MACHINE LEARNING IN ARTIFICIAL INTELLIGENCE: TOWARDS A COMMON UNDERSTANDING

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ABSTRACT

The application of "machine learning" and "artificial intelligence" has become popular within the last decade. Both terms are frequently used in science and media, sometimes interchangeably, sometimes with different meanings. In this work, we aim to clarify the relationship between these terms and, in particular, to specify the contribution of machine learning to artificial intelligence. We review relevant literature and present a conceptual framework that clarifies the role of machine learning in building (artificial) intelligent agents. Hence, we seek to provide more terminological clarity and a starting point for **(interdisciplinary) discussions and future research.**

Keywords: Artificial Intelligence, Machine Learning, Deep Learning, Intelligent Systems

1. INTRODUCTION

In his US Senate hearing in April 2018, Mark Zuckerberg stressed the necessary capabilities of Facebook's "AI tools (…) to (…) identify hate speech (…)" or " (…) terrorist propaganda" [1]. Researchers would typically describe such tasks of identifying specific instances within social media platforms as classification tasks within the field of (supervised) machine learning [2]–[4].

However, with the rising popularity of artificial intelligence (AI) [5], the term AI is often used interchangeably with machine learning—not only by Facebook's CEO in the example above or in other interviews [6], but also across various theoretical and application-oriented contributions in recent literature [7]–[9]. Carner (2017) even states that he still uses AI as a synonym for machine learning, although knowing this is not correct [10]. Such ambiguity may lead to multiple imprecisions both in research and practice when conversing about methods, concepts, and results.

Despite the frequent use of the terms, there is hardly any helpful scientific delineation. Thus, this paper aims to shed light on the relation of the two terms machine learning and artificial intelligence. We elaborate on the role of machine learning within instantiations of artificial intelligence, precisely within intelligent agents. To do so, we take a machine learning perspective on the capabilities of intelligent agents as well as the corresponding implementation.

The contribution of our paper is threefold:

1. We expand the theoretical framework of Russell & Norvig (2015) [11] by further detailing the "thinking" layer of any intelligent agent by splitting it into separate "learning" and "executing" sublayers.
2. We show how this differentiation enables us to distinguish different contributions of machine learning for intelligent agents.
3. We draw on the implementations of the execution and learning sublayers ("backend") to define a continuum between human involvement and agent autonomy.

In the remainder of this paper, we first review relevant literature in the fields of machine learning and artificial intelligence. Next, we present and elaborate our conceptual framework which highlights the contribution of machine learning to artificial intelligence. On that basis, we derive an agenda for future research and conclude with a summary, current limitations, and an outlook.

2. Related Work

As a base for our conceptual work, we first review the different notions, concepts, or definitions of machine learning and artificial intelligence within extant research. In addition, we elaborate in greater detail on the theories which we draw upon in our framework.

2.1. Terminology

Machine learning and artificial intelligence, as well as the terms data mining, deep learning, and statistical learning, are related, often present in the same context, and sometimes used interchangeably. While the terms are common in different communities, their particular usage and meaning varies widely.

Figure 1. General terminology used in this paper

| Process | Methods | Instantiation |

In statistics, the focus is on statistical learning, which is

defined as a set of methods and algorithms to gain knowledge, predict outcomes, and make decisions by constructing models from a data set [12]. From a statistics point of view, machine learning can be regarded as an implementation of statistical learning [13].

In computer science, machine learning focuses on designing efficient algorithms to solve problems with computational resources [14]. While machine learning utilizes approaches from statistics, it also includes methods not entirely based on previous work of statisticians—resulting in new and well-cited contributions [15], [16]. The method of deep learning has raised significant interest in recent years [17]. Deep learning models, composed of multiple processing layers, are capable of learning representations of data with multiple levels of abstraction. Deep learning has drastically improved machine learning capabilities, e.g., in speech [18] and image recognition [19].

Data mining describes the process of applying quantitative analytical methods to solve real-world problems. In machine learning, data mining is the process of generating meaningful machine learning models. Artificial intelligence applies techniques like machine learning and statistical learning to mimic intelligence in machines.

2.2. Machine Learning

Machine learning describes a set of techniques used to solve real-world problems with the help of computer systems that can learn to solve a problem instead of being explicitly programmed [23]. It can be divided into **supervised** and **unsupervised learning**, with supervised learning being the most widely used [24].

Supervised learning uses a series of examples ("past experience") to build knowledge about a task [25]. The creation of a machine learning model typically involves three main phases:

1. **Model initiation:** Define the problem, prepare the dataset, and choose an algorithm.
2. **Performance estimation:** Validate parameter permutations and select the best configuration.
3. **Deployment:** Put the model into practice to solve tasks on unseen data [27].

Learning in general depicts a key facet of human cognition, which allows processing vast amounts of information and adapting to new inputs [28]. Machine learning models mimic this ability in a controlled environment.

2.3. Artificial Intelligence

Artificial intelligence (AI) is rooted in multiple disciplines such as computer science, philosophy, and futures studies. In this work, we focus primarily on computer science to identify the contribution of machine learning to AI and differentiate both terms.

AI research can be separated into four main streams based on objective (thinking vs. acting) and decision type (human-like vs. rational) [11]:

Objective	Application	Humanly	Rationally
Thinking	Cognitive Modeling	Laws of Thought	
Acting	Turing Test	Rational Agent	

The **Rational Agent** stream is particularly relevant for implementing machine learning within AI. Rational agents are autonomous, perceive their environment, adapt to change, and pursue goals [11].

2.4. Layers of Agents

Intelligent agents can be divided into frontend (acting capabilities) and backend (thinking capabilities). The backend contains the learning backend (model building) and executing backend (model execution), which are central for machine learning implementations [45]–[52].

2.5. Types of Learning

Agents may be simple-reflex (once-trained models) or learning agents (continuous learning). Simple-reflex agents execute pre-built models, whereas learning agents improve models based on feedback from the environment [55]–[63].

2.6. Continuum Between Human and Machine Involvement

Human involvement in machine learning tasks can vary across data collection, model building, and execution. Agent autonomy ranges from minimal (full human involvement) to full autonomy [65]–[70].

3. Research Priorities

Further research is needed to empirically validate and refine

the conceptual framework. Key priorities include:

1. Mapping practical and academic ML-enabled AI projects to the framework.
2. Reducing human involvement via transfer learning and concept drift adaptation [72]–[74].

4. Conclusion

This paper clarifies the role of machine learning within artificial intelligence, particularly intelligent agents. Key points:

- Simple-reflex agents use once-trained models; learning agents continuously update models.
- Machine learning in agents consists of learning backend (training) and executing backend (execution).
- Human involvement determines the degree of agent autonomy.

The framework remains conceptual and requires empirical studies to validate practical applicability. However, it provides a clear distinction between machine learning and AI, emphasizing precise terminology and agent-level implementation.

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