The Management of Artificial Intelligence: Developing a Framework Based on the Artificial Intelligence Maturity Principle

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Abstract

The use of Artificial Intelligence (AI) must be systematically managed and coordinated to optimally support corporate goals and enable AI to create added value for organizations. This poses new challenges for traditional Information Technology (IT) management. Although initial approaches to managing AI as an extension of traditional IT management exist, the management of AI is still in its infancy. Therefore, the goal of our research is the development of an integrated management framework that combines insights from AI maturity model research with an overarching AI management perspective. In a multi-method and design science-oriented research process, an AI maturity model, an AI management metamodel, and a web-based AI maturity assessment and management tool combining both previous models are developed and evaluated. In addition, several smaller studies are conducted to demonstrate how AI-based information systems can be managed corresponding to the different dimensions of the integrated AI management framework.

Keywords

Artificial Intelligence, Machine Learning, Maturity Model, Information Technology Management, Design Science Research

1. Introduction

Artificial Intelligence (AI) is increasingly evolving from a pure research domain to a driver for innovative companies. Almost all industries are already intensively engaged in the application of AI solutions and this emerging technology is widely seen as a key game changer [39]. Despite its more than 50-year history, AI research also seems to be at its peak today [31]. New publications, AI architectures and programming frameworks are proposed daily and each field is trying to implement AI solutions for its own specific industry [39]. AI is increasingly benefiting from the growing data volumes enabled by other emerging trends such as cloud computing and many experts promise a bright future for AI [9, 21]. Due to the current attention given to this field, governments, private organizations and individuals are allocating more and more resources to support research opportunities for AI [39].

The field of AI encompasses many technical methods such as Machine Learning (ML) [6, 27], Natural Language Processing [19], Computer Vision [13], Knowledge Representation [26] or Robotics [36]. While these technical methods and implementations of AI have been intensively researched in areas such as computer science or cognitive science since the 1950s [24, 31, 37], a more business and strategy-oriented view of managing AI technologies for entire organizations is still relatively new [4]. In addition, the practical application of AI in organizations still lags behind the research advances in AI algorithm development. The key challenge for the future use of AI in businesses is to develop suitable application scenarios, to convert these into prototypes and to develop operationally usable applications

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that can then be operated productively and continuously evolved [7]. Only when applications are used productively AI can be applied either to reduce costs through automation or to generate additional revenue through new business models or better interaction with customers. Therefore, the adoption and diffusion of AI in organizations appears to be heavily influenced by more impact factors than the pure technical engineering of AI-based information systems. For example, the proper integration of AI into business processes requires large, high-quality and balanced data sets [14], new explanatory approaches [29] or compliance with ethical principles in the autonomous operation of AI systems [20]. However, no overarching framework exists in the literature that addresses all of these specific AI management challenges. Therefore, the aim of our research is to identify the dimensions, which determine the adoption and diffusion of AI innovations and its management in organizations, provide new methodological approaches to support the application of AI by analyzing the previously identified AI management dimensions and finally develop an AI management framework. Thereby, the entire research process follows the following overarching Research Question (RQ):

> **RQ:** How can a management framework be designed that fosters the adoption and diffusion of Artificial Intelligence in organizations?

To answer this research question, a multi-step, design science-oriented research approach is followed (cf. section 3). The research procedure consists of four main iterations, each answering a different sub-question with regard to the overarching research question. Additionally to these four main iterations, a parallel research stream investigates new approaches and methods on how AI-based information systems can be managed in each of the individual dimensions of the AI management framework.

2. Managing Artificial Intelligence with Maturity Models

The use of Information Technology (IT) must be systematically managed and coordinated to optimally support corporate goals and enable IT to create added value for the organization. This systematic management task is known as IT management [30]. However, IT innovations based on different sub-areas of AI pose new challenges for IT management and in some cases require new approaches [5, 7, 8]. For these new challenges, the term AI management has been introduced [7, 8]. AI describes the ability of artificially constructed systems to act intelligently or mimic cognitive and intelligent behavior as well as the science and engineering involved [15]. Furthermore, AI is understood as a technology cluster closely linked to the concept of “Narrow AI” introduced by Kurzweil [22] and which has an increasing impact on today’s businesses and industries [39]. AI management subsumes systems, models and methods for the systematic steering of AI in organizations [5]. It recognizes the potential of AI for business challenges, develops productive solutions, operates them and continuously evolves them [7]. AI management is not only focused on the development of new algorithms, software or hardware, but it ensures that AI can be productively used in organizations and that a real value contribution is achieved. Managing AI requires a deep understanding of the respective algorithms and the specifics of AI methods require new processes, new structures and new competences to ensure the professional handling of AI [8]. Thereby, AI management is a component of IT management [7].

In IT management, Maturity Models (MMs) are a widely used tool for managing and coordinating various relevant aspects like organizational competences and technologies [3]. They are used as a strategic component for continuously comparing and defining a path or a roadmap in different evolutionary states [2] and as benchmarks to assess and improve organizational capabilities [34]. MMs were originally proposed in the 1970s by Nolan and Gibson [28] and mostly consist of a sequence of maturity levels for a class of objects. Since then, MMs have defined an own research area and many different MMs have been developed for different application domains such as software development, quality management and data analytics [25, 33]. The most prominent example is the Capability Maturity Model (CMM), which is used to assess the quality of the organization’s software process and to determine actions for its improvement [10]. An initial overview of 237 different MMs in 20 application domains including an initial classification scheme can be found in the paper of Wendler [38]. As digital transformation has accelerated in recent years, the number of MMs has also increased significantly and the use of MMs seems to be a suitable tool for the successful integration of key technologies into the processes of a digitalized enterprise [12]. This includes the use of MMs for AI management. While initially several generic AI MMs were developed at a high level of abstraction [1, 17, 23, 32], industry-specific AI MMs have been increasingly developed in recent years to ensure better applicability for companies [11, 15, 35]. Therefore, an abstract view of management capabilities analogous to generic AI MMs can serve as an initial guide, while an industry-specific description of management capabilities and industry-specific AI MMs address the concrete application of AI management in business practice. Subsequently, our AI management framework should also include these two buildings blocks (generic metamodel and industry-specific application model).

3. Research Approach

The goal of this research is to design an AI management framework based on the idea of the AI maturity of organizations and to provide initial methodological approaches on how to advance in the different dimensions of the management framework. Therefore, this work follows an overall design science research approach with several iterations (cf. Figure 1). Following the first phases of the methodological considerations of Becker et al. [3], existing AI MMs will be analyzed with a systematic literature review in the beginning of the research process. Depending on the results of this analysis, either the dimensions of an existing AI MM will suffice as a first orientation or a new AI MM is designed and evaluated using qualitative research methods (e.g. expert interviews and focus group discussion) in an application domain of choice. The resulting artifact will be an industry-specific AI MM that can be directly applied by practitioners such as IT managers or consultants. In the next iteration, the dimensions of the analyzed, mostly industry-specific MMs are abstracted independently of their application domain and an initial metamodel for the AI management framework is designed. The dimensions of the metamodel are then evaluated with a survey using a quantitative-qualitative questionnaire with information systems and AI experts of different companies. In this step, the resulting artifact will be a metamodel that serves researchers and practitioners as an initial guide to AI management. After a successful evaluation of the metamodel, a web-based information system for the AI management framework with the underlying AI MM will be developed. In the first step, it will be conceptualized using an User Interface (UI) prototype. This initial UI prototype is evaluated again with a cognitive walkthrough methodology. The resulting artifact will be a conceptual UI model that help scientist and MM developers in the application of their specific AI MM. Finally, the UI prototype will be developed into a complete web-based information system. By disseminating the self-assessment part for an initial AI maturity analysis of the web-based AI management framework via an openly accessible web interface, the framework will be evaluated and (hopefully) used by many researchers and practitioners. The final artifact is a web-based AI management and maturity assessment tool that can be used by practitioners such as IT managers or consultants to manage AI technologies in the target company.

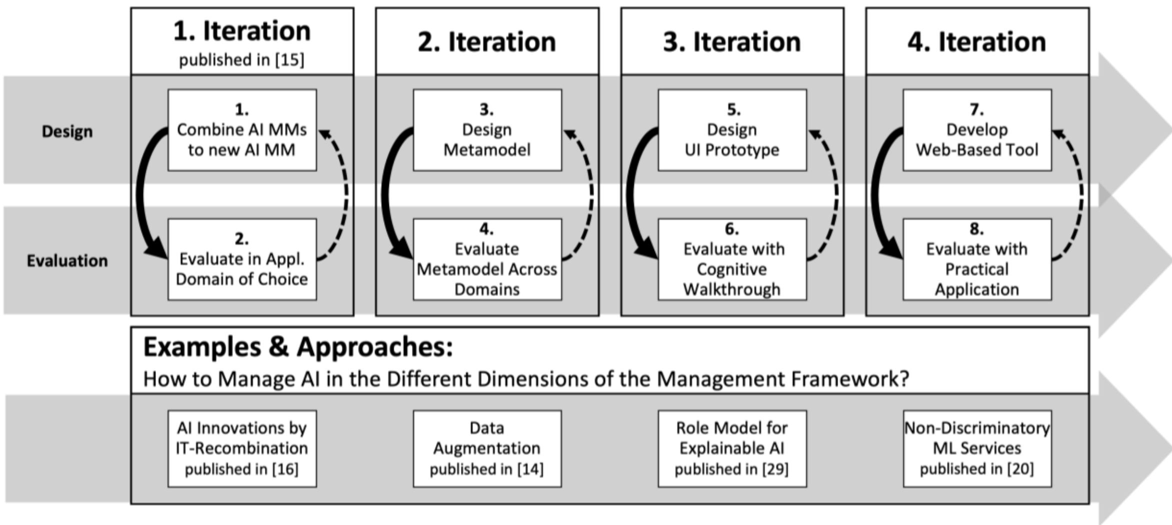

Figure 1: Overall Research Approach for Designing the Artificial Intelligence Management Framework

During this central, design-science oriented and multi-method research process, small-scale studies for each dimension will be conducted to provide scientific and practical examples of how AI can be managed in different dimensions of the AI management framework. So far, the first iteration with the development of the Auditing Artificial Intelligence Maturity Model (A-AIMM) [15] and the four small-scale studies [14, 16, 20, 29] have already been conducted and published. The other three iterations (metamodel, UI prototype and web-based tool) are currently in progress and are expected to be published in the next two years. In the following, the results of the already completed research [14–16, 20, 29] as well as some preliminary results of the research in progress are briefly described.

4. Preliminary Ideas and Results

4.1. Artificial Intelligence Management Dimensions

Table 1

Description of the Artificial Intelligence Management Dimensions Based on Fukas et al. [15]

Dimension	Description
Technologies	The *Technologies* dimension describes the IT-infrastructure, technologies and tools required for the use of AI on a large scale. It subsumes the necessary IT-infrastructure components to enable the development and use of AI. In addition, the implementation of concrete AI technologies is included in this dimension.
Data	Since many AI solutions rely on high-quality data management, the *Data* dimension addresses the various aspects of this data management. For example, it includes the quantity and quality as well as the secure and efficient processing of data as a prerequisite for enabling AI.
People & Competences	The *People and Competences* dimension addresses all aspects related to an organization's human resources. It includes identifying the personal competences that employees must possess to develop, use and improve AI technologies as well as training existing employees or recruiting new employees with regard to these competences.
Organization & Processes	Today, companies are formally defined by the terms organization and business processes. These two terms are closely linked and can hardly be considered separately. Therefore, the *Organization & Processes* dimension refers to these company characteristics, such as company size, organizational structure and processes that influence the development, use and improvement of AI solutions.
Strategy & Management	The *Strategy & Management* dimension describes the planning and formulation of goals and strategies for the use of AI in a company in terms of content, scope as well as temporal and spatial reference and how the company's management could enable the use of AI.
Budget	The *Budget* dimension refers to the amount a company is willing to invest in AI. This amount can be considered, for example, as an alibi investment or as a strategic investment in future projects.
Products & Services	When an organization progresses with its AI maturity, the use of AI should have a positive impact on its products and services, e.g. in terms of quality or price. The *Products & Services* dimension assesses this impact of AI on the organization's business, classifies the extent to which AI becomes a critical part of product and service development and whether AI products and services are offered to clients.
Ethics & Regulations	The use of AI raises numerous ethical issues that impact corporate governance in several ways. For example, AI must comply with corporate values and policies that protect the privacy and security of customers or it must be able to disclose the reasons behind the decisions it makes. The *Ethics & Regulations* dimension addresses the establishment of ethical values and standards related to the use of AI, such as data privacy, transparency and fairness in the organization.

The first steps of this work have already been accomplished. In 2021, one of the first industry-specific AI MMs was developed following the design science-oriented development procedure of Becker et al. [15]. The systematic literature review at the beginning of the A-AIMM development process revealed that some scientific attempts already met the requirements for a well-developed MM for AI management of Becker et al. [3] and therefore these models were combined into a new one covering all relevant aspects found so far. Subsequently, the new and combined AI MM was extended by interviewing experts in the field of auditing, revealing pressing ethical and regulatory issues related to the adoption and diffusion of AI in organizations. A detailed description of the dimensions that guide the further development of the AI management framework can be found in Table 1 whereas a condensed version of the AI MM with a total of five AI maturity levels is illustrated in Figure 2.

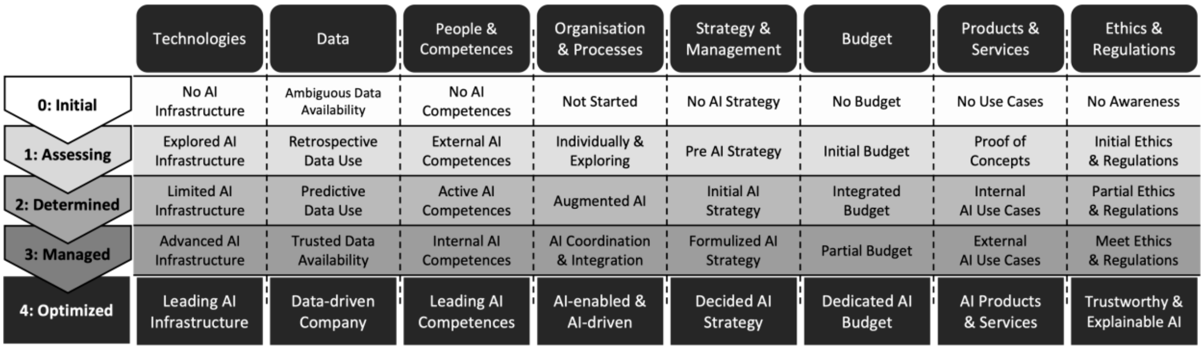

Figure 2: Artificial Intelligence Maturity Model Based on Fukas et al. [15]

With the A-AIMM, an initial design of different levels and control questions was also developed to assess the state an organization is in regarding its management of AI. For the implementation of the AI management framework as a web-based information system, these levels and control questions are currently being further developed with an additional scoring system.

4.2. Additional Studies for the Management Dimensions

In addition to the central research approach described in section 3, we have already conducted small-scale methodological and evaluative studies on each dimension during our research to provide scientific and practical examples of how AI-based information systems can be managed in the different dimensions of the AI management framework (cf. Table 2):

Table 2
Already Published Studies Corresponding to the Artificial Intelligence Management Dimensions

Title	Dimensions	Reference
Innovation by Information Technology Recombination: How Artificial Intelligence Progressive Web Apps Foster Sustainable Development	*Technologies*	[16]
Augmenting Data with Generative Adversarial Networks to Improve Machine Learning-Based Fraud Detection	*Data*	[14]
Towards Personalized Explanations for AI Systems: Designing a Role Model for Explainable AI in Auditing	*People & Competences, Ethics & Regulations*	[29]
Proposing a Roadmap for Designing Non-Discriminatory ML Services: Preliminary Results from a Design Science Research Project	*Ethics & Regulations*	[20]

One example on how organizations can make progress in the *Technologies* dimension of AI management is by combining AI with other promising technological approaches. This was shown in a study that examined how combining AI with the Progressive Web App technology can realize economic, environmental as well as social benefits and create additional value [16].

Another study as part of our research process provides an idea on how to manage data for ML-based financial fraud detection, which suffers greatly from dataset imbalance [14]. By using Generative Adversarial Networks to create synthetic data samples for minority classes, datasets can be balanced, which ultimately enables better training on datasets for fraud detection. This study has demonstrated the importance of the *Data* dimension to AI management and provided an example of how practitioners can handle datasets with similar problems for the use of AI-based information systems.

A third study found that different roles have different requirements for the application of AI-based information systems in organizations [29]. Moreover, it is necessary to give personal explanations to the different roles involved in the application of AI in order for AI to be accepted and used in an organization. This study highlights the importance of the *People & Competences* as well as the *Ethics & Regulations* dimension for AI management and provides a role model that can help practitioners to manage their various team members in the application of AI-based information systems.

Finally, a fourth study revealed that even state of the art AI-based face recognition algorithms suffer from discrimination against ethnic groups [20]. Based on this result, a roadmap for designing non-discriminatory ML-Services was derived that will be further developed in future research. This study has shown that especially AI-based information systems, which are not explicitly programmed but implicitly developed through a training and test process, need new AI management policies regarding the *Ethics & Regulations* dimension.

5. Theoretical and Practical Contributions

As mentioned in section 1 and 2, the management of AI-based information systems is a pressing issue to enable today's organizations to adopt and leverage AI on a large scale. In the past, research mostly focused on purely technical implementation of AI-based information systems. But in recent years, the AI research community has become more and more aware that several socio-technological factors are important for the use of AI in today's organizations. Therefore, a fairly new research area has emerged in recent years that focuses on the adoption and diffusion as well as the management of AI.

With our research we contribute directly to this current research field and extend the body of knowledge in the field information systems engineering [4]. We provide the first AI management framework that ties directly to the extensively researched field of MMs. Our AI management framework is developed on a solid scientific foundation by using a multi-method, design science-oriented research approach. The different dimensions can guide other AI management researchers to develop methods that promote the adoption and diffusion of AI in organizations. These methods (including our AI management framework) should then be applied in the organizational practice to bridge the gap between scientific AI research and practical AI application.

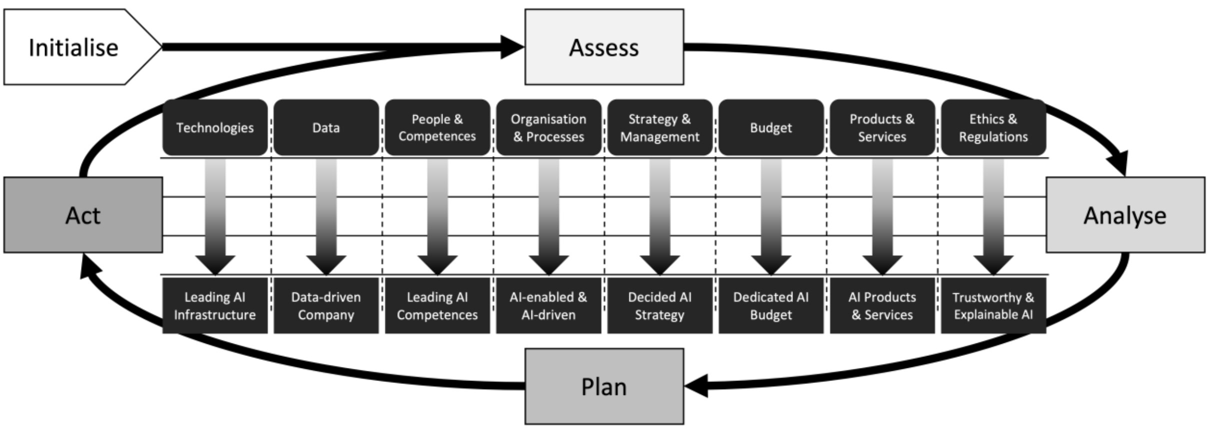

Figure 3: Continuous Improvement Cycle by Using the Artificial Intelligence Management Framework

Practitioners benefit from our research through the application of the AI management framework. It can serve organizations as an internal benchmarking tool and as an enabler to determine their current status quo with regard to the adoption and diffusion of AI technologies. With the planned web-based information system (cf. section 3), the AI management framework can be easily integrated into the daily operations of any organization. Through a continuous improvement process (cf. Figure 3), each organization can iteratively become an AI-enabled organization by receiving recommendations for further use of AI based on its current capabilities. Finally, our AI management framework forms the basis for certified AI management systems that are currently being developed by the International Organization for Standardization (ISO) [18]. By applying our AI management framework, organizations could more easily achieve a potential AI management systems certification.

6. Conclusion and Outlook

In this paper, we present a multi-step, design science-oriented research approach to develop a management framework that fosters the adoption and diffusion of AI in organizations. We clearly formulate the research question (cf. section 1), identify a significant problem in the field of research (cf. section 1 and section 2) and outline the current status of the problem domain and related solutions (cf. section 2). Our research methodology consists of four main iterations with an additional parallel research stream to investigate new approaches and methods on how AI-based information systems can be managed in each of the individual dimensions of the AI management framework (cf. section 3). Following this research methodology, we present preliminary ideas and the results achieved so far (cf. section 4). Finally, we outline the theoretical and practical contributions of our work to the problem domain and highlight their uniqueness (cf. section 5). In the future, we will follow up the presented research methodology and conduct the next steps to develop the AI management framework. We will design an industry-independent AI management metamodel and operationalize it by developing a web-based information system with a systematic scoring system. The final integrated management framework, together with all its components (industry-specific maturity model, generic metamodel, web-based tool and methodical guidelines), will enable the continuous improvement of AI adoption and guide companies on their way in becoming AI-enabled organizations.

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