Artificial Intelligence to Analyze Huge Amounts of Juridical Documents via Edge Computing

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Abstract

The constant and continuous development of new technologies for the automatic processing of information has led to a massive growth of data and information in various areas that govern the development of social life. There are many sectors on which a significant impact has been had: health care, nutrition, training, information, economic and industrial processes, etc. In recent years there has been a specific interest in the use of computer and telematic technologies in the justice sector to make the execution of processes and activities related to the management of law faster and more efficient (telematic civil process; collection, deposits, and electronic archiving of provisions, minutes of hearings and documents; electronic notification of acts, etc.). Artificial Intelligence (AI) in the juridical-legal field represents a modern and advanced solution for managing the high quantity of valuable and necessary documents for carrying out justice processes. Given the particular criticality referred to the management of information and data, an architectural solution of the Edge Computing type is proposed for the localization of IT resources (of which a conceptual diagram is shown), which allows data processing in a decentralized way in opposition to the centralized one typical of Cloud Computing. This solution brings considerable advantages in terms of processing latency, reduction of data traffic, and greater resilience in the event of an interruption in the data connection. In addition, it allows for more efficient data security and confidentiality management in opposition to cybercrimes. Edge Computing has been adopted in the IoT environment, allowing to process considerable quantities of locally produced data and to send a compressed version to remote systems.

This work lists and illustrates the main proprietary software tools for law management and the main AI tools, APIs, and open-source libraries for the development of legal applications. Legal analytics technology, i.e., the use of various forms of AI ranging from Natural Language Processing (NLP) to Machine Learning and Data Science, can enhance the cognitive heritage represented by the jurisprudential and regulatory *corpus* (collection of material). In judicial activity, we can distinguish the phases of knowing and deciding. In the stages of knowing, where the study of the facts, rules, and jurisprudence applicable to the dispute is required, AI can bring significant added value due to its remarkable ability to collect and process data with a processing power that cannot be compared to human ability. In the stages of deciding, the decision-making activity must always remain in the hands of the judge, as a human being, with the ability to capture all the nuances, peculiarities, and unrepeatable specificities of each case.

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1 Introduction

In the last decade, the continuous and constant advances in technological and software have massively contributed to increasing information and data production. The increase in data production has significantly impacted various fields, including life science, medicine, biology, and juridical. These fields are now shifting towards data-generator domains.

For example, multiple types of juridical sentences and other judicial documents are generated daily in the juridical field. These documents must be adequately stored for future consultation by other juridical actors. Because the juridical actors may need to search through juridical databases to find previously relevant facts that could aid and support in the properly conduct of the legal process as well as in writing new juridical documents necessary for write the final sentence.

The advent of smart devices, wearables, sensors, and many other intelligent devices laid the foundation for the Internet of Things (IoT) [2]. The IoT enables smart devices to collect and exchange data, leading to increased automation, data production and accumulation in various domains.

IoT presents several advantages such as: *i)* high-performance, *ii)* scalability and *iii) trustness*. On the other hand, IoT also has disadvantages such as: *j)* security risks; *jj)* Privacy issues; *jjj)* vast amount of heterogeneous data generated by IoT devices can overwhelm data storage and processing capabilities. Efficient data management, filtering, and real-time processing mechanisms are essential due to the vast amount of data generated.

All these drawbacks pave the way for different types of cybercrimes. IoT devices are data generators that the juridical actors must acquire and examine to produce facts, for determining if a cybercrime has occurred. To prevent cyber crimes, juridical-legal data produced and managed in the context of processes and those created and managed through IoT in the domotic, care and judicial fields require high security and confidentiality. Nowadays, the juridical actors must manually analyze different types of heterogeneous documents and information, a tedious and error-prone process. The necessary information are spread across various locations on the intranet and the internet, causing the judge to conduct multiple searches to find what she/he needs. Hence, the necessity of software tools able to automatically gather and analyze relevant information spread online in several repositories arise. Those softwares can assist juridical actors to gain insights and knowledge to make accurate, precise and aware decisions in few time.

At this regard, juridical actors can use AI [22, 23] to automatically retrieve and analyze all documents that match their research criteria. It could support juridical actors by quickly analyzing vast amounts of juridical data and retrieving relevant information to support the juridical actors tasks. AI autonomously can investigate documents, contracts, and agreements to identify critical facts and anomalies relevant for the correct continuation of the criminal proceedings.

It's important to note that AI complements human lawyers and judges, enhancing efficiency and providing insights, but it does not replace them in complex legal reasoning and ethical considerations.

For AI systems to learn effectively, they need access to diverse and high-quality data. This allows them to make accurate predictions and generalize their understanding.

However, data must be gathered and stored according to the privacy rules. This implies that sensitive information must be analyzed in trusted computational sites such as Edge Computing systems [15].

Edge computing [19] is a distributed computing paradigm that improve the performance and security of many applications, by allowing sensitive data to be processed and stored locally without being sent to external cloud servers.

In this work, we provide an overview of some well-known software frameworks and APIs based on AI and suitable to be used in juridical field. We compared the investigated frameworks and APIs to highlight their strengths and drawbacks. The comparisons allow us to provide some tips use-ful in supporting juridical professionals in the choice of the most suitable framework based on its needs. The rest of the paper is structured as follows. Section 2 defines the AI, Edge Computing, IoT and the description and comparison of some software frameworks and APIs based on AI. Section 3 provides a comparison between the investigate AI software frameworks and APIs, along with a general concept of architecture based on Edge Computing and AI to analyze each kind of document in a trustworthy environment, including legal documents. Finally, Section 4 concludes the manuscript and provides some possible future works.

2 Related Works

This section defines and explains the concepts of AI, Edge Computing, and IoT technologies. Additionally, it provides a list of software frameworks and APIs that utilize AI for legal analysis purposes.

2.1 Artificial Intelligence

AI [22, 23] is the simulation of human intelligence in machines programmed to perform tasks that typically require human intelligence [6]. It involves the development of computer systems or algorithms that can analyze, interpret, and learn from data, make decisions or predictions, and adapt to changing events.

AI is a vast field encompassing various technologies, including machine learning, NLP, computer vision, expert systems, and robotics. These technologies enable AI systems to process and comprehend vast amounts of data, identify patterns, extract meaningful insights, and carry out complex tasks. Machine learning, a subset of AI, involves training algorithms with data to learn and improve without explicit programming. Deep learning, a type of machine learning, uses neural networks with multiple layers to process and interpret complex data representations [4]. AI systems can perform tasks such as image and speech recognition, natural language understanding and generation, recommendation systems, autonomous vehicles, fraud detection, law, and medical diagnosis [10, 20, 14].

The ultimate goal of AI is to create intelligent machines that can perform autonomous tasks such as reasoning, problem-solving, learning, perception, and language understanding [13].

2.2 Edge Computing

Edge computing [19] is a distributed computing paradigm that brings computation and data storage closer to the source of data generation rather than relying on centralized cloud infrastructure.

In edge computing, data processing, and storage occur at or near the edge of the network, typically on edge devices or edge servers closer to the data source or end-user devices. Edge computing is a powerful tool that offers many benefits to various applications. It processes data right where it is generated, at the edge of the network, significantly reducing latency and optimizing bandwidth usage. This is especially important for real-time applications such as autonomous vehicles and augmented reality. Furthermore, Edge Computing provides enhanced data privacy and security [24] by allowing sensitive information to be processed and stored locally, avoiding centralized cloud servers. It also ensures offline

operation and resilience, ensuring critical services continue functioning even when network connectivity is disrupted. In addition, Edge Computing enables distributed computing across multiple devices, improving overall system performance and scalability [1]. It has been widely adopted in various industries, including healthcare [3], manufacturing, and transportation, to meet industry-specific real-time monitoring, control, and analysis requirements.

As the use of IoT devices continues to grow and real-time applications become increasingly crucial so the benefits of edge computing cannot be ignored [18].

2.3   Internet of Things

IoT [12] refers to a network of physical devices, vehicles, appliances, and other objects embedded with sensors, software, and connectivity that enables them to collect and exchange data. These interconnected devices can communicate with each other and other systems over the internet.

The IoT concept involves establishing a network of interconnected objects to gather, exchange, and analyze data to interact with their environment and perform tasks. These objects, also referred to as "smart devices" or "smart objects," encompass a variety of items ranging from household appliances such as thermostats, lights, and refrigerators to industrial machinery, vehicles, and wearable technology. IoT devices are equipped with sensors to collect information about their surroundings, including temperature, humidity, location, and movement. This data can be shared with other devices or centralized platforms to analyze, process, and activate actions or decisions. The IoT could revolutionize a range of industries by increasing automation, efficiency, and connectivity. It provides opportunities for improved monitoring, control, and optimization of processes and enhanced data-driven decision-making. The applications of IoT can be utilized in smart homes, cities, healthcare, agriculture, transportation, manufacturing, and juridical corporations.

However, the IoT also presents challenges, including data privacy and security concerns, interoperability issues, scalability, and managing the vast amounts of data generated by interconnected devices. Addressing these challenges is crucial to harnessing the full potential of the IoT while ensuring the protection of privacy and maintaining a secure and reliable infrastructure.

2.4   AI software frameworks for Law

The legal industry is greatly influenced by AI technology, as it can automate various legal activities. Here are some popular AI software tools and APIs commonly used in law to simplify routine and repetitive tasks within the legal profession.

2.4.1   Proprietary AI software frameworks for Law

AI software frameworks are utilized for faster and more precise analysis of legal documents and vast amounts of data. These AI-powered systems can efficiently assist humans in processing and extracting relevant information from several documents. As a result, accuracy is improved, and errors are minimized. Here is a list of popular AI frameworks commonly utilized in the law field.

- LexisNexis Context[1] is an AI-enhanced legal research tool that utilizes machine learning algorithms to analyze and interpret legal texts. It provides context-specific information, highlights key passages, and offers related documents for comprehensive research. LexisNexis Context includes a vast database of legal documents, such as case law, statutes, regulations, and secondary sources. A subscription is required to use it.

- Westlaw Edge[2] is an AI-powered legal research platform that leverages advanced algorithms and analytics to provide lawyers with quick access to relevant case law, statutes, and secondary sources. Westlaw Edge AI enhances legal research with NLP, advanced search functionality, analytics, and predictive insights. It includes comprehensive and up-to-date information on legal authorities, helping lawyers understand potential outcomes and tailor their strategies accordingly. A subscription is required to use it.

- Kira Systems[3] is an AI contract analysis platform that automates reviewing and extracting critical information from contracts and other legal documents. Kira Systems uses AI and machine learning to extract and categorize necessary provisions from legal documents, saving time and automating the manual extraction process. It also assists in due diligence and integrates with legal workflow tools and document management systems. The flexible and customizable platform enables users to create custom models and workflows. A subscription is required to use it.

- eBrevia[4] is an AI-powered contract analysis software specifically designed for the legal industry. It uses sophisticated NLP and machine learning techniques that simplify and automate contract analysis and extraction for legal professionals, reducing errors and providing valuable insights. A subscription is required to use it.

- Neota Logic[5] is a platform that enables the development and deployment of smart, automated applications for the legal industry. It combines AI with legal expertise to create smart applications that can automate several steps of the legal processes, provide legal assistance, and support decision-making. It offers a no-code development environment for building intelligent applications, enhancing the legal processes efficiency. A subscription is required to use it.

2.4.2   *Open source AI frameworks, APIs and libriries for Law*

AI-powered tools and APIs for developing juridical applications are even available as open-source software. These open-source APIs and software tools offer a wide range of capabilities for AI in law, including NLP, machine learning, and deep learning functionalities. They provide a foundation for developing custom AI applications or integrating AI

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[1] https://www.lexisnexis.com/en-us/products/context.page
[2] https://legal.thomsonreuters.com/en/products/westlaw-edge
[3] https://kirasystems.com
[4] https://www.legal.io/legal-software/5156350/eBrevia
[5] https://neota.com

capabilities into juridical systems and workflows. Here are listed some well-known software frameworks, APIs, and libraries.

- spaCy [21][6] is a popular open-source NLP Python library that provides tools for text processing, named entity recognition, part-of-speech tagging, and dependency parsing. spaCy can break text into tokens, assign grammatical categories, and identify essential entities such as persons, organizations, locations, dates, etc. It also offers lemmatization capabilities and support for text classification tasks. It is highly customizable, supports multiple languages, and can analyze legal text and extract information.

- NLTK (Natural Language Toolkit) [5][7] is an open-source Python library designed to facilitate the development and application of NLP techniques. It offers pre-built datasets and tools for loading, preprocessing, and manipulating legal datasets, tokenization, part-of-speech tagging, named entity recognition, text classification, sentiment analysis, machine learning, and statistical modeling. NLTK is an excellent device for developing legal NLP applications. Legal professionals can utilize application developed using NLTK for text analysis and document processing.

- Gensim [17][8] is an open-source Python library for topic modeling and document similarity analysis. It offers a range of features that can be used even to analyze legal documents. Gensim is a helpful tool for text preprocessing, cleaning, extracting topics, computing document similarity, and normalizing legal texts. Gensim supports word vector models, which aid in understanding legal terms and identifying relevant documents. Lastly, it allows the creation of document indexes for efficient retrieval and searching. Gaining deeper insights and supporting decision-making in the legal domain is possible with the use of Gensim's features.

- FastText [11][9] is a Python library for efficient text classification and representation learning developed by Facebook Research. While FastText is a general-purpose library, it can be applied to various domains, including law. FastText is a powerful text classification tool that can accurately categorize legal documents. It learns word embeddings and has language identification functionality for multilingual legal environments.

- Keras [8, 9][10] is a high-level deep-learning library written in Python. While Keras is a general-purpose library, it can be effectively used in various applications within the field of law. It simplifies custom neural network creation for legal tasks like document classification and sentiment analysis. It offers pre-trained models and useful text-processing utilities like tokenization and vectorization.

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[6]https://spacy.io
[7]https://www.nltk.org
[8]https://pypi.org/project/gensim/
[9]https://fasttext.cc/docs/en/python-module.html
[10]https://keras.io

Table 1 provides a summary of the features and functionalities provided by the investigated software frameworks and APIs.

AI platforms are improving legal research, analytics, and contract management, but ethics, bias mitigation, and human oversight should be prioritized for responsible and effective use in the legal field. Overall, AI has transformed the legal industry by automating tasks, improving efficiency, providing data-driven insights, and enhancing access to legal information and services. While AI offers numerous benefits, it also presents new challenges that require thoughtful approaches to ensure its responsible and effective use within the legal profession.

3 Discussions

Software tools are essential to support professionals from every domains in accomplish their tasks in an easy, faster and accurate manner.

The advent of AI enables the development of intelligent frameworks that can autonomously support users in their activity by proposing suitable solutions to their problems.

Many AI frameworks can support judges in writing juridical reports and documents by automating certain aspects. AI frameworks can analyze judges' previous decisions and compare them to similar cases to identify patterns, inconsistencies, or potential biases. This analysis can help judges maintain consistency in their sentencing and make more informed decisions based on legal precedents. At the same time, AI frameworks can assist judges in managing their caseloads by organizing case-related documents, highlighting essential information, and summarizing complex legal arguments. To this end, many software frameworks are available each of which has strengths and weaknesses. Follows a comparison between the investigated software frameworks.

LexisNexis Context, and Westlaw Edge, are AI-based legal research platforms providing comprehensive access to a vast collection of legal materials. Both use advanced NLP techniques to analyze and understand legal texts, enabling users to fast find relevant information and precedents, focusing on assisting judges in writing sentences, case law, statutes, and regulations.

Kira Systems and eBrevia, conversely, use AI to analyze contracts and additional documents, extracting critical information from those documents by employing machine learning approaches. Their assist professional, especially in contract management and contract review.

Neota Logic uses AI to create expert systems and automation tools for legal and compliance tasks. No coding is required to design interactive applications that streamline legal processes, generate documents, conduct compliance assessments, and give legal advice.

Moreover, each explored framework provides advanced search functionalities, citation analysis, legal analytics, and visualization tools to aid research and analysis.

In detail, LexisNexis Context, Westlaw Edge, and Neota Logic are frameworks designed to work specifically with legal documents making them the ideal frameworks for automating repetitive legal tasks and providing more reasonable legal solutions. Kira Systems and eBrevia specialize in

contract management, but their features and functionalities may also be helpful for analyzing the legal validity of contracts than other specific legal documents.

Finally, among the investigated software frameworks, Neota Logic is the one that allows users to graphically design from scratch interactive and automatic applications without coding. Thus, Neota Logic is in the middle between frameworks and APIs, allowing everyone to implement the most opportune analysis strategy concerning the needs to be achieved.

APIs offer developers a standardized way to access and exchange information, perform specific tasks, and implement custom applications. They provide methods, data formats, and authentication mechanisms as intermediaries between the developer and repositories or services. APIs are helpful tools for developers to create customized applications that automate studies performed manually by juridical professionals, making their work more straightforward. From our point of view, we selected and analyzed the most appropriate AI APIs to develop customs applications for the juridical field. Follows a comparison between the selected AI APIs.

spaCy [21] and NLTK [5] are general purpose AI open-source Python libraries founded on NLP, providing general methods and functions for text processing. They provide protocols to developed text documents analysis approaches. spaCy and NLTK can be used only from developers to implement custom applications responding to the needs of juridical professionals. They are the ideal tools to automatize the current investigation steps performed manually, simplifying, assisting and improving the law professionals' jobs.

Gensim [16] is an open-source Python library for topic modeling and document similarity analysis. Gensim is the ideal APIs to build applications for creating interactive analysis reports using vector modelling to figure out relevant juridical terms, from vast amount of legal documents in few time. In addition, it create a terms-indexes catalogue for subsequently analysis. In this way judges gain deeper insight to use in her/his legals studies.

FastText [11] is an open-source Python library to classify text documents. FastText can be used to develop application for the classification of legal documents. It provides functions based on word embedding [7] for the documents language identification, when processing multilingual legal documents.

Keras [8] is an open-source neural network Python library. It can be used to develop specific application for the analysis of juridical documents. Keras can be used to develop customs neural networks for the classification and sentiment analysis of juridical documents. In this manner, Keras provides protocols useful for developer to train neural networks for tasks like legal document classification, relevant terms extractions and many more.

The investigated APIs help create personalized applications that meet the needs of individual judges and legal structures. When selecting APIs for an application, it's essential to consider the judge's requirements to provide the best solution for their professional expectations. It's also important to note that it is possible combining multiple APIs that can help legal professionals solve complex issues with greater accuracy and reliability.

Figure 1 depicts a conceptual architecture of a system encompassing the Edge Computing to implement a scalable, trusted and secure environment for the local analysis of juridical documents using AI applications. In addition it allow to collect data through the IoT devices, manually and web scrapping.

4 Conclusions

From what has been illustrated, the current moment is mature for a review of juridical-legal technology so that, in the procedural field, we can quickly arrive at a sentence by eliminating procedural errors and reducing the risk of judicial mistakes. AI with extraction techniques of legal arguments (argument mining), automatic maximization (summarization), and automated creation of documents (document builder) represent valid support to the preparatory work of the judges. In practice, through the AI technologies currently available, the jurisprudential and regulatory *corpus* can be annotated and processed with algorithms that can predict the outcome of a judgment, extract the legal arguments, and sim-

Table 1. Table summarizes the main features and functionalities provided from the investigated software frameworks and APIs. In the table, the attributes have the following meaning: Sub is short for Subscription; OS refers to Open-Source; GP stands for General Porpouse; Ext indicates the APIs' Extensibility; Type specifies the application category; ARF refers to Analytic and Reporting Functionalities; DB indicates the Database availability; AI specifies the type of provided AI; Domain refers to the software frameworks and APIs application Domain.

| Tool	Sub	OS	GP	Ext	Type	ARF	DB	AI	Domain
LexisNexis	Yes	No	No	No	WebApp	Yes	Yes	NLP	Legal Analysis
Westlaw Edge	Yes	No	Yes	No	WebApp	Yes	Yes	NLP	Legal Analysis, Tax
Kira	Yes	No	No	No	WebApp	Yes	No	NLP	Contract Management, Finacial
eBrevia	Yes	No	Yes	No	WebApp	Yes	No	NLP	Contract Management, Finacial
Neota Logic	Yes	No	Yes	No	WebApp	Yes	No	NLP	Legal Analysis, Insurance, Tax
FastText	No	Yes	Yes	Yes	API	Yes	No	ML	General Purpose
Gensim	No	Yes	Yes	Yes	API	Yes	No	NLP	General Purpose
Keras	No	Yes	Yes	Yes	API	Yes	No	NN	General Purpose
NLTK	No	Yes	Yes	Yes	API	Yes	No	NLP	General Purpose
spaCy	No	Yes	Yes	Yes	API	Yes	No	NLP	General Purpose
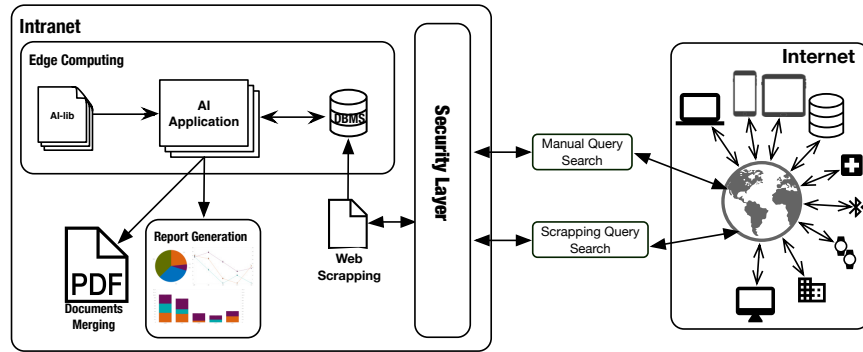
Figure 1. The proposed conceptual architecture based on Edge Computing and AI.

plify the work of drafting the jurisprudential maxims. However, in the era of AI applied to law, the decision and control phases will always have to remain the strict competence of justice operators to guarantee human decisions.

5 Acknowledgment

6 References

[1] K. Aruna and G. Pradeep. Performance and scalability improvement using iot-based edge computing container technologies. *SN Computer Science*, 1:1–7, 2020.

[2] K. Ashton et al. That 'internet of things' thing. *RFID journal*, 22(7):97–114, 2009.

[3] L. Barillaro, G. Agapito, and M. Cannataro. Edge-based deep learning in medicine: Classification of ecg signals. In *2022 IEEE International Conference on Bioinformatics and Biomedicine (BIBM)*, pages 2169–2174, 2022.

[4] L. Barillaro, G. Agapito, and M. Cannataro. Scalable deep learning for healthcare: Methods and applications. BCB '22, New York, NY, USA, 2022. Association for Computing Machinery.

[5] S. Bird. Nltk: the natural language toolkit. In *Proceedings of the COLING/ACL 2006 Interactive Presentation Sessions*, pages 69–72, 2006.

[6] M. A. Boden. *Artificial intelligence*. Elsevier, 1996.

[7] P. Bojanowski, E. Grave, A. Joulin, and T. Mikolov. Enriching word vectors with subword information. *arXiv preprint arXiv:1607.04606*, 2016.

[8] F. Chollet. *Deep learning with Python*. Simon and Schuster, 2021.

[9] F. Chollet et al. Keras, 2015.

[10] P. Hamet and J. Tremblay. Artificial intelligence in medicine. *Metabolism*, 69:S36–S40, 2017.

[11] A. Joulin, E. Grave, P. Bojanowski, M. Douze, H. Jégou, and T. Mikolov. Fasttext.zip: Compressing text classification models. *arXiv preprint arXiv:1612.03651*, 2016.

[12] I. Lee and K. Lee. The internet of things (iot): Applications, investments, and challenges for enterprises. *Business horizons*, 58(4):431–440, 2015.

[13] K.-K. Mak and M. R. Pichika. Artificial intelligence in drug development: present status and future prospects. *Drug discovery today*, 24(3):773–780, 2019.

[14] S. M. Mathews. Explainable artificial intelligence applications in nlp, biomedical, and malware classification: a literature review. In *Intelligent Computing: Proceedings of the 2019 Computing Conference, Volume 2*, pages 1269–1292. Springer, 2019.

[15] J. Pan and J. McElhannon. Future edge cloud and edge computing for internet of things applications. *IEEE Internet of Things Journal*, 5(1):439–449, 2018.

[16] R. Řehůřek and P. Sojka. Software Framework for Topic Modelling with Large Corpora. In *Proceedings of the LREC 2010 Workshop on New Challenges for NLP Frameworks*, pages 45–50, Valletta, Malta, May 2010. ELRA.

[17] R. Rehurek and P. Sojka. Gensim–python framework for vector space modelling. *NLP Centre, Faculty of Informatics, Masaryk University, Brno, Czech Republic*, 3(2), 2011.

[18] J. Ren, Y. Pan, A. Goscinski, and R. A. Beyah. Edge computing for the internet of things. *IEEE Network*, 32(1):6–7, 2018.

[19] W. Shi and S. Dustdar. The promise of edge computing. *Computer*, 49(5):78–81, 2016.

[20] H. Surden. Artificial intelligence and law: An overview. *Georgia State University Law Review*, 35:19–22, 2019.

[21] Y. Vasiliev. *Natural language processing with Python and spaCy: A practical introduction*. No Starch Press, 2020.

[22] P. H. Winston. *Artificial intelligence*. Addison-Wesley Longman Publishing Co., Inc., 1984.

[23] P. H. Winston. *Artificial intelligence*. Addison-Wesley Longman Publishing Co., Inc., 1992.

[24] R. Yang, F. R. Yu, P. Si, Z. Yang, and Y. Zhang. Integrated blockchain and edge computing systems: A survey, some research issues and challenges. *IEEE Communications Surveys & Tutorials*, 21(2):1508–1532, 2019.