ARTIFICIAL INTELLIGENCE (AI)

in Industry 4.0

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What is AI?

- Simulates Human intelligence
- Solves Problems autonomously
- Key Driver of Industry 4.0

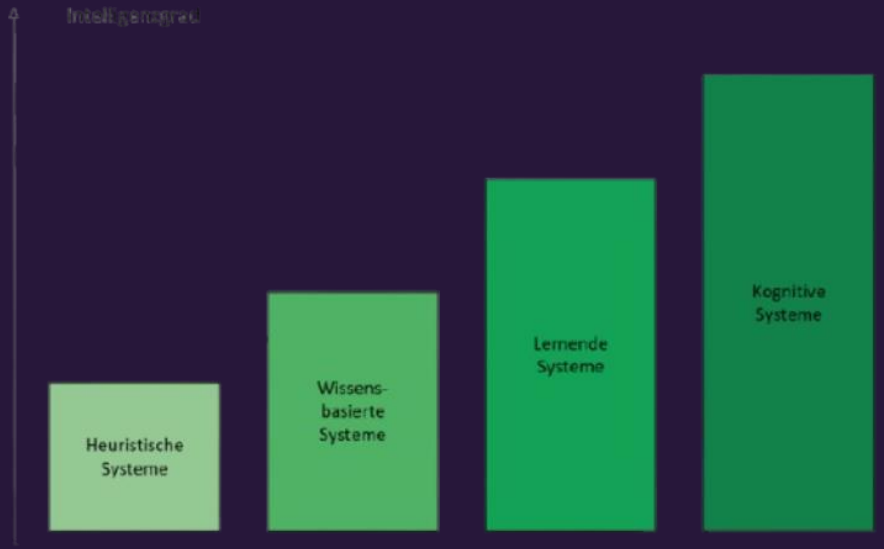
“Computers perform tasks humans are better at”

Intelligence:
Independence / Efficiency / Complexity

History of AI

History began in 1950: Alan Turing -> Turing Test

4 Phases



AI in Industry 4.0

- Digitalization and Automation
- AI as the central technology

Enables:

- Data Analysis
- Autonomous decisions
- Process optimization

Result: Smart, self-optimizing production

Industrial Applications

- Predicitive maintenance
- Intelligent robotics
- Supply chain optimization
- Automated quality control

Examples:

- Smart Factory (Siemens/Bosch)
- AI logistics (Amazon)
- Autonomous driving (Tesla, Waymo)

Machine Learning

- Learns from data
- No explicit programming

Training data → **Model building** → **Validation & testing**

Goal:

- Pattern recognition
- Predictions

Types of Machine Learning

- **Supervised Learning** -> Input + known Output
- **Unsupervised Learning** -> Pattern detection
- **Reinforcement Learning** -> Learning by reward

Applications:

- Face recognition
- Recommendation systems
- Medical diagnosis
- Financial Forecasting

Deep Learning

- Subfield of Machine Learning
- Based on neural networks
- Uses large datasets

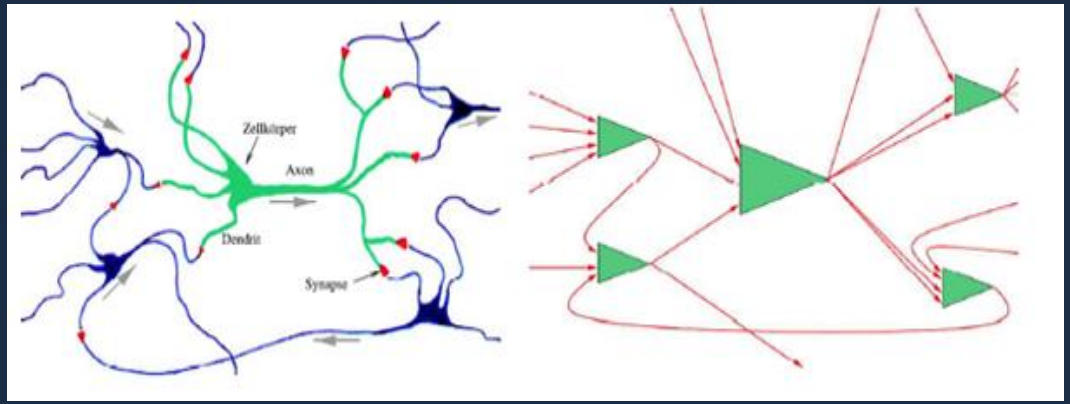
Characteristics:

- Automatic feature learning
- High accuracy
- Self-improving systems

Image recognition / Voice assistant / Generative AI

3.6 Neural Networks

From biological inspiration to artificial intelligence



3.6 Neural Networks — Biological Basis

Origin: Neural networks are networks of nerve cells in the brain of every living being, providing complex interconnections and adaptability.

Natural Neuron: A single neuron has many inputs (synapses). When a threshold is reached, it transmits a signal via the axon.

AI Principle: Artificial neural networks take nature as their model — simplified and arranged in layers for computational purposes.

Layers: Input layer → Hidden layers → Output layer. Each layer transforms features at increasing levels of abstraction.

3.6 Neural Networks — Image Recognition

Example: An image with 128 pixels depicting a cat: all 128 pixels connect to neuron inputs. Each neuron has 4 inputs → 32 neurons in the first layer.

Weights: Each pixel has a different weight (edge vs. center). Weights and thresholds are two key parameters per neuron.

Layers: A second layer of 8 neurons (4 inputs each) follows. Successive layers increase abstraction until 'cat' is output.

Training: Parameters are adjusted via supervised machine learning until every cat image is correctly recognized.

3.6 Neural Networks — Deep Learning

Deep Learning: Uses many intermediate layers to continuously create new representations. Requires powerful GPUs; training can take several weeks.

Transparency Problem: Without additional effort, no conclusions can be drawn about how a prediction emerges — a 'black box'.

Practical Consequence: In the financial sector, deep learning is deliberately avoided in favor of more interpretable machine learning models.

GPUs vs CPUs: Traditional CPUs are not sufficient for deep learning. Graphics processing units (GPUs) provide the necessary parallel computation power.

Data Mining

Extracting knowledge from large datasets

3.7 Data Mining — Overview & Models

Definition: Analyzing large amounts of data from various sources to gather useful information — finding unknown patterns, anomalies, and correlations.

Descriptive: Uncovers commonalities in historical data. Techniques: clustering (grouping similar data) and association rule learning. (Was happened?)

Predictive: Classifies future events or estimates unknown outcomes. Example: credit scoring. Techniques include decision trees. (What will happen?)

Prescriptive: Considers constraints to recommend actions, e.g., optimizing marketing mix for highest ROI. Uses 'if-then' rule patterns. (How can we make it happen?)

3.7 Data Mining — Text Mining & Process

Text Mining: With the proliferation of unstructured data (internet, emails, PDFs, audio), text mining has become a significant related discipline.

Data Preparation: Requires parsing, filtering, and transforming unstructured data before it can be used in predictive models.

Preprocessing: Data preparation and exploration are equally important as the mining itself — not a standalone step.

Postprocessing: Model validation, scoring, and performance monitoring complete the data mining pipeline.

Ethics & the Labor Market

AI's impact on employment and productivity

3.8 AI Impact on the Labor Market

12%

Automation potential
for jobs in Germany
(Federal Ministry of Labor)

300M

Full-time jobs at risk
globally from AI
(Goldman Sachs, 2023)

60–70%

Productivity increase
possible via generative AI
(McKinsey, 2024)

Administrative and legal functions are most affected. Generative AI enables faster processes in software development and customer interactions, leading to significant competitive advantages.

Ethics and Law in the Use of AI

Challenges of transparency, liability & data protection

3.9 Core Ethical Challenges

Decision Attribution: Humans are often held responsible for AI decisions even though they have difficulty defending themselves against machine suggestions.

Transparency: AI decisions are often based on non-traceable correlations — legally problematic and hard to audit.

Data Protection: AI frequently accesses and links personal data, raising serious privacy concerns that require continuous regulation.

Discrimination: AI can encourage discrimination when decisions are based on non-transparent criteria, requiring diverse training data.


• FAKE

3.9 AI Ethics: Deep Fakes & Weak vs. Strong AI

Deep Fake Examples

- Viral fake image of Trump's 'arrest'
- Pope Francis in a white puffer jacket
- These spread rapidly on social media
- Raises issues of transparency, fairness, non-malice
- Platforms must introduce labels/watermarks

Weak vs. Strong AI

- Weak AI: Intelligent in a narrow context, can exceed humans in specific tasks
- Strong AI: Hypothetical — human-like intelligence across all domains
- Transition demands proactive ethical frameworks
- Ethics, guilt, and responsibility concepts must be redefined
- Algorithms now intervene in broad social contexts

Model for AI Ethics Principles

Beneficence · Transparency · Justice · Privacy

3.10 The Six Ethical Principles

✦ Beneficence

Using AI for the good of society; improving quality of life.

◎ Transparency

Ensuring accountability; AI decisions must be explainable.

✕ Non-Maleficence

Protecting against harm; preventing misuse and damage.

⊙ Autonomy

Preserving freedom of choice for individuals.

⊜ Justice

Preventing discrimination; requiring diverse and fair datasets.

▣ Privacy

Protecting personal data; building user trust.

3.10 Implementing Ethical AI

Value Alignment: AI systems must be aligned with human values through deliberate design choices and stakeholder participation.

Communication: Clear communication about AI decisions and their limitations is essential for accountability and public trust.

Fairness Measures: Fairness requires diverse data sets and broad participation in AI development to avoid encoding existing biases.

Standards & Regulation: International standards and national regulations can safeguard ethical principles without slowing down innovation.

Summary

3.6 Neural Networks: Biologically inspired models with layers, weights & thresholds. Deep learning = many layers but lacks transparency.

3.7 Data Mining: Descriptive, predictive & prescriptive modeling to discover patterns. Text mining handles unstructured data.

3.8 Ethics & Labor: AI may replace up to 300M jobs globally. Productivity gains of 60–70% possible via generative AI.

3.9 Ethics & Law: Challenges: attribution, transparency, data protection, discrimination, deep fakes, and weak vs. strong AI.

3.10 Ethics Model: Six principles: Beneficence, Transparency, Non-Maleficence, Autonomy, Justice, Privacy.