A03 - Neural Network Zoo

Deep Learning Artificial Intelligence (ITAI-2376)
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1. Introduction to Neural Networks

i. What is Neural Network & Deep Learning

Neural networks and deep learning are key concepts in the field of artificial intelligence (AI), especially in tasks involving pattern recognition, image analysis, natural language processing, and more.

a. Neural Network:

A neural network is a machine learning model that makes decisions in a way that resembles the human brain, using processes that imitate how biological neurons collaborate to recognize patterns, evaluate possibilities, and reach conclusions. They consist of layers of interconnected "neurons" or nodes that process input data, identify patterns, and make decisions. Each connection has an associated weight, which adjusts as the network learns from data, improving its predictions or classifications over time.

b. Deep Learning:

Deep Learning is a subset of machine learning that uses neural networks with many layers, hence the term "deep", to model complex patterns in large datasets. Deep learning utilizes representation learning, also known as feature learning, to map input features (comparable to predictor variables in traditional statistics) to an output. This mapping takes place across multiple interconnected layers, each consisting of numerous neurons. Each neuron acts as a mathematical processing unit, and together, they are designed to learn the relationship between the input features and the output.

These deep neural networks are capable of automatically learning hierarchical features, which makes them particularly powerful for solving problems that are difficult to program manually, such as recognizing faces in photos or translating languages.

ii. Structure of Neuron

Artificial Neural Networks (ANNs) are composed of artificial neurons, also known as units, which are organized into layers that together form the complete network. Each layer can contain anywhere from a few units to millions, depending on the complexity required to detect patterns within the data.

Typically, an ANN consists of three types of layers, that are as follows:

1. **Input layer** - The input layer receives raw data from the external environment, which the network needs to process or learn from

2. **Hidden layers** – The data from input layers is then passed through the hidden layers, where it is transformed into representations that are more meaningful for prediction
3. **Output layer** - Finally, the output layer produces the network's response or result based on the input data.

In most neural networks, units are interconnected across layers, with each connection assigned a weight that determines how much one unit influences another. As data flows through these connections from one unit to the next, the network gradually learns patterns and relationships within the data, ultimately producing an output from the output layer.

In biological neurons, activation refers to the firing of the neuron, which occurs when incoming signals are strong enough to exceed a certain threshold. In artificial neural networks, this concept is represented by an **Activation Function**, a mathematical function that transforms the input into an output, effectively determining whether and how a neuron should activate.

2. The Zoo Concept

i. Neural Network Zoo:

The Neural Network Zoo is a visual metaphor and educational tool in Artificial Intelligence (AI) that illustrates the wide variety of neural network architectures. Similar to a zoo where each animal represents a different species, this concept portrays each type of neural network as a unique "creature," making it easier to compare their structures, understand their distinct features, and grasp their specific uses. Just like animals vary in form and function, neural networks come in many shapes and are designed to handle specific tasks, from image recognition to time series prediction.

ii. Create a visual chart or a set of cards with different neural network "animals"

Neural Network Type	Animal	Description
Convolutional Neural Network (CNN)	Cheetah	Fast and precise, CNNs excel at spotting patterns in images and visual data.
Recurrent Neural Network (RNN)	Raccoon	Curious and adaptable, RNNs handle sequences, remembering recent information to inform outputs.
Long Short-Term Memory (LSTM)	Lemur	Wise and attentive, LSTMs remember important details over long sequences, improving RNNs.
Generative Adversarial Network (GAN)	Chameleon	Creative and ever-changing, GANs generate new data by competing networks refining each other.

Autoencoder	Squirrel	Efficient and resourceful, autoencoders compress data and reconstruct it with minimal loss.
Feedforward Neural Network (FNN)	House Cat	Simple and reliable, FNNs pass information straightforwardly for basic classification tasks.
Transformer	Owl	Intelligent and far-sighted, Transformers excel at processing sequences in parallel, like language.

3. Interactive Activity:

i. Choose a "neural network animal".

The animal selected for this activity is CNN - Cheetah

ii. Research one different type of network, understand its structure, how it works, and its typical applications.

a. What is CNN?

Convolutional Neural Networks (CNNs) stand out from other neural network types due to their exceptional performance with image, speech, and audio signal data. They are composed of three main types of layers:

a) Convolutional Layer
b) Pooling Layer
c) Fully Connected (FC) Layer

The convolutional layer is typically the first in the network and may be followed by additional convolutional or pooling layers. The fully connected layer comes at the end, serving as the final step before output. As data moves through each layer, the network gradually increases in complexity. Early layers detect basic features like edges and colors, while deeper layers learn to recognize larger patterns or shapes. By the final layers, the network can interpret high-level features and accurately identify the object in the input data.

b. Structure of CNN

Key components of CNN structure is as follows:

a) Input Layer - Example: A 28x28 pixel grayscale image becomes a 28x28 matrix of values.
b) Convolutional Layers - These are the CNN's "eyes." They use filters (also called kernels) to scan over the image and extract features like edges, textures, or shapes. Each filter creates a feature map that highlights specific patterns.

c) Activation Function (usually ReLU) - Adds non-linearity, allowing the network to learn complex patterns.
d) Pooling Layers (often Max Pooling) - Downsamples feature maps to reduce dimensionality while keeping the most important information.
e) Like how a cheetah focuses only on key movement in its surroundings, ignoring background noise.
f) Fully Connected (Dense) Layers - Flatten the features and make a final prediction (e.g., this image is a "cat").
g) Output Layer - Produces the final classification or decision (e.g., label, probability).

c. How CNN Works

a) See: The CNN takes an image and breaks it into parts using convolutional filters.
b) Focus: Pooling helps it zoom in on the most important features.
c) Understand: Deeper layers combine low-level features (edges) into high-level concepts (shapes, objects).
d) Decide: The final layers use this understanding to classify or interpret the image.

d. Application of CNN

a) Marketing: Social media platforms use image recognition to suggest potential tags for people in uploaded photos, making it easier for users to identify and tag friends.
b) Healthcare: In medical imaging, computer vision assists radiologists by enhancing the detection of cancerous tumours within otherwise healthy tissue.
c) Retail: Some e-commerce platforms offer visual search features, enabling users to find and receive product recommendations such as clothing items that match or complement existing outfits.
d) Automotive: Although fully autonomous vehicles are still in development, computer vision technology is already enhancing vehicle safety with features like lane detection and advanced driver assistance systems (ADAS).

4. References:

1. What is a neural network? IBM, 06 October 2021[What is a Neural Network? | IBM]
2. Georgevici, A.I., Terblanche, M. Neural networks and deep learning: a brief introduction. *Intensive Care Med* **45**, 712–714 (2019). https://doi.org/10.1007/s00134-019-05537-w [Neural networks and deep learning: a brief introduction | Intensive Care Medicine]
3. Artificial Neural Networks and its Applications, 04 Apr, 2025 [https://www.geeksforgeeks.org/artificial-neural-networks-and-its-applications/]