Deep learning applications

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Chaima ahlem karima djellab
MCB
Faculty Of economics management and financial sciences
Chaima-ahlem-karima.djellab@univ-annaba-dz

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Objectives

By the end of this course, students will be able to

1. Remember: Identify and define key deep learning concepts, functions, and architectures.
2. Understand: Explain differences between ML and DL, and interpret how neural networks operate.
3. Apply: Implement deep learning models using Keras and TensorFlow for real datasets.
4. Analyze: Compare and evaluate different models, and diagnose issues such as overfitting.
5. Evaluate: Justify model choices and optimization techniques with evidence.
6. Create: Design and develop innovative deep learning applications and research projects.

Introduction

This course introduces the fundamentals and applications of deep learning with a focus on economics and management. Students will learn to build and evaluate neural network models using TensorFlow and Keras, and apply them to real-world tasks such as prediction, classification, and time series analysis.

I Prerequirese

To successfully follow this course, students should have:

1. Mathematics & Statistics**:** Basic knowledge of linear algebra (matrices, vectors), probability, and statistics.
2. Programming Skills: Familiarity with Python programming (variables, loops, functions, libraries).
3. Machine Learning Basics: Understanding of supervised and unsupervised learning, regression, and classification.
4. Data Handling: Ability to use libraries such as NumPy, Pandas, and Matplotlib for data preprocessing and visualization.
5. English Reading Skills: Ability to read and understand scientific material in English (documentation, research papers).

The following test is designed to assess your prerequisites.

Quiz 1

A probability of 0.8 means the event is

A Very likely

B Random

C Very unlikely

D Impossible

Quiz 2

In a dataset, the *median* represents:

A The largest number

B The smallest number

C The middle value

D The total sum

Quiz 3

If a dataset contains “Client Name, Invoice Amount, Payment Date”, it is

- **A** Unstructured data
- **B** Structured data
- **C** Random data
- **D** Noise

Quiz 4

In Excel, a “function” is used to

- **A** Enter text
- **B** Perform a specific calculation
- **C** Draw images
- **D** Translate data

II Unit One: General Overview of deep learning

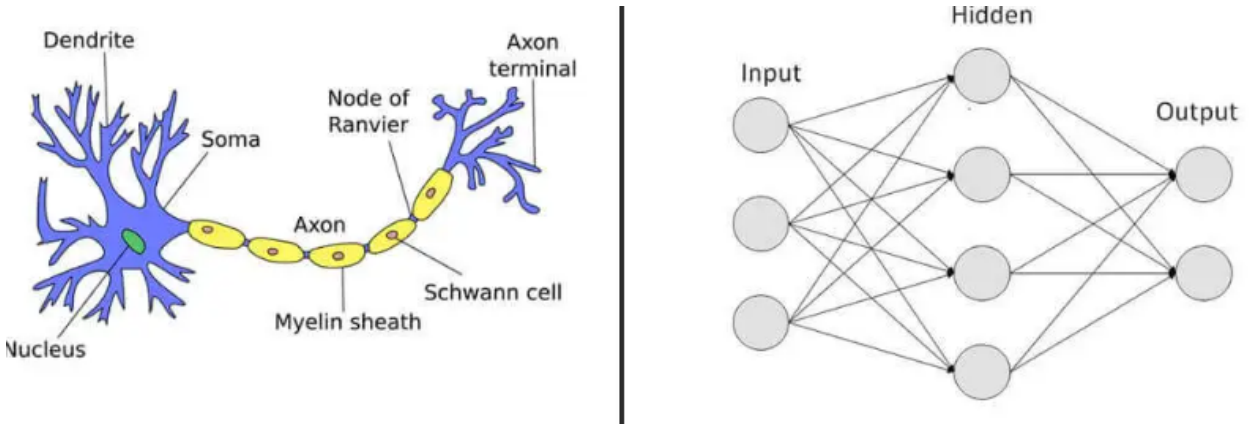
1. Introduction

Artificial Intelligence (AI) is a branch of computer science that focuses on creating systems capable of performing tasks that normally require human intelligence. These tasks include reasoning, learning, problem-solving, understanding language, and perception. AI does not refer to a single technology but to a collection of methods that allow computers to analyze data, make decisions, and improve over time.

One important part of AI is *Deep Learning*, which uses artificial neural networks to process large amounts of data and discover hidden patterns. In accounting and taxation, deep learning can be used to automate tasks such as invoice processing, fraud detection, financial forecasting, and tax analysis. By using deep learning, organizations can save time, reduce errors, and improve the accuracy of their financial reports.

2. What the deep learning concept ?

Deep Learning is a branch of Artificial Intelligence (AI) and Machine Learning (ML) that focuses on teaching computers to learn from data using structures called *artificial neural networks* as presented in figure 01. These networks are inspired by the human brain and are made of layers of "neurons" that can recognize patterns and make decisions.



Unlike traditional machine learning, where humans must select the features or rules to analyze data, deep learning models can automatically discover these features by themselves. This is possible because they use many layers of processing — that is why we call it **"deep"** learning.

Deep learning can handle very large and complex data such as images, sounds, texts, or financial records. It becomes more accurate as it processes more data. For example, in accounting and taxation, deep learning can be used to analyze financial statements, detect anomalies, or predict future trends based on historical data.

In simple terms, deep learning allows computers to *learn from experience*, just like humans, but on a much larger scale and at a much faster speed.

2.1. Artificial intelligence

Artificial Intelligence (AI) is the field of computer science that focuses on creating machines and systems capable of performing tasks that normally require human intelligence. These tasks include understanding language, recognizing images and sounds, solving problems, learning from data, and making decisions.

AI systems use algorithms and data to simulate human thinking and behavior. The goal of AI is not only to automate simple tasks but also to help humans make better and faster decisions. Examples of AI include virtual assistants, chatbots, fraud detection systems, and financial forecasting tools.

In summary, Artificial Intelligence enables computers to *think, learn, and act intelligently* in various domains such as business, healthcare, accounting, and taxation.

2.2. Machine learning

Machine Learning (ML) is a branch of Artificial Intelligence (AI) that allows computers to learn from data without being explicitly programmed. Instead of following fixed instructions, a machine learning system analyzes large amounts of data, finds patterns, and uses these patterns to make predictions or decisions.

For example, in accounting and taxation, a machine learning model can learn from past financial records to detect unusual transactions or predict future expenses. The more data the system receives, the more accurate its predictions become.

In simple terms, machine learning teaches computers to improve their performance automatically through experience, just like humans learn from practice.

2.3. Deep learning VS Machine learning

Deep Learning is a subfield of Machine Learning, and both are key parts of Artificial Intelligence (AI). They share the same goal: enabling computers to learn from data and make decisions without direct human instructions. However, they work in different ways.

In traditional Machine Learning, humans need to select and prepare the features (the important information) that the algorithm will use to make predictions. For example, to predict a company's financial risk, a machine learning system might use features such as revenue, expenses, and profit margin — all chosen by a human expert. The algorithm then learns from these features to make decisions.

Deep Learning, on the other hand, can automatically discover the right features by itself. It uses artificial neural networks with many layers that process data in stages, just like the human brain. These layers allow the system to learn complex and abstract patterns from raw data — such as recognizing a face in an image or identifying fraud in a large set of accounting records.

The main advantage of Deep Learning is its ability to handle *big data* and to improve accuracy as more data is provided. However, it also requires more computing power and training time compared to traditional machine learning models.

In summary, Machine Learning relies more on human guidance, while Deep Learning learns automatically from large and complex data using deep neural networks.

2.4. Deep learning application in management and economics field

Deep Learning plays a growing and essential role in both economics and management. It allows organizations to analyze large volumes of data, detect patterns, forecast trends, and support decision-making processes that were previously difficult to perform with traditional methods. Economic and business environments generate massive amounts of data daily — from financial transactions and market prices to customer feedback and operational logs. Deep Learning helps process this information automatically and extract actionable insights, enabling faster and more accurate strategic decisions.

Below are the main domains of application, presented in detail with concrete examples.

a) Macroeconomic Forecasting and Policy Analysis

Deep Learning models, such as Recurrent Neural Networks (RNN) and Long Short-Term Memory (LSTM) networks, are increasingly used to predict macroeconomic indicators like GDP, inflation, and unemployment. These models can process massive datasets, including historical economic statistics, satellite imagery, and textual data from news or social media, allowing policymakers to simulate the impact of different policy scenarios or external shocks.

The study "Deep Learning Models For Inflation Forecasting" applied a hybrid VAE-ConvLSTM model on 134 monthly US economic series. The model outperformed traditional econometric techniques in predicting inflation trends. (hedibert.org, 2023[1])

b) Financial Risk Analysis, Asset Pricing & Trading

In finance, Deep Learning is widely applied to detect hidden patterns in market data, predict stock prices, assess credit risk, and automate trading decisions. Models such as Bi-LSTM or Deep Reinforcement Learning (DRL) allow firms to respond dynamically to market changes, optimize investment portfolios, and reduce exposure to risk. These models process high-dimensional financial data more efficiently than traditional methods.

Forecasting Stock Prices via Deep Learning During COVID-19 used Bi-LSTM models to predict Turkish stock prices before and after the pandemic, demonstrating improved prediction accuracy compared to traditional models. (ejtas.com, 2023[2])

c) Business Management & Decision Support (Operations, Process, Supply Chain)

Deep Learning enhances managerial decision-making by predicting operational outcomes, identifying bottlenecks, and optimizing supply chains and business processes. Neural networks can analyze historical process logs, sales data, and operational metrics to provide managers with actionable insights, helping them allocate resources efficiently and improve overall productivity.

The study "Predicting Process Behaviour using Deep Learning" applied RNNs to real business process logs to predict subsequent process events, enabling better operational planning and risk management. (arxiv.org, 2016[3])

d) Marketing, Customer Analytics & CRM

Deep Learning allows organizations to analyze customer behavior in detail, segment markets, predict churn, and personalize marketing campaigns. Models such as CNNs and NLP networks can process clickstream data, transaction histories, reviews, and social media content to provide precise insights into consumer preferences and behavior.

Deep Learning for Customer Churn Prediction in E-Commerce Decision Support" used deep neural networks to predict which customers were likely to leave, allowing the company to implement proactive retention strategies. (tib-op.org, 2023[4])

1. https://hedibert.org/wp-content/uploads/2023/03/theoharidis-guillen-lopes-2023.pdf?utm_source=chatgpt.com
2. https://ejtas.com/index.php/journal/article/view/646?utm_source=chatgpt.com
3. https://arxiv.org/abs/1612.04600?utm_source=chatgpt.com
4. https://www.tib-op.org/ojs/index.php/bis/article/view/42?utm_source=chatgpt.com

e) Accounting, Auditing & Financial Compliance

In accounting and auditing, Deep Learning models detect anomalies, automate auditing processes, and enhance compliance monitoring. By analyzing invoices, contracts, and financial statements, these models reduce human errors and accelerate fraud detection, providing more reliable financial reporting.

Enhancing fraud detection in accounting through AI: Techniques and case studies demonstrated how deep learning can detect unusual patterns in corporate financial data, improving audit efficiency and accuracy. (fepbl.com, 2024[5])

f) Sustainable Business & Economic Planning

Deep Learning supports sustainable business strategies by integrating macroeconomic, environmental, and social data. It helps companies monitor resource usage, predict environmental impact, and align operations with sustainable development goals while considering broader economic trends.

Application of Machine Learning Algorithms for Sustainable Business Management Based on Macro-Economic Data used machine learning models (including deep learning approaches) to analyze sustainability metrics alongside economic indicators, helping firms plan strategies aligned with both profitability and sustainability. (mdpi.com, 2022[6])

5. https://www.fepbl.com/index.php/farj/article/view/1232?utm_source=chatgpt.com
6. https://www.mdpi.com/2071-1050/14/16/9964?utm_source=chatgpt.com

Conclusion

Deep Learning has emerged as a transformative technology in both economics and management. By enabling the analysis of massive and complex datasets, it allows organizations, financial institutions, and governments to make more informed, data-driven decisions. Across multiple domains — from macroeconomic forecasting and financial risk management to marketing, operations, accounting, and sustainability planning — deep learning has demonstrated its ability to uncover hidden patterns, predict trends, and automate complex tasks.