A Cyclical Approach to Legal Document Analysis: Leveraging AI for Strategic Policy Evaluation

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Abstract

This article presents an approach to the analysis of legal documents that integrates artificial intelligence (AI) technologies to optimize processes of data extraction, classification, and compliance assessment to legal norms. With a focus on the accuracy of analysis, the study demonstrates how the application of advanced machine learning algorithms and natural language processing can significantly enhance the quality of legal text processing. The results show the AI algorithms' average weighted accuracy in analyzing AI development strategies by countries and categories at 0.91, with the highest accuracy in the "Specific Targets" category (1.0) and "AI Development Strategy" (0.99), indicating a high potential for AI application in legal analytics. These findings underscore the need for further research to optimize AI algorithms aimed at improving analysis accuracy in complex legal domains.

1. Introduction

Today, it is practically impossible to imagine our lives without using artificial intelligence (AI) in the modern world. In his blog, Bill Gates concluded that the widespread use of neural networks will be possible by 2030, with AI tools being used everywhere in the USA in just 1.5 years, and in African countries — in 3 years. The co-founder of the technology corporation emphasizes that preparations are still underway for a technological boom [1]. Developed and developing countries have already approved national programs and AI development plans, which indicates an awareness of the role of new technologies in the development and functioning of states and, in perspective, the formation of a humane digitized environment. Moreover, most governments declare their leadership in technology development (namely by attracting significant investments in research and focusing on the development of technologies

in the field of national defense). It is projected that by 2030, the economic benefits of using AI will be greatest in China and North America, which will constitute 70% of the global economic impact of AI [2].

AI is one of the key technologies of the new stage of economic development (known as "Industrial Internet of Things" or "Industry 4.0"), and the formation of a new society ("Super Smart Society or Society 5.0").

The implementation of AI technologies influences a country's competitive potential, especially regarding national security and defense, industrial, and social development. A country's approved development strategy, serving as the foundation of a defined policy course regarding the regulation and introduction of new technologies, is a means to minimize the threats and challenges associated with the development of these technologies.

The integral map of concepts for the development of new technologies is diverse and distinct. Despite the similarity of general tasks, principles, and methods, these strategies must each time be adapted to unique conditions, leading to different paths toward the more or less similar general goals of the international community.

Therefore, a hot problem is the analysis of AI development strategies (of developed and developing countries) regarding key aspects of development and legal implementation at the national level.

Considering the above and the relevance of the research, this article presents a new cyclical approach to the analysis of legal documents, based on the application of advanced AI algorithms. The aim of the study is to develop a comprehensive method that will automate the processes of analysis, classification, and assessment of compliance of legal documents with established norms and standards. It is demonstrated how the application of this approach can optimize the processes of working with legal texts, improve the accuracy of their analysis, and contribute to effective decision-making in the legal sphere. The study also emphasizes the importance of regulation and standardization in the use of AI technologies in jurisprudence, considering potential threats to data confidentiality and security.

The structure of this work is organized in such a way that it initially presents a review of existing AI research and technologies used in the legal field, and then describes in detail the developed cyclical approach and its implementation through a series of stages of legal document analysis. The conclusions emphasize the significance of the obtained results and the prospects for further research in this area.

2. Related Work

The advancement and expansion of AI over the years have been fostered by a continuous search in algorithms, machine learning methods, and integrating statistical analysis into understanding the world at large [3].

The field of science and technology, particularly in AI inventiveness and creativity, had earlier been subjected to human intervention. However, with the recent development in AI and the era of «big data», machines can now invent devices and processes autonomously [4]. This has led to an endless application of artificial intelligence in several sectors and industries such as healthcare, real estate, entertainment, logistics and transport, banking and financial services, travel, retail and e-commerce, manufacturing and food technology [5]. The field of jurisprudence is no exception too of using AI. The topic of technology in the legal sphere is

quite extensive, which creates the need to investigate all relevant events and processes that currently have the greatest impact on the legal system and social relations [6] Legal technology encompasses the use of various technological tools and innovations to improve legal practice, enhance legal processes, and facilitate better access to justice. These technologies aim to improve efficiency, accuracy, and accessibility in the legal field [7]. The majority of the resources in this field are presented in text forms, such as judgment documents, contracts, and legal opinions. Therefore, most Legal AI tasks are based on Natural Language Processing (NLP) technologies. Many tasks in the legal domain require the expertise of legal practitioners and a thorough understanding of various legal documents. Almost all models are better at case analyzing than knowledge understanding, which proves that knowledge modelling is still challenging for existing methods. How to model legal knowledge to LQA is essential as legal knowledge is the foundation of LQA [8].

The use of AI in jurisprudence opens new horizons for litigation, legal analysis, and the administration of justice. Research in this field shows that AI can help reduce search time, improve quality, and effectively extract relevant information from expanding textual sources, such as decisions of Brazilian courts [9].

In the context of the Indian judicial system, AI is used for data storage and retrieval, multi-party litigation systems, online dispute resolution platforms, and even predicting court decisions [10].

The need for regulation of AI technologies in jurisprudence is critical for standardizing policy and assessing data privacy threats [11]. AI can also be implemented in justice as a psychological phenomenon, integrating legal and psychological aspects to establish the limits of its application in law enforcement activities and court proceedings [12]. The emergence of AI-related crimes poses global challenges to jurisprudence, prompting potential improvements in legislation to respond to these new types of criminal activity [13].

Research in the field of document analysis with cyclical processing, information extraction, machine learning, and NLP demonstrates a wide range of applications and methodologies. The study [14] considers the analysis of citations using NLP and ML techniques to assess the impact of citations in scientific assessment.

In [15], different approaches to keyword extraction and synonym generation are explored, highlighting the benefits of the extreme learning model. In [16], the application of NLP and ML to patient reviews is analyzed, [17] focuses on text classification in multi-turn corpora, and [18] investigates deep learning for document analysis. These studies highlight the significant potential of NLP and ML in diverse applications, from analyzing reviews to classifying texts.

Below is a comparative Table 1 of approaches and quantitative assessments of the closest analogues among scientific articles.

Compared to the closest studies [24-26], this study demonstrates higher accuracy (0.91) in the analysis and classification of legal documents due to the integration of advanced machine learning and natural language processing algorithms.

Therefore, this study not only ensures high accuracy of analysis but also shows better adaptation to various aspects of legal documents, making it a more efficient and reliable tool for legal analysis and strategic policy evaluation.

Table 1

Comparative Analysis of Closest Analogues

Study	Approach	Quantitative Assessment
[24]	Use of AI-based software to improve speed and accuracy of analysis	No specific numerical values given, but a significant increase in speed and accuracy noted
[25]	Implementation of deep learning for text classification in legal document review	Classification accuracy: 0.87, performance across multiple document classes
[26]	Integration of AI and machine learning for document analysis and accuracy prediction	Prediction accuracy: 0.89, improvement in document analysis accuracy

3. Approach to the analysis of documents with cyclic processing

The approach to analyzing documents and extracting relevant information can be considered a sequence of operations that includes text analysis, pattern recognition, and data categorization. The objective is to transform unstructured textual data (documents) into a structured format (table) based on predefined categories. This includes several steps:

1. Text Preprocessing [19]. Before analyzing documents, it is necessary to convert them from raw text data into a format that is easily processed. This process includes [20]

- Tokenization: the division of text into words or phrases.
- Normalization: converting text to a uniform case, removing punctuation.
- Stemming or Lemmatization: reducing words to their base or root form.

These steps simplify the text and facilitate the detection of patterns. Formally, for a set of documents $D = \{d_1, d_2, \ldots, d_m\}$, each document d_i is subjected to preprocessing to obtain the processed document d_i'.

2. Feature Extraction [21]. The process of identifying text attributes that may indicate its relation to predefined categories. Mathematically, this is described as: transforming the text data d_i' into a feature vector $x_i \in R_n$, where each dimension corresponds to a separate feature. This step converts the text into a form suitable for machine learning analysis.

3. Classification [22, 27, 28]. The use of document features to classify it into predefined categories using machine learning models. The classification function $f: \mathbb{R}^n \to \{1, 2, \ldots, k\}$ maps the feature vector x_i to a label y_i, that corresponds to the category. Choosing an adequate model and its parameters is crucial for ensuring accuracy.

4. Information Storage. The classified information is stored in a structured format. This can be represented by a matrix $M \in \mathbb{R}^{m \times k}$, where each row corresponds to a document, and each column corresponds to a category. The element M_{ij} is filled based on the classification results of document i for category j.

This approach integrates scientific text processing methods and mathematical principles of classification to automate the process of extracting information from textual documents, ensuring efficient and accurate data processing. We will illustrate this approach with Figure 1,

which depicts an algorithm with several steps, beginning with the definition of the table structure ("Step 1: Define Structure"), moving to the listing of documents for analysis ("Step 2: List Documents"), processing each document to extract information corresponding to each category ("Step 3: Process Documents"), filling the table with extracted information ("Step 4: Populate Table"), exporting the table to an Excel file ("Step 5: Export to Excel"), and providing access or a method for downloading or accessing the Excel file ("Step 6: Access Excel File"). Steps 3 and 4 indicate a focus on detail: Step 3 involves the cyclical processing of each document to extract information, and Step 4 involves the cyclical creation of new rows in the table with the extracted information.
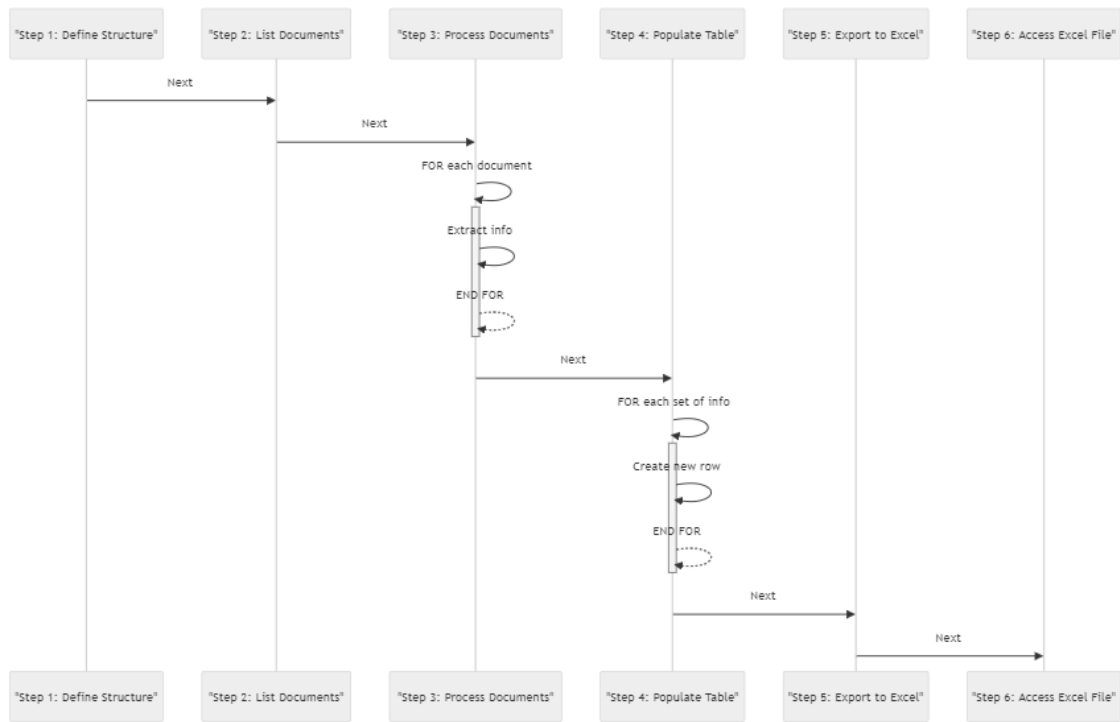

Figure 1: Document Analysis with Cyclical Processing.

4. Implementation

To implement the proposed method (see section 3) for analyzing AI development strategies, NLP and machine learning methods [23] were used, specifically Python libraries such as NLTK for text preprocessing, Scikit-learn for feature extraction and classification, and Pandas for structuring and storing data in tabular format.

For achieving specific goals, data were used that were collected from official state websites, governments, and international organizations (namely the full text of concepts, development strategies approved at state and international levels).

Based on the analysis of AI development strategies in ten different countries and regions, a systematic table was formed that reflects the key aspects of each strategy.

This approach allows for the assessment and comparison of the presence of AI development strategies, special legal regulation (both rigid and flexible approaches), the definition of specific goals at the national level, the definition of the concept of AI, as well as the presence of high-level and practical guidelines from principles to AI implementation.

Therefore, to analyze this issue, experts in jurisprudence have proposed the structure in Table 2.

Table 2
Structure of the results

№	Parameter	Description
1	Country	The name of the country or region for which the AI strategy was analyzed is indicated
2	AI Development Strategy	Reflects whether a country or region has an officially formulated AI development strategy
3	Legally Binding	Indicates the presence of legally binding regulations aimed at
4	Regulation	regulating AI
5	Non-Binding Guidelines	Shows whether there are non-mandatory guidelines or recommendations for regulating AI
	Specific Targets	Indicates whether there is a focus on specific national goals in the context of AI
6	AI Definition	Shows whether there is a clear definition of AI in the documents
7	High-Level Guidance	Indicates the presence of high-level guidelines from international organizations
8	Practical Guidance	Shows whether there are practical guidelines for the implementation of AI principles

Based on the proposed approach, Table 3 with the AI results for 10 documents was formed, and simultaneously, 5 experts in jurisprudence were also asked to form a corresponding table (Table 4).

To assess the effectiveness of AI in analyzing AI development strategies in different countries, a comparison was made between the results of data processed by AI (see Table 3) and the results of expert evaluations (Table 4).

In the study of effectiveness, the method of direct comparison of results obtained by AI with expert ratings across a range of key parameters was applied.

The accuracy of the AI was determined based on the percentage of agreement between the AI-generated data and the verified expert data.

The overall effectiveness of the AI analysis was measured as the average accuracy across all categories, which allowed for an assessment of its ability to adequately understand and interpret strategic documents in the field of AI development.

Table 3

AI processing results

Country	AI Development Strategy	Legally Binding Regulation	Non-Binding Guidelines	Specific Targets	AI Definition	High-Level Guidance	Practical Guidance
EU	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Brazil	Assumed Yes	Assumed No	Assumed Yes	Yes	Assumed Yes	Assumed Yes	Assumed Yes
Finland	Yes	Not specified	Yes	Yes	Not specified	Yes	Yes
India	Yes	Not specified	Yes	Yes	Not specified	Yes	Yes
Japan	Yes	Yes	Yes	Yes	Yes	Yes	Yes
USA	Yes	Not specified	Yes	Yes	Not specified	Yes	Yes
China	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ukraine	Yes	Not specified	Not specified	Not specified	Not specified		Not specified
Quebec	Yes	Not specified	Yes	Not specified	Not specified	Yes	Yes
Columbia	Yes	Not specified	Not specified	Yes	Not specified	Yes	Not specified

The following criteria were defined within the method for evaluation:

- A full match between the results obtained by AI and expert data was scored as 1 point, indicating identical information and high accuracy of AI analysis.
- A partial match, where AI used the "Assumed" marker to assess parameters that were acknowledged as correct by experts, was assigned a score of 0.9 points. This reflects a high level of consistency in results, albeit with some degree of uncertainty in interpretation.
- A complete mismatch, where the information provided by AI did not correspond to expert assessments, received 0 points, indicating a complete divergence in inferences.

This differentiated evaluation system provides a deeper understanding of AI's effectiveness in analyzing and interpreting complex strategic documents.

Particular attention is paid to AI's ability to make adequate inferences in conditions of uncertainty, which is a key aspect in assessing its potential as an analytical tool in a wide range of applications.

These results indicate a significant potential for AI in analytical research aimed at developing and improving strategies in the field of AI, and they also define directions for further enhancement of data processing and analysis algorithms.

Table 4
The results of the work of 5 experts

Country	AI Development Strategy	Legally Binding Regulation	Non-Binding Guidelines	Specific Targets	AI Definition	High-Level Guidance	Practical Guidance
EU	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Brazil	Yes	Not specified	Assumed Yes	Yes	Assumed Yes	Yes	Assumed Yes
Finland	Yes	Not specified	Yes	Yes	Not specified	Yes	Yes
India	Yes	Not specified	Yes	Yes	Not specified	Yes	Yes
Japan	Yes	Yes	Yes	Yes	Yes	Yes	Yes
USA	Yes	Yes	Yes	Yes	Not specified	Yes	Yes
China	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ukraine	Yes	Not specified	Assumed Yes	Not specified	Yes	Yes	Yes
Canada	Yes	Not specified	Yes	Not specified	Not specified	Yes	Yes
Columbia	Yes	Not specified	Not specified	Yes	Not specified	Yes	Not specified

The analysis of Table 5, which demonstrates a comparison of results obtained by AI with expert evaluations, revealed a high overall accuracy of AI in identifying AI development strategies by countries and categories. The average weighted accuracy across categories is 0.91, which indicates the effectiveness of AI in understanding and analyzing complex data. AI showed the highest accuracy in the "Specific Targets" category with a score of 1.0 and "AI Development Strategy" with an overall accuracy of 0.99. However, in categories such as "Legally Binding Regulation", "Non-Binding Guidelines", "AI Definition", "High-Level Guidance", and "Practical Guidance", a somewhat lower accuracy is observed (ranging from 0.89 to 0.8), which may suggest the need for further improvement of AI algorithms for better identification and interpretation of these aspects.

The highest accuracy by country is observed for the EU, Finland, India, Japan, China, and Quebec, where AI achieved full correspondence (1.0) with expert evaluations. However, in the case of Ukraine, the accuracy is only 0.43, which indicates significant discrepancies between AI and expert evaluations in certain categories. This could indicate a need for further refinement of AI algorithms to ensure more accurate analysis in cases with complex information or insufficient data.

Thus, the implementation of the proposed approach confirms the high efficiency of using AI in the analysis of AI development strategies in various countries and regions, as reflected in Table 4. The overall AI analysis accuracy of 0.91 demonstrates its high potential as an analytical

tool for assessing complex strategic documents. Particularly important is the fact that AI shows high accuracy not only in defining the general goals of development strategies but also in understanding the legal aspects of AI regulation and practical guidelines for their implementation. Despite some challenges associated with the analysis of specific categories, such as "Legally Binding Regulation" and "Practical Guidance," where accuracy was lower, the results underline the significant potential for further refinement of AI algorithms to improve analysis accuracy.

Table 5
Comparison of the obtained results

Country	AI Development Strategy	Legally Binding Regulation	Non-Binding Guidelines	Specific Targets	AI Definition	High-Level Guidance	Practicl Guidance	*Accuracy by country*
EU	1	1	1	1	1	1	1	*1*
Brazil	0.9	0.9	1	1	1	0.9	1	*0.96*
Finland	1	1	1	1	1	1	1	*1*
India	1	1	1	1	1	1	1	*1*
Japan	1	1	1	1	1	1	1	*1*
USA	1	0	1	1	1	1	1	*0.86*
China	1	1	1	1	1	1	1	*1*
Ukraine	1	1	0	1	0	0	0	*0.43*
Quebec	1	1	1	1	1	1	1	*1*
Columbia	1	1	1	1	1	1	0	*0.86*
Accuracy by category	*0.99*	*0.89*	*0.9*	*1*	*0.9*	*0.89*	*0.8*	*0.91*

5. Conclusions

The results of the current research demonstrate the significant potential of applying AI in the process of analyzing legal documents, confirming the effectiveness of the proposed cyclical approach. The overall data processing accuracy using AI was 0.91, indicating high reliability and precision of the obtained results. Particularly impressive results were achieved in the categories "Specific Targets" and "AI Development Strategy," where the accuracy was 1.0 and 0.99, respectively, evidencing AI's ability to precisely identify key elements of AI development strategies.

Based on the comparison conducted with expert evaluations (where the overall accuracy of the AI analysis was 0.91), we confirmed the high efficiency of AI in analyzing AI development strategies at the international level. The lowest accuracy by countries was recorded for Ukraine (0.43), which highlights the importance of adapting analysis approaches to the specifics of each particular legal system, in this case, the Ukrainian language.

These conclusions demonstrate the significant potential for applying AI in analytical research in the legal field, as well as indicating directions for further improvement of legal document processing and analysis technologies. Ensuring high accuracy in analysis is key to

enhancing the efficiency of legal processes and developing effective strategies for regulating and using AI at both national and international levels.

Based on the conducted analysis, future scientific research should focus on developing improved algorithms to increase the accuracy of classification and analysis of legal documents, particularly in categories like "Legally Binding Regulation" and "Practical Guidance," where accuracy was found to be lower. Another important direction is the development of methods for the effective processing and analysis of Ukrainian legal texts, which contain a large amount of unstructured information, in order to ensure a deeper understanding of the context.

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