Application of Machine Learning for E-justice

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Abstract. Decision support systems (DSS) in law enforcement have a long history. Starting from the late 50s, they have been developed through several architectural approaches. Still, having a proven capability of DSSes to improve legal practice, the real-world application is limited due to multiple issues, including lack of trust, interpretability, validity, scalability, etc. The paper develops a service-based decision support platform for machine learning applications for eGovernance and internal policy modelling and presents a case study of the application of the platform for the case of migration law enforcement. We have developed a decision support platform a number of micro services that connect with each other asynchronously via the REST protocol. The artificial intelligence core of the platform was built upon a knowledge base, which includes machine learning models and methods. In this work we have developed a method of structuring, analysis of legal data models based on machine learning. In the course of computational experiment, the efficiency of the developed method was proved and the interpretation of the obtained results was performed to provide recommendations for the enhancement of administrative regulation.

1. Introduction
Decision support systems (DSS) have a long history in the law enforcement [1]. Starting from the late 50s, they have been developed through several architectural approaches. Still, having a proven capability of DSSes to improve legal practice, the real-world application is limited due to multiple issues, including lack of trust, validity, scalability, etc. Since the 1990s, the idea of creating systems to support legal decision-making that do not produce imperative independent reasoning and conclusions has become popular worldwide. As a result, research into intellectual legal systems, which until the 1990s had focused on the tasks of search and reasoning, had begun to expand towards multitasking. The digitalization of administrative processes that is currently happening provides prospects the application of machine learning methods for the data and process analysis [2]. This leads to the possibility of application of text mining, data mining, and process mining methods for an enhanced comprehending the legal processes and the way they can be optimized. However, the there is still an issue of the quality and structure of the data, which prevent us from the efficient application of machine learning methods that require highly structured data. Moreover, laws undergo constant modifications, which demands automatic tracking of the legal practice like application pattern recognition. Artificial intelligence-based systems can automate the process of text mining and process mining to provide structured data and enable the analysis of the law practice.
2. Related Works

Over the past 30 years, a large number of legal information systems have been developed:

- with the integration of the argumentation function (for example, BankXX [3], LexrideLaw [1], as well as the NAI framework Web application on the SaaS architecture [4]);
- with prediction function integration (for example, SPLIT-UP [5], SMILE+IBP [6], VJAP [7]);
- with integration of document, content and knowledge management functions (FLEXICON [8], KONTERM[9], experimental software and hardware system for scientific and practical search and management of multimedia court content based on procedural ontology e-Sentencias [10], EUNOMOS [11], CLIEL [12]).

As a result of the widespread digitalization and the development of e-government, the rationale and development of legal systems for reference purposes have become particularly important. For example, models have been proposed to ensure control and support of the legislative process in a multilingual environment in European countries [13,14].

In the past 15 years, experiments have been conducted to introduce machine learning and data extraction methods into legal information systems for various purposes [15–18] and one interesting recent development of this kind is a system CLAUDETTE [19]. Over the past few years, experiments have emerged to organize information legal systems on the basis of big data [20,21].

The work on the application of artificial intelligence method to analyze law practice has just started, so we don’t have many reference implementations [22,23]. They are mainly in line with the dogmatic (formal-legal) method, while there are some interdisciplinary projects especially in the info-communicative facets of law [24]. It is necessary to mention that these research works are not based on the most modern accomplishments in information technologies [25].

Governments and law makers in different countries have begun to apply the machine learning for the analysis of law practice. This indicates a rising interest to the machine learning methods in the area of public administration [26]. Governments of larger regions have shown progressive experience of application of intelligent data analysis methods and machine learning for the improvement of administration [27]. For example, for the examination of catering amenities in Chicago [28], for the organization and implementation of fire safety regulation and management in New York [29].

Scientific studies showed the feasibility of text analysis of court decisions in different languages [28]. For example, court decisions on human rights [30] and the research of the German court decision definitions using the specific semantics and language structure of the German language. [31]. However, studies of the Russian law-making can be hardly identified. This is due to the specifics of the language and lack of access to the Russian court decisions.

In Russia, information systems are being developed for forensic analysis, crime detection and investigation, and models for extracting and intellectual analysis are being developed based on extensive court practice data [32,33].

DSSs have a proven ability to improve legal practice, but their application in real-life situations is limited due to many problems, including lack of trust, validity, scalability, etc. Now, as in early studies, the processing and input of raw data, which are unstructured documents in legal information retrieval systems, requires considerable expert efforts. In addition, because these systems are becoming service oriented, completer and more accurate through the use of complex logical, mathematical, statistical and computer methods and facilitate the routine work of lawyers, these systems do not yet provide a high degree of completeness, accuracy and user-friendliness, processing of intellectually complex requests and solving complex and complex problems.

The recent development of machine learning and other artificial intelligence (AI) technologies [7] emphasizes both mentioned strengths and drawbacks of DSSs. Moreover, relying on the available data, such technologies fall into the dependency on data and information uncertainty. Uncertainties originate in almost every step of a decision-making process.

In the UK, Charles Stevens and his colleagues, who created the prototype JAES system, consider it promising to build systems based on legal reasoning on the type of cases, connected to the "whiteboard" template and service-oriented architecture. [34].
Data-driven methods employ large amounts of empirical data processed with statistical machine learning methods to abstract patterns [26]. The need for validity and interpretability is currently recognized as an essential problem to be solved by researchers. Validation of data-driven models often requires lengthy and expensive practical evaluation, using metrics that are intuitive to lawyers and go beyond measures of technical accuracy and include measurements of quality and effectiveness. Implementation and adopting machine learning methods can be reasonably straightforward. Still, the interpretation of the provided outcomes is sometimes complicated and indistinct due to the black-box nature of machine learning models.

3. Objectives
Our research in general aims at development methods for eGovernance and Policy modeling using artificial intelligence. We propose the architecture that unites legal information systems and services to consider, firstly, variety and variability of computer methods of working with legal data, and secondly, variability in application of methods for solving legal tasks. It has been demonstrated that hybridization of systems leads to expansion of the domain area and at least partially solves this problem [35]. Therefore, the basic elements of the architecture should be taken as microservices that function on the basis of a successful methodology in limited subject areas and compete with each other in solving specialized tasks. The paper develops a service-based decision support platform for a law enforcement and presents a case study of the application of the platform for the migration law enforcement cases.

4. Methods
To implement the proposed approach, a platform for model-based decision support was developed. It includes both general instrumental solutions and basic methodological procedures for the application of the approach.

To solve the research task on the intellectual analysis of the judicial practice of application of the article of the Code of Administrative Offences of the Russian Federation at the stage of revision of resolutions (decisions) in cases of administrative offences, the data of the State Automated System of the Russian Federation "Justice" (public resource) were used. The empirical basis in the amount of 8804536 court rulings and decisions on cases of administrative offences of 321 Gb was formed with the help of a crawler through POST queries with some parameter in JSON. As a result of queries, full documents of judicial acts were received, which, as a rule, have a large volume, and not all their fields have values (zero values). Fields of documents were filtered out with only significant data left. The data were processed by Apache Spark using Python together with the Jupyter notebook.

The judicial acts placed in state information system "Justice" are weakly structured, the basic information necessary for intellectual analysis is contained in them in unstructured form in texts in natural (Russian) language. For this reason, a significant contribution to the quality of the resulting models is made by the developments of the members of the authors’ team in the field of natural language text processing. Significant amounts of weakly structured data significantly change the requirements to pre-processing technologies. The necessary data were extracted from the texts of court decisions, on the basis of which the problem of classification was solved [32].

4.1. NLP Methods
The concept of Term Frequency (TF) and Inverse Document Frequency (TF-IDF) is widely used to compute a weight or importance of a term in a text or a document [36]. As the TF-IDF conception is based on the information entropy and expected mutual information [37] it can be represented the following manner [36]:

Let $D = \{d_1, \ldots, d_m\}$ be a corpus of documents and $T = \{t_1, \ldots, t_k\}$ be a corpus of terms included in $D$. Then TF-IDF is a matrix $n \times m$, which is built by the following formula:
\begin{equation}
TFIDF(t, d, D) = \frac{n(t_i)}{n(t_i | d_j)} \times \log \frac{m}{|d_j | e | d_j | \epsilon}
\end{equation}

where \(n(t_i)\) is the frequency of the term \(t_i\) in the document \(d_j\) [37]. In our study we TF-IDF to produce n-grams.

4.2. Correlation Analysis

The correlation matrix was calculated using the Pearson correlation coefficient. By the example of the law on migration, a correlative analysis of these court decisions was carried out. The following parameters were extracted from the texts of court decisions: Administrative Law, Canceled of Appointment, Year, Fine_size, Article 2.9 Insignificance, Article 24.5 Excluding, Article 4.5 Expiration date, Extenuating circumstances, Aggravating circumstances, Repentance, Guilt admission, Assistance to police, voluntary reporting of an offence (Communication), not previously involved (First time), Have_a_baby, Continued_violation, Repeated offence (Second_time), Administrative penalty (Under_punishment).

This machine learning method demonstrates the likelihood of the outcome of a court case to overturn an administrative offence, depending on the circumstances of the case and the year of the decision. The task of classification was to predict the abolition of the fine for violation of the migration law Chapter 18 of the CAO by means of gradient boosting and decision trees. The precision recall metric was used to evaluate the quality of the classification forecast.

4.3. Regression

The model to predict the size of the fine was solved by regression with the help of random forest and gradient busting. Due to the fact that the classes were not balanced the automatic balancing of the model weights was applied. The mean absolute error (MAE) metric was used to evaluate the quality of the regression forecast.

5. Results

In the course of the research, the electronic data more than 5 millionth court acts issued by courts in various regions of Russia were analyzed. The data are selected randomly. Of the judicial acts, 95.3% concerned the imposition of penalties and 3.7% concerned the termination of proceedings.

The most common administrative offense in the analyzed data is petty hooliganism (Article 20.1 of the Code of Administrative Offences of the Russian Federation), entailing in law enforcement practice an administrative fine from 500 to 1000 rubles or administrative arrest within the range of 1 to 15 days. Common articles include an article on fire safety (20.4) and the article on migration (18). The task of n-grams producing was resolved by using TF-IDF as it was described in the methods section. It allowed calculating the weights of each term in a document. The most important n-grams were filtered and used in the work (Figure 1).

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig1.png}
\caption{The analysis of the court decisions texts.}
\end{figure}

Correlation of a law article with a period of time is a dynamic indicator that clearly indicates the presence of significant changes in law enforcement practice, if the value of the correlation is different
for different time periods. For the analysis of decisions on the migration law, 50438 decisions were used in the period from 2015 to 2019. As a rule, such dramatic changes that can be seen on the correlations of an article of the law and time periods are associated with significant changes in the law. By the example of the correlation matrix (Figure 2) it can be seen that the offences provided by Articles 18.1, 18.2, 18.8, 18.10, 18.11, 18.15, 18.16 and 18.17 of the Code of Administrative Offences of the Russian Federation have no correlation with all years.

![Heatmap](image-url)

**Figure 2.** Heatmap results of correlation analysis of court decisions data on migration law.

This is confirmed by simple observation. The legislator made the last significant changes to Article 18.1 - in 2009, to Article 18.2 - in 2014, to Article 18.8 - in 2013 (in 2016 this article only singled out special parts with more severe penalties for the same offences committed in Moscow, St. Petersburg, Moscow and Leningrad regions), to Article 18.10 - in 2015, in article 18.11 - in 2007 (in 2016 there was a technical change of the term in the article), in article 18.15 - in 2015 (in 2016 there was a technical change of the term in the article), in article 18.16 - in 2014, in article 18.17 - in 2013. These articles did not show any change in the zero value of the correlation for the time periods 2016, 2017 and 2018. In contrast, article 18.9 of the Code showed a change in the values of correlation between 2017 and 2018 (zero correlation) compared to 2016 (positive correlation). In this case, a dynamic indicator, which follows some significant change in the practice of administrative responsibility based on Article 18.9 of the Code. The presence of such changes is objectively confirmed by the fact that the legislator made changes to Article 18.9 of the Code in 2017 and 2018. Clarification of the nature of changes that occurred over time requires the use of other analytical tools. In addition, other methods allow to identify more complex changes in judicial and administrative practice, for which the simple correlation of the two indicators is not enough. It is also important to note that not all legislative changes significantly affect the practice of applying the articles of law. In particular, with regard to Articles 18.8, 18.11 and 18.15, this dynamic indicator did not appear, as the changes in the law were of a technical nature. In Article 18.8, in addition to the general case, some parts of the article specified private cases of violation, while in Articles 18.11 and 18.15 the outdated term was replaced by a current one, corresponding to the modern legislation. Thus, this indicator can show how serious the changes in the law were for real legal practice. The correlation of an article of the law with different

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circumstances mitigating or aggravating the penalty is an indicator of individualization of the penalty. Individualization of punishment is one of the most important principles of prosecution. Lack of individualization of punishment (zero correlation with each of the circumstances), as a rule, means violations in the process of law enforcement. No correlation is a normal practice only in cases when the law provides only one variant of punishment, without any alternatives. Otherwise, no correlation to any circumstances mitigating or aggravating the penalty means that the enforcer reduces the proceedings, avoids clarifying the facts of the case, and the penalty imposed is not individualized (in practice, in this case, a minimum penalty is imposed to avoid appealing the amount of the penalty). This violates the rules on the imposition of penalties (article 4.1 of the Code) and makes alternative penalties provided for by the legislator a "dead" norm. For example, article 18.1 provides various penalties. In particular, in parts 1 and 2 of this article, which are applied most frequently, the punishment for citizens is a fine of two to five thousand rubles. However, in practice, an administrative fine for this offence is imposed in the minimum amount (2,000 rubles). The correlation matrix shows that Article 18.1 has a zero correlation with each of the circumstances of the case that mitigate or aggravate the penalty, which is fully consistent with actual practice. On the contrary, Articles 18.8 and 18.15 of the Code have a non-zero (positive or negative) correlation with many circumstances that affect the individualization of punishment.

5.1. Classification Results to Predict the Cancellation of Penalties for the Violation of the Migration Law

To predict the cancellation of the punishment for the migration law violation, the classification problem was solved. Gradient busting gave the best result with AUC = 93.

Figure 3 shows the nature of the impact (positive or negative) of various parameters of the case on the outcome of judicial review of the case.

![Figure 3](image-url)  
**Figure 3.** Features impotence distribution using SHAP values.

For example, the establishment of any mitigating circumstances ("Extenuating") by the court is associated with the abandonment of the previously issued administrative penalty order, while the cancellation of the order is associated with the absence of mitigating circumstances established by the court (Figure 3).

This result is due to the fact that mitigating circumstances are established by the court to mitigate the penalty, i.e. in a situation where an administrative penalty is to be imposed and there are no grounds for discontinuing the proceedings. Mitigating circumstances such as repentance and guilt admission are well explained: establishing these circumstances means that the person is indeed guilty of the offence (the person repents of the act or confesses guilt) and therefore the court refuses to set
aside the earlier sentencing order. On the contrary, the establishment of the circumstances precluding the proceedings ("Exceptional circumstances (Art. 24.5)"") shows their high relevance to reversing an earlier ruling. The same result shows the determination of the insignificance of the offence (Art. 2.9), which entails exemption from administrative liability. Interestingly, the aggravating circumstances ("Aggravating") taken as a whole have no obvious connection either with the annulment of an earlier ruling or with the maintenance of that ruling unchanged. Given that mitigating and aggravating circumstances under the law are equally part of the subject matter of proof in a case, this means that in practice the process of establishing mitigating circumstances is different from the process of establishing aggravating circumstances. Both the offender, who can obtain a less severe punishment thanks to them, and the court, who can obtain a legal and fair decision thanks to them, are interested in establishing mitigating circumstances, which are less likely to be appealed and revoked on the basis of the unfairness of the punishment imposed. For the same reasons, no one is interested in identifying aggravating circumstances that would lead to a heavier penalty, and they are identified for objective reasons (obviousness of the offence, availability of relevant information in the public registers, etc.).

This method allows to reveal the importance of the influence of any parameters of the case on the result of its resolution, and for clarification and interpretation of the results obtained it is acceptable to use both traditional methods and other computational tools.

Thus, foreign citizens are often brought to justice under the administrative offences in question. It is therefore in this category of cases that the fact that the offender has underage children may, in some cases, have a major impact on the reversal of an earlier sentencing order (some red dots in positive terms on the line "Have a baby"). The meaning of this significance is that a foreign offender may have a child with Russian citizenship, and in this situation the court sometimes finds some reason to overturn an earlier sentencing order, acting in the interests of an international family.

Some dependencies are more complex. In particular, the fine line ("Fine-size") shows that average fines (purple dots in negative values) correlate well with a refusal to review an earlier ruling, while low and high fines (blue and red dots) correlate well with a cancellation of an earlier ruling. Such a result in the category of cases under consideration may have a large number of interpretations, which requires further intellectual analysis.

5.2. Regression Results to Predict the Amount of a Fine for Violating the Migration Law

The model to predict the size of the fine was solved the regression with the help of random forest and gradient boosting. As a result, the gradient boosting gave a better result Test-mae:1290.87732 1290.8781587419678. Grid search CV with max_depth=11, min_child_weight=5.

In the Figure 4 the array of cases of the category under consideration shows the significance of different parameters of the case for determining the amount of penalty.

![Figure 4](image-url)
For example, the mitigating and aggravating circumstances ("Extenuating" and "Aggravating") are almost equally important in determining the amount of a fine, but the different types of mitigating and aggravating circumstances vary considerably; for example, repentance is a more important mitigating circumstance, with a score of 588, than assistance in investigating an offence ("Assistance"), with a score of 93. The main reasons for these differences are the habituality of such circumstances in legal practice. "Repentance" is very often established by the court by receiving a response from the offender to the standard question: "Do you repent of what you have done? For the offender, this "repentance" is to obtain a lighter penalty and only the offender's words are proof of repentance, as in the case of a Guilt admission with a 509. "Facilitation" of justice is established on the basis of the real actions of the offender, which are rarely recorded and even less frequently documented. Therefore, "aid" is rarer and more unusual for the court and has less impact on the amount of the fine than "remorse", although it has immeasurably greater social utility. However, this method often does not allow you to set the direction of injection of some parameters on the other. Other methods and services can be used for this purpose.

6. Discussion and Conclusion
The combination of various microservices in a single architecture will serve as a factor in the integration of various methods of legal data mining. Currently, these methods are applied scattered. Although these methods allow gaining new knowledge in the domain of law, each of these methods raises questions of interpretation. In this work we have developed a method and a set of models of structuring and analysis of legal data. This was implemented as a service to provide its functions to the users. The efficiency of the developed method was proved and the utilization of the obtained results was used to produce recommendations for the improvement of administrative practice. Each of the considered areas to improve administrative regulation is based on a thorough empirical study based on the data of electronic court decisions.

Comparison of the developed system with the state of the art can be done considering its efficiency and performance of the machine learning models. The resulting AUC = 93 reached on the test dataset places our solution among the top performing systems. For example [22] provided AUC=85 and [23] AUC = 91. Our solution also provides a better interpretation of the results to provide more value to the potential users. Considering the level of interest in administrative process reform, this research will contribute to the development of methods for improving administrative legislation and scientific understanding of law as a social tool. In this article, using the various articles of the Russian Code of Administrative Offenses as an example, the possibilities of the consistent use of different methods for analyzing legislation and law enforcement on the basis of various static and dynamic indicators were shown. This allowed gaining more complete knowledge about the law and methods of its interpretation. With certain reservations, these same indicators and methods can serve for the predictive purposes.

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References
[1] Giord M 2017 LexrideLaw: An argument based legal search engine Proceedings of the International Conference on Artificial Intelligence and Law
[2] Oleg Metsker Egor Trofomov 2019 Text and Data Mining Techniques in Judgment Open Data Analysis for Administrative Practice Control Electron. Gov. Open Soc. Challenges Eurasia EGSE 2018
[3] Rissland E L, Skalak D B and Friedman M T 1996 BankXX: Supporting legal arguments through heuristic retrieval Artif. Intell. Law
[4] Libal T and Steen A 2019 NAI - The normative reasoner Proceedings of the 17th International Conference on Artificial Intelligence and Law, ICAIL 2019
[5] Stranieri A, Zeleznikow J, Gawler M and Lewis B 1999 Hybrid rule - neural approach for the automation of legal reasoning in the discretionary domain of family law in Australia Artif. Intell. Law
[6] Ashley K D and Brüninghaus S 2009 Automatically classifying case texts and predicting outcomes Artif. Intell. Law
[7] Grabmair M 2017 Predicting trade secret case outcomes using argument schemes and learned antitative value eect tradeos Proceedings of the International Conference on Artificial Intelligence and Law
[8] Gelbart D and Smith J C 1993 Flexicon: An evaluation of a statistical ranking model adapted to intelligent legal text management Proceedings of the International Conference on Artificial Intelligence and Law
[9] Schweighofer E and Winiwarter W 1993 Legal expert system KONTERM — automatic representation of document structure and contents Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)
[10] Casanovas P, Binefa X, Gracia C, Teodoro E, Galera N, Blázquez M, Poblet M, Carrabina J, Monton M, Montero C, Serrano J and López-Cobo J M 2009 The e-sentencias prototype: A procedural ontology for legal multimedia applications in the Spanish Civil Courts Frontiers in Artificial Intelligence and Applications
[11] Boella G, Di Caro L and Leone V 2019 Semi-automatic knowledge population in a legal document management system Artif. Intell. Law
[12] García-Constantino M, Chapman K, Atkinson K, Coenen F, Robson K, Bollegala D and Roberts C 2017 CLIEL: Context-Based information extraction from commercial law documents Proceedings of the International Conference on Artificial Intelligence and Law
[13] Agnoloni T, Bacci L, Francesconi E, Peters W, Montemagni S and Venturi G 2009 A two-level knowledge approach to support multilingual legislative drafting Frontiers in Artificial Intelligence and Applications
[14] Nanda R, Siragusa G, Di Caro L, Boella G, Grossio L, Gerbaudo M and Costamagna F 2019 Unsupervised and supervised text similarity systems for automated identification of national implementing measures of European directives Artif. Intell. Law
[15] Hachey B and Grover C 2005 Automatic legal text summarisation: Experiments with summary structuring Proceedings of the International Conference on Artificial Intelligence and Law
[16] Mozina M, Žabkar J, Bench-Capon T and Bratko I 2005 Argument based machine learning applied to law Artif. Intell. Law
[17] Ashley K D and Walker V R 2013 Toward constructing evidence-based legal arguments using legal decision documents and machine learning Proceedings of the International Conference on Artificial Intelligence and Law
[18] Šavelka J and Ashley K D 2015 Transfer of predictive models for classification of statutory texts in multi-jurisdictional settings Proceedings of the International Conference on Artificial Intelligence and Law
[19] Torrisi A, Bevan R, Atkinson K, Bollegala D and Coenen F 2019 Automated bundle pagination using machine learning Proceedings of the 17th International Conference on Artificial Intelligence and Law, ICAIL 2019
[20] Maurushat A, Bennett-Moses L and Vaile D 2015 Using “big” metadata for criminal intelligence: Understanding limitations and appropriate safeguards Proceedings of the International Conference on Artificial Intelligence and Law
[21] McGinnis J O and Stein B 2015 Originalism, hypothesis testing and big data Proceedings of the International Conference on Artificial Intelligence and Law
[22] Volkov 2011 Law and law enforcement in Russia: interdisciplinary research
[23] Matveeva M 2014 Monitoring of law-making: the problem of theoretical justification Proc. Russ. Acad. advocacy 2 44–7
[24] O R 2017 Priorities of information society development in Russia: legal support Law Enforc. Monit. 3 71–6
[25] Engineering S K-N L and 2008 U Ethem Alpaydin. Introduction to Machine Learning (Adaptive Computation and Machine Learning Series). The MIT Press, 2004. search.proquest.com
[26] Hampton W. M. 2014 Predictive Coding: It’s Here to Stay E-Discovery Bull. Pract. Law J.
[27] Anon Choucair B., Bhatt J., Mansour R. How cities are using analytics to improve public health //Harv Bus Rev. – 2014.
[28] Glaeser E L, Hillis A, Kominers S D and Luca M 2016 Crowdsourcing City Government: Using Tournaments to Improve Inspection Accuracy Am. Econ. Rev. 106 114–8
[29] Heaton B New York City Fights Fire with Data, GOV’T TECH
[30] Aletras N, Tsarapatsanis D, … D P-P-P C and 2016 undefined Predicting judicial decisions of the European Court of Human Rights: A natural language processing perspective peerj.com
[31] LREC S W- and 2008 undefined Linguistic Description and Automatic Extraction of Definitions from German Court Decisions. pdfs.semanticscholar.org
[32] Metsker O, Trofimov E, Sikorsky S and Kovalchuk S 2019 Text and data mining techniques in judgment open data analysis for administrative practice control Communications in Computer and Information Science
[33] Metsker O, Trofimov E, Petrov M and Butakov N 2019 Russian Court Decisions Data Analysis Using Distributed Computing and Machine Learning to Improve Lawmaking and Law Enforcement Procedia Computer Science
[34] Stevens C, Barot V and Carter J 2011 The next generation of legal expert systems - New dawn or false dawn? Res. and Dev. in Intelligent Syst. XXVII: Incorporating Applications and Innovations in Intel. Sys. XVIII - AI 2010, 30th SGAI Int. Conf. on Innovative Techniques and Applications of Artificial Intel.
[35] Burke R 2007 Hybrid web recommender systems Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)
[36] Aizawa A 2003 An information-theoretic perspective of tf-idf measures Inf. Process. Manag.
[37] Dey A, Jenamani M and Thakkar J J 2017 Lexical TF-IDF: An n-gram Feature Space for Cross-Domain Classification of Sentiment Reviews Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)