Machine Learning (ML) Basics

- **Machine Learning (ML):** A **subset of AI** used to build **logical models**.
    - In business environments:
        - **Exploratory analysis** with **Jupyter Notebooks**.
        - **Graphical interfaces (GUIs)** for **pipeline management**.
- **Models:**
    - Trained using **labeled or unlabeled datasets**.
    - Consist of:
        - **Parameters:** Adjustable values.
        - **Structure:** Neural networks, decision trees, etc.

Data Splitting for Model Training

- **Training Set (60%-80%)**
    - Provides **input data** to train the model.
    - Must contain the **correct output (target variable)**.
- **Validation Set (10%-20%)**
    - Used to **evaluate and fine-tune** the model during training.
    - Does **not** adjust the model's parameters.
    - Helps **measure accuracy**.
- **Test Set (10%-20%)**
    - Evaluates **final model performance** on unseen data.
    - Kept separate from training and validation to **prevent bias**.

Data Formats in ML

- **Structured Data:** Stored in **relational databases**.
- **Unstructured Data:** Includes **text, images, audio, video, etc.**
- **Labeled Data:** Contains **additional metadata (categories or classes)** for each instance. Essential for **supervised learning**.
- **Unlabeled Data:** No assigned categories or labels. Used in **unsupervised learning**.

Supervised Learning

- **Definition:** ML technique where a model is trained on **labeled datasets**.
- **Main Approaches:**
    - **Classification:** Assigns labels to inputs based on training data.
        - **Confidence Score:** Probability of a correct classification.
        - **Use Cases: Spam detection, image classification**.
    - **Regression:** Predicts **continuous values** from labeled training data.
        - Estimates the **relationship between independent variables** and the **dependent variable (target variable)**.
        - **Use Cases: Price prediction**.
- **Types of Classification:**
    - **Binary Classification:** Two possible outputs (e.g., **"Yes/No"**, **"Class A/Class B"**).

Unsupervised Learning

- **Definition:** Discovers **hidden patterns and structures** in **unlabeled data**.
- **Main Techniques:**
    - **Clustering:** Groups data into **clusters** based on **similar features**.
        - **Use Cases: Customer segmentation, image grouping**.
    - **Dimensionality Reduction:** Simplifies large datasets by **reducing the number of features** and removing noise.
        - **Use Cases: Data visualization**.

Reinforcement Learning (RL)

- **Definition:** A model (agent) learns by interacting with an **environment** through **trial and error**.
- **RLHF (Reinforcement Learning from Human Feedback):**
    - Adjusts models based on **human-provided feedback**.

Model Performance & Error Analysis

- **Overfitting:** A model **fits the training data too well**, leading to **poor generalization** on new evaluation data.
- **Underfitting:** A model is **too simplistic**, failing to capture patterns in the data, resulting in **poor performance even on training data**.

Bias & Variance Trade-off

- **Bias (Underfitting):**
    - Error caused by **overly simple assumptions** in the model.
    - Leads to **underfitting** (fails to capture patterns).
    - **Solution:** Increase model complexity.
- **Variance (Overfitting):**
    - Error caused by **high sensitivity to small variations** in the training data.
    - Occurs when a model is **too complex** and **memorizes training data instead of generalizing**.
    - **Solution:** Simplify the model, apply **regularization**, or **increase training data**.

Feature Engineering

- **Definition:** The process of **transforming and creating new features** from existing data to **improve model performance**.
- **Techniques include:**
    - **Normalization & Scaling**
    - **Handling missing values**
    - **Encoding categorical variables**

Deep Learning (DL)

- **Definition:** A subset of **Machine Learning (ML)** that uses **multiple layers of neurons** to model complex data.
- **Requires large datasets** and is widely used for **image and speech recognition**.
- **Neural Networks Structure**
    - **Neurons (Nodes):**
        - Each neuron **receives inputs**, processes them, and produces an **output**.
        - Neurons **communicate** with each other, passing or blocking information to the next layer.

    - **Layers:**
        - **Input Layer**
        - **Hidden Layers:** One or more layers that handle most of the **processing and learning**.
        - **Output Layer**
- **Types of Neural Networks**
    - **Convolutional Neural Networks (CNNs):** Designed for **grid-structured data**, such as **images**.
    - **Recurrent Neural Networks (RNNs):** Designed for **sequential and time-series data** (e.g., **text, video, and speech**).
        - Uses **loops in its architecture** for **self-feedback**.
        - Useful for tasks with **variable-length inputs and outputs**, such as **language translation**.

Classification Metrics

- **Confusion Matrix:** A tool to evaluate classification performance, displaying results in four categories:
    - **True Positives (TP), False Positives (FP), True Negatives (TN), False Negatives (FN)**.
- **Precision:** Measures how many positive predictions were correct.
    - Formula: **TP / (TP + FP)**.
- **Accuracy:** Measures the overall correctness of predictions.
    - Formula: **(TP + TN) / (TP + TN + FP + FN)**.
- **AUC-ROC (Area Under the Curve - Receiver Operating Characteristic):**
    - Measures a model's ability to distinguish between classes in **binary classification**.
    - **ROC Curve:** Plots **True Positive Rate (Sensitivity) vs. False Positive Rate**.
    - **AUC Values:**
        - **1.0** = Perfect classifier.
        - **0.5** = No classification power (**random guess**).
    - Useful for comparing **multiple classification models**.

Regression Metrics

- **Mean Squared Error (MSE):**
    - Measures how well a model predicts **continuous values**.
    - Penalizes **large errors more heavily**.
    - **Example:** Predicting house prices—large prediction errors for **expensive houses** have a **greater impact on MSE**.

Automated Machine Learning (AutoML)

- **Definition:** Automates the **training and selection of ML models**.
- **Capabilities:**
    - Automatically **chooses the best algorithm** for tasks like **classification and regression**.
    - **Optimizes hyperparameters** without manual intervention.
    - **Preprocesses data**, handling **cleaning and transformation** automatically.

Machine Learning Designer

- **Visual interface** for creating **machine learning models without coding**.
- **Drag-and-drop components** to build workflows.
- **Allows preprocessing, training, and evaluation** within a single interface.

- **Key Features:**
    - **Modules:** Split Data, Join Data, Select Columns in Dataset, Add Rows.
    - **Important Parameters:** Access Token, Model Name, REST Endpoint Name.
    - **Supported Languages: Python and R**.

Azure AI Vision (formerly Azure Computer Vision)

- **Focuses on enabling AI to identify and understand objects, people, and text in images and videos**.
- **Capabilities:**
    - **Image Classification:** Automates **categorization and labeling** of elements in images.
    - **Optical Character Recognition (OCR):** Converts printed documents into **editable and searchable text**.
    - **Face Detection & Analysis:** Identifies and verifies individuals in **images and videos**, analyzing facial expressions for **emotion recognition**.
    - **Object Detection:** Identifies and **locates objects in images and videos** in real-time.
    - **Image Analysis:** Extracts **detailed information** from images, including objects, faces, text, and inappropriate content.
    - **Dense Captions:** Generates **sentence-level descriptions** for up to **10 regions** in an image.
    - **Captions:** Provides a **general description** of an image.
    - **Face:** Detects and analyzes **faces in images**.
    - **Video Analysis:** Analyzes **video content**.
    - **Spatial Analysis:** Detects the **presence and movement** of people in video feeds.
- **Custom Vision**
    - **Allows training custom AI models** using user-provided images.
    - **Supports both image classification and object detection** within the same platform.
    - **Can detect multiple objects in an image**, each with a **bounding box**.

Natural Language Processing (NLP)

- **AI branch focused on enabling computers to understand, interpret, and generate human language**.
- **Key NLP Techniques:**
    - **Tokenization:** Splits text into **words, phrases, or linguistic units** (e.g., ["The", "cats"]).
    - **Lemmatization & Stemming:** Reduces words to their **base or root form** (e.g., ["the", "cat"]).
- **Use Cases of NLP:**
    - **Virtual Assistants:** Siri, Alexa, and other AI-powered assistants interpret and respond to user queries.
    - **Sentiment Analysis:** Determines the **emotion or sentiment** expressed in text.
    - **Machine Translation: Automatically detects and translates languages**.
        - When **language detection is uncertain**, the confidence score is **NaN**.

Azure AI Language (NLP Services)

- **Provides advanced NLP capabilities** to process and analyze text.
- **Features:**
    - **Named Entity Recognition (NER):** Identifies specific elements like **names, locations, and organizations**.
    - **Personally Identifiable Information (PII) & Protected Health Information (PHI) Detection.**
    - **Sentiment Analysis:** Classifies text as **positive, negative, or neutral**.
    - **Language Detection:** Returns the **language name, confidence score, and ISO 639-1 code**.
    - **Key Phrase Extraction:** Identifies **main topics and concepts** for categorization.
    - **Custom Text Analytics:** Enables domain-specific text analysis.

Azure AI Speech

- **Speech-to-Text (STT):** Converts **spoken language into written text**.
- **Text-to-Speech (TTS):** Generates **natural-sounding speech** from text.
- **Speaker Recognition:** Identifies speakers **based on voice characteristics**.

Azure AI Translator

- **Cloud-based neural machine translation service** for multilingual applications.

Knowledge Mining

- **Extracts structured information** from **large volumes of unstructured data**.

Azure AI Document Intelligence (formerly Form Recognizer)

- **Recognizes and extracts text, layout, and key-value pairs from documents and forms**.
- **Not to be confused with Azure AI Vision OCR.**
- **Use Case:** Locating a **product image within a product catalog**.

Azure AI Search

- **Advanced search platform combining traditional search and generative AI capabilities**.
- **Extracts insights from structured, semi-structured, and unstructured documents**.
- **Does not support conversational queries**.

Generative AI (GenAI)

- **AI field that creates new content**, including:
  - **Chatbots & Virtual Assistants**
  - **Image Generation**
  - **Code Generation**
  - **Music Composition**
- **Foundation Models (FM)**
  - **GPT (OpenAI)** – Text generation.
  - **DALL-E (OpenAI)** – Image generation.
- **Large Language Models (LLMs)**
  - **Advanced AI models designed to understand, generate, and interact with human language**.
  - **Generate content based on user inputs (prompts)**.
  - **Non-deterministic** – Same input may produce different outputs.
- **Azure OpenAI Service**
  - **Provides access to OpenAI's language models**, including **GPT-4**.
  - **Allows fine-tuning models** for specific tasks or datasets.
- **OpenAI Studio**
  - Requires **REST Endpoint and Authentication Key**.

OpenAI Codex

- **AI model specialized in code generation**.
- **Understands natural language and generates code accordingly**.

Azure AI Bot Service

- **Platform for building and publishing bots**.
- **Supports integration with websites, Microsoft Teams, Facebook, and other platforms**.

Azure Conversational Language Understanding (CLU)

- **Identifies user intents and extracts key information from natural language input**.
- **Allows training models tailored to specific business domains**.
- **Optimized for industry-specific tasks, enhancing model accuracy and performance**.
- **Enables AI-driven applications, such as chatbots and virtual assistants**.

Responsible AI Standards

- Microsoft follows ethical AI principles to ensure **fairness, security, and transparency**.
- **Key Principles:**
    - **Fairness:** Ensures **equal treatment** for all users.
    - **Reliability & Security:** Protects against **failures and vulnerabilities** while ensuring accurate results.
    - **Privacy & Security: Data confidentiality** and prevention of unauthorized access.
    - **Inclusion: Designing AI systems accessible to diverse users and contexts**.
    - **Transparency:** Explains **how AI models work**, making them understandable for users.
    - **Accountability:** Implements **ethical AI governance frameworks**.