

TECHNOLOGICAL, ECONOMIC, SOCIAL, ETHICAL AND LEGAL FACTORS KEY TO THE DEVELOPMENT OF NOVEL AI-BASED TECHNOLOGIES

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Abstract: In light of the declarations of key AI economies and experts (USA, China) to accelerate AI adoption, including in the area of so-called home AI, this article discusses the factors contributing to the broader application of artificial intelligence (AI) in improving existing and developing entirely new market technologies. This applies particularly to automating routine tasks to increase efficiency, reduce human error, and improve access to products and services, especially personalized ones. Ethical issues are addressed, particularly those related to algorithmic bias, transparency of decision-making, and accountability for these decisions. The article concludes by highlighting the multifactorial reasons for the potential success of implementing new AI solutions, including consideration of sustainability and interdisciplinary collaboration and regulatory frameworks to ensure responsible and effective integration of AI with existing solutions.

Computer science, law, artificial intelligence, machine learning, technologies, market applications.

CZYNNIKI TECHNOLOGICZNE, EKONOMICZNE, SPOŁECZNE, ETYCZNE I PRAWNE KLUCZOWE DLA ROZWOJU NOWYCH TECHNOLOGII OPARTYCH NA SZTUCZNEJ INTELIGENCJI

Streszczenie: W świetle deklaracji gospodarek i ekspertów kluczowych dla AI (USA, Chiny) o przyspieszeniu zastosowania AI, w tym w obszarze tzw. domowego AI artykuł omawia czynniki szerszego zastosowania sztucznej inteligencji (AI) w ulepszaniu dotychczasowych i wypracowaniu zupełnie nowych technologii rynkowych. Dotyczy to zwłaszcza automatyzowania rutynowych zadań w celu zwiększenia wydajności, zmniejszenia liczby błędów ludzkich i poprawy dostępu do produktów i usług, zwłaszcza spersonalizowanych. Poruszane są kwestie etyczne, w szczególności dotyczące stronniczości algorytmicznej, przejrzystości podejmowanych decyzji i odpowiedzialności za podjęte decyzje. Artykuł kończy się podkreśleniem wieloczynnikowych przyczyn potencjalnego sukcesu we wdrażaniu nowych rozwiązań w obszarze AI, w tym uwzględnienia perspektywy zrównoważonego rozwoju i interdyscyplinarnej współpracy i ram regulacyjnych w celu zapewnienia odpowiedzialnej i skutecznej integracji AI z dotychczasowymi rozwiązaniami.

Keywords: Informatyka, prawo, sztuczna inteligencja, uczenie maszynowe, technologie, zastosowania rynkowe.

1. Introduction

Rapid advances in computing power and specialized hardware, such as graphics processing units (GPUs), enable the creation of increasingly complex artificial intelligence (AI) models. The availability of massive data sets fuels the training of advanced algorithms and supports data-driven innovation [1]. The falling costs of cloud computing are

making AI development more accessible to startups, researchers, and small businesses. AI implementation increases economic productivity by automating tasks and streamlining decision-making across industries [2]. Socially, AI is transforming labor markets, creating new job roles while simultaneously displacing routine or repetitive ones. The widespread use of AI systems is impacting daily life through personalized services, automation, and digital

assistants. Ethical concerns arise about fairness, bias, transparency, and the potential for AI to exacerbate existing social inequalities. Ensuring responsible AI requires robust privacy safeguards, especially when systems rely on sensitive personal data [3]. Legal frameworks are evolving to regulate AI accountability, security standards, and the rights of individuals affected by automated decisions. International cooperation is increasingly necessary to harmonize AI regulations, prevent abuses and foster safe global innovation [4].

2. Observed gaps

From a technological perspective, there is a research gap in developing AI systems that are both highly efficient and reliably interpretable, especially for complex deep learning models. Current research insufficiently considers AI's resilience to adversarial attacks and failures in real-world, risky environments. There is limited empirical research on the actual impact of AI on productivity, long-term growth, and macroeconomic inequality [5]. Economic research often overlooks the needs and constraints of small and medium-sized enterprises (SMEs) in implementing and integrating AI. Social science research lacks comprehensive longitudinal studies of how AI is transforming labor markets, social norms, and human well-being [6]. There is also a lack of sufficient analysis of AI's impact on marginalized groups, especially in countries in the Global South, characterized by diverse cultural and infrastructural conditions. Ethics research often focuses on principles rather than practical, scalable methods for implementing fairness, transparency, and accountability in real-world systems [7]. There remains a gap in understanding how to implement ethical guidelines in organizations with limited resources or technical expertise. From a legal perspective, research is still ongoing on how to create enforceable and flexible AI regulations that keep pace with rapid technological change. There is a particular lack of cross-border legal research, especially on the harmonization of AI standards, liability rules, and user protection in an international context [8].

3. Technological factors

The technological advancement of AI-based technologies is primarily driven by the rapid increase in computing power, including GPUs and specialized AI accelerators. Advances in deep learning architectures, such as transformer and diffusion models, significantly expand

the range of tasks that AI systems can perform [9]. The availability of large, high-quality datasets enables the creation of more accurate and generalizable AI models. Advances in machine learning frameworks and tools, such as PyTorch and TensorFlow, lower the barriers to experimentation and implementation. Edge computing and on-device AI improve real-time processing, privacy, and energy efficiency for AI applications. Improvements in data processing pipelines support faster learning cycles and more scalable AI development [10]. Research in model compression and optimization helps reduce the computational costs associated with running large models. Advances in multimodal learning enable AI systems to process and integrate text, images, audio, and other types of data. Better simulation environments and synthetic data analysis tools make it easier to train AI systems in complex or rare scenarios [11]. Advances in human-AI interaction technologies allow AI systems to communicate with users more naturally and effectively.

4. Economic factors

Economic factors influencing the development of AI-based technologies include increasing global investment from governments, corporations, and venture capital funds, which accelerates innovation and commercialization. AI-based automation promises significant cost savings for companies, motivating them to implement and integrate AI into their operations [12]. AI's potential to increase productivity and efficiency across various sectors fosters competition and ongoing technological advancement. Differences in access to financial resources create disparities in AI adoption between large enterprises and small and medium-sized enterprises. AI technologies are contributing to the emergence of new markets, products, and business models, stimulating economic growth [13]. AI-induced changes in labor demand are impacting wages, employment structures, and workforce planning. The growing demand for AI skills is driving investments in education, training, and talent acquisition. Economic incentives are driving companies to prioritize data collection and digital transformation to support AI development. Reducing the costs of cloud computing and AI tools is making advanced technologies more accessible to a wider range of users. Global competition for AI leadership is shaping national economic strategies, influencing policy decisions and innovation priorities [14].

5. Social factors

Societal factors influencing the development of AI-based technologies include changing public attitudes toward automation and digitalization, which shape the degree of AI adoption in everyday life. AI's impact on the workforce, including job cuts and the creation of new roles, influences social stability and expectations for job retraining. The widespread use of digital platforms increases familiarity with AI-based services, fostering further adoption [15]. Demographic trends, such as aging populations, are driving demand for AI solutions in healthcare, caregiving, and accessibility. Cultural differences influence how societies perceive the risks and benefits of AI, shaping adoption rates in different regions. Education levels and digital literacy determine how effectively people can use and benefit from AI technologies. Concerns about privacy, surveillance, and the misuse of personal data affect public trust in AI systems [16]. Social inequalities can be exacerbated or alleviated by AI, depending on how access to the technology is distributed. The integration of AI into communications, media, and social networks is influencing public discourse and information ecosystems. Societal expectations for transparency, security, and ethical behavior are putting pressure on software developers and policymakers to ensure responsible implementation of AI [17].

6. Ethical factors

Ethical considerations in the development of AI-based technologies begin with the need to ensure fairness, ensuring that AI systems do not reinforce or amplify existing societal biases. Transparency is essential because users and stakeholders must understand how AI systems make decisions that impact their lives. Accountability is a priority, requiring clear mechanisms for determining who is responsible when AI systems cause harm or make mistakes. Protecting user privacy is crucial, especially when AI uses sensitive personal data for training and decision-making purposes [18]. Developers must consider the potential for AI to be used for malicious purposes, including surveillance, manipulation, or disinformation. Ethical design requires minimizing unintended consequences by anticipating risks and auditing system behavior throughout the development process. Human oversight remains a key ethical principle to ensure that AI does not act autonomously in ways that violate human rights or safety [19]. Inclusivity is important because AI should be designed

to serve diverse populations, not to exclude marginalized groups from its benefits. Ensuring informed consent is crucial when AI interacts with users or collects data in contexts where individuals may not fully understand the technology [20]. Ethical development of AI requires ongoing reflection, interdisciplinary collaboration, and ongoing evaluation as the technology evolves.

7. Legal factors

Legal factors influencing the development of AI-based technologies begin with the need for clear regulations that define acceptable uses of AI and set standards for safety and reliability. Liability frameworks are essential for determining who is liable when AI systems cause harm, make poor decisions, or fail [20]. Data protection regulations, such as privacy laws, shape how organizations can collect, store, and use personal data for AI training and deployment. Intellectual property laws influence how AI-generated content is owned, shared, and commercialized. Compliance requirements force companies to document AI development processes, risk assessments, and decision-making procedures. Cross-border legal differences create challenges for global AI deployment, as companies must navigate multiple regulatory environments. Regulations governing automated decision-making aim to ensure transparency and protect individuals from unfair or discriminatory consequences. Regulations for high-risk AI applications—such as those in healthcare, transportation, or law enforcement—impose stricter oversight and testing requirements. Standards and certification frameworks help ensure that AI systems meet technical, ethical, and safety criteria before being released to the market. The evolving regulatory framework aims to balance innovation with public protection, guiding the responsible and accountable use of AI technologies.

8. Directions for further research

Future technological research should focus on developing AI models that are not only efficient but also explainable, robust, and energy-efficient. Developing secure and privacy-preserving AI methods, such as federated learning and differential privacy, will be essential for trustworthy systems. Economic research should seek more accurate models for predicting the long-term impact of AI on productivity, employment dynamics, and global

competitiveness. Further work is needed to understand how companies of all sizes can effectively implement AI and overcome financial and organizational barriers. Social research should analyze how AI affects human behavior, social cohesion, and cultural norms, especially in diverse populations [21]. Research assessing the role of AI in shaping future skills and developing reskilling strategies will be crucial for managing workforce transitions. Ethics research must strive for practical tools and frameworks that enable developers to measure, mitigate, and monitor bias and fairness issues in AI systems. Additional efforts are needed to integrate ethical risk assessment into organizations' daily AI development processes. Legal research should strive to create adaptive and enforceable regulatory frameworks that balance innovation with safety and accountability. Cross-jurisdictional research will be crucial to harmonizing global AI standards, ensuring consistent protection, and preventing regulatory gaps and abuses.

9. Conclusions

In summary, the development of AI-based technologies is being shaped by rapid technological advances that continually expand system capabilities while simultaneously posing new challenges in reliability and governance. Economically, AI promises significant productivity gains, but its benefits depend on sustainable investment, widespread adoption, and thoughtful management of market disruptions. Societally, AI's impact on work, behavior, and social structures underscores the need for inclusive strategies that support all groups in this process of constant change. From an ethical perspective, ensuring fairness, transparency, and accountability remain crucial to maintaining public trust and preventing harmful or biased outcomes. From a legal perspective, evolving regulatory frameworks will play a crucial role in guiding responsible innovation, clarifying accountability, and protecting individual rights in an AI-driven world.

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