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Artificial Intelligence in Technology and Innovation: Concerns and Future Directions

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ORIGINAL RESEARCH PAPER

Abstract
This article explores current trends and future projections of artificial intelligence (AI) in technology, economics, and the environment. Using data from sources like the AI Index, AI history, and AI investments, we analyze AI-driven technological advancements. The study looks at the growth and impact of advanced language models in natural language processing (NLP), the economic effects of AI, and the sustainability challenges of its computational needs. We address these issues by suggesting strategies for future research and governance to align AI development with social and environmental goals. By examining historical AI data, we highlight AI's significant role in shaping the tech landscape. Our opinion is based on current reviews, evidence, and concerns, situating our findings within broader AI and innovation discussions. We offer interpretations and thoughtful speculations on the future direction of AI technology, providing practical insights and strategic advice to guide its development.

Keywords: Artificial Intelligence, Technology, Innovation, AI Index, AI companies, Future of AI

1 Introduction

Artificial intelligence (AI) is rapidly changing the current state of technology and innovation across a variety of industries [1]. AI is an interdisciplinary field that uses machine learning, deep learning, and other advanced computational techniques to create systems capable of performing tasks that would normally require human intelligence, and beyond [2]. The integration of AI into various industries has resulted in significant improvements in efficiency, accuracy, and innovation, allowing faster development in basic data processing to more complex decision-making and problem-solving processes [3]. However, with these advancements come significant challenges and concerns, particularly in terms of economic impact and environmental sustainability. As AI keeps growing, it will affect industries more and the everyday lives of people, with the need for cautious implementation using its potential [4].

AI has become a significant driver of innovation and efficiency in a variety of industries, as it automates coding tasks, optimizes algorithms, and automates manufacturing processes, lowering operational costs and improving product quality [5]. The rapid proliferation of AI technologies is reflected in the growing number of AI-related patent applications, indicating increased interest and investment in AI research and development [6]. Moreover, the economic impact of AI is significant, providing opportunities for growth and innovation while also posing challenges such that large corporations have the resources to fully utilize AI, whereas smaller organizations may struggle to keep up, potentially leading to market consolidation and increased economic inequality [7]. Along with socioeconomic balance concerns, future AI research and development should also prioritize minimizing the environmental impact, particularly in terms of energy consumption [8].

The motivation behind this paper is to provide a comprehensive analysis of the diverse impacts of AI. By considering the technological, economic, and environmental components, this paper provides a balanced view of AI's current condition and future direction. It also tries to highlight possible issues and provide strategies for future research and governance to ensure that AI progress is consistent with broader social objectives.

The paper is organized as follows: The section "AI-Driven Trends and Future Projections Across Various Sectors" investigates how AI is driving innovation in a variety of technological sectors. The "Evolution and Impact of Advanced Language Models in Natural Language Processing" section discusses recent achievements in natural language processing and their implications. In "The Economic Impact and Future of Artificial

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Intelligence" how AI affects labor markets and economic growth is considered. "The Computational Evolution and Future Demands in Artificial Intelligence" section discusses the resource requirements of AI systems and their sustainability. Finally, the "Future Directions and Sustainability in Artificial Intelligence" section states possible future directions for AI growth and highlights related dangers that need to be handled by also including a subsection named "Concerns with the Environmental Impact of Artificial Intelligence" which examines the environmental consequences of wide AI use. By addressing these concerns, this research hopes to contribute to a humble understanding of AI's role in current technology and innovation. It points out the importance of strategic planning in maximizing the benefits of AI while reducing its possible disadvantages. This study also aims to contribute to the ongoing discussion on AI in technology and innovation by analyzing current developments and discussing the potential future.

2 AI-Driven Trends and Future Projections Across Various Sectors

Artificial intelligence has had a major effect on technological growth, driving major improvements in a wide range of industries, including software development, the medical field, manufacturing, finance, transportation, and general research and development [9, 10]. AI's impact on technological development is already evident in the rapid rise in the number of patent applications, indicating the fast adoption and integration of AI technologies [11].

Hereby, Figure 1 shows the number of patent applications related to AI from 2010 to 2019 across various sectors, according to the data obtained from an open database [12]. As stated, the telecommunications sector has experienced a dramatic expansion, particularly since 2016, followed by an increase in the banking, life sciences, and transportation sectors. This trend points out the increasing popularity and accelerating adoption of AI technologies.

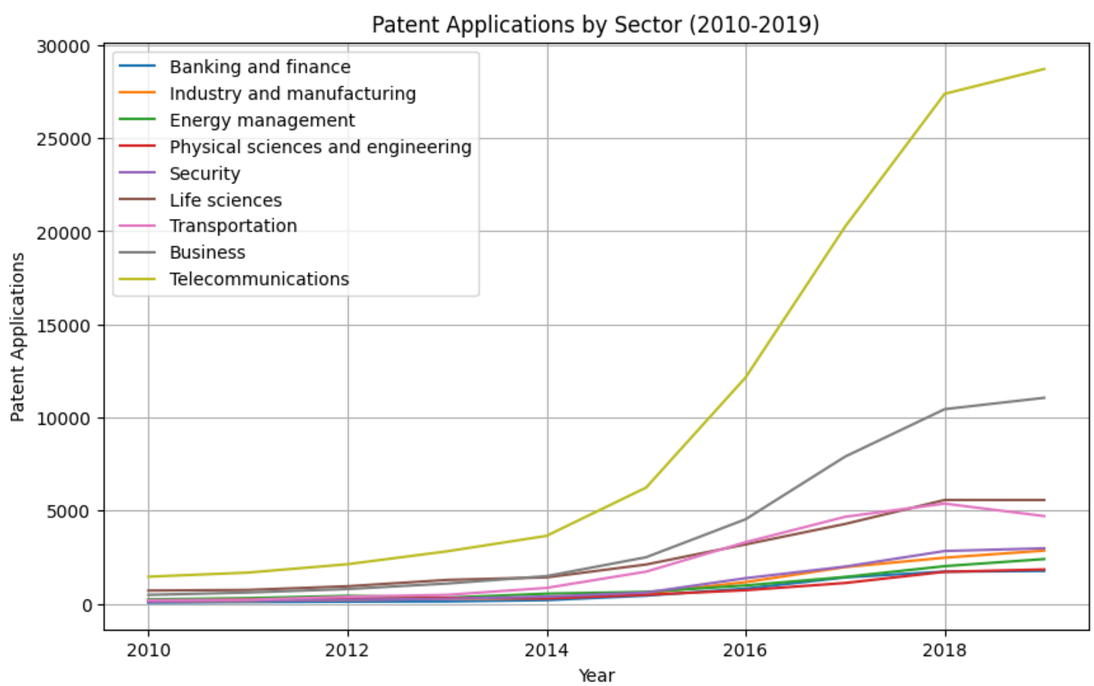

Figure 1. Total patent applications per year related to AI for different sectors.

AI-driven robotics and automation structures have improved manufacturing procedures and reduced operational costs [10]. For instance, predictive maintenance systems, which predict machine failures before they occur, reduce downtime while lowering costs [13]. By improving product quality and reducing human error, AI enhances the performance and productivity of manufacturing operations, resulting in significant cost savings and increased long-term viability [14]. AI integration in production not only improves operational performance but also increases the industry's ability to innovate and respond quickly to customer demands [15].

Moreover, the finance industry has also been reshaped by AI, with algorithms developing sophisticated trading strategies, dealing with risks, and detecting fraud [16]. Especially on high-frequency trading platforms, AI is used to research market trends and perform trades with high rates and precision that exceed human capabilities [17]. AI threat control systems investigate the creditor's reliability and forecast market fluctuations, reducing economic risks for banks [18], and AI fraud detection algorithms detect suspicious activity in real-time, thereby improving financial operations' reliability and safety, strengthening the financial industry's ability to adapt to emerging threats and possibilities [19].

In the transportation sector, AI is being used to improve self-driving vehicles, intelligent traffic management systems, and better logistics solutions [20]. Self-driving cars, powered by modern artificial intelligence algorithms, have the potential to reduce accidents while improving fuel efficiency [21], and AI-based monitoring systems optimize traffic flow, lowering congestion and emissions [22]. Logistics companies use AI to automate their operations, ensuring timely deliveries and efficient resource utilization [10]. Therefore, the integration of AI in transportation not only improves operational performance but also contributes to more secure and sustainable cities.

Artificial intelligence has also revolutionized research and development in a variety of fields. For example, in medicinal products, AI accelerates drug discovery by studying massive datasets of molecular systems and biological pathways to predict the efficacy of new compounds and identify potential side effects [23]. Materials technology benefits from AI models that predict the properties of new substances before synthesis, reducing the time and cost of experimentation [24]. AI simulation tools in engineering provide accurate projections of product performance, allowing for more efficient designs and reducing the need for physical prototypes [25]. These advances in R&D encourage innovation and accelerate the pace of discovery and product improvement.

AI-powered diagnostic devices that use advanced machine learning (ML) algorithms have accelerated medical imaging by detecting anomalies and diagnosing problems more accurately and rapidly [26]. These structures have transformed healthcare through the use of early disease detection and the development of personalized treatment techniques based on individual patient data [27]. Furthermore, predictive analytics in biomedical engineering improve resource utilization and patient experience by simplifying clinic processes [28].

AI also has a significant impact on mobile technology, which is increasingly being integrated into smartphones, smart speakers, wearables, and IoT devices, where it provides personalized recommendations, predicts user preferences, and automates routine tasks resulting in a paradigm shift in device design and capabilities [29]. Personal assistants, such as Siri and Alexa, provide a personalized experience through voice commands, proactive signals, and context-aware instructions, responding to user behavior, simplifying the user experience [30]. Modern smartphones include features like facial recognition, natural language understanding, and predictive text input, which improve security, usability, and efficiency while also reshaping user interactions, making devices more adaptable and personalized [31]. This shift is making technology more intuitive and user-centric, changing how we interact with electronic devices daily.

Figure 2 presents the forecasted patent applications related to AI from 2010 to 2028 for various sectors. It suggests significant growth in sectors such as security, business, transportation, and life sciences, implying that these fields will continue to drive innovation and AI adoption in the future.

AI has also accelerated the development of new technologies such as natural language processing (NLP) and conversational AI, allowing virtual assistants to recognize and respond to human speech in real-time [32]. Artificial intelligence-driven advancements in augmented reality (AR) and virtual reality (VR) have transformed entertainment, gaming, and experience enhancement, minimizing the distinction between the physical and virtual worlds [33]. As a result, the rise of AI has led to significant changes in consumer behavior, with people increasingly relying on AI-powered products and applications to simplify tasks, benefit from readily available information, and speed up decision-making [34].

3 Evolution and Impact of Advanced Language Models in Natural Language Processing

Advances in language modeling have significantly improved the capabilities of NLP systems, making them more context-aware and effective across a variety of applications [35]. Language modeling has evolved from basic statistical methods and early n-gram models to recurrent neural networks (RNNs) and long short-term memory networks (LSTMs), resulting in the state of the art with transformers and generative AI [36]. This progress has been accelerated by the demand for more accurate and context-aware language understanding, as well as the exponential increase in computational sources [37].

The simplest type of language modeling is based on n-gram models as they depend on the co-prevalence of words to predict the next phrase in a sequence, shooting the probability of a phrase given the previous $n-1$

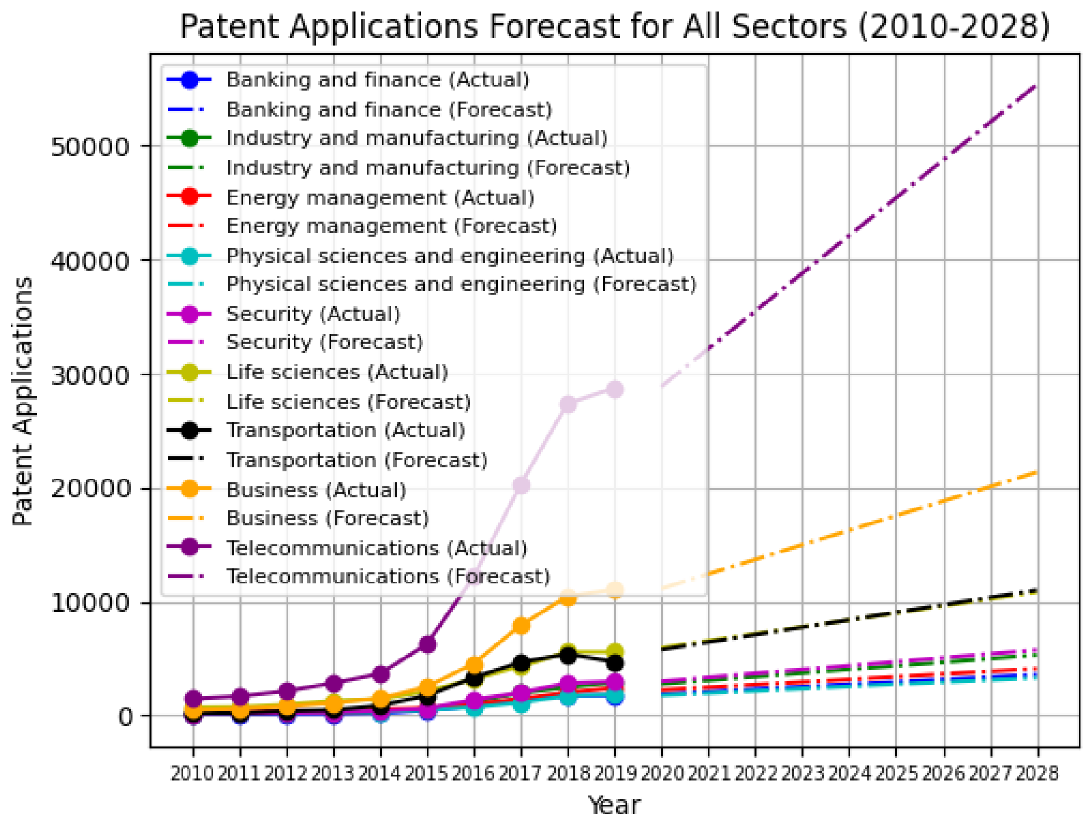

Figure 2. Forecasted total patent applications per year related to AI for different sectors.

words [38]. The basic representation can be found in Equation 3. For example, in a bigram version (n=2), the prediction of a word is completely dependent on the preceding phrase [39]. Because of their simplicity and low computational requirements, n-gram models allow them to run on machines without advanced hardware such as GPUs, consuming significantly less power [40, 41]. However, their limited context window limits their ability to capture more complex dependencies in texts, resulting in poor results for tasks that require more knowledge of the context [37].

$$P(w_i | w_{i-(n-1)}, \ldots, w_{i-1}) = \frac{C(w_{i-(n-1)}, \ldots, w_i)}{C(w_{i-(n-1)}, \ldots, w_{i-1})} \quad (1)$$

Here, $P(w_i | w_{i-(n-1)}, \ldots, w_{i-1})$ represents the probability of word w_i given the previous $n-1$ words, and $C(\cdot)$ denotes the count of occurrences of the given sequence in the training corpus.

The development of RNNs and LSTMs posed an important step in language modeling as these models are under the deep learning paradigm and offer a more advanced method of encoding context than n-gram models [41]. RNNs are intended to handle sequential data by maintaining a hidden state that updates as it approaches each element of the collection, theoretically capturing dependencies of any length [42]. LSTMs, a type of RNN, deal with the problem of vanishing gradients, allowing them to capture long-term dependencies more accurately [42]. This ability has made RNNs and LSTMs essential in improving the performance of many NLP tasks. Transformers, on the other hand, have the attention mechanism at their core and have transformed the field of NLP by eliminating the sequential processing of RNNs and instead processing the entire input sequence at once [43, 44]. The attention mechanism allows the model to assess the importance of various words in the input sequence, capturing complex dependencies regardless of their distance from one another [44]. This parallel processing capability increases efficiency and scalability, enabling transformers to handle larger datasets and more complex tasks [43].

Recent developments in generative AI (GenAI) have led to a surge in data and resource usage, with Large language models (LLM) models requiring vast datasets and extensive computational power [45, 46]. LLMs have revolutionized NLP by generating human-like text, but they require substantial resources for training and deployment, raising questions about their economic viability and environmental sustainability [47]. They also enable groundbreaking applications in content creation, automated customer support, and advanced research tools, but their substantial computational and energy requirements raise concerns about environmental impact and resource allocation [48].

4 The Economic Impact and Future of Artificial Intelligence

Advancements in GPU technology, the high costs of training and maintaining large AI models, and the transformative impact of AI-augmented research and development all contribute to the artificial intelligence economy [49]. While AI provides significant economic opportunities by increasing competitiveness, opening up new markets, and improving operational efficiencies, it also introduces challenges such as high costs, market consolidation, and workforce adaptation [50]. Dealing with these challenges is essential for maximizing AI's economic benefits and ensuring development in the long run.

GPUs have played an important role in the advancement of machine learning and artificial intelligence, and eventually, GPUs' price-performance ratio has improved dramatically over the years as semiconductor technology has advanced and economies of scale have increased [51]. This improvement has resulted in increased computational power and memory capacity at lower costs, however, the demand for high-performance GPUs frequently exceeds supply, causing price volatility [52]. As AI models become more complex, the demand for more powerful and efficient GPUs grows, emphasizing the importance of ongoing innovation in GPU technology, which makes continued investment in GPU research and development critical to meeting the increasing demands of AI applications [53].

Training and operating commercial LLMs are highly costly, since training these models necessitates the processing of massive datasets across thousands of GPUs for a long time, resulting in significant costs for computational resources, electricity, and cooling systems [47]. Although companies have experimented with various revenue models to help them reduce these costs, the costs of training and maintaining these models are prohibitively expensive for many end users, making them economically unfeasible without significant financial support [54]. One common approach is to incorporate advertising into AI services, which compensates costs with ad revenue [55]. Other approaches include providing subscription-based access to advanced features or forming partnerships with cloud service providers to distribute computational load [56]. These models contribute to increasing the accessibility of powerful AI tools while also generating revenue to cover high operational costs.

AI systems can process large amounts of data, identify patterns, and generate insights much faster than humans can, causing accelerated research processes that shorten product development cycles and speed up market entry [57]. AI-augmented R&D is transforming how companies innovate and develop new products, which improve competitiveness, accelerate growth, and open up new markets [58]. AI is enabling breakthroughs in industries such as pharmaceuticals, materials science, and energy, resulting in more effective drugs, advanced materials, and optimized energy systems, thus, integrating AI into R&D processes is crucial for companies seeking a competitive advantage [53, 51]. AI algorithms that provide predictive analytics, personalized marketing, and automated customer service are becoming increasingly common in a variety of industries, generating significant economic value [34]. These innovations improve not only operational efficiency but also customer experiences and satisfaction, resulting in increased revenue and market share [59]. Furthermore, the adoption of AI technologies is transforming traditional business practices, resulting in more agile and responsive business models capable of rapidly adapting to market changes [60].

Figure 3 illustrates the projected exponential growth in corporate investment in AI from 2022 to 2028, and the data were obtained from an open-sourced dataset from kaggle.com [12]. Using actual investment data, which represents the total corporate investment in artificial intelligence, adjusted for inflation up to 2021, the graph forecasts future investment using an exponential regression algorithm.

This exponential growth indicates a significant increase in resources dedicated to AI, highlighting the importance of future technological developments. The rapid increase in forecasted investment demonstrates confidence in AI's transformative potential across industries, emphasizing the necessity of proper planning and investment to optimize AI's economic benefits [15].

5 The Computational Evolution and Future Demands in Artificial Intelligence

Machine learning has advanced significantly, with three distinct eras: simple models (pre-2010), deep learning (2010-2020), and the current era of transformer models and generative AI (post-2020) [36]. Each era represents significant changes in computational demands, which have increased dramatically over the

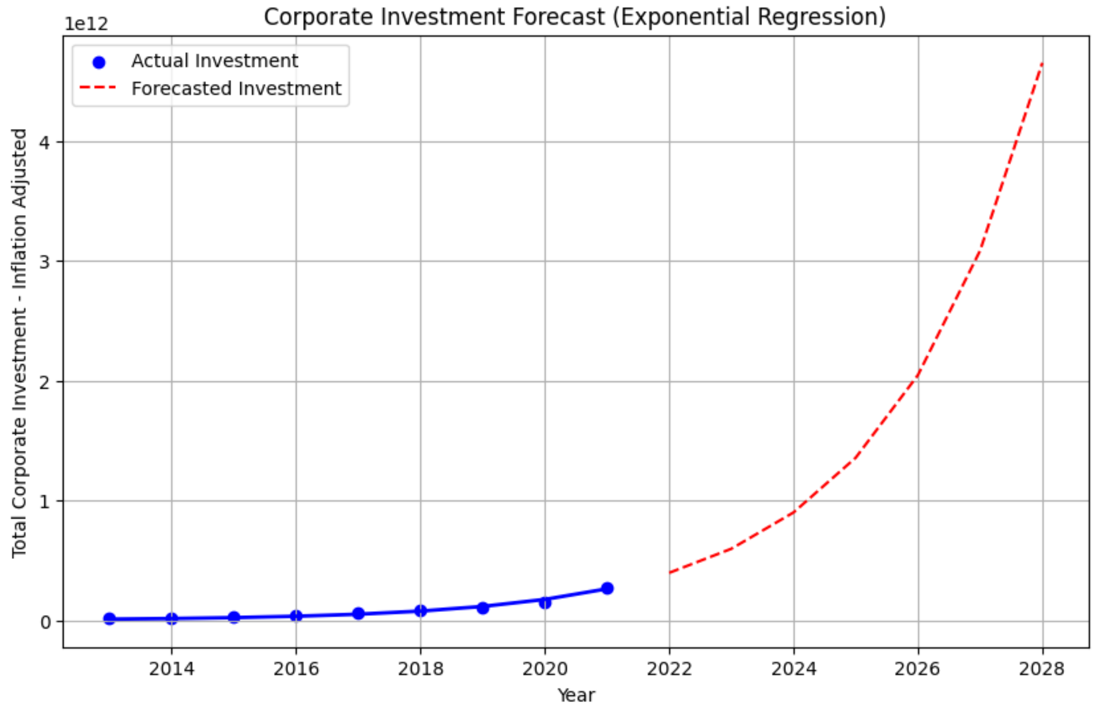

Figure 3. Forecasting future corporate investment in AI.

years. Pre-2010 models consisted of classical machine learning classifiers such as decision trees, linear regression, and support vector machines, where the computational requirements were relatively low, and most tasks could be completed using standard CPUs [61]. These models' simplicity required less data and computational power, making them accessible and efficient given the technical limitations of the time [51].

From 2010 to 2020, the development of machine learning changed with the introduction of deep learning, especially convolutional neural networks (CNNs) and recurrent neural networks (RNNs) and these models significantly increased computational demands, necessitating the use of GPUs to handle the large datasets required for effective training [62]. Moreover, GPUs' parallel processing capabilities allowed for more efficient training of these complex models, resulting in improvements in domains such as image and speech recognition [63].

On the other hand, transformers and generative AI (GenAI) models have impacted AI developments since 2020, increasing computational requirements to new levels [45]. Furthermore, while transformers provide significant benefits, they do so at a high cost because their training necessitates massive data and computational resources, with the attention mechanism initially having quadratic computational complexity to sequence length [64]. This makes transformers extremely resource-demanding, requiring high-RAM GPUs or specialized hardware such as TPUs (Tensor Processing Units) [65]. Figure 4 shows the LLM models by 2023 with their Massive Multitask Language Understanding (MMLU) scores and training compute relationships in terms of petaFLOPs, according to the open-access data from [12]. This figure simply presents the high number of computational units required to achieve the higher MMLU scores to reach the level of the models for understanding the human dialect.

The exponential increase in model sizes has resulted in a phenomenon known as the parameter gap, in which modern models, particularly those in NLP, contain billions of parameters [66]. The growth is motivated by the need for a more sophisticated understanding and generation of human language, but it poses significant challenges in terms of data, training time, and computing resources [49]. Modern NLP models require large datasets to function effectively, which presents several challenges, such as it becomes more difficult to ensure data quality with potential accuracy and relevance issues with the growing size of the datasets [67]. Security issues and regulations make data availability more difficult, even bringing up the continuous data scaling problem [68]. Accordingly, a forecast for the training compute in petaFLOPs can be found in Figure 5, which suggests that the computational complexity of the models will be more than 6 times that of the current models in 2023, based on an open-sourced dataset [12].

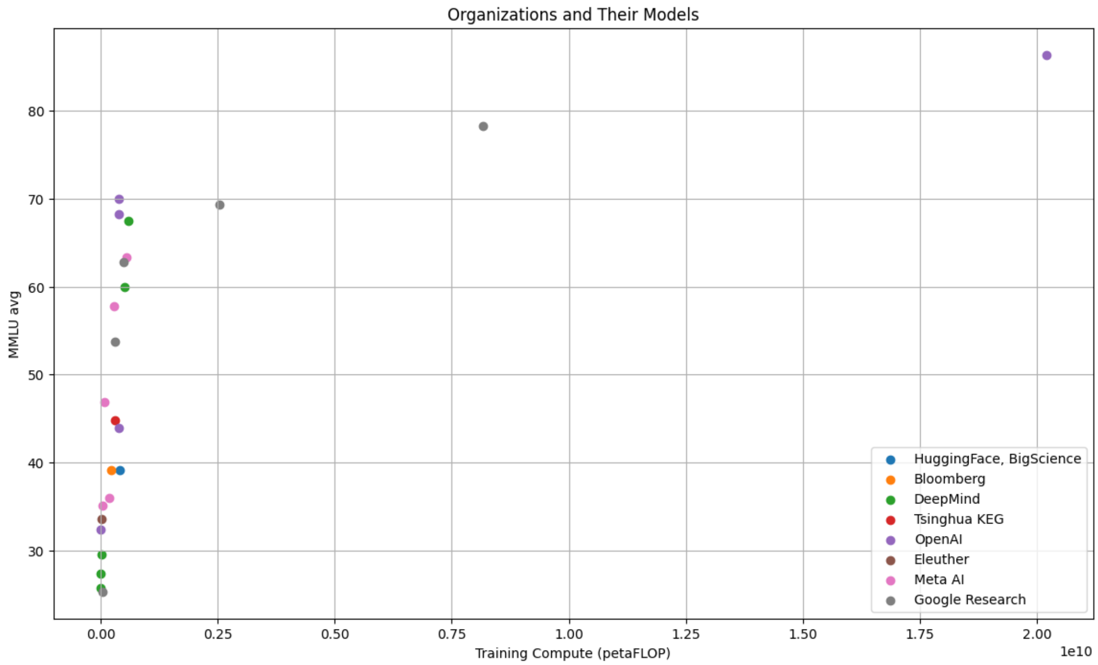

Figure 4. Published LLM models and corresponding organizations in 2023 for their MMLU and training compute values.

Motivated by the current computational demands for better LLM models, as given in Figure 4, a forecast of the average MMLU has been made. Accordingly, the forecasting model whose results can be found in Figure 6 suggests that the LLM models will almost completely be able to understand the human dialect as the predicted MMLU scores converge to 100% by the year 2028.

The future of AI has to find a balance between increasing computational capabilities and managing resource consumption since innovations in model efficiency, data usage, and hardware design will be essential in ensuring that the computational demand for AI remains stable [69].

6 Future Directions and Sustainability in Artificial Intelligence

Artificial intelligence has transformed many aspects of our daily routines, introducing groundbreaking discoveries and altering our interactions with technology [70]. AI's potential to revolutionize society is immense, offering new opportunities for innovation and growth. However, this potential is accompanied by concerns about energy consumption and environmental impact [8]. Balancing the benefits of AI with its resource demands is essential to ensuring that technological progress does not harm the environment, since finding this balance is vital for sustainable development [71].

The rapid growth of AI, driven by leading technology companies and rising demand, also has an unpredictable future. As AI evolves, a balance between its enormous potential and the need for responsible development should be managed [72]. By focusing on efficient models, sustainable data practices, and innovative computational technologies, AI can have a positive impact on society while maintaining environmental and economic health [8]. Embedding these principles in AI development promotes ongoing innovation and societal well-being, ensuring that AI's growth benefits the future [73]. Future initiatives should focus on developing more efficient AI models that can lower economic and environmental costs. This includes investigating sustainable data management procedures and developing computational technologies to improve AI's sustainability [74]. By prioritizing efficiency, ecological damage can be reduced while also making AI more economically viable [36].

6.1 Concerns with the Environmental Impact of Artificial Intelligence

The economic and ecological effects associated with the computational demands of AI models are mostly due to training large models requiring extensive data processing with a high number of GPUs, resulting in high costs for computational resources, electricity, and cooling [71]. Language models have evolved from the early versions focusing on word sequence analysis to the introduction of recurrent neural networks,

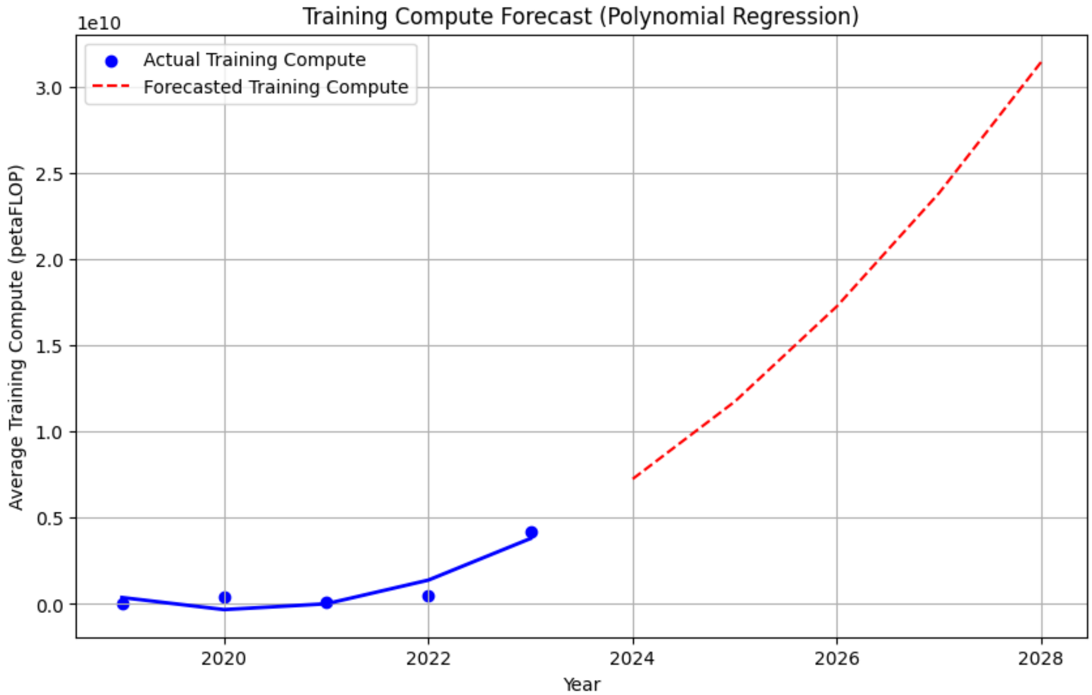

Figure 5. A forecasting of the training compute in petaFLOPs.

transformers, and generative AI with increased data complexity, resulting in higher energy consumption and a larger environmental footprint [46]. Training large language models has a significant environmental impact; training a single model emits as much carbon dioxide as several cars over its lifetime [75]. However, renewable energy alone is not a complete solution because it can be allocated to other business sectors too.

The energy consumption associated with AI training and inference increases carbon emissions and creates environmental issues [71]. The AI community may reduce these effects by promoting environmentally friendly technologies, using renewable energy, and establishing regulations that ensure AI technology growth aligns with environmental goals [19]. Many regions still rely heavily on fossil fuels for electricity generation, further compounding the environmental impact of AI's energy use and contributing to global warming and climate change [76]. Additionally, the energy-intensive nature of AI operations imposes financial burdens on organizations, increasing operational costs and potentially limiting the accessibility of AI technologies to smaller enterprises and low-developed countries [77].

The future of AI will require a decrease in resource consumption by introducing several strategies including optimizing AI models' energy efficiency, using model compression techniques, and using energy-efficient hardware [78]. Increasing the use of renewable energy sources in data centers can help reduce their carbon footprint while promoting AI systems with lower computational requirements can increase AI's accessibility and sustainability [8].

Conflict of interest

The authors have no conflict of interest to declare.
The authors declare that they have no competing financial interests.

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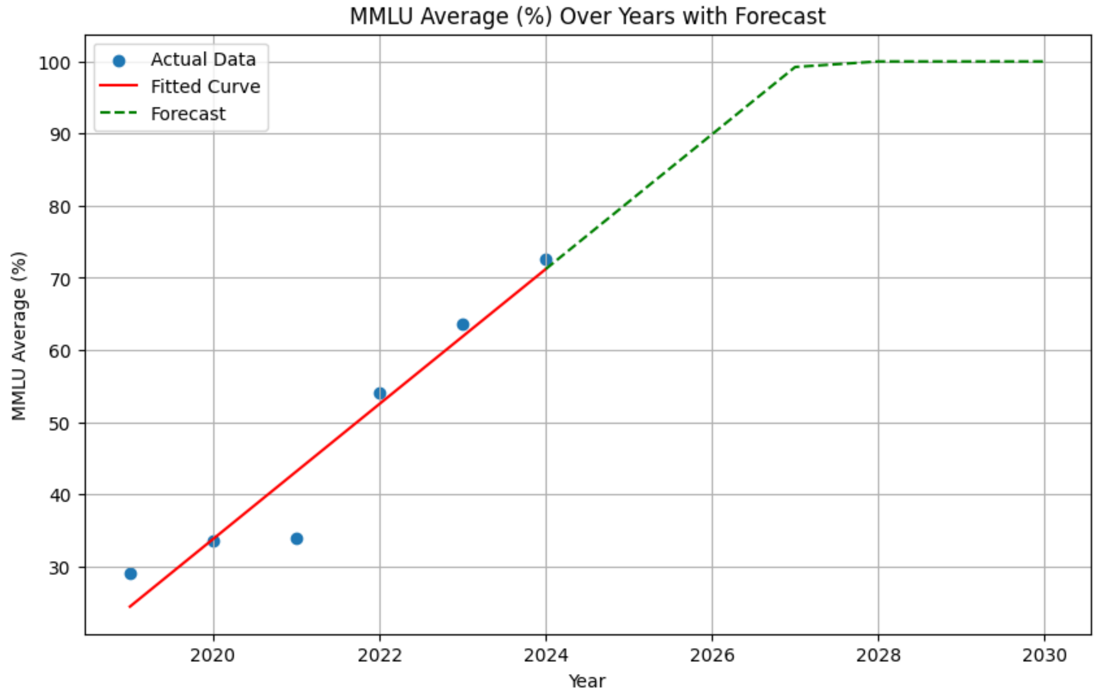

Figure 6. A forecasting of the average MMLU (Massive Multitask Language Understanding) values of the models.

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