LUMEN ET VIRTUS
ISSN: 2177-2789

HOW AI CAN REDUCE ERRORS AND SPEED UP PRODUCT APPROVAL WITHIN TECHNICAL STANDARDS

https://doi.org/10.56238/levv16n47-030

Submitted on: 11/03/2025 **Publication date:** 11/04/2025

Sandy Moreira da Silva

ABSTRACT

This article presents an integrative systematic review on the application of Artificial Intelligence (AI) in product design with a focus on technical compliance with regulatory standards. In the face of increasing regulatory complexity in sectors such as engineering, healthcare, and technology, AI has proven to be an ally in automating processes such as reading standards, classifying products, and generating compliance reports. The research was conducted based on publications indexed between 2018 and 2024, using strict selection criteria. The results show the use of technologies such as language models, neuro-symbolic systems and generative algorithms, with emphasis on their contribution to the reduction of errors and rework. Significant barriers were also identified, such as the absence of empirical validation, ethical dilemmas and regulatory challenges, especially in the Brazilian context. Comparative analysis allows us to understand the most advanced sectors, the associated risks, and the importance of explainability as a pillar for reliable and safe AI.

Keywords: Artificial Intelligence. Technical Compliance. Regulatory Standards. Product Design. Ethics in AI.

INTRODUCTION

The increasing complexity of regulatory environments imposes increasing challenges on organizations when it comes to product technical compliance. In sectors such as health, engineering, and technology, non-compliance with technical standards can lead to legal, economic, and reputational losses (Dias; Ferreira; 2023). In addition, the rules are frequently updated, and their interpretation can be hampered by technical language, lack of standardization, and dispersion of sources (Nazareno; 2024).

In this scenario, Artificial Intelligence (AI) has proven to be a strategic ally to deal with these regulatory requirements. The ability to process large volumes of data and identify complex patterns allows AI to support the compliance process in a more accurate and agile way (Arora et al.; 2024). Language models trained with standards and technical specifications are already being applied to analyze product documents, suggest classifications, and verify legal requirements even before the testing phase (Barbara et al.; 2024).

In addition to technical efficiency, the use of AI in compliance also contributes to the reduction of human error and the reduction of rework in critical stages of development (Dias et al.; 2023). By anticipating non-conformities and suggesting automatic adjustments, these technologies optimize the time and resources of the teams involved (Melo et al.; 2022). In parallel, the integration of AI into corporate processes raises important debates about ethics, privacy, and transparency (Silva; Domingues; 2024).

The justification for this study is based on the need to understand how AI can help technical teams comply with regulations that often present themselves as barriers to innovation (CIPL; 2023). At the same time, it is essential to explore solutions that ensure compliance without compromising the pace of development and autonomy of creative projects (Pizarro; 2024). It is also observed that, in the absence of integrated systems for automatic verification of standards, many companies face delays and high costs with manual processes (Pizarro; 2024).

In this context, this study aims to analyze how Artificial Intelligence can be applied in product design to ensure compliance with technical and regulatory standards. Specifically, it seeks to understand how AI can reduce errors and rework during technical development, identify methodologies already used by software with a focus on compliance, and assess the regulatory and ethical impacts of this integration.

This article is structured as follows: in section 2, the theoretical framework on artificial intelligence, compliance and ethics in technological development is presented; section 3 describes the methodology of the integrative systematic review adopted; section 4

presents the main results obtained based on the selected articles and critically discusses these findings; and, finally, section 5 presents the final considerations of the study.

THEORETICAL FOUNDATION

ARTIFICIAL INTELLIGENCE APPLIED TO DESIGN AND ENGINEERING

Artificial Intelligence (AI) originated in the 1950s, with the objective of simulating human thought through computer systems based on logical rules (Nazareno; 2024). Over the following decades, the field evolved driven by advances in data processing and artificial neural networks, which enabled the emergence of more autonomous and adaptive models (Dias et al.; 2023). These models began to learn from examples, overcoming limitations of systems solely based on fixed rules (Barbara et al.; 2024).

In engineering and product design, AI has begun to be incorporated to accelerate technical development and reduce manual failures at critical process steps (Arora et al.; 2024). Computer vision systems, for example, are used to detect visual nonconformities in physical structures such as electrical panels and mechanical components, with a high accuracy rate even without the use of large volumes of real data (Barbara et al.; 2024). These solutions optimize technical inspections and contribute to a more standardized analysis of the evaluated products (Dias et al.; 2023).

The use of Natural Language Processing (NLP) has been explored for the interpretation of technical standards and complex regulatory documents (Arora et al.; 2024). Platforms that use language models trained with normative terminologies have been able to identify semantic inconsistencies in product descriptions, reducing the risk of non-conformities during the technical approval stage (Silva; Domingues; 2024). This type of application is especially relevant in sectors with strict regulatory requirements and with constant updating of legal requirements (Nazareno; 2024).

AI has also been used to perform automatic technical classifications of products according to standards such as ISO 9999, speeding up the identification of the tests and verifications required for each category (Barbara et al.; 2024). This has allowed the anticipation of structural adjustments even before prototyping, with a direct impact on reducing rework and increasing the efficiency of the development cycle (Dias; Ferreira; 2023).

In addition to technical compliance, AI-based technologies have been applied to dynamically adapt products to the needs of users, while respecting regulatory parameters (Pizarro; 2024). These applications are common in systems with customizable interfaces, which integrate data-driven accessibility and usability components (Pizarro; 2024). Adaptive

design, guided by AI, also reinforces the role of engineering as an agent of inclusion and responsible innovation (CIPL; 2023).

AI has been used to monitor changes in technical standards and alert teams to changes that may impact ongoing projects (Melo et al.; 2022). This favors the construction of continuous compliance systems, with automated updates that help avoid penalties and interruptions in production processes (Nazareno; 2024). In this way, the application of Artificial Intelligence in design and engineering represents an evolution that combines technical precision, regulatory innovation, and strategic agility (CIPL; 2023).

2.2 CONCEPTS OF REGULATORY COMPLIANCE AND TECHNICAL STANDARDS

Regulatory compliance is a fundamental process to ensure that products and services meet the technical, legal, and safety requirements established by regulatory and regulatory bodies (Dias; Ferreira; 2023). In industrial sectors, this compliance is essential not only for the release of products on the market, but also for the mitigation of operational, legal, and reputational risks (Nazareno; 2024). Failure to comply can result in sanctions, financial losses and, in more serious cases, damage to the physical integrity of end users (Silva; Domingues; 2024).

International technical regulations are documents that establish criteria, methods and parameters for the production and evaluation of goods and services. Among the main standards used worldwide is the set of ISO standards, maintained by the International Organization for Standardization, which ranges from quality management to specific requirements for technical products (Barbara et al.; 2024). An important example is ISO 9999, which classifies assistive products based on their functionalities, and is widely used to guide safety certifications and testing (Arora et al.; 2024).

In the context of health and biotechnology, the *Food and Drug Administration* (FDA) acts as a regulatory body in the United States, requiring medical devices and technologies applied to health to undergo rigorous safety and efficacy evaluation processes before being approved for commercialization (Dias et al.; 2023). These processes involve technical validation, laboratory tests and documentary compliance according to recognized international standards.

In the European Union, the regulation of AI products has been structured from a risk-based approach, with the classification of systems into categories such as low, medium, high, and unacceptable (CIPL; 2023). Products classified as high risk, such as biometric systems, require proof of compliance with technical requirements, external audits, and

transparency and traceability mechanisms (Nazareno; 2024). This model seeks to balance innovation and protection of fundamental rights, favoring the social acceptance of AI.

In Brazil, the actions of the National Health Surveillance Agency (ANVISA) have also evolved to keep up with the demands of digital transformation, including the regulation of software such as medical devices and specific regulatory requirements for smart products (Dias; Ferreira; 2023). ANVISA adopts several ISO standards and international protocols as a reference, in addition to requiring detailed technical records and reports for certifications.

The interpretation of these standards, however, is not always direct, as many of them have dense technical language, requiring highly qualified professionals for their analysis and correct application (Silva; Domingues; 2024). In this sense, Artificial Intelligence has gained space as a support tool in the reading and application of standards, facilitating the automatic identification of requirements and accelerating adaptation processes (Arora et al.; 2024).

Understanding the concepts of regulatory compliance and the main regulatory standards is indispensable for any innovation proposal oriented to safety, legality and technical quality. The combination of technical rigor with emerging technologies is one of the most promising ways to make compliance with standards more efficient, automated, and accessible to a greater number of companies (CIPL; 2023).

2.3 *PRIVACY BY DESIGN* AND AI ETHICAL PRINCIPLES

The advancement of Artificial Intelligence has driven discussions about ethics, responsibility, and fundamental rights in the development of technologies that directly affect people's lives (Silva; Domingues; 2024). The ability of algorithms to make decisions based on personal, often sensitive, data makes it urgent to incorporate principles that ensure the fair and transparent use of these tools (Pizarro; 2024). In this context, the concept of *Privacy by Design* proposes that privacy protection be considered from the design of systems, and not only in later phases.

The *Privacy by Design* model, widely disseminated by scholars and adopted in legislation such as the General Data Protection Law (LGPD) in Brazil and the General Data Protection Regulation (GDPR) in Europe, is based on the principle of data minimization, seeking to limit collection to only what is strictly necessary for the specific purpose (Silva; Domingues; 2024). Techniques such as anonymization, pseudonymization, and access control are recommended to reduce the risks associated with automated data processing.

However, there are important technical and legal challenges for the effectiveness of these principles in AI-based systems. Anonymization, for example, can be reversed in some

cases, especially when cross-referenced with other databases, compromising the promised protection (Pizarro; 2024). In addition, many AI systems still operate as "black boxes", making it difficult to explain their decisions and hold them accountable in case of errors or discrimination (Dias; Ferreira; 2023).

To deal with these risks, international documents have been proposing ethical governance guidelines for AI. The Recommendation on the Ethics of Artificial Intelligence, published by UNESCO in 2021, establishes principles such as respect for human rights, inclusion and non-discrimination, sustainability, transparency, and continuous human oversight (CIPL; 2023). These principles have served as the basis for more conscious legislation, institutional practices, and design projects.

Explainability is one of the central pillars of these discussions. It refers to the ability of an AI system to present in an understandable way the reasons behind its decisions, especially when these impact individuals directly or indirectly (Arora et al.; 2024). Explainable systems are essential to guarantee the right to challenge and strengthen public trust in automated solutions.

In this sense, ethical design becomes a strategic step in the development of products with AI. It must be guided not only by technical criteria of efficiency, but also by social, cultural, and legal commitments to users and the community (Pizarro; 2024). Initiatives that translate UNESCO's principles into design practices contribute to reducing the negative impact of AI and promoting the responsible and safe use of these emerging technologies.

2.4 INTERNATIONAL REGULATION AND CHALLENGES FOR BRAZIL

The regulation of Artificial Intelligence has been the subject of attention in several countries, with approaches ranging from preventive, corrective, ethical-normative, and risk-oriented models (CIPL; 2023). The European Union stands out for adopting a robust regulatory framework, based on the classification of AI systems by risk levels: unacceptable, high, limited, and minimal, requiring proportional measures according to the degree of potential impact (Nazareno; 2024). This approach allows for a balance between innovation and protection of fundamental rights, such as privacy and non-discrimination.

In the United States, regulation follows a decentralized model, with different states and agencies establishing specific guidelines. Instead of imposing a single national legislation, the country has adopted guiding principles, such as those proposed in the *AI Bill of Rights*, which advocates safety, explainability, human action, and protection against algorithmic bias (CIPL; 2023). This flexibility aims to preserve the innovation environment, although it faces criticism for the lack of regulatory uniformity.

In the United Kingdom, the focus is on self-regulation combined with coordination between different sectors of public administration. Initiatives such as the AI Standards Hub seek to foster the development of technical standards aligned with the guidelines of the International Organization for Standardization (ISO), especially with regard to the certification and traceability of automated systems (Dias et al.; 2023). This model bets on technical governance as a pillar of trust in AI.

In Brazil, the debate around the regulation of Artificial Intelligence advances on different legislative and institutional fronts. The General Data Protection Law (LGPD) represents an important milestone in establishing legal grounds for the processing of personal data, including the right to review automated decisions (Silva; Domingues; 2024). However, the LGPD is still considered insufficient to address the specifics of AI, especially in relation to explainability and accountability for algorithmic failures.

Two legislative proposals in progress are highlighted: PL 21/2020 and PL 2338/2023. The first introduces ethical principles and guidelines for the development and use of AI, while the second proposes a classification of systems by risk, along European lines, in addition to providing for the creation of an independent regulatory authority (Nazareno; 2024). Both face the challenge of regulating without compromising innovation, especially among startups and technology-based companies.

Another important advance was Resolution No. 23,732/2024 of the TSE, which establishes specific rules for the use of AI in electoral campaigns, including the prohibition of *deepfakes* and the requirement to identify manipulated content (Dias; Ferreira; 2023). This resolution highlights the strategic role of public institutions in defining ethical and operational limits for the application of AI in Brazil.

Even so, the country faces significant obstacles, such as the absence of standardized metrics to assess the degree of risk of intelligent systems, the low technical capacity of control agencies, and the difficulty of harmonizing the national legal framework with international guidelines (Pizarro; 2024). Building effective regulation requires not only clear standards, but also technical, fiscal, and educational instruments that promote the safe and ethical adoption of AI.

METHODOLOGY

This study was developed based on an integrative systematic review, with the objective of identifying, analyzing and synthesizing scientific publications that deal with the application of Artificial Intelligence in product design with a focus on technical and regulatory compliance. The choice of this methodological approach is justified by the

possibility of bringing together different types of studies (theoretical, empirical, technical and normative), allowing a broad and critical analysis of the theme in question.

The search for materials was carried out between March and April 2025, covering the publication period between 2018 and 2024, in order to ensure the topicality of the discussions and alignment with recent advances in AI technology and regulation. The main databases used to survey the articles were: Google Scholar, Scopus, ScienceDirect, SpringerLink and CAPES Journals. Relevant technical and institutional documents were also included, such as UNESCO guidelines, CIPL and Brazilian legislative reports.

The following inclusion criteria were adopted: (a) full articles available in Portuguese, English, or Spanish; (b) publications that address the application of AI in technical compliance, regulatory, product design, or corporate compliance contexts; (c) documents between the years 2018 and 2024; and (d) studies with clearly described methodologies. The exclusion criteria were: (a) repeated publications in more than one database; (b) texts without evident methodological rigor, such as opinion articles; (c) studies focused exclusively on AI in marketing or finance, unrelated to the topic of technical compliance.

Data analysis followed the following methodological steps: (1) exploratory reading of titles and abstracts for initial screening; (2) full reading of the selected texts; (3) organization of studies according to thematic criteria; and (4) categorization of articles based on the following aspects: authors and date, purpose of the study, type of AI technology used, methodology applied, main results, and limitations pointed out.

The final systematization was carried out by means of a comparative table that presents, in a synthetic way, the central contributions of each selected study. This organization allowed the structuring of the discussion by thematic axes and the identification of convergences and gaps in the approaches found in the current literature.

RESULTS AND DISCUSSION

The following is a synthesis of the studies selected for this integrative systematic review. The table organizes the articles according to their objectives, AI technologies used, methodologies adopted, main results obtained, and limitations pointed out, allowing a comparative view of the relevant contributions to the field of automated technical compliance.

Table 1 - Summary of the studies analyzed on the application of AI in the technical compliance of products

Author (Year)	Objective of the Study	AI Technology	Methodology	Main results	Limitations pointed out
Arora et al.; 2024	Propose CompliAT framework to	LLMs, NLP, RAG	Theoretical proposal with	Reduces time, automates	No empirical validation; depends on

	verify technical compliance with AI		practical example	classification and reporting	human curation
Barbara et al.; 2024	Verify Enclosure Compliance with Neuro-Symbolic AI	Deep Learning, ASP	DL with synthetic data + ASP	High accuracy and scalability even without real data	Limitations with component overlap and unfavorable angle images
Dias et al.; 2023	Introduce TestLab for AI-powered automated testing	ML, RL, NLP	Framework with 3 independent modules	High test coverage, integration with CI/CD	Lack of practical validation; User Dependency for Expected Values
Silva; Domingues; 2024	Analyze Privacy *by Design challenges* in the AI cycle	Generative AI, Anonymization	Critical literature review	Defends privacy by design; Warning of ethical risks	Lack of clear operational guidelines
Pizarro; 2024	Discuss ethical impacts of AI on design	Big Data, Algorithms, UNESCO	Theoretical and critical review	Translates UNESCO principles into design actions	No empirical validation; Conceptual study
Pizarro; 2024	Analyze Lensa app social impacts based on AI ethics	Generative AI, Stable Diffusion	Documentary case study	Criticism of facial data exploitation and artistic styles	Analysis of a single product; No technical tests
Days; Ferreira; 2023	Assessing the risks and benefits of AI in corporate compliance	ML, Chatbots, Predictive	Review + case study (Alice/CGU)	AI reduces fraud, automates compliance and monitoring	Risks of bias, opaque decisions, lack of oversight
CIPL; 2023	Offer global recommendations for AI regulation	3-Tier Governance	Normative proposal	Proposes *sandboxes*, intelligent oversight, and organizational accountability	Risk of regulatory overburden and lack of legal clarity
Nazarene; 2024	Discuss international experiences and challenges of AI regulation in Brazil	Generative AI, Legal Frameworks	Comparative legislative study	Proposes classification by risk, traceability and national regulatory authority	Lack of standardization and risk of inhibiting innovation
Melo et al.; 2022	Compare AI regulatory strategies in 5 countries	ISO/IEC, Soft Law, Sandboxes	Comparative case study	Maps actions of the EU, US, UK, AUS and Japan; suggests guidelines for Brazil	Difficulty of global harmonization and lack of objective metrics

Source: The author (2025)

The integrated analysis of the selected studies allows the identification of patterns, contradictions and relevant gaps to understand how Artificial Intelligence has been applied to the technical compliance process in product design. By systematizing the contributions of

different areas such as engineering, computer science, law and technological ethics, it becomes possible to observe the methodological advances and also the practical and regulatory limits that still restrict the full adoption of these technologies. The diversity of approaches found shows that the field is in consolidation, with innovative proposals that are not always accompanied by empirical validation or consolidated normative guidelines.

Among the studies that present practical applications, those that propose complete frameworks and technologies already tested in real or simulated contexts stand out. Arora et al. (2024) developed the CompliAT system, which uses language models to verify the compliance of assistive products with ISO standards, automating tasks that previously required time and specialized knowledge. Similarly, Barbara et al. (2024) proposed a neuro-symbolic approach to inspect electrical panels with high accuracy, combining *deep learning* with logic programming. Dias et al. (2023) presented TestLab, an intelligent testing environment that employs reinforcement learning and language processing to identify software failures, optimizing technical quality control.

In contrast, other studies take a more conceptual and normative approach, prioritizing ethical, legal, and philosophical discussions. Silva; Domingues (2024) analyze the challenges of implementing *Privacy by Design* in AI systems, pointing out the need for structural changes in development processes. Pizarro (2024) discusses the influence of design in maintaining unfair practices and proposes the application of UNESCO principles to mitigate algorithmic inequalities. The CIPL report (2023) offers strategic guidelines for global regulations, advocating for smart oversight based on results and organizational accountability.

The comparison between these study groups shows the complementarity between practice and theory. While the technical proposals show the potential of AI to increase efficiency, reduce errors, and automate compliance, the conceptual works remind us that the implementation of these tools without an ethical and regulatory basis can generate significant risks. Most practical solutions, while promising, still lack robust empirical validation and face obstacles related to legal interpretation, social acceptability, and transparency of their decision-making processes. Thus, it is clear that technical advancement needs to go hand in hand with the construction of ethical and regulatory guidelines to ensure not only functionality, but also legitimacy and safety.

Among the Artificial Intelligence technologies identified in the studies analyzed, some stand out for their high applicability and direct impact on compliance verification processes. Large Language Models (LLMs) and tools based on Natural Language Processing (NLP), for example, have gained ground for their ability to understand and interpret complex

technical documents. Arora et al. (2024) demonstrated how these technologies can be applied in the automated analysis of ISO standards, allowing not only the classification of products, but also the suggestion of structural adjustments based on regulatory requirements.

The use of NLP is also present in the intelligent testing environment proposed by Dias et al. (2023), TestLab, which employs this technology to generate test scripts from source code, covering different levels of automated validation. In this context, artificial intelligence not only expands test coverage, but also contributes to the traceability and consistency of software development in regulated industries.

Another relevant advance is in the combination of Deep Learning and Answer Set Programming (ASP), as proposed by Barbara et al. (2024). The integration of these two approaches results in neuro-symbolic systems capable of performing visual inspections with high accuracy, even when available data are scarce. This hybrid architecture offers advantages both in terms of technical performance and logical interpretation, and is especially useful in scenarios where decisions need to be justified based on explicit rules.

On the other hand, the use of generative models such as Stable Diffusion, analyzed by Pizarro (2024) in the case study of the Lensa application, reveals important ethical risks. Despite their creative potential, these technologies can be used to reproduce discriminatory patterns, violate copyright, and compromise users' privacy, especially when the data used for training is not clearly regulated or auditable.

The potential of these technologies to automate the reading of technical standards, interpret structural data, and generate compliance reports is undeniable. However, as they gain autonomy and complexity, so does the need to ensure their explainability, that is, the ability to clearly demonstrate how decisions were made. Silva; Domingues (2024) point out that, without adequate transparency mechanisms, AI can become an opaque tool, making it difficult to hold accountable and correct any flaws.

Despite the technical progress evidenced in several of the proposals analyzed, one of the most recurrent barriers is the absence of robust empirical validation. Arora et al. (2024), for example, present a promising framework based on language models, but still without tests in real environments or results published in industrial contexts. A similar situation is observed in the study by Pizarro (2024), which analyzes the ethical impacts of AI on digital design, but does not conduct practical tests with users or simulated environments. The CIPL report (2023) also lacks experimental data, focusing on strategic recommendations, which limits the proof of the effectiveness of its regulatory proposals.

In addition to the lack of validation, ethical and legal risks permeate almost all studies, especially with regard to the use of sensitive data, the opacity of algorithms, and the possibility of automated discrimination. Silva; Domingues (2024) warns of the dangers of reversible anonymization and the difficulty of ensuring data minimization in AI systems. Already Dias; Ferreira (2023) highlight the importance of maintaining human supervision in automated compliance processes, pointing out that opaque algorithmic decisions can reinforce inequalities and generate negative impacts on corporate management.

In the Brazilian context, regulatory challenges also stand out as obstacles to the safe implementation of AI. Nazareno (2024) points out the lack of normative standardization, the absence of a specialized regulatory authority, and the risk that excessively restrictive regulations end up inhibiting technological innovation. The debate around Bills 21/2020 and 2338/2023 reveals the tensions between ensuring protection for citizens and, at the same time, preserving the competitiveness of the national productive sector.

Given these barriers, the urgent need for specific and structured regulations that consider the real risks of technologies, promote the transparency of systems and encourage good practices from the conception of projects becomes evident. The CIPL (2023) advocates a layered regulatory approach, combining ethical principles with organizational accountability and smart supervision, as a way to promote a regulatory environment that is both safe and innovative.

The analysis of the studies reveals that certain sectors have been standing out in the adoption of Artificial Intelligence technologies applied to technical compliance. The engineering area is one of the most advanced, with concrete proposals to automate critical stages of product development. Barbara et al. (2024) demonstrated how the inspection of electrical components can be performed through a neuro-symbolic architecture, capable of detecting visual nonconformities with high accuracy even in complex images. Similarly, Arora et al. (2024) developed a system aimed at the automatic classification of assistive products based on ISO standards, using language models that process technical data and generate compliance reports.

In the health area, the demand for security and traceability has encouraged initiatives aimed at regulating medical software and smart devices. Silva; Domingues (2024) discuss the challenges of applying *Privacy by Design* in this sector, where the sensitivity of personal data requires extra care. Nazareno (2024) points out that agencies such as ANVISA have been improving their protocols to keep up with technological transformations, inspired by practices of international agencies such as the FDA, which requires rigorous validations for AI-based products.

Another sector with relevant application is information technology, especially in software development and public compliance. The TestLab project, described by Dias et al. (2023), proposes an intelligent testing environment that allows validating automated functionalities in code, contributing to quality control in accelerated development cycles. The Alice system, cited by Dias; Ferreira (2023), shows how AI can be used in the public sector to identify fraud in government procurement, improving the transparency and effectiveness of enforcement actions.

In the field of international regulation, there is a growing effort to establish global parameters on the use of AI. The CIPL (2023) proposes a normative model that combines ethical principles, organizational responsibility, and technical supervision, while Nazareno (2024) analyzes how Brazil can adapt such guidelines to its legislative reality. Countries such as the United Kingdom and the members of the European Union also frequently appear in studies as references in more consolidated regulations, especially when adopting models based on risk classification and international interoperability.

On the other hand, some strategic areas are still poorly represented in the literature, such as the agri-food industry, the legal sector and technical-professional education. The paucity of studies in these fields indicates an opportunity for future research, especially in adapting AI solutions to less digitized contexts or with fragmented sectoral regulations. This gap reinforces the need to expand the interdisciplinary debate and promote the responsible use of AI in different segments of society.

The applications of Artificial Intelligence in regulated contexts not only involve technical issues, but also profound social and legal implications. The use of personal data on a large scale, often sensitive, demands special attention to the protection of fundamental rights. Silva; Domingues (2024) discuss the risks related to reversible anonymization and automated information processing, warning that, even with the use of techniques such as pseudonymization, the exposure of the individual remains a concrete possibility. Pizarro (2024) reinforces this concern by arguing that, when they are not guided by ethical principles, algorithmic decisions can reinforce historical inequalities and make the social impacts of technology invisible.

The construction of ethical governance structures for AI has been one of the focuses of international institutions such as UNESCO. The document published by the organization in 2021 proposes guidelines aimed at the protection of human rights, inclusion, diversity, and sustainability, topics that also appear as central to the recommendations of the CIPL (2023), which advocates the adoption of risk-based regulations, organizational responsibility, and intelligent supervision. Arora et al. (2024) also highlight the importance of

model explainability, emphasizing that understanding automated decision-making processes is key to ensuring transparency and social trust in AI adoption.

The issue of inclusion in automated environments is particularly sensitive when it comes to public services or products with great social impact. The absence of clear accessibility criteria and the lack of representation of different social groups in training data can lead to systemic exclusions and the reinforcement of already existing inequalities. In contexts of high bureaucratization and low transparency, as occurs in some instances of public administration, AI runs the risk of only automating exclusionary practices if it is not accompanied by equity-oriented public policies (Pizarro; 2024).

In the case of developing countries, such as Brazil, the lack of standardized technical measures to mitigate algorithmic risks makes the creation of institutional control and evaluation mechanisms even more urgent. Nazareno (2024) points out that the absence of a dedicated regulatory authority, added to the lack of technical and human resources in inspection agencies, hinders the implementation of public policies that guarantee legal certainty and the protection of rights in the use of AI. This scenario reinforces the need for internationalization of good practices, in addition to the continuous technical training of professionals involved in the technological development and regulation chain.

CONCLUSION

The analysis of the studies selected in this integrative systematic review demonstrates that Artificial Intelligence has high potential to optimize technical compliance processes in different sectors. Technologies such as language models, symbolic algorithms, and computer vision have been applied in the automation of reading standards, verifying structures, and generating regulatory reports, contributing to the reduction of human errors and the anticipation of failures during product development.

This study offers an up-to-date view on the relationship between AI and regulatory compliance, bringing together relevant contributions that can serve as a reference for researchers, practitioners, and regulators. The thematic systematization of the studies allowed mapping the most advanced sectors and reinforcing the importance of integrating technological innovation with ethical and legal responsibility. Even so, important limitations were observed, such as the absence of empirical validations and the fragmentation between technical and legal approaches, in addition to the restrictions imposed by the selection criteria and time frame of the review.

REFERENCES

1. Arora, C., Grundy, J., Puli, L., & Layton, N. (2024). Towards standards-compliant assistive technology product specifications via LLMs. *arXiv*. https://arxiv.org/abs/2404.03122

2. Barbara, V., & et al. (2023). Neuro-symbolic AI for compliance checking of electrical control panels. *arXiv*. https://arxiv.org/abs/2305.10113

3. Center for Information Policy and Leadership. (2023). *Ten recommendations for a global AI regulation*. https://www.informationpolicycentre.com/uploads/5/7/1/0/57104281/cipl_ten_recommendations_global_ai_regulation_portuguese_oct23.pdf

4. Chamber of Deputies. (2023). *Regulation of artificial intelligence*. Digital Library of the Chamber of Deputies. https://bd.camara.leg.br/bd/bitstreams/e70dbbf8-faaa-4347-b023-30a187ee8bf2/download

5. Dias, C. C., & Ferreira, R. V. (2023). The use of artificial intelligence in compliance activity: Risks and benefits. *CPJM Scientific Journal, 2*(8), 219–234. https://www.researchgate.net/publication/374929195_O_uso_da_inteligencia_artificial_na_atividade_de_compliance_riscos_e_beneficios

6. Dias, T., & et al. (2023). TestLab: An intelligent automated software testing framework. *arXiv*. https://arxiv.org/abs/2306.03602

7. National School of Public Administration. (2022). *Regulation of artificial intelligence*. https://repositorio.enap.gov.br/bitstream/1/7419/1/2022.12.08%20%20Regula%C3%A7%C3%A3o%20da%20Intelig%C3%AAncia%20Artificial.pdf

8. Pizarro, C. V. (2023). Design and ethics in AI: Reflections from the social impact of Lensa as a digital product based on artificial intelligence. *Design & Technology Magazine, 17*. https://www.researchgate.net/publication/382805004_Design_e_etica_em_IA_reflexoes_a_partir_do_impacto_social_do_Lensa_enquanto_produto_digital_baseado_em_Inteligencia_Artificial

9. Pizarro, C. V. (2024). Challenges for design in the era of artificial intelligence: Reflections and propositions to favor ethics in design. *Cuaderno, 221*, 57–69. https://dialnet.unirioja.es/descarga/articulo/9684615.pdf

10. Silva, T. D., & Domingues, P. M. (2024). Artificial intelligence and privacy: The challenges of privacy by design. *ARC: Advances in Knowledge Representation, 4*(2), 160–191. https://periodicos.ufmg.br/index.php/advances-kr/article/download/52813/44775/199635