Current State of Research on Artificial Intelligence-based Startups: A Systematic Mapping Study

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March 2023

Abstract

Context: Artificial Intelligence (AI) startups have received significant attention in recent years due to their potential for driving innovation in various industries. With the increasing interest in AI startups, there is a need to understand the current state of research in this field.

Objectives: The objective of this study is to provide a holistic overview of the research on AI startups, including their applications, technologies used, and the facets of AI that are studied. Additionally, this study aims to identify the ethical considerations and regulatory frameworks that need to be addressed to ensure the responsible and beneficial use of AI in different industries.

Methods: To achieve these objectives, a systematic mapping study was conducted, analyzing 44 publications on AI startups. The study identified the current trends in research on AI startups, including the business domains studied, the AI technologies applied, and the facets of AI that were analyzed.

Results: The study found that AI startup research is of great interest in the AI community, with an increasing number of publications on this topic over the years. Healthcare, finance, and agriculture are the most studied business domains in the literature. The most widely applied AI technology among AI startups is machine learning, followed by computer vision and natural language processing. AI startups have been extensively studied for their applications in various use cases, including opportunities, challenges, business models, and consequences. However, the study of ethics in AI startups has been comparatively limited.

Conclusions: The integration of AI systems into various industries requires careful consideration of ethical and regulatory frameworks. The responsible and beneficial use of AI systems can have significant benefits for society as a whole, but this requires careful consideration of the ethical and regulatory frameworks that govern their implementation. AI startup research plays a critical role in developing new analytical techniques and models, exploring ethical and privacy implications, and addressing issues related to transparency, bias, and privacy. By promoting diversity and inclusion in development teams and establishing codes of ethics for AI developers, we can prevent bias and promote ethical practices in AI development, and advance the state of AI startup research.

Keywords: Artificial Intelligence Startups, Software Startups

Acknowledgement

We would like to express our deepest gratitude to our research supervisors, Prof. Xiaofeng Wang and Jorge Augusto Melegati Goncalves, for their invaluable guidance, support, and advice throughout the research process. Their unwavering commitment and valuable insights have been instrumental in shaping our research and bringing it to fruition. We are also grateful for the time they dedicated to meeting with us, despite their busy schedules, and for providing us with constant feedback that helped us to build our confidence and progress in our work.

Furthermore, we extend our heartfelt appreciation to our parents for their unwavering support, encouragement, and sacrifice in providing us with the opportunity to pursue quality education and complete this research. Their love and encouragement have been a source of motivation for us throughout this journey.

We would also like to extend our gratitude to all our good friends for their unwavering support and encouragement throughout this research journey. Your support, motivation, and uplifting words have been a constant source of inspiration and strength for us. We truly appreciate the time and effort you have invested in cheering us on and being a pillar of support during this challenging yet rewarding process.

Additionally, we would like to express our special thanks to Saagarika, a dear friend, for her invaluable assistance with the plots in our research. Her expertise and dedication were instrumental in creating high-quality visuals that effectively conveyed our research findings. We are truly grateful for her time, effort, and willingness to help us in this regard.

Lastly, we would like to thank the Free University of Bozen-Bolzano for providing us with the opportunity to enhance our research capabilities and broaden our knowledge through the master's program. We are truly indebted to this institution for its unwavering support and contribution to our academic and personal growth.

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Chapter 1

Introduction

The field of artificial intelligence (AI) is undergoing rapid growth and has the potential to significantly impact our daily lives, work, and social interactions. It can be defined as "the theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages" [dic].

Although, the inception of AI dates back to the 1950s, we have only recently experienced the implementation of AI with many real-world applications [Rii+18].

With the potential to revolutionize industries ranging from healthcare to finance, it is no surprise that AI will have a disruptive effect on organizations everywhere and across a variety of industries [DR18].

At the forefront of this growth are the growing number of AI startups, companies that are leveraging cutting-edge technology and innovative business models to bring new AI solutions to market.

We use the definition of AI startups from [MS20] "as an organisation characterised by an innovative business model adapted to the needs of its turbulent milieu, engaged in the development of technological solutions, both in terms of software and hardware, with the use of artificial intelligence".

AI startups are focused on creating new products and services that leverage different AI technologies such as machine learning, natural language processing, computer vision, and neural networks among others to solve complex business problems and automate various processes.

AI startups play a significant role in bringing AI to new industries. AI can be applied to many different business domains and businesses across industries including healthcare, finance, agriculture, transportation, and more.

These developments have raised many questions about the role of AI as a technology in the economy, as well as its impact on organizations and people [FO17].

According to Aghion et al. (2019), their research suggests that in the short to medium term, AI has the potential to increase economic growth by as much as 1.2% per year. In the long term, this potential could be even higher, reaching

up to 2.0% per year [AJJ18]. The McKinsey Global Institute report "Notes from the AI Frontier" highlights the impact of AI on various industries and functions, and provides insights into how organizations are using AI to drive growth and innovation. The report analyzes hundreds of use cases from around the world, covering industries ranging from healthcare to manufacturing. The authors identify four key ways in which AI can create value for organizations: automating business processes, creating new products and services, improving decision-making, and optimizing resource allocation. Overall, the report suggests that the potential benefits of AI are significant and wide-ranging, and that organizations that invest in AI are likely to gain a competitive advantage [Man+18].

The impact of AI on organizations is significant for several reasons. AI has the potential to automate routine tasks and improve efficiency, allowing organizations to reduce costs and increase productivity. This can lead to significant improvements in profitability, which is driving widespread adoption of AI across industries. This impact is only set to grow as AI startups emerge and challenge traditional industries. These startups have the capability to disrupt established players by leveraging cutting-edge AI technology and innovative business models to create new products and services.

Exploring the business model facet of AI startups can be important as AI startups are innovating new models and leverage latest AI technologies to improve their own operations and also stay informed about the latest trends in the AI startup ecosystem.

In this thesis, we explore different AI technologies studied. We also attempt to find out which business domains of AI startups implemented which AI technologies.

The implications of AI are far-reaching and complex, and can have both positive and negative impacts. Though AI offers a vast array of opportunities for businesses and individuals to innovate and improve their operations. The trend toward greater automation in organizations has created worries about the impact on employment. The article [BM17] highlights the potential for job displacement as a result of advances in AI and machine learning, and suggests that policymakers and society at large will need to address the challenges and implications of these technological changes, including the potential loss of jobs. The consequences of AI raise concerns about job losses and create uncertainty about the future of work [SA14].

One of the biggest concerns about the use of artificial intelligence (AI) in the workplace is the potential for algorithmic management to perpetuate bias, lack transparency, and erode employee control. However, as discussed by [DK15], a more promising approach to deploying AI in the workplace is through collaboration between humans and machines, rather than attempting to replace human decision-making entirely. In a human-AI collaboration model, humans and machines work together, with each contributing their respective strengths to achieve better outcomes.

Manyika et al. (2017) point out multiple benefits of human-AI collaboration in a range of industries [Man+17]. Amershi et al. (2014) also showed that

humans and machines working together can be more effective than either alone in a variety of tasks. Overall, these studies suggest that AI is not all scary, and that human-AI collaboration can lead to improved efficiency, productivity, and decision-making in many areas [Ame+14].

Therefore, it is important to balance the potential risks and benefits of algorithmic management with a careful consideration of how AI can be used in collaboration with humans to improve work processes and outcomes in a transparent, fair, and ethical manner.

As AI becomes more ubiquitous, concerns have been raised about the ethical implications of its use. One of the key challenges in developing ethical AI systems is ensuring that they align with societal values and norms, and do not harm human beings. Several recent studies have emphasized the importance of developing ethical frameworks for AI, with clear guidelines for ensuring that these systems are transparent, explainable, and accountable. For instance, Floridi et al. (2018) [Flo+18] argue that ethical considerations should be integrated into every stage of the AI development process, from conception to deployment. Meanwhile, [BY14] Bostrom and Yudkowsky (2014) stress the need for AI researchers to engage in discussions around ethical concerns, and to work towards developing AI systems that reflect human values.

Another important ethical issue in AI is the potential for bias and discrimination. As AI systems become more prevalent in decision-making processes, there is a risk that these systems may perpetuate existing societal biases and inequalities. This issue has been highlighted in several recent studies, including Buolamwini and Gebru (2018) [BG18], discovered that facial recognition technology has a tendency to produce more errors when analyzing images of individuals with darker skin tones, and Crawford and Paglen (2019) [CP19], who discuss the potential for AI to reproduce and amplify existing power imbalances.

In addition to these concerns, there is also the question of how to ensure that AI systems are used for the benefit of society as a whole, rather than just a select few. This issue is explored by Floridi (2019) [Flo19], who argues that ethical AI must be aligned with the broader public interest, and that AI researchers and practitioners have a responsibility to work towards this goal.

Overall, these studies highlight the critical importance of addressing the ethical dimensions of AI. By taking a proactive approach to ethical AI development, we can ensure that these systems are designed and deployed in a way that is consistent with our values, and that they contribute to a more just and equitable society.

Despite the progress made in AI, many potential use cases remain unexplored and in their infancy. For example, in the healthcare industry, AI has the potential to revolutionize drug discovery and personalized medicine, yet much work remains to be done in order to fully realize these possibilities [Wlu20]. In addition, there are numerous other industries that have yet to fully embrace the potential of AI, including agriculture, transportation, and construction, among others. However, as AI technology continues to improve and mature, it is likely that we will see an increasing number of innovative use cases and applications of this powerful technology in the years to come.

Considering significant impact of AI on organizations and the wide-ranging impact of AI on various facets, it is crucial to gain a deeper understanding of the current state and trends of the AI startup landscape. The field is continuously evolving and there are new technologies and applications every year. However with the fast increasing body of knowledge, it becomes more and more difficult to keep track of all latest developments. Therefore, performing a mapping study on AI startups would be a valuable endeavor to identify business domains, emerging technologies, and potential implications of AI startups.

In this thesis we provide a holistic overview of latest research by providing a synthesis of the current body of knowledge on AI startups. Therefore, a systematic mapping study on peer-reviewed publications is conducted. We delve specifically into which AI technologies are studied, what are the business domains reported and what facets of AI are studied in the literature.

We have noticed an increase in the number of publications about AI startups over the years. Among the various business domains reported, a significant number of studies concentrate on healthcare, finance, and agriculture. Machine learning, computer vision, and natural language processing are the most widely studied and applied AI technologies in the AI startup literature. We observed significant interest in the applications of AI in various business domains, as well as the opportunities and challenges of AI. 'Business models' and 'consequences' of AI are two other facets researched.

The remainder of the thesis is organized as follows. Chapter II presents the related work, which provides the context for our research. Chapter III describes the applied research method, including the data collection and analysis procedures. In Chapter IV, we present the main results of the study. Chapter V discusses the implications of the findings for theory and practice. Chapter VI examines the potential threats to validity of the research and how we addressed them. Finally, chapter VII concludes the thesis by summarizing the key findings, contributions, and limitations of the research.

Chapter 2

Background and Related Work

In this chapter we present the most relevant studies contributing to the formation of a body of knowledge focused on AI in software startups. The materials reviewed here were mostly collected during the execution of a systematic review of the literature.

2.1 AI technologies

There are several definitions of AI in literature given in different dictionaries and studies. The Merriam-Webster dictionary gives the following two definitions: 1) a branch of computer science dealing with the simulation of intelligent behavior in computers; 2) the capability of a machine to imitate intelligent human behavior [Mer23]. Artificial intelligence is defined as intelligent systems designed to carry out certain activities without the need for programming by using data, analysis, and observations [Ant18]. For the purpose of this paper, we use the latter definition. It is important to note that AI is implemented through different technologies such as machine learning, natural language processing, computer vision, and neural networks, which are rapidly evolving and expanding the potential applications of AI in various domains. We use the classification of AI technologies proposed in [Enh+22]. The classification is relevant for research related to AI startups because it provides a structured framework for categorizing and analyzing different types of AI technologies that are relevant to startups.

Based on the classification, in this chapter, we define some AI technologies. Machine learning is a subset of Artificial Intelligence. It has become increasingly popular in recent years, driven by the growing availability of data and advancements in computational power. [Afi19]. The primary objective of machine learning is to enable machines to acquire the ability to learn from data, forecast the future, and find relationships that can help people make decisions

[Afi19; WHZ19]. The mapping study has also explored various other essential AI technologies, which are summarized in Table 3.3. Currently, the majority of AI technologies are employed in conjunction with machine learning or deep learning approaches. As an example, chatbots employ both natural language processing (NLP) and machine learning techniques, as highlighted in Baby et al. (2017) [BKS17]. NLP is defined as "the process through which machines can understand and analyze language as used by humans" [Jar18]. Computer vision refers to a collection of methods for obtaining, manipulating, examining, and comprehending intricate, multi-dimensional data from our surroundings, aimed at scientific and technical investigations [JHG99]. A neural network is an extensively parallelized and distributed processor that comprises basic processing units, which are inherently capable of retaining experiential knowledge and making it accessible for practical use [Hay09].

2.2 Startups

Startups are newly established companies that are designed to rapidly scale and grow. There is no single, universally accepted definition of 'startup' [Pat+14]. They are typically founded by entrepreneurs who are looking to disrupt existing markets, create new products or services, and generate significant financial returns. In [Rie11], the author describes startups as "ventures designed to create a new product or service under market conditions of great uncertainty". In academic literature, software startups are more focused on innovation. For example, authors Melegati et al. (2020) point out that "Software startups develop innovative software products in environments of time-pressure and a lack of resources, constantly searching for sustainable and scalable business models" [MEW20]. Lacking agreement on a definition of the term startup, we use this definition: Software startups are startups whose main aim is developing new and innovative software-intensive products or services from which business value is created [Pan+17]. Unlike established companies, startups are characterized by a high degree of uncertainty and risk, as they often operate in untested or rapidly changing markets. Despite these challenges, startups are an important driver of innovation and economic growth, and have attracted significant attention from investors, policymakers, and the general public. In recent years, the emergence of artificial intelligence (AI) has presented new opportunities and challenges for startups, as they seek to leverage this technology to create new products and services, optimize operations, and gain a competitive edge in the market.

2.3 AI Startups

The existing literature on AI startups is vast and diverse, covering various aspects of artificial intelligence and its applications in the startup ecosystem.

In recent years, artificial intelligence (AI) has emerged as a transformative

technology that is rapidly disrupting industries and driving innovation across many sectors. As a result, there has been a surge of interest in AI startups, which are seen as important drivers of innovation and economic growth. To better understand the AI startup ecosystem, a comprehensive overview of the key themes and research questions is essential. Below, we present an overview of the current work on all key themes.

According to the Startup Genome Report (2020) [Gen20], the global AI startup ecosystem is rapidly expanding, with AI startups emerging in various business domains, including healthcare, finance, and retail. AI startups are attracting significant funding from a range of investors, including venture capital firms, angel investors, and corporate investors. This suggests that there is strong investor interest in AI technology and its potential for market disruption. Additionally, the report highlights the importance of specialized solutions for specific industry domains as a key area of interest for AI startups.

One potential area of focus in the literature on AI startups are leveraging emerging technologies to create new products and services. For example, the use of natural language processing and machine learning algorithms in chatbots and virtual assistants has led to rapid growth and development in this area. As a result of these technological advancements, chatbots have become much more intelligent and can now understand human users and provide human-like responses. With the potential for further growth and development in the future, there is a need for ongoing research and analysis to guide future innovations in chatbot technology. [IL17]. Other emerging technologies that are being utilized by AI startups include computer vision, robotics, and blockchain. By examining how these technologies are being applied by AI startups, we could gain insights into the factors driving innovation in this space and the potential impact of these startups on various industries.

Considering the significant growth and potential of AI startups, it is essential to gain a deeper understanding of the key trends, challenges, and opportunities in this field. By conducting a systematic review of the literature on AI startups, it is possible to identify the key research themes and opportunities for future research, which can inform the development of effective strategies for fostering the growth and success of AI startups.

Despite the tremendous potential of AI and the high levels of enthusiasm surrounding it, there is still a limited comprehension of the current status of AI adoption, the expectations of organizations, and the obstacles they confront while implementing and utilizing these solutions [Mik+19].

Numerous initial studies have thoroughly documented the potential benefits of utilizing AI technologies in the public institutions [WM19].

The Internet of Things (IoT) is a system of interconnected physical objects that communicate with each other through the internet, enabling the exchange of data and information without human intervention [AIM10]. This technology has a wide range of applications across various industries, including healthcare, agriculture, and industrial machines.

In healthcare, IoT devices such as wearable fitness trackers, health monitoring systems, and smart medical devices can collect and transmit data about

patients' health and wellness to healthcare providers in real-time. This information can be used to monitor patients remotely, track their progress, and provide personalized care [Pau+21].

In agriculture, IoT sensors can be used to monitor soil moisture, temperature, and nutrient levels, as well as track the growth and health of crops. This data can be used to optimize irrigation, fertilization, and pest control, resulting in more efficient and sustainable farming practices [KP20].

In industrial machines, IoT technology can be used to monitor equipment performance, detect and diagnose faults, and predict maintenance needs. This information can help prevent downtime, reduce maintenance costs, and improve overall equipment effectiveness. [Ara+20].

AI capabilities have been found to be widely employed in the healthcare industry, with a particular focus on the domains of diagnostic medicine, healthcare administration, and drug research and development, as per preliminary research [IV15; Fle18; HT17].

Overall, these papers suggest that AI startups in healthcare are exploring a range of business models, from predictive analytics services to AI-driven clinical decision support systems. While there are many opportunities for AI in healthcare, there are also significant challenges, such as data privacy concerns, regulatory barriers, and the need for significant investment in data infrastructure and talent.

The author Murdoch (2021) in their paper highlights concerns related to patient data privacy and protection, specifically focusing on the issues of access, use, and control of this data by private entities [Mur21].

Removing patient identifiers and anonymization are two common methods used by researchers to work with medical data [Kus+12].

Several recent studies have drawn attention to the potential use of emerging computational techniques for identifying individuals within health data repositories managed by either public or private organizations [Hay13].

The authors Ahuja et al. (2012) in their paper, discuss the advantages of moving healthcare data to the cloud. They also point out the challenges of privacy and security faced by healthcare organizations [AMZ12].

Cloud services promise high availability and reliability, which can help ensure that health organizations can provide uninterrupted services to patients.

Another study by Vayena et al. (2018) propose a concept of "systemic oversight" to mitigate the ethical challenges associated with health research, particularly in the context of big data [VB18].

In 2010, a comparative survey conducted by author Bahrammirzaee [Bah10] reports about AI applications in finance. The author reviews 3 AI techniques namely: artificial neural networks (ANNs), expert systems, and hybrid intelligence systems, in finance domain. One of the main reasons for applying newer techniques and aiming for innovation is to enhance access to financial institutions to every person which leads to poverty reduction [Tea04]. The financial domains which use ANNs include credit evaluation, portfolio management, financial prediction and planning. The author evaluated the performance of traditional methods with NN methods and found that latter outperformed the

former. The higher performance is one of the many reasons for today's interest in research into Finance.

According to van Liebergen, banks have been employing machine learning techniques for over a decade to identify instances of credit card fraud, and have achieved notable levels of success in doing so [Van+17].

Machine learning has the potential to improve credit risk measurement for lending decisions [JL19]. However, there are potential problems associated with using ML for lending. One such problem is the potential for error due to training data that does not accurately represent the diversity of loan applicants. Another problem is that higher-risk borrowers may learn to mimic the behavior of lower-risk borrowers to improve their chances of being approved for loans. While deep learning techniques could improve lending decisions, their lack of transparency presents a significant obstacle, particularly in the EU, where citizens have the right to an explanation for decisions made by automated processing [GF17]. There are ongoing initiatives aimed at reducing the lack of transparency associated with deep learning and enhancing the interpretability of the results [Kni17].

The finance industry is experiencing significant changes due to the implementation of artificial intelligence, particularly in areas such as fraud detection, banking chatbots, algorithmic trading, and regulatory and policy frameworks [Buc19].

According to Kirilenko and Lo (2013), machine learning can also be used to create investment and order execution strategies. They describe how advancements in financial and computing technology have led to algorithmic trading becoming a significant component of financial trading systems [KL13].

Overall, these papers suggest that AI is being used in a variety of ways in the finance industry, from providing better predictions to creating new trading platforms and services. However, there are also challenges in using AI in finance, such as regulatory compliance and ethical concerns.

The increasing adoption of AI is leading to a parallel race for developing regulations around AI [Smu21].

The Ethics Guidelines for Trustworthy AI by the European Commission's High-Level Expert Group on Artificial Intelligence (AI HLEG) [HLE19] defines ethics in AI as the set of moral principles and values that should guide the design, development, deployment, and use of AI systems. The guidelines underscore the critical role of guaranteeing that AI is directed towards serving the human good, upholding democratic values and fundamental rights, and respecting privacy, dignity, autonomy, diversity, and the environment. Furthermore, the guidelines highlight the importance of establishing accountability, transparency, and explainability in AI, and involving all concerned stakeholders in ethical deliberations and decision-making.

According to Jobin et al. (2019) [JIV19], a systematic review of AI ethics guidelines from different countries has revealed that there is a lack of consistency and coherence among these guidelines. This could lead to confusion and uncertainty for AI startups as they try to navigate the complex ethical landscape of AI. The study revealed that most of the guidelines on AI ethics provide general

principles and values, and do not offer practical advice on how to implement them. This lack of practical guidance can be problematic for AI startups seeking specific instructions on how to create and operate ethical and trustworthy AI systems.

AI startups are increasingly developing and deploying AI systems that can have a significant impact on individuals and society as a whole. A code of ethics can help guide AI startups in making ethical decisions and building trust with users and stakeholders. A code of ethics can guide AI startups to develop AI systems that respect individual rights, minimize harm, and promote social justice, thereby navigate the complex ethical landscape of AI and build trust with users and stakeholders.

Mittelstadt et al. (2019) [Mit+19] focus more on the technical aspects of algorithm design and deployment, rather than on high-level principles and values. They identify three main areas of technical concern in the ethics of algorithms: bias and discrimination, explainability and transparency, and accountability and responsibility. AI startups can benefit from a technical focus on issues like bias and transparency to develop more trustworthy and ethical systems that can help gain the trust of users and stakeholders. However, it's crucial for AI startups to be aware of broader ethical debates and principles and to ensure that their technical decisions align with ethical considerations to avoid negative consequences in the future. There is a general consensus among scholars and experts that regulations have not kept pace with the rapid development and deployment of AI.. The study by Jobin et al. (2019) [JIV19] found that many existing AI ethics guidelines lack consistency and coherence, and that they often focus on high-level principles without providing practical guidance for implementation.

Both the authors argue that current regulations are insufficient to keep pace with the rapid technological advancements in AI, and that new regulatory frameworks are necessary to ensure responsible development and deployment of AI. They suggest that future research should focus on developing agile and flexible regulatory frameworks that can keep up with the pace of technological change and address the complex ethical issues that arise with AI.

2.4 Related work

Yang et al. (2019) conducted a comprehensive review to investigate the current status of artificial intelligence (AI) development. The review highlights the rapid growth of AI across various domains, such as natural language processing, computer vision, and robotics. Additionally, the authors identify several key challenges that must be addressed to realize the full potential of AI, including ethical considerations, bias mitigation, and explainability. The findings of this review provide valuable insights for researchers, practitioners, and policymakers seeking to understand the current landscape and future directions of AI development [YZ19].

[Hol+18] highlights the current and future trends in Artificial Intelligence (AI) and Machine Learning (ML) and the increasing interest from academia, in-

dustry, and the public due to the remarkable achievements in statistical learning from big data. The industry is heavily investing in AI, leading to the emergence of spin-offs and start-ups at an unprecedented rate.

Ensuring security and privacy in machine learning is crucial for the success of AI startups' research. The importance of usable security research and fingerprinting/watermarking mechanisms that satisfy specific criteria to ensure transparency, privacy, and explainability in data-driven research is highlighted by the author in their paper. By implementing such measures, AI startups can increase the trust of investors, stakeholders, and customers, which can significantly contribute to their growth and success.

[Bor+21] is a Systematic Literature Review (SLR) that endeavors to offer insight into the contemporary reported business value and contributions of AI, as well as research and practical implications for AI usage, while also highlighting prospects for future AI research. The author Borges et al. (2021) suggests that although there is a consolidation in the definition of AI, there is still a lack of clarity in defining it, and more research is needed on the societal and personal effects of recent AI advances. He also highlights several areas that lack research, such as the psychological elements of robot-human interaction and technophobia in robotics.

Similar to [Bor+21], the systematic literature review (SLR) by Collins et al. (2021) explores various aspects of artificial intelligence (AI), including its definitions, societal and personal impacts, and concerns related to technophobia. The study delves into different applications of AI, such as machine learning in research, expert systems, service robots, robot-human interaction, advanced chatbots, and machine vision. The SLR also highlights gaps in current research, such as the need for further investigation into the interactive and psychological elements of robot-human interaction, the impact of AI on agriculture sustainability and the public sector, and the potential for complementary assets to generate value from information systems [Col+21].

The systematic literature review (SLR) on artificial intelligence in animal farming [BX22] aims to examine the current state of research and development in this field. It encompasses various sub-fields of animal farming, including dairy, poultry, pig, beef, and sheep farming. The review identifies the potential applications of AI in animal farming, including animal welfare monitoring, precision feeding, disease diagnosis, and prediction of production parameters. The review also highlights the challenges in implementing AI in animal farming, such as data collection and management, the need for large amounts of high-quality data, and the lack of standardization in data formats. Additionally, the review discusses the limitations of existing AI models and the need for further research to improve their accuracy and reliability.

The findings of this review are useful for AI startups researching the application of AI in animal farming, as it provides insights into the current state of research and highlights areas for further investigation.

Chapter 3

Systematic mapping study

To gain insight into the current state of research on AI-based startups, a systematic mapping study was conducted. This involved defining research questions, selecting digital databases, and constructing search strings. We then performed database searches using these search strings to obtain relevant papers. Once we had identified relevant papers, we extracted specific data to answer the defined research questions (RQs).

3.1 Objective and research questions

The aim of this thesis is to identify the current state of research on artificial intelligence (AI) based startups. AI is being applied to a wide range of industries and sectors, from healthcare to finance to retail. By studying these domains, AI startups can identify opportunities for innovation and gain insights into the specific challenges and needs of each industry. AI encompasses a broad range of technologies, including machine learning, natural language processing, computer vision, and neural networks. By understanding these technologies and how they can be applied to specific use cases, AI startups can develop more effective solutions and products. Exploring AI facets: AI is not just about technology; it also encompasses various ethical, social, and legal considerations. By exploring these facets, AI startups can better understand the potential risks and challenges associated with AI development and deployment, and develop strategies for mitigating them. Hence, we focus on business domains, AI technologies and facets studied as part of a systematic mapping study. As a result, the objectives are summarized in Table 3.1 as research questions:

Research question RQ-1 aims to understand the current trends in research publications, publication venues over the last few years.

RQ-2 intends to examine business domains mentioned in the literature and investigate how artificial intelligence has impacted those domains. The impact of artificial intelligence (AI) on business domains is significant and far-reaching.

RQ-1	How has research on AI startups changed over the years?
RQ-2	What are the business domains reported in AI startups literature?
RQ-3	Which AI technologies have been reported in AI startups literature?
RQ-4	Which implication/facets of AI is studied in AI startups literature?

Table 3.1: Research Questions

AI technology has the potential to revolutionize various industries by automating tasks, optimizing processes, and improving decision-making.

RQ-3 seeks to identify and analyze the AI technologies that have been reported in the literature. This research question is important because it provides insights into the current state of AI research and development, as well as the practical applications of AI in various domains. Understanding the AI technologies that are currently being used can help researchers and practitioners identify gaps in current research and development efforts, as well as identify opportunities for future innovation and advancement.

RQ-4 aims to explore the different implications and facets of AI that have been studied in the literature. This research question is relevant for research because it provides a comprehensive understanding of the complex and multidimensional nature of AI, and the various ways in which it can impact society, the economy, and individuals. By examining the different implications and facets of AI that have been studied, researchers can identify gaps in current research and development efforts, and prioritize areas for future investigation.

3.2 Data sources and search strategy

To begin a systematic search, we first created a search string by combining various keywords that were relevant to our research questions. In order to address the wide scope of our research problem, we determined that a highly comprehensive search string was necessary. Accordingly, we identified keywords and then formualted a search string from research questions according to population, intervention, comparison and outcome (PICO), as suggested in [Kee+07].

This would enable us to cover all relevant areas of our research problem and ensure a thorough approach to our search strategy.

Population: Population may refer to particular software engineering role, category, an application area [Kee+07]. In our context, the population are startups.

Intervention: The intervention could be the software methodology, tool, technology, or procedure. In the context of this study, we consider Artificial intelligence as an intervention to be investigated.

Comparison: We do not compare any processes used while conducting mapping studies.

Outcomes: No outcome is considered, as we do not focus on empirical studies

Table 3.2: Selected databases and retrieved papers

Database	Papers
ACM Digital Library	53
IEEE Digital Library	754
Scopus	1654
Total	2461

evaluating systematic mapping. We mention the keywords, synonyms related to population and intervention in Table 3.3).

The final search string consists of several search terms (as mentioned in Table 3.3) are combined using the Boolean operator "OR". We identified the primary studies by applying the search string on scientific databases. The selected scientific databases on which we performed the search are shown in (Table 3.2), along with the number of publications retrieved from each database (up to May 2022). We selected the databases (ACM Digital Library, IEEE Digital Library, and Scopus) considering their coverage and use in the domain of artificial intelligence, startups, and software engineering and their ability to handle advanced queries. This resulted in 2461 papers.

3.3 Screening of relevant papers

The systematic search strategy consisted of searches in three online databases. The criterion that guided the inclusion of a paper was that the study presented a contribution to the body of knowledge on artificial intelligence in startups. We excluded search results that were:

- not peer-reviewed (gray literature, books, presentations, blog posts, etc.),
- not written in English,
- not related to research on AI startups
- editorials, table of contents, message of chairs
- clearly obsolete (more than 20 years old)

After applying exclusion criteria, the total number of papers was reduced to 52. One paper that was excluded from the study was titled "AI-enabled project initiation: An approach based on RFP response document." This paper was excluded because it did not meet the inclusion criteria of our study, which focused specifically on research of AI startups. While the excluded paper provided insights on AI-enabled project initiation, it was not directly relevant to our research question. Therefore, we excluded it from our analysis. Further limitations due to unavailability of certain papers resulted in a final selection of 44 papers. The full text of these 44 papers was manually reviewed, and relevant data was extracted to address the defined research questions. See figure 3.1.

Table 3.3: Search string

Keywords	Related to	Synonyms
Artificial Intelligence	Intervention	"Artificial Intelligence", "AI", "Computer Vision", "Natural Language Processing", "Conversational AI", "Neural networks", "Deep Learning", "Inference", "Audio Processing", "Machine Learning", "Sensor Processing", "Speech Recognition", "Gesture Recognition", "Video Analytics", "Bots", "Image Recognition", "Text Analytics", "Robotic Process Automation", "Biometrics Identity", "Semantics", "Virtual Assistants", "Context-Aware Computing", "Recommendation Systems", "Augmented Reality"
Startups	Population	"startups", "start-up", "start-up*"

3.4 Data extraction and mapping

To answer the defined research questions, the following data were extracted from all publications: We read the titles, keywords, abstracts, and the body of each paper. We extracted several data to answer the research questions defined in table 3.1.

- Title
- Abstract
- Publication type (RQ1)
- Publication year (RQ1)
- AI business domain (RQ2)
- AI technology domain (RQ3)
- Facets (RQ4)

AI business domains: We clustered similar business domains and gave a label. We have not found any scientific publication proposing a classification for business domains. So, we utilize the classification used in industry literature. We classified the business domains based on industry or sector in which they operate. For example, we extracted the business domains such as Finance, agriculture, healthcare, and so on. In Table 4.1 we list every single classification.

Facets: We used the terms that are close to meaning what the paper is about. For example, we use "Application" as a group to signify that the facet discussed in the paper is applications of AI in several domains. Each facet talks about the implications of AI. In Figure 4.5, we display a pie chart depicting the different types of facets we discovered in the mapping study.

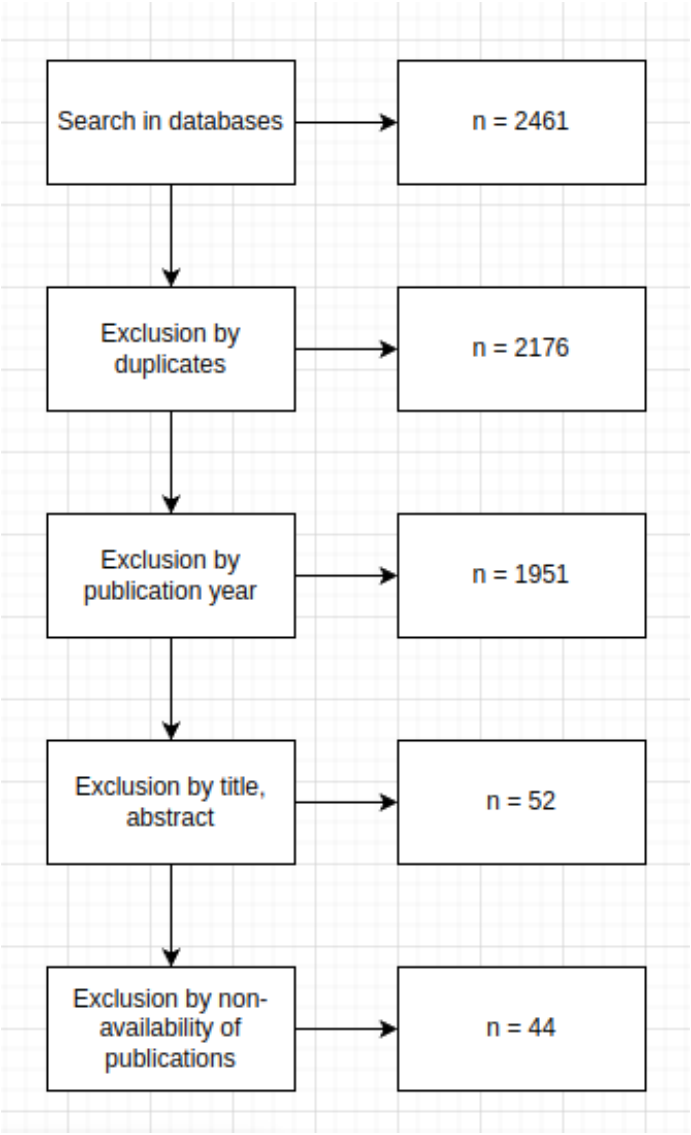

Figure 3.1: Search process

Chapter 4

Results

This chapter is structured according to the research questions. It presents for each research question all related findings from the analysis and synthesis of the extracted data.

4.1 RQ-1: How has research on AI startups changed over the years?

The research activity is estimated by the number of publications over the years and the the publication venues.

4.1.1 Distribution of publication year

Figure 4.1 shows the distribution of the number of publications over the years. From the year 2018 on wards we see an increase in the number of publications (with the exception of 2020). The year 2021 especially has seen almost twice the number of publications. It is to be understood that data for the year 2022 is incomplete (The data presented is only up to May 2022.)

4.1.2 Publication venues

We grouped the papers collected according to publication venues into journals, conference papers and book chapters. The results are mentioned in Figure 4.2. A total of twenty two journals, three book chapters and nineteen conferences are covered in this study between the years 2016 and mid-2022 (the data presented is only up to May 2022).

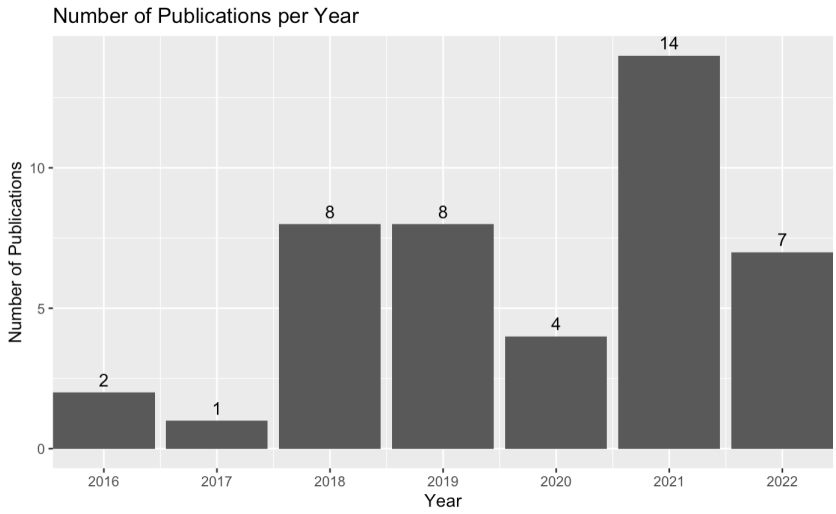

Figure 4.1: Publication per year

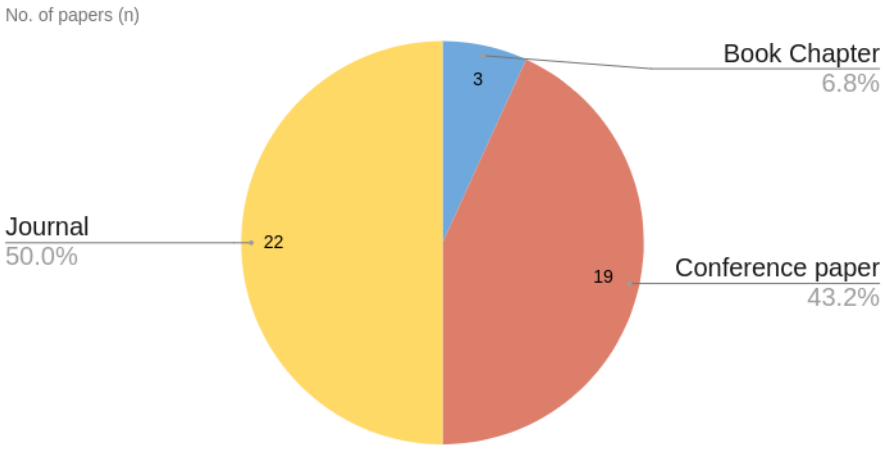

Figure 4.2: Publication Venue

4.2 RQ-2: What are the business domains reported in AI startups literature?

The table 4.1 lists the business domains where AI technologies are applied. We have extracted 8 different business domains from the literature. We apply Functional classification based on business domain: These classifications are based on the function they perform, such as production, marketing, or finance. The

domains extracted from the studies include: Agriculture, Finance, Healthcare, Pharmaceuticals, Social media, Tourism, Industrial machines, and Transportation.

The healthcare domain has been researched more than the other domains.

Table 4.1: RQ3

AI business domains	No. of papers
Agriculture	3
Finance	4
Healthcare	12
Pharmaceuticals	1
Social media	1
Tourism	1
Industrial machines	1
Transportation	1
"Domains Not specified"	20
Total	44

In this section, we describe the business domains and the impact of AI technologies on the business domains. We visualize the impact using a bubble plot (4.3).:

4.2.1 Agriculture

Artificial Intelligence (AI) has made significant contributions to the agricultural industry by automating various tasks such as soil treatment, irrigation, pest control, weed control, and yield prediction, precision farming recommendations based on satellite and drone data analysis [MB21; KP20; Bab+22]. IoT sensors are often used in soil treatment as they provide real-time data on soil moisture, temperature, pH levels, and other relevant parameters. This data helps farmers optimize their soil treatment plans and ensure that crops receive the correct amount of water and nutrients. Furthermore, startups are developing AI-powered trading platforms for agricultural products. AI applications are mainly focused on predicting plant and soil conditions, with the goal of optimizing the application of pesticides and fertilizers. The use of IoT sensors in combination with AI technology is contributing to increased efficiency and productivity.

4.2.2 Finance

In the case of Finance, the impact of AI technologies has led to automation of business operations. The demand for faster banking services from customers has gone up [ZK18]. It has impacted other banking services such as wealth management, financial advising and retirement planning. The use of chatbots and roboadvisers have gone up extensively providing a host of personalized

service. Although the challenges raised are also many. Such as transparency, bias, privacy. There is also call for regulating the AI use in finance domain [LL18].

4.2.3 Healthcare

AI technology is rapidly advancing in the healthcare industry, with a focus on personalized medicine based on a patient's medical history, genetics, diet, and stress levels. AI is also being utilized to improve access to treatment recommendations, manage Parkinson's disease, detect and monitor COVID-19 patients, and optimize remote patient monitoring services [Cab+18].

IoT sensors along with the use of AI technology are used for remote patient monitoring. Other use cases include COVID-19 screening, optimizing clinical trials of drugs and vaccines, and prediction of cases [SMY21]. Along with IoT and AI, there is an example of utilizing blockchain and cloud technology to enhance access to electronic health records which leads to better patient outcomes [Pau+21].

4.2.4 Pharmaceuticals

In this section, we will explore the role of artificial intelligence (AI) in the pharmaceutical industry's research and development (R&D) domain, which focuses on developing new drugs and treatments to improve patient health outcomes. The discussion will center on the potential for AI to improve efficiency and accelerate drug discovery and development processes. Additionally, we will emphasize the significance of digitization and data sharing, which are essential aspects of the pharmaceutical industry. Overall, this section will provide insight into the pharmaceutical industry's R&D domain, highlighting how the integration of AI technologies can lead to groundbreaking advancements in drug discovery and development. [Sch+21].

4.2.5 Social media

The author Jaimes [Jai16] discusses how the abundance of visual content, such as images and videos, has played a significant role in the progress of artificial intelligence. The proliferation of smartphones, cameras, and social media has led to an explosion of images online, which has enabled researchers to develop computer vision algorithms that can analyze and interpret visual data. The paper also highlights the value of images in various industries, such as advertising and marketing, and the cultural significance of visual content. Finally, the paper concludes by noting how these factors have come together to drive innovation in AI, and how the development of computer vision technology has contributed to the progress of AI overall.

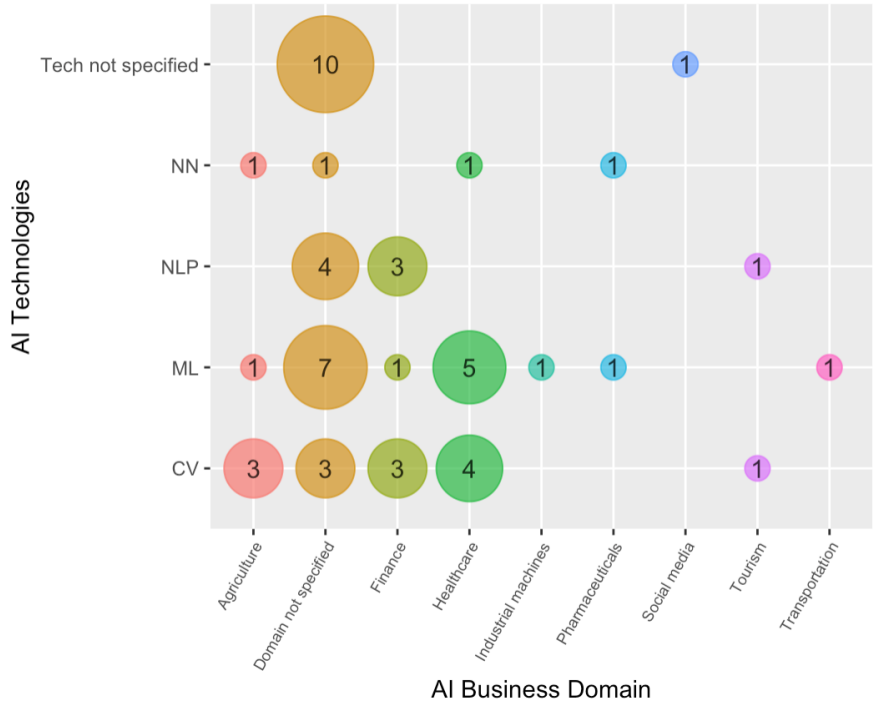

Figure 4.3: AI biz domain v AI technologies

4.2.6 Tourism

In the paper, the author describe the characteristics of AI start-ups in the tourism industry, specifically in the pre-trip and post-trip phases. The importance of security, safety, and transparency in AI solutions are emphasized, particularly with regards to privacy issues. The paper identified marketing automation, customer service, and relationship management as areas where AI solutions are commonly used in the industry [Fil+21].

4.2.7 Industrial machines

The paper [RW22] on Industrial machines business domain explores the adoption of artificial intelligence in a traditional industrial environment to achieve smart manufacturing. The steel firm optimized their production line by using an ML-based computational methodology to improve the productivity and quality of the blast furnace. The steel company used real-time data to create a machine learning model that provided recommendations for optimal furnace conditions to the operators, which led to increased process efficiency and better quality control. The model was trained to identify potential anomalies and disruptions

that could impact process optimization. As a result, the company was able to achieve a competitive edge by maintaining consistent quality and productivity levels. The research centered on the use of machine learning techniques for enhancing quality and productivity in continuous materials processing.

4.2.8 Transportation

The author Chopra [Cho21] discusses the potential impact of technological trends on air cargo facilities. It focuses on the challenges of implementing AI in cargo management due to the complexity of revenue generation and dependencies on multiple variables. The paper identifies important areas for the digitization of the air cargo industry and highlights different areas within the domain of transportation where AI could be used in the future.

The common research trends across the study are the application of artificial intelligence (AI) and machine learning (ML) technologies in various industries such as air cargo, pharmaceuticals, industrial manufacturing, tourism, and social media. The studies also discuss the potential impact of AI on different aspects of these industries, including process optimization, quality improvement, efficiency, and customer service. Additionally, the texts highlight the importance of digitization and data sharing in these industries to facilitate the integration of AI technologies. Overall, the common research trend is the exploration of AI and ML applications across industries to improve business processes and outcomes.

4.2.9 Domain Not Specified

We have one row termed "Domains Not specified" which has the highest number of publications (20 studies). It is named so because these publications do not mention any particular business domains. The common trends observed for "Domain Not Specified" related to AI include the challenges and opportunities of implementing AI technologies in enterprise contexts, the need for new business models and innovation in professional services, the economic promise of AI, and the impact of AI on data analytics and privacy. Other trends include the need for trustworthy AI, the importance of proprietary data for AI startup growth, the challenges of investing in AI, and the importance of knowledge engineering and information architecture in AI system development. Additionally, there is a focus on the evaluation and quality of AI services and the growth and scaling dynamics of AI startups. Overall, the trends in AI indicate the need for innovation, collaboration, and investment to fully realize the potential of this rapidly evolving field.

4.3 RQ-3: Which AI technologies have been reported in AI startups literature?

Figure 4.4 lists the number of papers and different technologies used to realize AI. We classify the AI technologies based on classification proposed in [Enh+22].

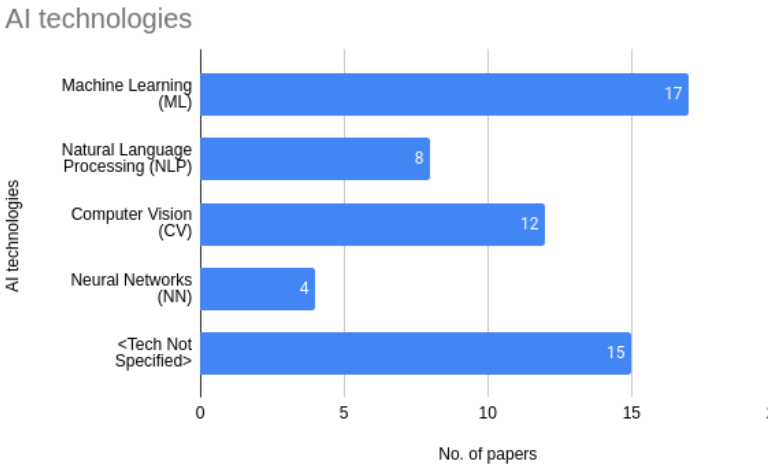

Figure 4.4: AI technologies

We synthesized our findings into a table that highlights the AI technologies studied in the literature on AI startups. Some of the technologies include Machine Learning (ML), Natural Language Processing (NLP), Neural Networks (NN), and Computer Vision (CV) as mentioned in Fig 4.4. We define each technology in chapter 2.1. We observe Machine Learning is applied and reported extensively along with Computer Vision and Natural Language Processing in that order. The remaining papers (15) don't mention any technology domains specifically. Hence, they are named as "Tech Not Specified".

4.4 RQ-4: Which implication/facets of AI is studied in AI startups literature?

We identified the implications/facets of AI and classified them into 6 facets. See Figure 4.5:

4.4.1 Current Advances and Trends

The two studies we found in the mapping study in the context of Current Advances and Trends facet talk about the current trends in AI industry. The metrics the authors use to signify interest in AI industry are the increase in

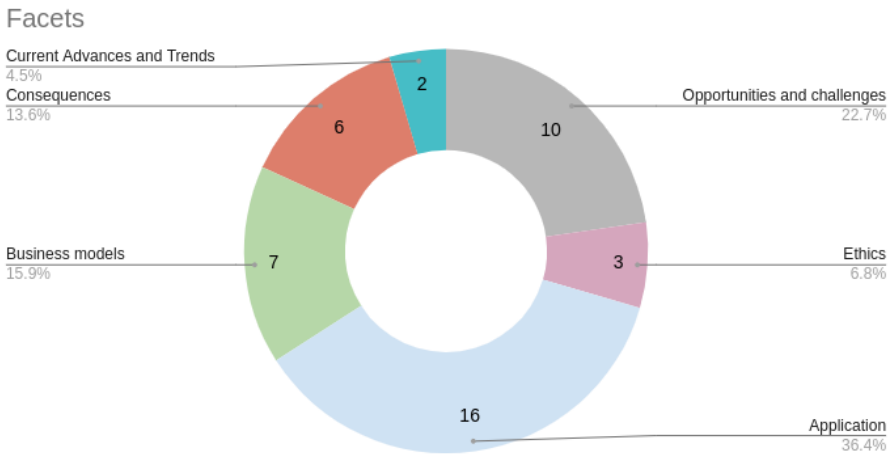

Figure 4.5: Facets

number of publications presented in conferences and increase in AI startups funding. The growth of AI is also seen in terms of usage of AI in different business domains such as healthcare, manufacturing, transportation, environment and justice. The recent trends in the computer vision research, sales of robots, and development of human interfaces are also discussed by [YZ19]. The author Holzinger (2018) raises the importance of security and privacy in machine learning, as well as the need for usable security research and fingerprinting/watermarking mechanisms that meet specific criteria to ensure transparency, privacy, and explainability in data-driven research [Hol+18]. There is a need for a mechanism which can detect a data leak with one record as most algorithms face this challenge. The author proposes such a fingerprinting mechanism with the following criteria:
1) Single Record Detection, meaning detection of data leaks can be achieved with just one compromised record,
2) Collusion Protection, where partners should not be able to collude to extract or remove fingerprints,
3) High Performance, meaning the protection mechanism must not require a lot of resources in terms of calculation time or additional storage requirements, and
4) Low Distortion: It is crucial for the algorithm not to add significant distortion to the data during analysis, as this would decrease its usefulness.
These criteria will ensure that the protection mechanism is usable, requires minimal resources, and maintains the value of data used in analysis.

The author also suggests that the use of Explainable AI (EAI) can help address the issue of understanding and estimating distortions in data. EAI can enable better understanding of decisions made by AI models, which can aid in identifying and reducing the distortions introduced by algorithms, especially those related to privacy concerns. The author emphasizes the importance of

adapting algorithms for anonymization and machine learning to reduce the distortions, which requires overcoming the black-box nature of machine learning. Therefore, EAI can play a critical role in developing solutions that effectively leverage the power of machine learning while ensuring privacy.

Overall, the papers provide insights into the present and future trends in AI and the challenges that come with them.

4.4.2 Application

Application facet is concerned with the application of AI in several domains. We identify the different areas of application where AI startups are being used. This could include industries such as healthcare, finance, retail, manufacturing, and transportation.

The use of AI in healthcare is rapidly advancing with new developments and trends emerging. One specific area where AI is making significant contributions is in personalized medicine, where health or treatment recommendations for a patient are based on their medical history, genetics, past diseases, diet, and stress levels AI is also being used to improve access to recommendations and automated treatments, manage Parkinson's disease, and detect and monitor COVID-19 patients [Cab+18].

Remote patient monitoring services are also being improved through AI technologies, which can detect problems immediately using sensors and optimize clinical trials of drugs and vaccines against the virus. Additionally, AI is being used in screening, treatment interventions, rehabilitation, and predicting projections of cases and mortality related to COVID-19 [SMY21]. Machine learning, natural language processing, computer vision, and IoT are among the technologies driving these developments. Finally, blockchain and cloud computing are being used to ensure secure access to health records. Overall, the use of AI in healthcare is showing promising potential to improve patient outcomes and access to medical care [Pau+21].

AI is being used in agriculture to perform tasks such as soil treatment [MB21], precision farming recommendations based on satellite and drone data analysis [Bab+22], irrigation, pest control, weed control, and yield prediction [KP20]. Startups are also developing AI-powered trading platforms for agricultural products. Prediction of plant and soil conditions is a major focus of AI applications in agriculture, particularly in optimizing the application of pesticides and fertilizers. Overall, AI is contributing to increased efficiency and productivity in the agriculture industry.

AI has impacted the finance industry by providing convenience and speed in banking services. Customers demand personalized and quick services and loathe time spent searching for answers. The use of AI in wealth management [ZK18] has allowed for the analysis of customer savings and devising of retirement plans. Analysts in the finance industry scour through large amounts of data to assess the value of stocks. AI has been used to detect bad behavior in financial transactions. Fintech has been integrated into banking services, and

personalized services such as financial advice are being provided by robots and chatbots [LL18].

4.4.3 Business models

To put it simply, a business model is a theoretical framework that outlines how a business operates and conducts its activities. It describes the system by which a company carries out its operations and functions [OPT05]. The business models facet is important for understanding the emerging business models in AI startups and the innovation in these models. Understanding the business models of AI startups can provide insights into the direction of innovation and the potential impact of these startups in their respective domains, such as healthcare.

The high expectations and potential for AI technology have led to a shift in the relationship between AI research and business. Previously, AI research was mainly driven by academia and received little attention from the industry. However, with the increasing commercialization of AI technology, big corporations, venture capitalists, and technological giants are now heavily investing in AI startups and funding AI research. This has led to a growing focus on developing innovative business models that leverage AI solutions to create value for customers and partners [Met+18].

We explore the intersection of AI and business models in this section. The paper [Web+22] emphasize the need for novel digital business models that incorporate data analytics and AI to drive innovation and optimize production processes. Specifically, the papers focus on the strategic transformation processes needed to achieve success with these new models. They also highlight the differences between AI startup business models and traditional IT-related business models, with four distinct patterns emerging from an analysis of 100 AI startups. One key aspect of AI business models is the need for quality evaluation of AI services, which enables startups to develop personalized, customized services that satisfy customer needs and create new value. Overall, the papers demonstrate the importance of AI in driving innovation and competitiveness in business, but also highlight the need for careful strategic planning and evaluation of AI services to ensure success.

In this section, we discuss the emerging business models in AI-driven healthcare startups. The authors Garbuio et al. [GL19] identifies three fundamental ways businesses can use AI: assisted intelligence, augmented intelligence, and autonomous intelligence. The article emphasizes the importance of identifying the target user and area of value creation for healthcare startups. Healthcare startups are classified based on the type of problem they address, such as telemedicine services or image recognition. The article highlights the potential benefits of AI in precision medicine and patient-centered care. However, it also recognizes the need for transparency and trust in the development of autonomous intelligence systems.

Another paper discussing business models in healthcare by Kulkov [Kul21] focuses on the design parameters and elements of the business model for AI providers in healthcare. Specialization is identified as a key area for success-

fully integrating AI solutions. The design themes include improved access to healthcare, responsiveness to patients and doctors, and privacy of medical data. The article emphasizes the importance of privacy in AI systems used in healthcare and suggests that developers of AI systems ensure that they don't collect data or identify patients/final users with the data by processing the medical data. Additionally, privacy and security decisions should be taken into consideration when adopting new technologies. The article concludes that there is limited knowledge on the business models of companies offering AI solutions exclusively in healthcare.

4.4.4 Opportunities and challenges

The opportunities and challenges facet of AI refers to the various possibilities and obstacles associated with the implementation and use of AI in different domains. It involves exploring the potential benefits and drawbacks of AI and identifying ways to overcome the challenges in order to fully leverage the benefits. Also include opportunities for growth and innovation, as well as challenges related to funding, talent, and market competition.

In their study, Iliashenko et al. (2019) [IBD19] explore the potential advantages and obstacles associated with integrating artificial intelligence (AI) technology in the healthcare industry. The authors categorize the various AI systems utilized in healthcare and provide a global map of the leading AI startups operating in this field. They highlight the increasing popularity of telemedicine and similar applications, and describe various algorithms, such as wearable sensor data collection and speech recognition. The paper also discusses the two possible ways of positioning AI in medicine: as a tool to assist doctors and patients, or as a substitute for medical professionals. However, there are challenges with reliability, quality of services, privacy, safety, laws, responsibility, and the technical aspect of AI in healthcare. Chip architectures play an important role in transitioning from traditional computing architectures to AI architectures, but finding the best architect for AI workloads involves a complex calculation. Health data is privileged and accessing it involves strong regulatory controls, and the cost of moving data is huge. The authors conclude that the resources required make AI projects cost-prohibitive. In the Finance domain, there are challenges in implementing AI in the public cloud due to security concerns. To address this, an approach to building an AI architecture for finance is proposed, which aims to incorporate finance expertise and specificities into AI. This will enable effective utilization of AI technologies in finance. The approach focuses on analytics and forecasting for business-to-business operations, and involves developing a framework that integrates finance-specific data, algorithms, and models. Additionally, factors such as data privacy and regulatory compliance are taken into consideration. The ultimate goal is to develop AI-powered tools and solutions that can enhance decision-making, risk management, and operational efficiency in finance [SZ21].

Another study by Ghandour et al. (2021) provides a systematic literature review on the opportunities of AI in banking such as personalized financial

services and decision making, and the challenges that need to be prioritized such as job loss, privacy breaches, and loss of emotional human touch [Gha+21].

The author Beckert (2021) discusses the concept of "Trustworthy AI" and suggest ways for implementation in startups and companies. It is often only discussed in a research context and not commonly implemented in real-world settings. One of the reasons for the slow adoption of Trustworthy AI in real-world settings is the different mindsets of software engineers and scientists. While software engineers tend to prioritize efficiency and functionality, scientists focus on the principles of Trustworthy AI, such as fairness, transparency, and accountability [Bec21].

The author recommends making existing implementation guidelines for Trustworthy AI accessible and actionable for software engineers, computer scientists, and managers in order to effectively incorporate these principles into the design and development of AI systems from the beginning.

AI cannot be treated like other software programmes due to its technical complexities and societal impacts. Trustworthy AI requires extending existing software design principles and involving social scientists and stakeholders in the implementation process. Setting up mixed teams of software engineers, computer scientists, ethicists, and social scientists is crucial for successful Trustworthy AI projects.

Figure 4.6 represents a bubble plot depicting relationships between Facets and business domains. The number inside the bubble represents the number of publications here. For example: Agriculture has 3 publications under Application facet.

4.4.5 Consequences

The Consequences facet of AI focuses on the potential impacts of AI on society and the economy. The facet also examines how AI affects various aspects, such as economic growth, innovation, and public policy.

The proposed framework by Ghurra et al. (2021) to understand AI's implications encompasses several aspects, including the impact of AI on entrepreneurship, economic growth, and society as a whole [GH21]. It highlights the potential benefits of AI, such as improved productivity, efficiency, and innovation, as well as the potential risks, such as job displacement, bias, and ethical concerns. The framework also emphasizes the importance of developing policies and strategies that promote responsible and ethical AI adoption, including the need for transparency, accountability, and human oversight. By adopting this framework, policymakers, businesses, and individuals can better understand the implications of AI and develop strategies to harness its potential while mitigating its risks.

A study by Cautela et al. (2019) focused on AI's impact on design thinking found that AI can play a role in both the initial stage of forming teams and identifying user needs, as well as in later stages of testing and verifying concepts. In the crucial phase of team building and task management, AI can enhance efficiency by helping to develop teams with diverse mixes of people and cultures

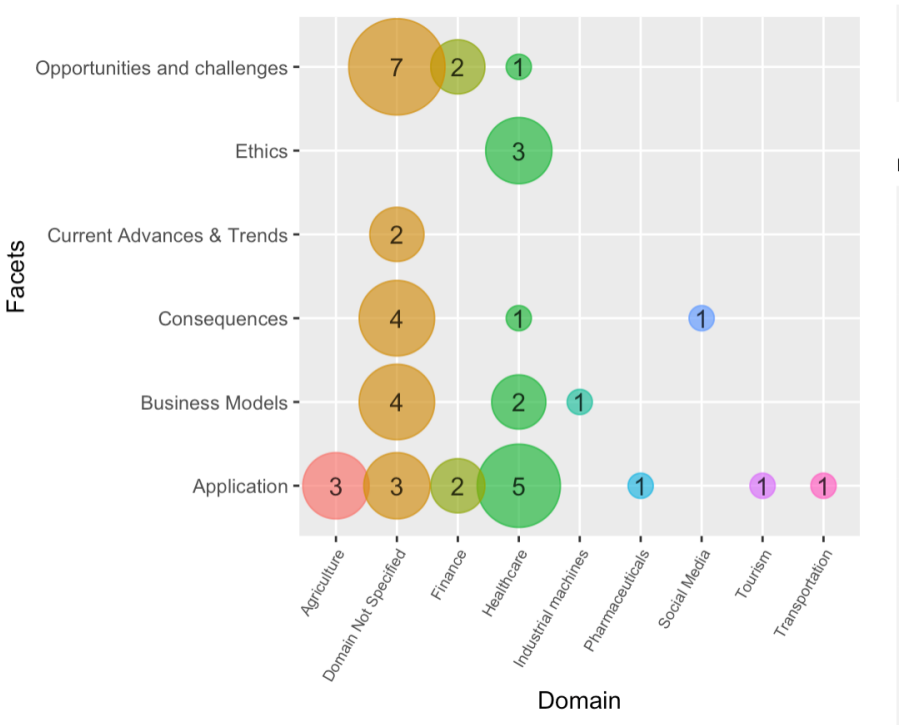

Figure 4.6: AI Business domain v Facets

based on neuroscientific evidence of individuals' intrinsic traits and attitudes. [Cau+19].

Bessen and his colleagues conducted a study in 2022 [Bes+22] that explores the correlation between access to proprietary data and increased funding for startups. The findings indicate that startups with access to proprietary data tend to receive more funding than those with only customer data. This implies that the origin of the training data could be a crucial factor in gaining a competitive edge, and may play a role in determining the success of a startup.

This paper [Lau19] specifically discusses the ethical concerns, risks, bias, and transparency issues related to AI. Additionally, it provides information about the key AI technologies, such as machine learning (ML) and perception technology, and highlights the trends in national AI strategies, including policy announcements, regulations, and strategies adopted by various countries to utilize AI.

4.4.6 Ethics

We describe the ethical issues related to AI startups, such as privacy, bias, and transparency. Also present different approaches that researchers and practitioners are taking to address these issues.

We will discuss three important studies related to ethics in AI. It is surprising that we only found studies on ethics in the healthcare domain. [Vak+20] covers a range of topics related to AI and its impact on society. The first section emphasizes the need for AI ethics to be considered as a non-functional requirement in software engineering projects, especially in startup environments where most AI is practiced. The lack of formal methods and tools to implement AI ethics is a concern and the paper argues that AI systems, despite their unique nature, must meet the same requirements as conventional software systems.

The second study we discuss the paper by Howard et al. (2018) [HB18] which focuses on healthcare and the challenges in implementing new technologies, particularly in radiology. The development process is often not streamlined, and there is a fear of health professionals becoming redundant. Moreover, the transition to a less stringent regulatory environment entails various technological and human-technological concerns that could substantially elevate the associated risks. The paper suggests that regulation is needed to keep up with developers and ensure the safety and efficacy of AI tools in healthcare.

The third paper on Ethics in AI startups by Duke '[Duk22] explores the potential impact of bias on the design and development of next-generation robots, specifically in areas such as face recognition, voice recognition, search engine apps, and the justice system. The paper identifies various ways in which bias could be introduced into the design of these systems, such as the use of biased training data and the lack of diversity in development teams. The paper proposes several strategies to prevent or mitigate bias, such as scrutinizing the behavior of robots to ensure they are operating in an unbiased manner and establishing a code of ethics for developers to follow. Overall, the paper stresses the importance of addressing bias to prevent negative consequences for those who interact with future robotic systems.

Chapter 5

Discussion

The continuously growing interest in the research domain of AI worldwide resulted in the publication of a large number of research articles containing diverse knowledge.

In this chapter we summarize our findings by: addressing the research questions (RQs). The objective of this study was to determine the current state of research on AI-based startups. Hence, a systematic mapping study was conducted. In this chapter, we present the findings of our systematic mapping study on AI-based startups. We address the research questions (RQs) and summarize our results on four aspects: (1) the current state of research on AI-based startups, (2) the business domains reported in AI startups literature, (3) the AI technologies reported, and (4) the implications/facets of AI studied in the AI startups literature. By performing the mapping study, we provide insights into the current state and future research on AI-based startups, and discuss the implications for research and practice.

The analysis of the research activity include the publication trend and publication venue. The findings indicate that the research about AI startups has received considerable attention. One indication for this is the increase in number of the publications every year. More than 70% of studies in selected sample have been published in the last 4 years. Moreover, the publications are spread over number of distinct conferences (15), journals (20) and book chapters (3).

The highest number of publications (45.4%) belongs to "Domain Not Specified", followed by Healthcare (27.2%). On the other side, only 9% are Finance and 6% are Agriculture. Several business domains have been studied with a particular interest in healthcare and however most of the studies don't restrict to a particular domain. The reasons behind increased interest in AI from the healthcare domain are many. One of the many reasons is the increase in providing innovative solutions by AI-driven health care startups [GL19]. The remaining business domains has received little attention.

After classifying the 44 publications by different AI technologies, we observe Machine Learning (17) is reported and applied extensively along with Computer Vision (12) and Natural Language Processing (8). Only 4 studies have

been found for Neural Networks. The remaining papers (15) don't mention any technology domains specifically. Hence, they are named as "Tech Not Specified". Our findings and analysis also shows the combination of several AI technologies applied together.

Here, we will explore how emerging AI technologies such as Machine learning (ML), Computer Vision (CV), Natural Language Processing (NLP) and Neural Networks (NN) improve the efficiency and impact the existing processes in several business domains.

We will delve into how Artificial Intelligence (AI) and the Internet of Things (IoT) are revolutionizing the agricultural industry by automating various tasks such as soil treatment, irrigation, pest control, weed control, and yield prediction. AI is helping farmers to optimize their production, reduce waste, and increase efficiency.

The use of IoT sensors in soil treatment is particularly important, as it provides real-time data on soil moisture, temperature, pH levels, and other relevant parameters. This data helps farmers to make informed decisions about how much water and nutrients to apply to crops, which can lead to more efficient use of resources and increased yields.

AI-powered trading platforms are another example of how AI is making a difference in agriculture. These platforms help farmers to predict market demand for their products, which can lead to better prices and more efficient use of resources. AI is also being used to predict plant and soil conditions, which can help farmers to optimize the application of pesticides and fertilizers. This can help to reduce waste, minimize environmental impact, and increase efficiency.

The impact of AI in agriculture has led to new developments in technology. Apart from what is reported in literature, we can expect developing new sensors, algorithms, and data analysis techniques to improve the efficiency and effectiveness of agricultural processes. In addition, AI and IoT generate large amounts of data that require analysis and modeling to provide insights into agricultural systems.

There is a potential research area in developing new analytical techniques and models for AI and IoT data analysis in agriculture. This could include developing machine learning algorithms that can analyze large amounts of data from IoT sensors to identify patterns and trends in soil health, crop growth, and other factors that impact agricultural productivity.

Researchers could also explore ways to integrate data from multiple sources, such as satellite imagery and weather data, to provide more comprehensive insights into agricultural systems. Additionally, there is potential for research into the use of AI and IoT to develop predictive models for crop yield and quality, which could help farmers to optimize their production and improve profitability.

As AI and IoT continue to transform the agricultural industry, it is essential to consider the potential policy implications that come with these technologies. Researchers can play a crucial role in shaping policies that promote the adoption and scaling of AI and IoT in agriculture. One another potential research area is developing new analytical techniques and models for AI and IoT data analysis

in agriculture.

This includes identifying ways to ensure that the benefits of these technologies are shared fairly among all stakeholders, including farmers, consumers, and the wider community. Additionally, researchers can address concerns related to privacy, data ownership, and ethical use to ensure that these technologies are deployed in a responsible and sustainable manner.

AI has improved the efficiency and speed of drug discovery and development in the pharmaceutical industry. It can predict drug interactions, optimize clinical trials, and identify new drug targets, among other applications.

We explore the adoption of AI/ML in the industrial machines business domain to achieve smart manufacturing.

The impact of AI in the tourism industry is significant, particularly in the pre-trip and post-trip phases. AI start-ups are leveraging technology to provide solutions in areas such as marketing automation, customer service, and relationship management. The use of AI in these areas can result in improved customer experiences and increased efficiency for businesses.

However, there is a need to explore the ethical and privacy implications of using AI solutions in the industry. There is scope for research to identify specific areas in the tourism industry where AI solutions can be most effective. Also, investigating issues related to data privacy, bias, and transparency in AI algorithms cannot be overstated.

AI technology is increasingly being used in healthcare to provide personalized treatment based on a patient's medical history, genetics, diet, and stress levels. It is also being utilized for remote patient monitoring, COVID-19 screening, and to optimize clinical trials of drugs and vaccines. IoT sensors are commonly used alongside AI for remote patient monitoring, while blockchain and cloud technology are being used to enhance access to electronic health records, leading to better patient outcomes.

The development and implementation of AI technology in healthcare have the potential to revolutionize the field, with the potential to enhance patient outcomes, lower expenses, and improve healthcare accessibility. However, the ethical implications and limitations of AI in healthcare also need to be studied to ensure that the technology is implemented in a safe, responsible, and effective manner.

By exploring the ethical implications of AI, researchers can ensure that the technology is implemented in a way that respects patient privacy, reduces bias, and promotes transparency and accountability. This is critical for building trust in AI technology and ensuring that it is accepted and adopted by healthcare practitioners and patients.

In order to build trust in AI technology used in healthcare, a possible solution is to implement the concept of Trustworthy AI, as suggested by author Beckert (2021) [Bec21]. This can be achieved by making existing implementation guidelines for Trustworthy AI such as "The Ethical Guidelines for Trustworthy AI by the European Commission's High Level Expert Group on AI (ALHEG)" [HLE19] accessible and actionable, enabling software developers to effectively incorporate them into the development of AI systems. By following

these guidelines, healthcare providers and developers can ensure that AI technology is developed and implemented in a responsible and trustworthy manner, ultimately leading to better patient outcomes.

CB Insights is a market intelligence platform that provides data-driven insights on startups, venture capital, and emerging industries [CB nt]. The platform uses machine learning and natural language processing to analyze large amounts of data and generate insights on trends, companies, and markets.

As AI continues to evolve and reshape various industries, it becomes increasingly important to understand the AI startup ecosystem and its various domains. CB Insights provides a wealth of data on the AI startup ecosystem, including emerging and niche areas that may not be covered by other sources. This data can be used as a basis for future research, such as exploring the characteristics and trends of different AI domains, identifying successful strategies for AI startups, or analyzing the impact of AI on different industries.

CB Insights releases an annual list of the top 100 AI startups based on their funding, market potential, and innovation. The list includes information such as the company name, category, product focus area, total disclosed funding in millions of dollars, country of origin, and select investors.

Column 1	Column 2	Column 3
“Data Annotation”	“Retail and CPG”	“Cybersecurity”
“Finance and Insurance”	“Transportation”	“Energy”
“Feature Stores and MLOps Platforms”	“Waste Management”	“Healthcare”
“Food and Agriculture”	“AI Model Monitoring”	“Document Analysis”
“Consumer Devices”	“AI Processors”	“Sales and CRM”
“Supply Chain and Logistics”	“Enterprise Search”	“Data Science Platforms”
“Manufacturing”	“Deep Learning Accelerators”	“Legal”
“Speech Recognition”	“Defense”	“Media”
“Education”	“AIOps(IT and DevOps Automation)”	“Waste Management”
“NLP and Conversational AI”	“Enterprise Search”	“Climate Risk Scoring”
“Mining”	“Machine Translation”	“Computer Vision”
“Gaming”	“Energy”	“ML Experiment Tracking”
“Construction”	“Smart Home”	“Remote Inspection”
“Water Leak Detection”	“Other R&D”	

Table 5.1: Categories/ Business domains from CB Insights data

In the context of a list of top 100 AI startups, ”category” most likely refers to the different business domains or industries in which these startups operate.

Each category represents a broad area of application where AI technologies can be utilized to address specific business challenges or opportunities.

Upon examining the list of categories (See the full list here 5.1) released by CB Insights, we notice that some of the categories overlap with the ones we have already identified in literature as part of the mapping study, such as "Transportation", "Finance", "Healthcare", and "Agriculture".

The overlap between our identified categories and the ones listed by CB Insights suggest a potential research gap in AI business domains, particularly in emerging and niche areas that are not covered by research. Exploring these gaps could provide valuable insights for future research on AI startups and their impact on various industries.

As mentioned in the results section, we have categorized the implications of AI into six different facets:

- Current Advances and Trends:
  The two studies found in the mapping study shed light on the current trends in the AI industry, with metrics such as an increase in publications presented in conferences and AI startups funding serving as indicators of interest in the field. The growing adoption of AI in various business domains, including healthcare, manufacturing, transportation, environment, and justice, further demonstrates the field's growth.

  However, amidst the excitement surrounding AI, it is important to consider the potential risks associated with the use of this technology. As highlighted by Holzinger (2018), security and privacy are critical concerns that must be addressed in machine learning. Specifically, there is a need for usable security research and fingerprinting/watermarking mechanisms that meet specific criteria to ensure transparency, privacy, and explainability in data-driven research.

  To address these concerns, Holzinger proposes a fingerprinting mechanism that satisfies four essential criteria. First, the mechanism must enable the detection of a data leak with only one leaked record. Second, partners should not be able to collude to extract or remove fingerprints, ensuring collusion protection. Third, the protection mechanism should not require significant resources in terms of calculation time or additional storage requirements, ensuring high performance. Finally, the algorithm must not introduce a large amount of additional distortion, thus preserving the value of data used in the analysis.

  By satisfying these criteria, the proposed fingerprinting mechanism can be considered usable and effective in maintaining privacy and security in machine learning. Overall, it is crucial to continue researching and developing solutions that address the potential risks associated with AI while also leveraging the technology's many benefits.

  Developing more effective and efficient security and privacy mechanisms for machine learning: While Holzinger proposes a fingerprinting mechanism, further research could focus on developing additional methods or

improving upon existing ones to ensure better privacy and security in data-driven research.

Developing explainable AI as a potential area of future research: As AI systems become more complex, it becomes harder to understand how they reach certain decisions, which can be a problem. Therefore, explainable AI is an approach that aims to ensure AI systems are transparent and can be easily understood by humans.

- Application
  The Application facet of AI focuses on the various industries and domains where AI is being used. AI startups are being applied in several areas, including healthcare, finance, retail, manufacturing, and transportation.

  In healthcare, AI is making significant contributions in personalized medicine, where patients' medical history, genetics, past diseases, diet, and stress levels are used to recommend personalized treatments. AI is also improving access to recommendations and automated treatments, managing Parkinson's disease, and detecting and monitoring COVID-19 patients. Additionally, AI is optimizing clinical trials of drugs and vaccines against the virus, predicting projections of cases and mortality related to COVID-19, and ensuring secure access to health records through blockchain and cloud computing. Machine learning, natural language processing, computer vision, and IoT are among the technologies driving these developments. The use of AI in healthcare shows great potential to improve patient outcomes and access to medical care.

  In agriculture, AI is contributing to increased efficiency and productivity through tasks such as precision farming recommendations based on satellite and drone data analysis, pest control, weed control, and yield prediction. Startups are developing AI-powered trading platforms for agricultural products, and prediction of plant and soil conditions is a major focus of AI applications in agriculture. Overall, AI is contributing to increased efficiency and productivity in the agriculture industry.

  The finance industry has also seen significant impacts from AI, providing convenience and speed in banking services. AI is used in wealth management to analyze customer savings and devise retirement plans, detect bad behavior in financial transactions, and personalize services such as financial advice using robots and chatbots. Analysts in the finance industry are also using AI to assess the value of stocks. The integration of Fintech into banking services has further accelerated the use of AI in finance.

  There is a need to understand the potential benefits and drawbacks of AI in all AI applications, as well as the social and economic impacts of its integration into services provided by AI.

  As AI is integrated into healthcare and finance services, there is a need for legal and regulatory frameworks that ensure data privacy, protection, and liability. Future research could explore and develop guidelines and regulations for AI applications in these industries.

Transparency and Explainability: As AI algorithms become more complex, there is a growing need for transparency and explainability in decision-making. Researchers could focus on developing methods for making AI decisions more transparent and understandable to users. (check again)

There is also a risk of biased outcomes if algorithms are not designed and trained in a way that is fair and inclusive.

The use of algorithms to make decisions about loans or credit can lead to discrimination against certain groups. One such problem is the potential for error due to training data that does not accurately represent the diversity of loan applicants. While deep learning techniques could improve lending decisions, their lack of transparency presents a significant obstacle, particularly in the EU, where citizens have the right to an explanation for decisions made by automated processing [GF17].

In conclusion, AI is rapidly advancing and being applied in various domains, leading to promising potential for improved outcomes and increased efficiency. The use of AI in healthcare, agriculture, and finance highlights the diverse applications of AI and its impact on society. The continued exploration and development of AI technologies will pave the way for more efficient, personalized, and effective services across multiple industries.

- Business models
  The discussion on the business models facet highlights the importance of understanding how AI startups operate and conduct their activities, as well as the need for novel digital business models that incorporate data analytics and AI to drive innovation and optimize production processes. The papers emphasize the strategic transformation processes needed to achieve success with these new models and the need for careful planning and evaluation of AI services to ensure success.

  The intersection of AI and business models is particularly important in the healthcare industry, where AI is rapidly advancing and making significant contributions to personalized medicine, remote patient monitoring, and drug and vaccine optimization. Garbuio et al. [GL19] identified three fundamental ways businesses can use AI in healthcare: assisted intelligence, augmented intelligence, and autonomous intelligence. The article emphasizes the importance of identifying the target user and area of value creation for healthcare startups, and it also recognizes the need for transparency and trust in the development of autonomous intelligence systems.

  Kulkov [Kul21] discusses the design parameters and elements of the business model for AI providers in healthcare. Specialization is identified as a key area for successfully integrating AI solutions, and privacy is emphasized as an essential consideration for AI systems used in healthcare. The article suggests that developers of AI systems ensure that they don't collect data or identify patients/final users with the data by processing the medical data, and privacy and security decisions should be taken into consideration when adopting new technologies.

Overall, the discussion on the business models facet underscores the importance of understanding the emerging business models of AI startups and the innovation in these models. With the increasing commercialization of AI, startups must position and focus their AI research within a larger business model to ensure sustained funding and strategic reach. In the healthcare industry, in particular, startups must prioritize privacy and trust considerations to ensure the adoption and success of their AI solutions.

One approach to understanding the role of AI in business models is to explore how new AI technologies can be incorporated into existing industries to improve efficiency and decision-making. This type of research aims to identify the ways in which AI can be used to optimize existing business models and practices in different domains. To do so, researchers should gain a thorough understanding of both the technology and the business practices of the industry in question. Future research may involve developing new AI applications and algorithms to optimize production processes and evaluate the impact of AI on business performance, as well as identifying and evaluating new business models for AI startups and exploring the strategic transformation processes needed to achieve success with these models.

- Opportunities and challenges
  The facet of AI concerning opportunities and challenges pertains to the potential advantages and obstacles related to the application and utilization of AI in various fields. It involves investigating the possible benefits and limitations of AI and determining methods to overcome the challenges to maximize its benefits. This facet also encompasses prospects for development and innovation, as well as difficulties related to financing, talent acquisition, and competition in the market.

  In healthcare, AI presents both opportunities and challenges. The potential benefits of AI include the ability to assist doctors and patients with tasks and to analyze large amounts of data collected from wearable sensors or speech recognition systems. The authors of a study classify AI systems used in healthcare and identify the top AI startups in this field [IBD19]. They also note the growing popularity of telemedicine and similar applications. However, there are challenges with the reliability, quality, privacy, safety, legal implications, responsibility, and technical aspects of AI in healthcare. AI can either act as a helper or replacement for doctors, but there are concerns that must be addressed to fully leverage its benefits.

  The facet of AI concerning opportunities and challenges pertains to the potential advantages and obstacles related to the application and utilization of AI in various fields. It involves investigating the possible benefits and limitations of AI and determining methods to overcome the challenges to maximize its benefits. This facet also encompasses prospects for development and innovation, as well as difficulties related to financing, talent

acquisition, and competition in the market.

The transition from traditional computing to AI architectures is reliant on chip architectures, but determining the best architecture for AI workloads is a complex process. Accessing health data is subject to stringent regulatory controls due to its privileged nature, and the cost of transferring data is significant. Consequently, the authors of a study conclude that the resources required to undertake AI projects make them prohibitively expensive.

Integrating AI into the public cloud in the finance domain presents security challenges. To address this, an approach is proposed to build an AI architecture for finance that incorporates financial expertise and specificities into AI. This will enable effective use of AI technologies in finance, with a focus on analytics and forecasting for business-to-business operations. The approach involves developing a framework that integrates finance-specific data, algorithms, and models while considering factors such as data privacy and regulatory compliance. The ultimate objective is to develop AI-powered tools and solutions that can enhance decision-making, risk management, and operational efficiency in finance [SZ21].

The study by Ghandour et al. (2021) provides valuable insights into the opportunities and challenges associated with the implementation of AI in banking. The opportunities include personalized financial services and decision making, which can lead to improved customer satisfaction and increased revenue for banks. However, the challenges that need to be prioritized include job loss, privacy breaches, and the potential loss of the emotional human touch that customers may expect in banking [Gha+21].

Future research could focus on developing AI-powered tools and solutions that address these challenges, such as developing ethical guidelines and regulations that govern the use of AI in banking. Additionally, studies could explore ways to mitigate the potential negative impacts of AI, such as job loss, by developing training programs and alternative job opportunities for affected employees. Finally, research could also focus on understanding how customers perceive and interact with AI-powered banking services, and how banks can ensure that their services maintain the appropriate level of human touch to meet customer expectations.

- Consequences
  The two papers provide complementary perspectives on the consequences of AI, with one focusing on a framework to understand the implications of AI and the other specifically discussing ethical concerns, risks, bias, and transparency issues related to AI.

  The framework proposed by Ghura et al. (2021) encompasses various aspects of AI's impact on entrepreneurship, economic growth, and society. It highlights the potential benefits of AI, such as improved productivity, efficiency, and innovation, while also acknowledging the potential risks, such as job displacement, bias, and ethical concerns. The framework

emphasizes the need for responsible and ethical AI adoption, including transparency, accountability, and human oversight. The authors suggest that policymakers, businesses, and individuals can better understand the implications of AI and develop strategies to harness its potential while mitigating its risks by adopting this framework [GH21].

On the other hand, Lauterbach et al. (2019) provide a detailed discussion of the ethical concerns, risks, bias, and transparency issues related to AI. They also provide information about key AI technologies, such as machine learning and perception technology, and highlight trends in national AI strategies, including policy announcements, regulations, and strategies adopted by various countries to utilize AI. The authors emphasize the importance of addressing the ethical concerns surrounding AI and implementing transparency and accountability mechanisms to mitigate the risks associated with AI [Lau19].

In summary, while Ghura et al. (2021) provide a comprehensive framework to understand the implications of AI, Lauterbach et al. (2019) provide a detailed discussion of the ethical concerns, risks, bias, and transparency issues related to AI. Both papers emphasize the importance of responsible and ethical AI adoption and highlight the need for transparency, accountability, and human oversight to mitigate the risks associated with AI.

Future research in this area should continue to focus on addressing the ethical concerns surrounding AI and developing strategies to harness its potential while mitigating its risks. One area of focus is investigating the long-term impacts of AI adoption on income inequality, privacy, and security. Understanding the role of policymakers and regulations in shaping the AI startup research is also important, as is improving public understanding and awareness of AI startups and their potential benefits and risks. Overall, future research should aim to address both the potential benefits and risks of AI adoption in order to promote responsible and beneficial use.

- Ethics
  In this discussion, we will focus on three studies that explore ethics in AI. It is noteworthy that these studies only concentrate on ethics in the healthcare sector. The first study by Vakkuri (2020) delves into various aspects of AI and its effects on society. The study's initial part stresses the need for AI ethics to be a non-functional requirement in software engineering projects, particularly in start-up environments where AI is mostly used. The paper argues that AI systems should meet the same standards as conventional software systems despite their distinct nature, and the lack of proper techniques and tools to execute AI ethics is a concern [Vak+20]. The findings have several implications for researchers who are developing AI systems in healthcare. The study emphasizes the need for ethical considerations to be an integral part of the development process for AI systems. As such, researchers must recognize the importance of

incorporating ethical principles into their work.

Researchers should also be aware of the unique challenges and concerns associated with developing AI systems in healthcare. These challenges include issues related to privacy, bias, and the potential for harm to patients. To address these challenges, researchers should consider the ethical implications of their work and seek to develop AI systems that are designed with the well-being of patients in mind.

Furthermore, researchers should recognize the importance of collaboration and communication with healthcare professionals and other stakeholders in the development process. Such collaboration can help ensure that AI systems are developed in a way that meets the needs of patients and healthcare providers and is consistent with ethical principles.

The second study discussed is a paper by Howard et al. (2018), which focuses on the challenges of implementing new technologies, specifically in the field of radiology in healthcare. The paper highlights that the development process for AI in healthcare is often not streamlined and that health professionals fear losing their jobs due to increased automation [HB18]. Additionally, the shift towards a lax regulatory environment has brought technological and human-technological issues that increase the risk of harm. The paper suggests that regulation is needed to keep up with developers and ensure the safety and efficacy of AI tools in healthcare. This is important because without proper regulation, the deployment of AI in healthcare could lead to a situation where patients receive substandard care or suffer harm. By developing and enforcing regulations, developers can be held accountable for the safety and efficacy of their AI systems. Overall, this study emphasizes the need for careful consideration and planning when implementing AI in healthcare, especially given the potential risks involved.

The findings of the second study by Howard et al. (2018) have several implications for researchers who are developing AI systems in healthcare, particularly in the field of radiology. The study highlights the need for careful consideration and planning when implementing AI in healthcare to ensure patient safety and prevent harm.

Researchers should prioritize the development of AI systems that are designed to work alongside healthcare professionals rather than replace them. This can help address concerns about job loss and ensure that healthcare professionals are able to provide high-quality care while using AI tools to support their work.

The author Jobin argues in his paper “The global landscape of AI ethics guidelines“ that ethical considerations and regulatory frameworks are necessary to ensure that AI systems are developed and deployed in a responsible manner that prioritizes human well-being and social values [JIV19].

Furthermore, researchers should recognize the importance of regulation in ensuring the safety and efficacy of AI tools in healthcare. Regulations can

provide a framework for developers to follow and ensure that they are held accountable for the safety and efficacy of their AI systems. This can help prevent situations where patients receive substandard care or suffer harm due to the use of AI tools.

Finally, researchers should prioritize collaboration with healthcare professionals and other stakeholders in the development process to ensure that AI systems meet the needs of patients and healthcare providers and are consistent with ethical principles. One potential area for future research could be examining the potential of AI to improve healthcare delivery and patient outcomes in other areas beyond radiology, such as diagnosis, treatment, and patient monitoring.

Conducting studies to identify potential biases in AI systems and developing methods to mitigate them, particularly in healthcare settings where the consequences of biased decisions can be severe is also important for future research in the field of AI and healthcare. These studies could include analyzing datasets used to train AI systems to identify any inherent biases, as well as exploring methods for adjusting algorithms to account for these biases. Additionally, investigating the impact of AI systems on healthcare professionals and patients, including their attitudes towards AI and the extent to which they trust AI-generated recommendations, could help inform the development of more effective and ethical AI systems.

The third paper by Duke [Duk22] focuses on the issue of bias in the design and development of next-generation robots. The paper highlights the various areas where bias could be introduced, such as face recognition, voice recognition, search engine apps, and the justice system. The use of biased training data and the lack of diversity in development teams are identified as some of the factors that could contribute to bias in these systems.

To address this issue, the paper proposes several strategies to prevent or mitigate bias. One of these measures involves monitoring the actions of robots to verify that they are functioning in an impartial manner, establishing a code of ethics for developers to follow, and promoting diversity and inclusion in development teams. The paper stresses the importance of addressing bias in order to prevent negative consequences for those who interact with future robotic systems.

Overall, the paper highlights the need for ethical considerations in the development of AI systems, particularly in startups where these systems are often created. The authors argue that addressing bias and promoting ethical practices in AI development can have significant benefits for society as a whole.

One of the important implications for researchers in the field of AI ethics is the need to prioritize diversity and inclusion in development teams and to be aware of potential biases in the design and development of AI systems.

This requires not only a diverse range of voices and perspectives but also a critical evaluation of the training data used to develop AI systems.

Researchers should also consider the importance of establishing codes of ethics for AI developers to follow. These codes of ethics can help ensure that AI systems are developed in an ethical manner, with a focus on fairness, transparency, and accountability. Furthermore, researchers should scrutinize the behavior of robots to ensure that they are operating in an unbiased manner and that any biases that are identified are corrected.

5.1 Threats to validity

To ensure the reliability and validity of our systematic mapping study, we conducted a comprehensive review of potential threats to validity, including the adequacy of our search strategy for identifying primary studies, the rigor of our study selection process, and the accuracy of our data extraction methods.

5.1.1 Identification of primary studies

It is important to consider the potential limitations and challenges associated with retrieving relevant papers when conducting research. To identify primary studies related to the intersection of "Artificial Intelligence" and "startups", a search string was developed (as described in chapter 3.2). Given the inconsistent use of terms related to "startup" in the literature, the search string was adapted to include variations of the term, such as "startups", "start-up", and "start-ups".

To identify relevant studies related to "Artificial Intelligence", a set of keywords and synonyms were chosen based on established academic knowledge and through an extensive review of existing publications. This approach aimed to ensure a comprehensive and inclusive search process that captured the most relevant and up-to-date research on the topic.

5.1.2 Study selection and data extraction

Relevant papers may have been overlooked by the author. Threats to study selection have been mitigated with the definition of the inclusion/exclusion criteria (see chapter 3.4). The data extraction phase of the study is conducted by listing relevant data to be extracted which will help in answering the research questions and thereby conducting the mapping study.

Chapter 6

Conclusion

As a summary, we can conclude that the main objective of this thesis was to identify the current state of research on AI startups and to provide a holistic overview about it. Therefore, a systematic mapping study was conducted. The significant contributions of this study are: Research about Artificial Intelligence startups is of great interest in AI community. However, articles published after the mentioned period were not analysed during this study due to time constraints. Due to the rise in AI startups providing innovative solutions, healthcare domain has received a lot of attention from AI startup literature. Apart from Healthcare, finance and agriculture are also studied. Machine learning is the most applied AI technology among AI startups. We have other technologies such as Computer Vision and Natural Language Processing reported in the literature. In AI startups, the most studied facet of AI startups is their applications in various use cases, with a focus on opportunities and challenges, business models, and consequences. Ethics is also studied but not very extensively.

Through this thesis, several intriguing findings were uncovered that necessitate further research. Research into AI startups and their impact on various industries is critical for developing new analytical techniques and models, exploring ethical and privacy implications, and addressing issues related to transparency, bias, and privacy. Understanding the emerging business models of AI startups is especially relevant since they are often at the forefront of innovation in AI.

However, it's important to acknowledge the limitations of AI startups research. Many AI startups are still in their early stages, making it difficult to determine their long-term impact on various industries. Additionally, the lack of regulations and guidelines for AI startups can lead to unethical practices that need to be addressed.

Legal and regulatory frameworks are necessary to ensure the responsible and beneficial use of AI in various industries, including healthcare, fin-

ance, agriculture, and tourism. The potential of AI in these industries is significant, but it's crucial to address ethical concerns related to the adoption of these technologies. Developing AI-powered tools that mitigate negative impacts such as job loss and income inequality, while also understanding the long-term impacts of AI adoption on society, should be a focus of future research.

Improving public understanding and awareness of AI is also essential. Ultimately, the successful integration of AI into different industries requires collaboration among researchers, policymakers, and stakeholders. The development and implementation of AI systems in various industries, including healthcare, agriculture, tourism, and robotics, require careful consideration of ethical and regulatory frameworks to ensure patient safety, prevent harm, and address concerns about bias and job loss.

Researchers should prioritize the development of AI systems that work alongside human professionals, recognize the importance of regulation, and collaborate with stakeholders to ensure that AI systems meet the needs of society and are consistent with ethical principles. Additionally, the promotion of diversity and inclusion in development teams and the establishment of codes of ethics for AI developers can help prevent bias and promote ethical practices in AI development.

In conclusion, while AI startups are driving innovation in the AI industry, there are still many challenges that need to be addressed, particularly in regards to ethical considerations and regulation. The responsible development and use of AI systems can have significant benefits for society as a whole, but this requires careful consideration of the ethical and regulatory frameworks that govern their implementation.

Appendices

Appendix A

Studies in final selection

Table A.1: Studies in final selection

Title	Author(s)	Journal	Year
Use of artificial intelligence in healthcare delivery in India	Pradhan, K. and John, P. and Sandhu, N.	Journal of Hospital Management and Health Policy	2021
Operating Enterprise AI as a Service	Casati, F. and Govindarajan, K. and Jayaraman, B. and Thakur, A. and Palapudi, S. and Karakusoglu, F. and Chatterjee, D.	Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	2019
Artificial Intelligence in Saudi Arabia: Leveraging Entrepreneurship in the Arab Markets	Ahmed, S.M.	Proceedings - 2019 Amity International Conference on Artificial Intelligence, AICAI 2019	2019
Artificial Intelligence Contribution to eHealth Application	Cabestany, J. and Rodriguez-Martín, D. and Pérez, C. and Sama, A.	2018 25th International Conference "Mixed Design of Integrated Circuits and System" (MIXDES)	2018
Artificial intelligence and augmented intelligence collaboration: Regaining trust and confidence in the financial sector	Lui, A. and Lamb, G.W.	Information and Communications Technology Law	2018
		Continued on next page	

Table A.1 – continued from previous page

Title	Author(s)	Journal	Year
Review on the status and development trend of AI industry	Yang, L. and Zhu, M.	2019 IEEE 4th International Conference on Cloud Computing and Big Data Analytics, ICCCBDA 2019	2019
"This is Just a Prototype": How Ethics Are Ignored in Software Startup-Like Environments	Vakkuri, V. and Kemell, K.-K. and Jantunen, M. and Abrahamsson, P.	Lecture Notes in Business Information Processing	2020
Artificial intelligence as a growth engine for health care startups: Emerging business models	Garbuio, M. and Lin, N.	California Management Review	2019
AI Startup Business Models: Key Characteristics and Directions for Entrepreneurship Research	Weber, M. and Beutter, M. and Weking, J. and Böhm, M. and Krcmar, H.	Business and Information Systems Engineering	2022
Artificial intelligence and policy: quo vadis?	Lauterbach, A.	Digital Policy, Regulation and Governance	2019
Big Techs and startups in pharmaceutical R&D – A 2020 perspective on artificial intelligence	Schuhmacher, A. and Gatto, A. and Kuss, M. and Gassmann, O. and Hinder, M.	Drug Discovery Today	2021
The role of data for AI startup growth	Bessen, J. and Impink, S.M. and Reichensperger, L. and Seamans, R.	Research Policy	2022
New Business Models on Artificial Intelligence—The Case of the Optimization of a Blast Furnace in the Steel Industry by a Machine Learning Solution	Redchuk, A. and Mateo, F.W.	Applied System Innovation	2022
Creating new tech entrepreneurs with digital platforms: Meta-organizations for shared value in data-driven retail ecosystems	Battisti, S. and Agarwal, N. and Brem, A.	Technological Forecasting and Social Change	2022
The Role of Innovation and IP in AI-Based Business Models	Bader, M.A. and Stummeyer, C.	FGF Studies in Small Business and Entrepreneurship	2019

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Table A.1 – continued from previous page

Title	Author(s)	Journal	Year
Sophisticated Embedding of Artificial Intelligence Techniques in Biomedical Engineering	Prasad, P.S. and Soma Sekhar, G. and Radha, S.	Lecture Notes in Networks and Systems	2022
A scaling perspective on AI startups	Schulte-Althoff, M. and Fürstenau, D. and Lee, G.M.	Proceedings of the Annual Hawaii International Conference on System Sciences	2021
Industry 4.0 applications for medical/healthcare services	Paul, S. and Riffat, M. and Yasir, A. and Mahim, M.N. and Sharnali, B.Y. and Naheen, I.T. and Rahman, A. and Kulkarni, A.	Journal of Sensor and Actuator Networks	2021
There is no AI without IA	Earley, S.	IT Professional	2016
Investing in AI	Corea, F.	SpringerBriefs in Applied Sciences and Technology	2017
Computer Vision Startups Tackle AI	Jaimes, A.	IEEE Multimedia	2016
Artificial intelligence (AI) for tourism: an European-based study on successful AI tourism start-ups	Filieri, R. and D'Amico, E. and Destefanis, A. and Paolucci, E. and Raguseo, E.	International Journal of Contemporary Hospitality Management	2021
The European way of doing Artificial Intelligence: The state of play implementing Trustworthy AI	Beckert, B.	2021 60th FITCE Communication Days Congress for ICT Professionals: Industrial Data - Cloud, Low Latency and Privacy, FITCE 2021	2021
Artificial Intelligence and Machine Learning as a Tool for Combating COVID-19: A Case Study on Health-Tech Start-ups	Singh, K. and Misra, M. and Yadav, J.	2021 12th International Conference on Computing Communication and Networking Technologies, ICCCNT 2021	2021
Quality evaluation model of artificial intelligence service for startups	Baek, C.H. and Kim, S.-Y. and Lim, S.U. and Xiong, J.	International Journal of Entrepreneurial Behaviour and Research	2021
How will artificial intelligence reshape the future of entrepreneurship and economic growth?	Ghura, H. and Harraf, A.	Studies in Computational Intelligence	2021

Continued on next page

Table A.1 – continued from previous page

Title	Author(s)	Journal	Year
Artificial intelligence in extended agri-food supply chain: A short review based on bibliometric analysis	Monteiro, J. and Barata, J.	Procedia Computer Science	2021
Next-generation business models for artificial intelligence start-ups in the healthcare industry	Kulkov, I.	International Journal of Entrepreneurial Behaviour and Research	2021
Is AI and digitization new avatar for air freighters and forwarders	Chopra, A.	Proceedings of the 2021 1st International Conference on Advances in Electrical, Computing, Communications and Sustainable Technologies, ICAECT 2021	2021
Expect evolution, not revolution: Despite the hype, artificial intelligence will take years to significantly boost economic productivity	Funk, J.	IEEE Spectrum	2020
Artificial Intelligence in Business: From Research and Innovation to Market Deployment	Soni, N. and Sharma, E.K. and Singh, N. and Kapoor, A.	Procedia Computer Science	2020
Opportunities and challenges of artificial intelligence in healthcare	Iliashenko, O. and Bikkulova, Z. and Dubgorn, A.	E3S Web of Conferences	2019
The impact of artificial intelligence on design thinking practice: Insights from the ecosystem of startups	Cautela, C. and Mortati, M. and Dell'Era, C. and Gastaldi, L.	Strategic Design Research Journal	2019
The Ugly Truth About Ourselves and Our Robot Creations: The Problem of Bias and Social Inequity	Howard, A. and Borenstein, J.	Science and Engineering Ethics	2018
A budding romance: Finance and AI	Zhang, X.-P.S. and Kedmey, D.	IEEE Multimedia	2018
A business model template for ai solutions	Metelskaia, I. and Ignatyeva, O. and Denef, S. and Samsonowa, T.	ACM International Conference Proceeding Series	2018

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Title	Author(s)	Journal	Year
Business model innovation and strategic transformation when confronting digital disruption: The case of data-driven business models for professional services	Fielt, E. and Westerveld, P. and Desouza, K. and Gable, G.	ACIS 2018 - 29th Australasian Conference on Information Systems	2018
Building artificial intelligent (ai) products that make sense	Regalado, R.V.	ACM International Conference Proceeding Series	2018
Current advances, trends and challenges of machine learning and knowledge extraction: From machine learning to explainable AI	Holzinger, A. and Kieseberg, P. and Weippl, E. and Tjoa, A.M.	Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	2018
Adoption of ai in agriculture: The game-changer for Indian farmers	Kumar, T. and Prakash, N.	Proceedings of the 13th IADIS International Conference ICT, Society and Human Beings 2020	2020
Opportunities and Challenges of Artificial Intelligence in Banking: Systematic Literature Review	Ghandour, A.	TEM Journal	2021
Deny, dismiss and downplay: developers' attitudes towards risk and their role in risk creation in the field of healthcare-AI	Duke, S.A.	Ethics and Information Technology	2022
Agritech Startup Ecosystem in Ukraine: Ideas and Realization	Babenko, V. and Zomchak, L. and Nehrey, M. and Salem, A.-B.M. and Nakisko, O.	Lecture Notes in Networks and Systems	2022
A scaling perspective on AI startups	Schulte-Althoff, M. and Fürstenau, D. and Lee, G.M.	Proceedings of the Annual Hawaii International Conference on System Sciences	2021

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