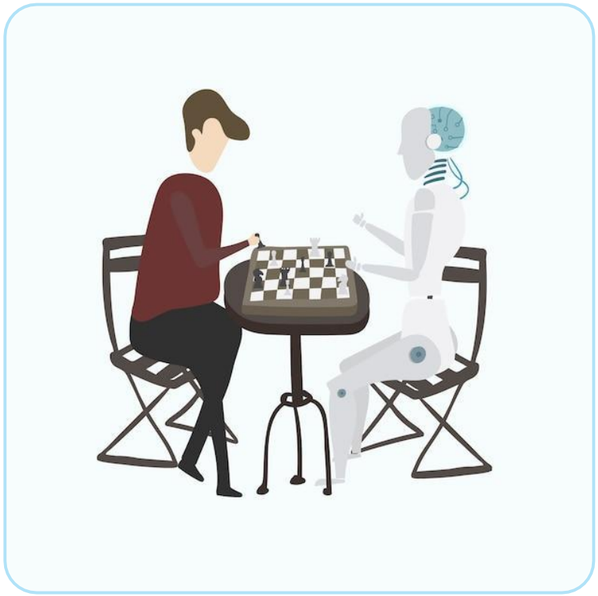
AI was revived as expert systems replicating human decision-making abilities.

Stanford University hosted the inaugural national conference of the American Association of Artificial Intelligence (AAAI) in 1980.

There was a shortage in funding for AI research and development after 1987.

Evolution of AI

1940 to 1950 | 1950s | 1960s | 1970 to 1980 | 1980 to 1987 | 1997 to 2006



1997: IBM Deep Blue beat world chess champion Gary Kasparov in 1997.

Companies like Facebook, Twitter, and Netflix also started using AI from 2006 onwards.

Evolution of AI

1940 to 1950 → 1950s → 1960s → 1970 to 1980 → 1980 to 1987 → 1997 to 2006 → 2012 onwards

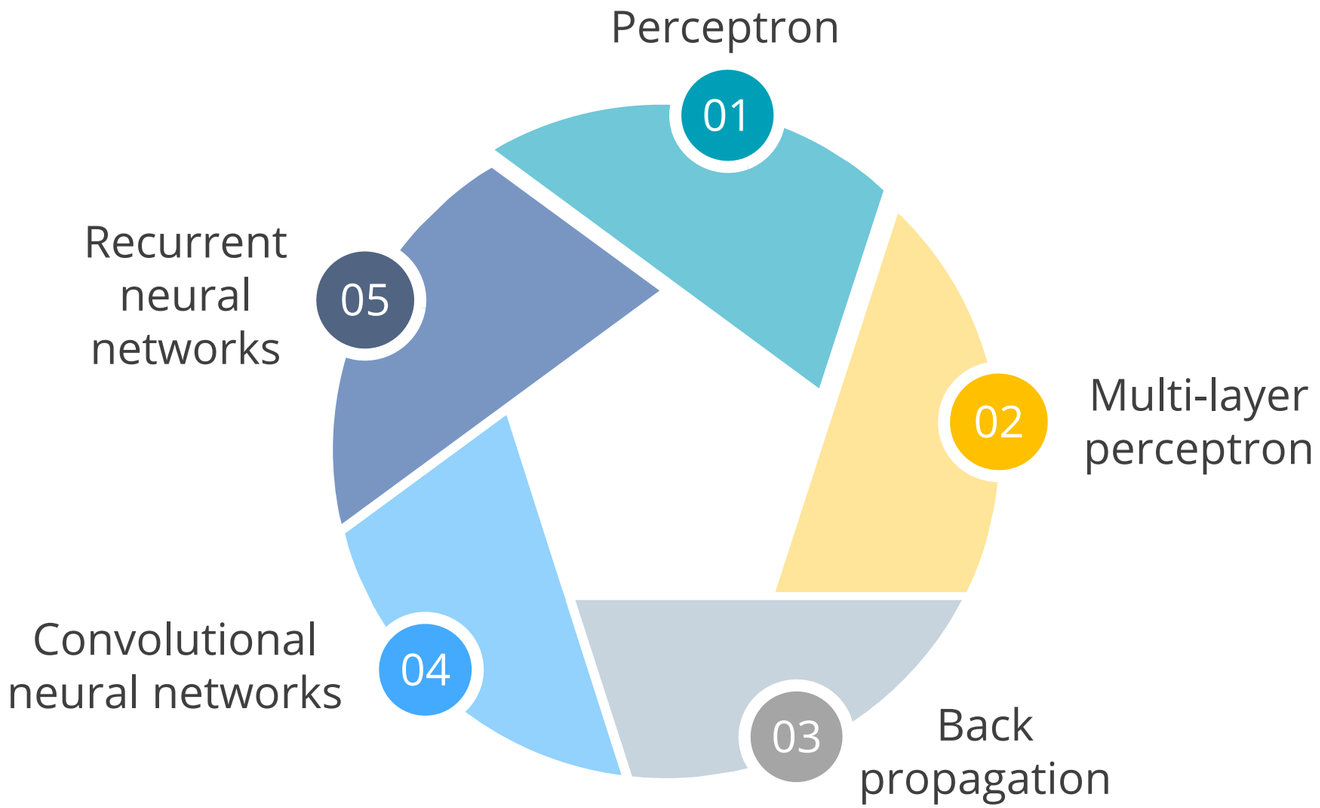
Considered to be a golden period, Deep Learning emerged as a giant in 2012.

Computer vision and natural language processing benefitted the most.

Motivation for Deep Learning

Deep Learning

The following are some of the key developments in the field of Deep Learning:

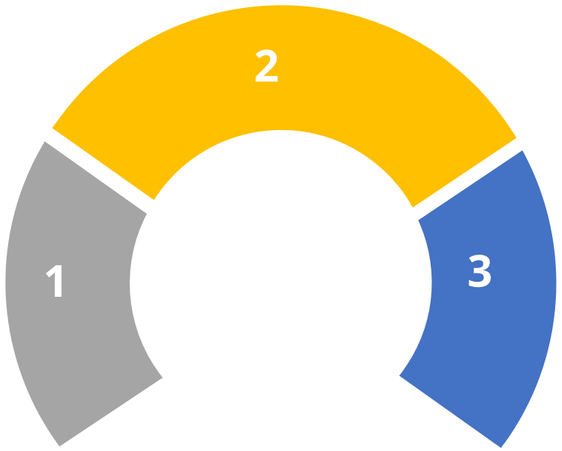


Deep Learning

DL helps solve real-world problems that were once considered impossible, such as:

Natural language understanding (NLU):
Teaches computers to comprehend and process human language

Image recognition:
Trains machines to accurately identify and classify objects within images



Speech recognition:
Enables computers to transcribe and understand spoken words

Deep Learning: Progress

The publication of the AlexNet paper in 2012 piqued global interest in Deep Learning, in which the proposed neural network achieved state-of-the-art performance in the ImageNet challenge.

ImageNet Challenge: Classification task

Images classified into 1000 categories

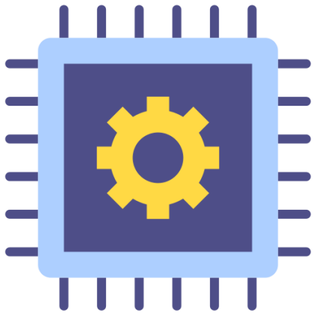
- Training data: 1.2 million images
- Testing data: 1.5 million images

The runner-up used hand-crafted features and the best available classification methods available at that time; however, the difference between the winner and the runner-up was more than 10%.

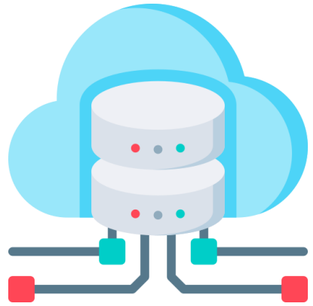
Deep Learning: Progress

The progress in Deep Learning encountered challenges primarily due to:

Lack of funding



Inadequate hardware



Expensive data storage

Deep Learning

Deep Learning

Deep Learning is a subset of machine learning, focusing on the use of deep neural networks to process and learn complex patterns from data.

Deep Learning focuses on training models to learn and make intelligent decisions from large datasets.

Deep Learning

DL can effectively utilize unstructured data from diverse domains, encompassing images, text, audio, and video, to discover patterns and make accurate predictions or classifications.

DL surpasses traditional machine learning by leveraging deep neural networks to extract patterns from unstructured data, resulting in superior performance in domains like computer vision, natural language processing, and speech recognition.

This technique enables Deep Learning models to extract complex features and achieve highly accurate predictions or classifications.

Deep Learning vs. Machine Learning

Deep Learning vs. Machine Learning

Deep Learning

- Subset of machine learning that focuses on training deep neural networks
- Handles unstructured data such as images, audio, text, and video
- Eliminates the need for manual feature engineering

Machine learning

- A broad field of training algorithms to make predictions or decisions based on data
- Works with structured and unstructured data
- Performance depends on the quality and relevance of engineered features

Deep Learning vs. Machine Learning

Deep Learning

- Excels in tasks like image recognition, natural language processing, and speech synthesis
- Requires substantial computational resources and large labeled datasets
- Utilizes deep neural networks with multiple layers and requires substantial computational resources

Machine learning

- Utilizes techniques like decision trees, support vector machines, and random forests
- Can be effective in a wide range of applications
- Utilizes neural networks with limited layers and requires fewer computational resources

Deep Learning vs. Machine Learning

Deep Learning

- To train DL models effectively, high-quality GPUs with ample RAM are crucial.
- It necessitates substantial computational power to process and learn patterns from vast quantities of data.

Machine learning

- Most problems like Data preprocessing, running simple ML models can be executed using a single powerful CPU.

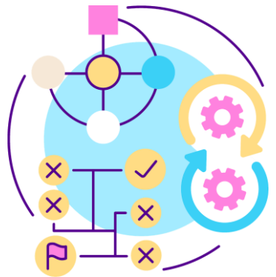
In conclusion, Deep Learning is designed for handling large datasets and performing extensive computations and is generally considered more expensive than machine learning.

Deep Learning: Successes in the Last Decade

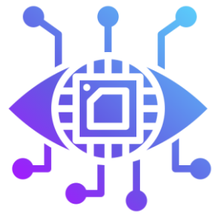
Deep Learning: Success in the Last Decade

In the past decade, Deep Learning has experienced exponential growth in the following areas:

Reinforcement learning



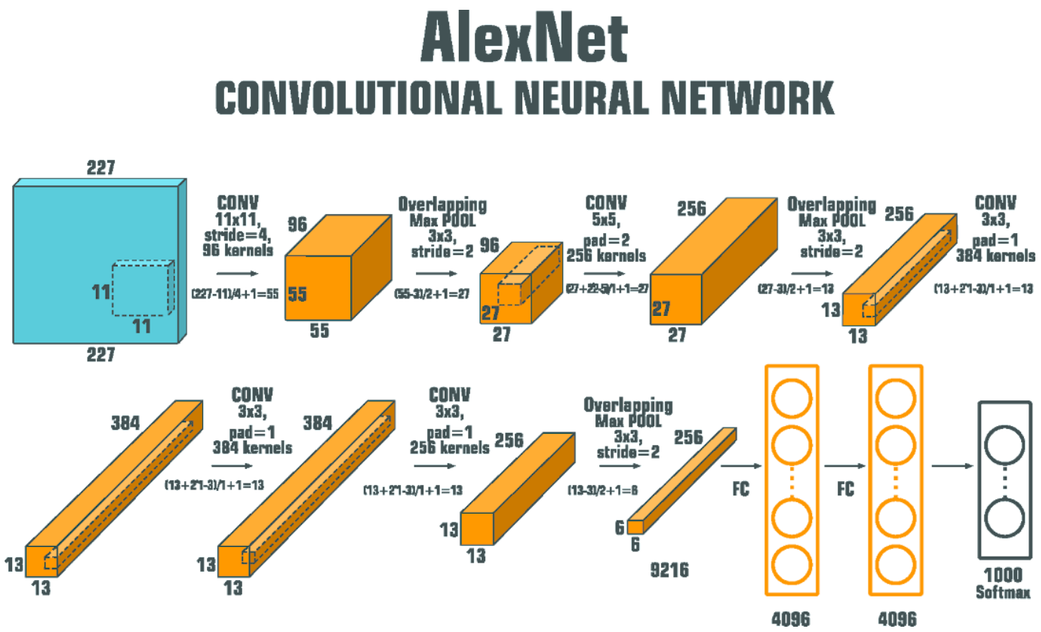
Computer vision



Audio processing

AlexNet (2012)

AlexNet emerged as the champion in the renowned annual image classification competition known as ImageNet.



Since then, any groundbreaking event in Deep Learning has been referred to as an ImageNet moment.

Word Embeddings (2013)

Word embeddings are dense representations of text data.

It was introduced by Tomas Mikolov as an efficient way to train word embeddings.

word2vec is the model used for word embedding.

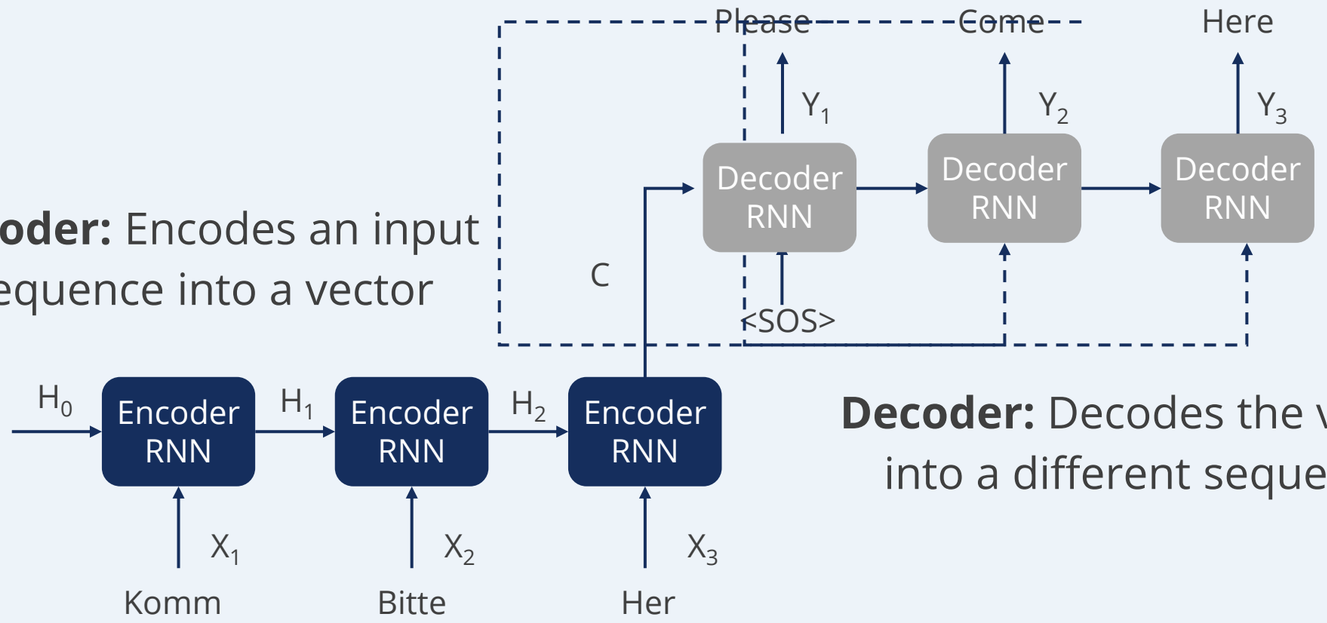
This model has been widely utilized for text data processing purposes.

Source: https://deepai.org/profile/tomas-mikolov

Sequence-to-Sequence Models (2014)

It comprises two components, both constructed using neural networks, making it a novel architecture in the field.

Encoder: Encodes an input sequence into a vector

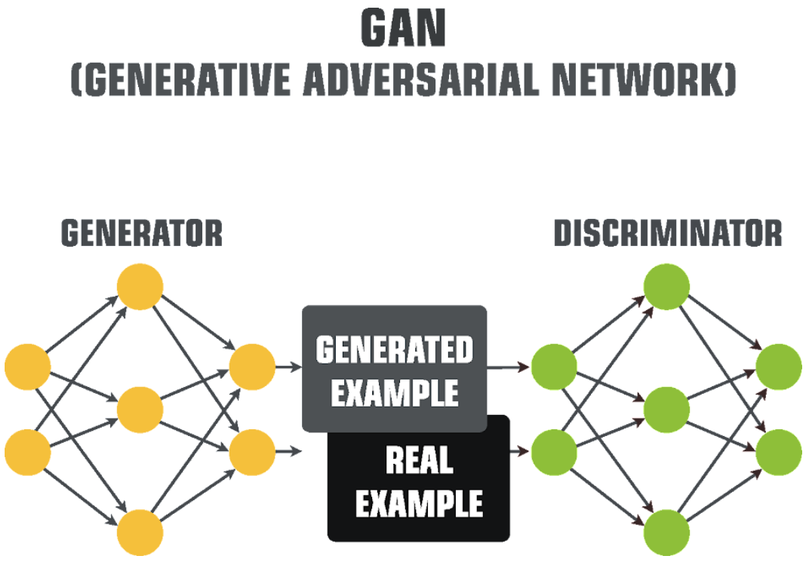


Decoder: Decodes the vector into a different sequence

This framework made complex tasks like machine translation and language generation easier and achieved top-notch performance.

Generative Adversarial Neural Network (2014)

GANs are Deep Learning models with a generator and discriminator. They generate realistic synthetic data through adversarial training.



These GANs possess the ability to generate life-like images, introducing a new dimension to computer vision research.

It led to the creation of new breeds of GANs such as Cycle GAN, Style GAN, and Pix2pix.

They can be used in fashion, art, and science.

AlphaGo Beats Human (2016)

AlphaGo, developed by DeepMind, is the first computer program to have defeated a professional human Go player.

Go is a more complex board game than chess.

AlphaGo, a reinforcement learning model, has achieved mastery in the game of Go.

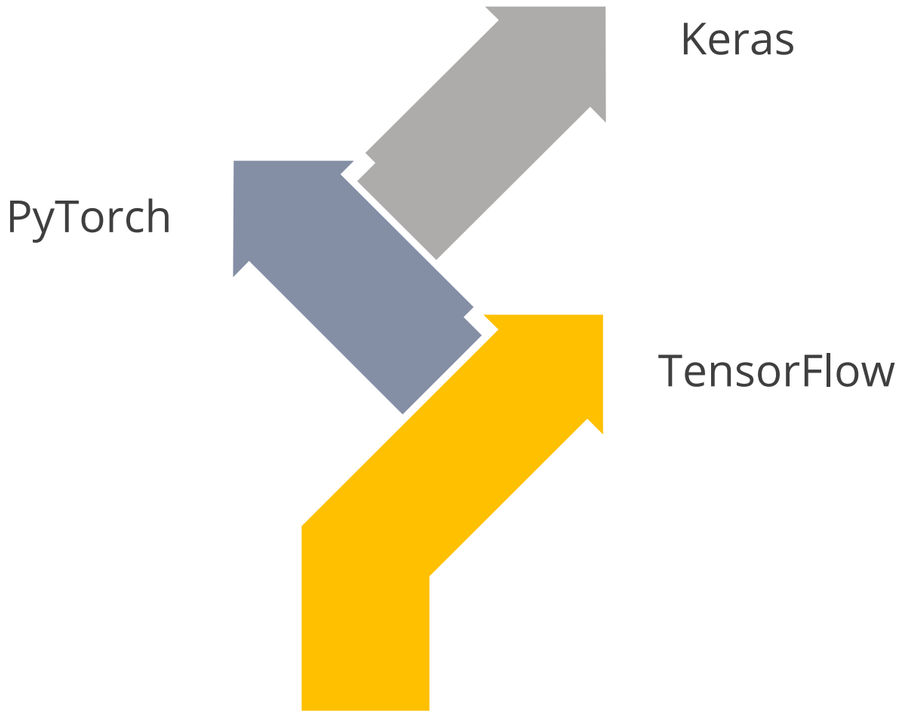
Transformers (2018)

They employ self-attention mechanisms to capture long-range dependencies in sequences, resulting in exceptional performance in tasks like machine translation, text generation, sentiment analysis, and question-answering.

The paper **Attention Is All You Need** introduces the transformer model and is recommended for anyone interested in NLP.

Deep Learning: Successes in the Last Decade

DL frameworks have supported the research community in their exploration with:



Key Reasons to Learn Deep Learning

Key Reasons to Learn Deep Learning

Ability to solve various problems across several industries

Widely used across different domains at scale such as:

- Fight against global warming
- Space exploration
- Autonomous vehicles
- Robotics

Key Reasons to Learn Deep Learning

Access to powerful graphics processing units (GPUs) at an affordable price

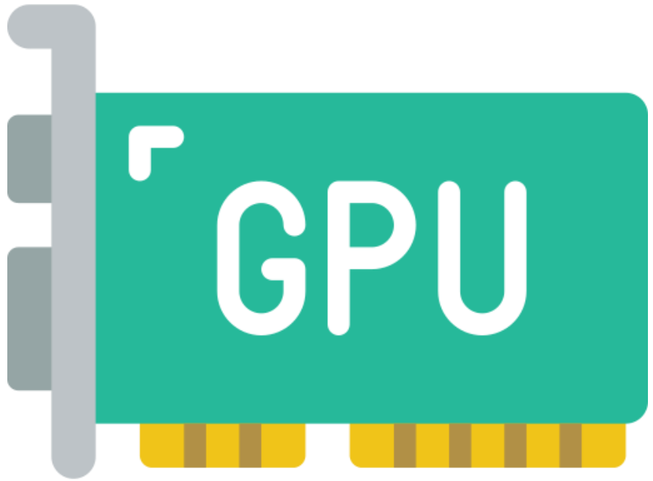
In 2007, NVIDIA launched the CUDA framework, which provides an API for GPU computing.

It enabled practitioners to easily use GPUs and accelerated the training of Deep Learning models.

Personal GPUs for Deep Learning are widely available, and renting GPUs from cloud providers like AWS or Azure is common.

Key Reasons to Learn Deep Learning

GPUs play a crucial role in accelerating Deep Learning computations due to their parallel processing capabilities.



Powerful graphics processing units (GPUs) are accessible at an affordable price.

A GPU performs parallel mathematical operations.

The operations are executed by multiple cores, which are comparatively less powerful but function in parallel.

Key Reasons to Learn Deep Learning

Free-to-use cloud notebooks

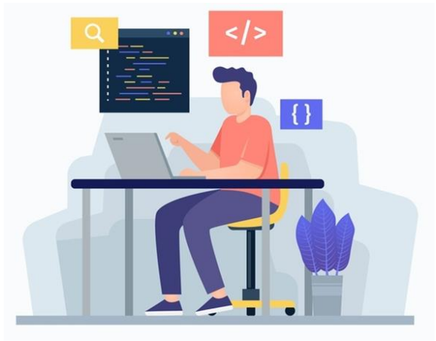
Collaboratory (Colab), provided by cloud service providers like Google, offers the opportunity to train Deep Learning models using GPUs for free.

The availability of these free compute resources has sparked an unprecedented level of contribution from researchers in the field of Deep Learning.

Key Reasons to Learn Deep Learning

Low barrier to entry

Deep Learning is easier if the learner has a prior knowledge of:



Basic Python programming

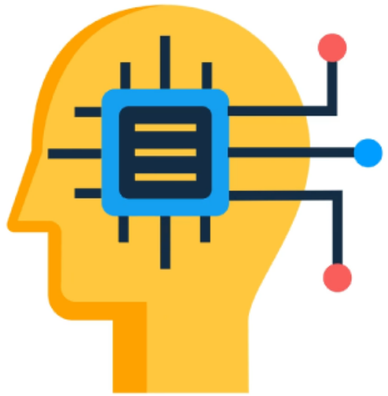
Data science and statistics

Basic linear algebra

Affordable hardware, cheap cloud services, and user-friendly frameworks like TensorFlow and PyTorch make training Deep Learning models more accessible.

Key Reasons to Learn Deep Learning

Requirement of trained Deep Learning experts and practitioners



Companies across industries have recognized the applicability of Deep Learning in areas such as technology, healthcare, finance, retail, manufacturing, and transportation.

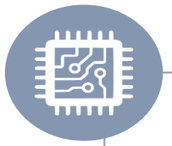
A shortage of trained professionals in the industry has created a golden opportunity to get into this field.

Applications of Deep Learning

Applications of Deep Learning

DL has diverse applications in various fields.

AI leverages deep learning within Natural Language Processing (NLP) to enhance human language interaction



Autonomous self-driving cars use computer vision for object detection and classification

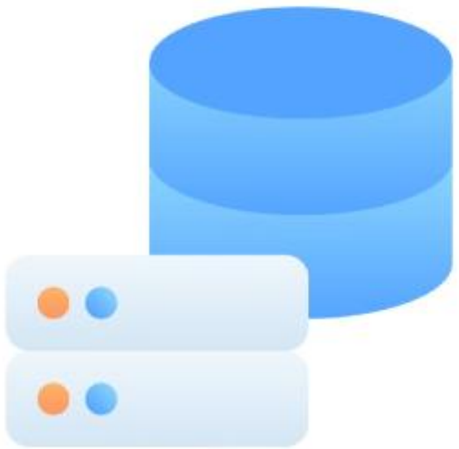
Automatic colorization of black-and-white images.

Deep Learning has made its mark in audio processing. Transforming speech to text with high accuracy

Limitations of Deep Learning

Limitations of Deep Learning

To learn a particular task, a significant amount of data is required.

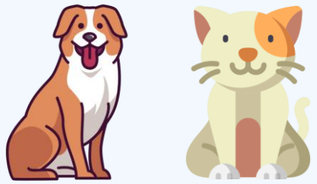


Huge data sets need to be collected, prepared, and labeled according to the intended task.

Limitations of Deep Learning

To learn a particular task, a significant amount of data is required.

Example



Consider using a deep learning model to differentiate cats from dogs

To train such a model:

- Collect many images of cats and dogs
- Label the images appropriately
- Feed the images to the model

Executing this task requires a lot of effort and time.

Limitations of Deep Learning

Expensive hardware is necessary to support the computational requirements.

High-speed RAM

GPUs

Deep Learning models are hardware-intensive.

Limitations of Deep Learning

DL models are not immune to overfitting and can be particularly susceptible to it

Unavailability of sufficient training data results in overfitting.

The model aligns with a minimal set of data points and fails to perform well on unseen datasets.

Limitations of Deep Learning

DL is more difficult to explain.

The models function like black boxes, with known inputs and outputs.

Deep Learning is not ideal for rigorous verification due to limited interpretability and reliability.

Deep Learning Frameworks

Deep Learning Frameworks

DL frameworks provide interfaces, libraries, and tools to facilitate the development of Deep Learning models. Additionally, they offer the flexibility to access and modify the underlying algorithms if needed.

The frameworks offer tried and tested foundations for:

- Designing
- Training
- Debugging
- Deploying

The frameworks provide simple ways to define models using ready-made and optimized functions.

Deep Learning Frameworks

The three popular Deep Learning frameworks are:

TensorFlow

It is an end-to-end, open-source platform for ML and DL.

It was developed by Google and coded using Python.

It is specifically optimized for the training and inference of neural networks.

Keras

Keras is an open-source Python framework for building and training deep neural networks with a user-friendly and modular interface.

It provides a Python interface for developing artificial neural networks.

It acts as an interface for the TensorFlow library.

It is qualified as an easy-to-use, simplistic interface.

PyTorch

Facebook developed and maintains PyTorch, an open-source Deep Learning framework. It is a capable deep-learning Python library that offers tough competition to TensorFlow.

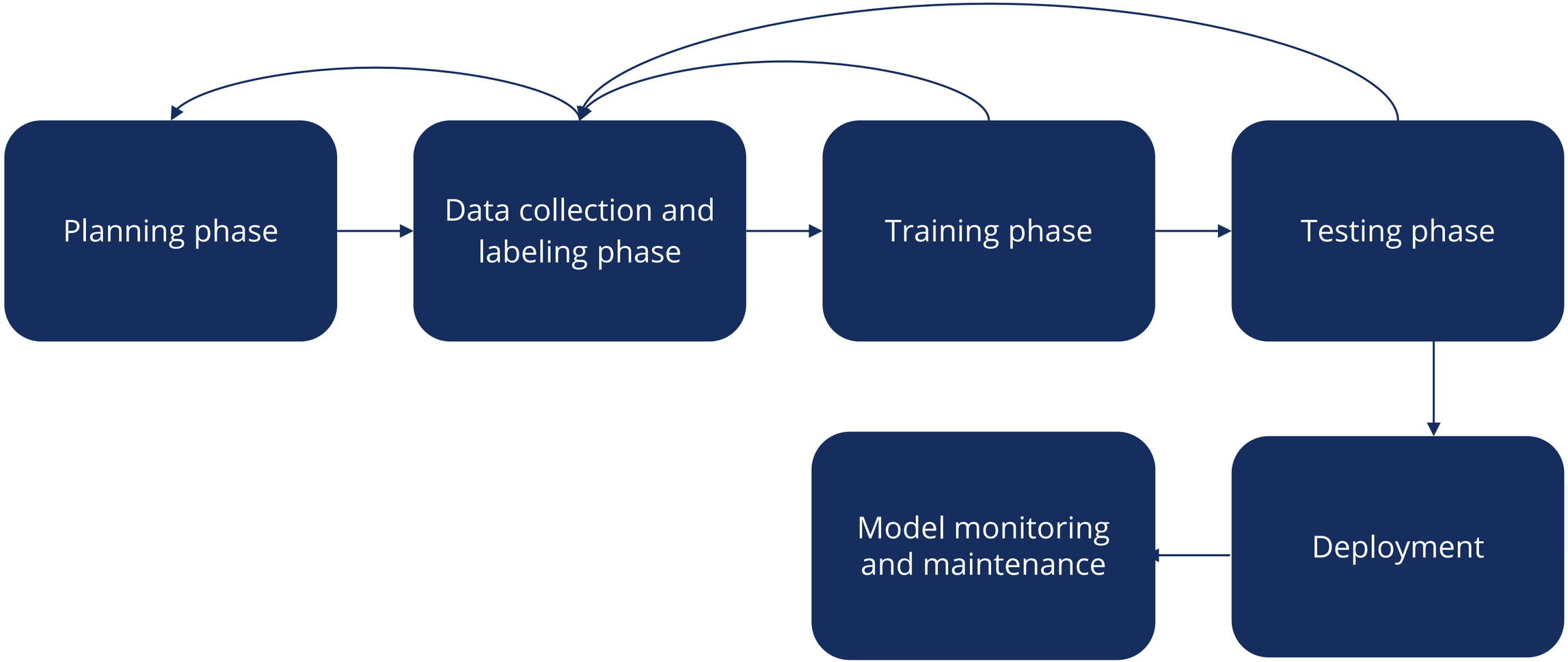
Two main features of PyTorch are:

- Tensor computing libraries like NumPy offer powerful GPU acceleration capabilities.
- A tape-based automatic differentiation system computes the numerical derivative of a function defined by a computer program.

Lifecycle of a Deep Learning Project

Deep Learning Lifecycle

It is a cyclical process consisting of the following four main phases:



Planning Phase

A DL project starts with the planning phase.

During this phase:

- Viability of the project is determined
- Goals are set
- Resources for the projects are planned

Data Collection and Labeling Phase

After the planning phase, the data collection and labeling phase gets initiated.

This phase involves:

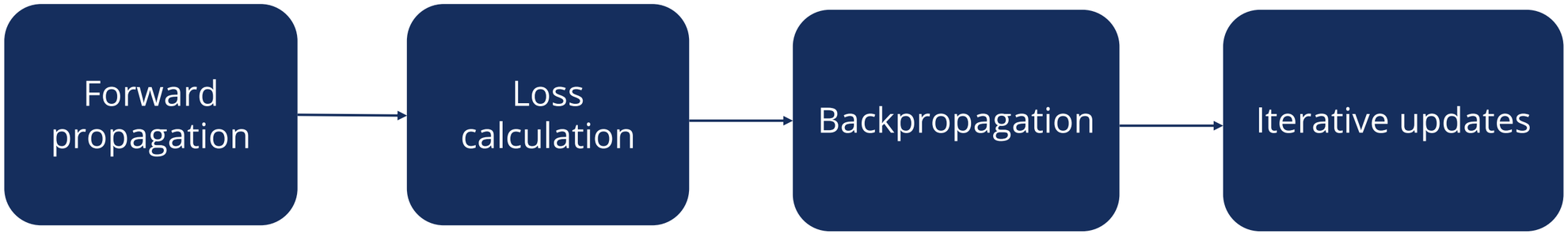
Setting up data capturing devices

Deciding how to label the collected data

If collecting or labeling data proves to be challenging, the project reverts to the planning phase to devise a more effective approach.

Training Phase

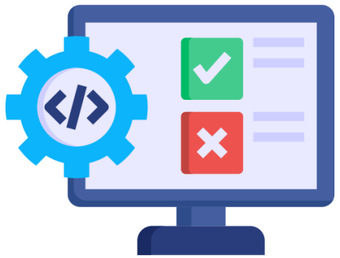
Once the collected data gets labeled, the project then moves to the training phase.



During Deep Learning training, the model learns from data by iteratively adjusting its parameters through forward and backward propagation. This minimizes errors and enhances predictions.

Training Phase

The chosen models are implemented and debugged.



The model's performance gets tested

The model undergoes continuous improvement until all the requirements are fulfilled.

Training Phase

Projects may revisit the data collection phase for the following reasons:

- Insufficient data leading to overfitting
- Improper labeling causing inaccurate or unreliable outcomes

Once the model achieves satisfactory results, it is deployed for production.

Testing Phase

In this phase, evaluate the trained model on unseen data, and analyze the results for improvement.

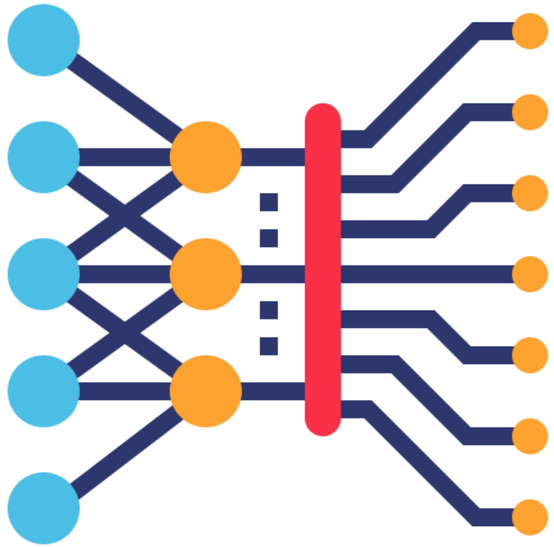
Tests are conducted on the model to compare the results with the planned success metrics and decide on whether to deploy the model or not.

In this phase, every process is recorded and versioned to maintain quality and reproducibility to ensure that its performance can be easily fixed if it degrades during production

The goal is to make the necessary adjustments or fixes to restore the model's performance to the desired level.

Deploying Phase

In this phase, the model is deployed into production for real-time use.



The end goal of this phase is the proper functionality of the model after deployment.

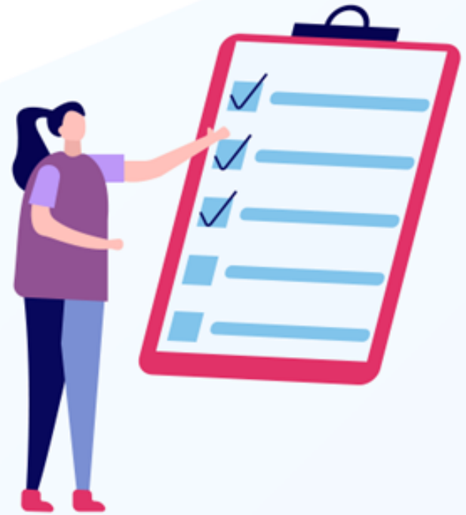
Model Monitoring and Maintenance

After deploying the model to production continuously check the model’s performance as it interacts with real-world data

Ensure ongoing model efficacy by being ready to retrain with new datasets or adjust the model parameters should there be a decline in performance

Key Takeaways

- Deep Learning (DL) is a specialized form of ML that uses artificial neural networks to solve complex problems.
- DL is well-suited for handling unstructured data due to its ability to extract complex features and handle greater complexity compared to machine learning.
- Deep Learning models require large amounts of data to learn different patterns and are more computationally intensive.
- A DL project life cycle consists of four main phases: planning, data collection and labeling, training, and testing and deploying.



Knowledge Check

Knowledge Check

1

What is an artificial neural network?

A. It is a computing system made up of several simple, highly interconnected processing elements called neurons.

B. It is a system that uses machine learning to solve complex problems.

C. It is a programming language used to write Deep Learning algorithms.

D. It is a system that uses artificial intelligence to solve complex problems.

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The correct answer is **A**

It is a computing system made up of several simple, highly interconnected processing elements called neurons.

Knowledge Check

2

What kind of hardware is required to train Deep Learning models?

A. Low-end CPU with minimal RAM

B. High-end CPU with sufficient RAM

C. Good quality GPU with sufficient RAM

D. Specialized hardware like ASICs or TPUs

Knowledge Check 2

What kind of hardware is required to train Deep Learning models?

A. Low-end CPU with minimal RAM

B. High-end CPU with sufficient RAM

C. Good quality GPU with sufficient RAM

D. Specialized hardware like ASICs or TPUs

The correct answer is **C**

A good quality GPU with sufficient RAM is required to train Deep Learning models as it is computationally intensive and works on a large amount of data to learn different patterns.

Knowledge Check

3

What are some popular Deep Learning frameworks?

A. TensorFlow, Keras, and PyTorch

B. MATLAB, R, and Octave

C. Spark, Hive, and Hadoop

D. None of the above

Knowledge Check 3

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B. MATLAB, R, and Octave

C. Spark, Hive, and Hadoop

D. None of the above

The correct answer is **A**

TensorFlow, Keras, and PyTorch are the popular Deep Learning framework.

Thank You