Research on an AI-based Smart Management Information System for Enterprise Judicial Cases: A Case Study of Power Grid Enterprises

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Abstract. Enterprise legal management is a crucial part of overall corporate management, particularly in handling a vast amount of judicial document data related to legal cases. Currently, due to limitations in data analysis and processing capabilities, enterprises have not fully harnessed the value of their case data, and the decision-support and risk prevention roles of intelligent case management are not fully realized. This paper presents a method for constructing an AI-based smart management information system for enterprise judicial cases, using power grid enterprises as a case study. It explores how to utilize AI technology at the intersection of law and electricity to process corporate case texts and extract valuable data, aiming to empower enterprise case management through big data and AI technology.

Keywords: Judicial Cases; Legal Management; Information System; Legal Artificial Intelligence.

1 Introduction

The goal of building world-class enterprises emphasizes the value creation capabilities of management. The management of enterprise judicial cases is a crucial aspect of legal compliance and risk management, significantly impacting a company's compliance operations and risk avoidance. Currently, enterprise legal work is constrained by data analysis and processing capabilities, primarily focusing on individual cases and failing to fully exploit the value of the vast number of resolved cases. Consequently, case management's supporting role in compliance management and risk control is not fully realized. The deep application of big data and artificial intelligence (AI) technologies in case management has become a hot research topic in the field of legal technology.

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For instance, Kalamkar et al. (2022) focused on developing a tool to identify named entities in Indian legal texts[1]. Zhou Xianhang et al. (2022) proposed an unsupervised learning-based model for legal document retrieval, addressing the limitations of traditional keyword-based methods in the context of specialized, lengthy legal documents[2]. Darji et al. (2023) fine-tuned a German BERT language model on legal entity recognition (LER) datasets[3]. Savelka (2023) explored the ability of pre-trained generative Transformer models (GPT) to semantically annotate legal texts in zero-shot learning environments[4]. Wu Huandong et al. (2022) examined recommendation techniques for criminal cases based on legal statutes[5]. Xu Hui et al. combined long short-term memory networks with attention models, modeling the process of generating standard legal documents as a "sequence translation" task[6]. Wang Gang et al. employed a Transformer structure more suitable for parallel acceleration, achieving notable results in legal document summarization using a pointer-generator network[7]. A judge in Colombia, Juan Manuel Padilla Garcia, has utilized ChatGPT to assist in trials, explicitly stating that the judgment included responses generated by ChatGPT[8].

However, current research has its limitations, particularly in the technical processing of legal texts specific to certain industries. These texts not only contain conventional legal terminology and regulations but also a substantial amount of specialized knowledge and terminology related to the power sector. This complexity increases the challenges in system design and implementation, while also raising demands for the model's comprehension and accuracy. Additionally, there are limitations in the application of AI to legal cross-application issues. Decision support systems often focus on specific laws, leading to model generalization problems when dealing with diverse legal issues involving multiple types of parties.

An AI-based smart management information system for enterprise judicial cases can efficiently and accurately identify and retrieve judicial cases while recommending relevant similar cases. It also deeply uncovers hidden information, providing intelligent support for management decision-making. In constructing this system, it is essential to train models tailored to different types of data based on the specific needs of various enterprise types. Therefore, this paper focuses on power grid enterprises for related research. This paper uses power grid enterprises as a case study to explore how to leverage AI technology at the intersection of law and electricity to process corporate case texts and extract valuable data, ultimately aiming to empower enterprise case management through big data and AI technologies.

2 Analysis of the Practical Situation of Smart Judicial Case Management Information Systems

2.1 Current Status of Related Smart Management Information Systems

Domestic enterprises have begun to utilize big data and artificial intelligence technologies to develop smart systems aimed at solving business problems. For instance, the State Grid Corporation of China has developed the "Power Grid Big Data Platform" to analyze and mine power grid operational data. Huawei has developed an "Intelligent

Document Generation System" that automatically generates documents and reports based on user needs. China Construction Installation Group has also developed an intelligent data analysis system based on digital construction to support smart manufacturing[9]. These systems provide valuable references for the intelligent construction of case management information systems.

Internationally, research and practice related to case management systems are also notable. For example, the Southwestern Electric Power Company in the U.S. has developed a "Case Management System" that facilitates intelligent analysis and collaborative handling of cases. The Texas Electric Company has implemented a "Smart Operation System" that similarly analyzes and manages operational data to improve efficiency. Additionally, IBM has created an "Automated Document Generation System" that generates documents and reports according to user requirements, offering useful insights for the construction of case management information systems.

2.2 Current Status of Smart Judicial Case Management Information Systems

Despite the considerable research on related smart management information systems, the development of intelligent management systems specifically for enterprise judicial cases has been relatively slow. Currently, systems such as the "Big Data Judicial Case Analysis and Processing System" developed by the Judicial Appraisal Center of Shandong University of Political Science and Law[10], and the "Case Collaborative Analysis System" from the Guangdong Electric Power Company[11], offer only limited analysis capabilities and demonstrate low levels of intelligence.

The most advanced smart judicial case management system in China is the Intelligent Management System for Court Case Documents developed by the Supreme People's Court. This system unifies the management of all cases within the courts, aiming to provide users with fast, convenient, and accurate court case inquiry services. It integrates the case information databases from courts at all levels across the country, allowing users to simply input relevant case information to retrieve corresponding case data.

Through this system, users can access information on various types of cases, including civil, criminal, and administrative cases, covering details such as case names, case numbers, the court handling the case, involved parties, and verdicts. Additionally, the system offers case information subscription and timely push notifications, helping users stay updated on the latest developments and verdicts. Research into the Intelligent Management System for Court Case Documents can provide valuable insights for constructing an AI-based smart management information system for enterprise judicial cases.

3 Theoretical Research on AI-based Smart Management Information Systems for Enterprise Judicial Cases

The AI-based smart management information system for enterprise judicial cases primarily employs theories such as knowledge graphs, natural language understanding, and deep learning. It addresses shortcomings in traditional case data modeling, dispute

focus analysis, and disposal strategy extraction, facilitating the design of relevant systems.

3.1 Knowledge Graph Representation Learning

Knowledge graphs display relationships between objective entities in a structured manner, showcasing unparalleled advantages in intelligent industries like intelligent search and personalized recommendation systems. Their application in the judicial field holds vast potential. Currently, the most widely used and mature knowledge graph is the general knowledge graph, which has low quality requirements and broad coverage but lacks depth, making it inadequate for expressing domain-specific knowledge.

Domain knowledge graphs derive their knowledge primarily from field or internal company data, offering a more detailed structure with stricter quality requirements for extraction. Knowledge representation learning, also known as knowledge graph embedding, relies on multi-relational and statistical relationship learning methods. The core of this approach involves mapping entities and relationships to a low-dimensional continuous vector space, thereby facilitating learning and reasoning within the knowledge graph.

Knowledge graphs serve as the theoretical foundation for constructing high-performance, unstructured databases of typical cases in power grid enterprises. By extracting and refining case information to build a case knowledge graph, case collections can be transformed into a semantic network understandable by computers, laying the groundwork for subsequent tasks such as semantic retrieval and document recommendation. Knowledge graphs also provide important theoretical support for researching case disposal strategies and legal document generation.

3.2 Multi-view Learning

Multi-view Learning is an important branch of machine learning that represents each sample through multiple feature sets, or "views." These feature sets may originate from different information sources or represent various interpretations of the same source. The core idea of multi-view learning is that different views can reveal distinct attributes of the data; by combining these views, a more comprehensive and in-depth understanding of the data can be achieved compared to any single view.

Multi-view learning is primarily applied in the study of open semantic retrieval support technologies. By performing multi-view semantic representation learning on the core elements of power grid enterprise cases, different complementary representations can be aggregated, leading to richer graph representations that provide essential prerequisites for conducting semantic retrieval.

3.3 Contrastive Learning Techniques

Contrastive learning is an unsupervised learning technique where positive samples are different versions of the same data sample (e.g., legal texts that have undergone data augmentation), while negative samples are dissimilar data samples. This method learns

the intrinsic structure and features of data by comparing similarities and differences between various samples, bringing similar data samples closer together in feature space while pushing dissimilar samples apart.

Contrastive learning serves as an important theoretical basis for the intelligent handling of legal texts and open semantic retrieval. After obtaining representations from different views of graph data, contrastive learning techniques can be applied to assess the consistency of nodes and graph representations across the two views, maximizing the mutual information between them and yielding more meaningful and distinct graph representations.

3.4 Pre-trained Language Models

The pre-training framework for language models has been enhanced beyond traditional pre-training by incorporating training on lexical structure, grammatical structure, and semantic information within text data, allowing for incremental training on large datasets. Newly constructed types of pre-training tasks can be seamlessly integrated into the training framework, enabling continuous semantic understanding learning. Through additional semantic tasks such as entity prediction, sentence causal relationship judgment, and article sentence structure reconstruction, the model captures multiple dimensions of natural language information, greatly enhancing general semantic representation capabilities.

Considering the uniqueness of judicial cases in power grid enterprises, it is essential to optimize underlying natural language processing techniques based on pre-trained language models tailored for legal documents relevant to these enterprises.

3.5 Document Parsing Technology

Document parsing has emerged as a rapidly developing research topic and a practical industrial demand in recent years. It refers to the process of understanding, classifying, extracting, and summarizing information contained in web pages, digital documents, or scanned documents, utilizing artificial intelligence technologies. Document parsing technology serves as the foundation for case recommendation systems by providing a searchable database for similar cases. With effective document parsing capabilities, key elements such as titles, subtitles, paragraph content, reading order, and table data within legal documents of power grid enterprises can be accurately identified. The parsed results are stored as a resource library.

3.6 Recommendation Algorithms

Recommendation algorithms are the core of recommendation systems. To enhance the extraction of features from recommended items and improve the accuracy of recommendation matching calculations, leveraging large-scale pre-trained models with low labeling requirements and strong generalization capabilities is often necessary. Additionally, extensive domain adaptation of pre-trained models is required, especially in vertical fields and small-sample scenarios, to refine the calculation of recommendation

matching at a granular level. The case recommendation technology within the system combines pre-training with fine-tuning to improve the accuracy of matching calculations while reducing reliance on labeled data, thereby providing foundational technical support for intelligent similarity assessment and automatic case recommendations.

3.7 Knowledge Extraction Technology

Knowledge extraction aims to identify specific knowledge from unstructured natural language text, typically involving named entities, entity relationships, and events. The corresponding sub-tasks include named entity recognition, relationship extraction, and event extraction. To summarize and deduce disposal strategies, it is essential to express the natural language legal documents of power grid enterprises in a structured format. Through knowledge extraction, case element knowledge graphs and disposal strategy knowledge graphs can be constructed, providing the prerequisites for subsequent modeling of disposal strategy patterns.

3.8 Language Models

The primary goal of language models is to assess whether a set of words can form a coherent statement that meets specific criteria or to predict the next word that may follow a given statement. By utilizing adjustable parameters within neural networks, these models can automatically learn the relationship between contextual vectors and current words from large-scale training data, capturing more complex semantic information within words. Language models are mainly applied in the generation of legal documents. By abstracting and summarizing disposal strategy knowledge graphs, general disposal strategies for specific case types can be obtained. Guided by these strategies, language models can be used for the controlled generation of legal documents.

4 Research on Key Technologies for an AI-Based Intelligent Management Information System for Corporate Judicial Cases

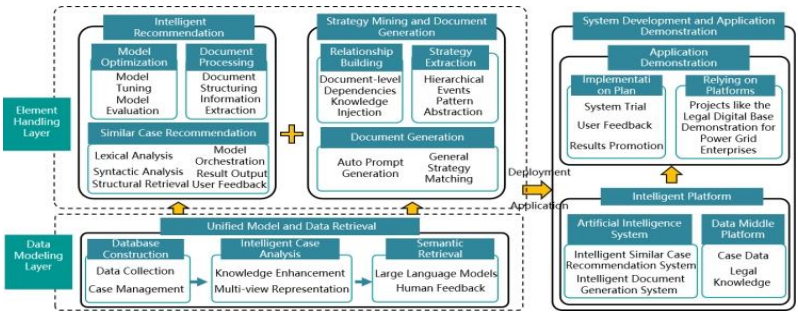

Fig. 1. Architecture Diagram of Key Technologies for an AI-Based Intelligent Management Information System for Corporate Judicial Cases

The research on AI-based case analysis and intelligent generation technology for power grid enterprises is conducted in four main areas, including data foundational technology research, text understanding and similar case recommendation research, case handling strategy mining research, and system development and application research, as shown in Figure 1.

4.1 Research on Data Foundation Technologies

Research Approach.

The research on data foundation technologies lays the groundwork for the overall study. We employ advanced AI methods widely used today to propose a unified modeling and human-aligned semantic retrieval scheme for unstructured power grid case documents. First, by integrating domain ontology and natural language processing techniques, we adopt active learning technology to build an intelligent system that can automatically extract and label power grid case texts, thereby constructing a high-performance database of typical unstructured power grid enterprise cases. Next, domain expert knowledge is used to fine-tune the pre-trained models for analyzing the key elements of case documents. At the same time, using graph convolutional neural networks (GCNs), we perform multi-perspective semantic representation of the knowledge graph of power grid legal cases. Finally, we design a semantic retrieval scheme based on hybrid experts and human feedback, where each expert model is independently trained to achieve optimal performance in its respective data subspace. By collecting human ranking data, reinforcement learning is used to optimize the component models, making the query more aligned with human habits and the questioner's intent.

Key Technologies.

The study involves the construction of a high-performance, unstructured database of typical power grid cases based on knowledge graph technology. First, a top-down, semi-automated ontology construction method is used for word segmentation of the case document collection, followed by syntactic analysis and part-of-speech tagging, with a heuristic rule-based document extractor. To acquire labeled data while reducing manual labor, we propose an active learning-based human-machine collaborative labeling method for power grid cases, optimizing the labeling strategy through model feedback. By combining the rule extractor with contextual information, we identify named entities, such as defendants and defense attorneys, and use regular expressions to identify entity attributes. These entities are segmented according to the structure of the case documents, corresponding to multiple information blocks in the ontology. Previously extracted ontology instances are then used to extract detailed attributes from each block, associating specific attributes with their respective content. In the entity relation extraction stage, co-occurrence rules are used to determine the relationships or dependencies between entities, and the extracted results are aggregated, tagged with entity types, and organized into the ontology structure. Finally, for the attribute documents generated from content extraction, an automated process is used to convert the documents into

RDF format according to relational database conversion rules, and the extracted results are imported into the database.

The research also focuses on multi-perspective semantic representation technology for intelligent analysis and core element extraction from power grid cases, using knowledge-enhanced pre-trained models. First, we study methods for enhancing graph data. For node feature enhancement, Gaussian noise is randomly added, and some feature dimensions are randomly masked. For graph structure enhancement, different views of the graph are compared to learn richer representations, with diffusion matrices as global views and adjacency matrices as local views. We then analyze and test different graph encoders by experimenting with encoding methods. Two dedicated graph neural networks are used to learn node representations for the two views. In each view, a graph convolutional network (GCN) serves as the basic graph encoder, with a multilayer perceptron projection head for learning node representations. A graph aggregation layer is introduced as the output function, utilizing the clustering properties of non-negative matrix factorization to unify multi-functional data generation and feature extraction, thus providing richer graph representations. Finally, a deep information maximization method is applied for end-to-end training to learn rich node- and graph-level representations. A discriminator is introduced to compare the consistency of node and graph representations between the two views, optimizing model parameters to maximize the mutual information between the views, resulting in more meaningful and distinguishable node and graph representations.

The study also explores semantic retrieval based on hybrid experts and human feedback alignment. First, a multi-stage pre-trained language model framework is built, encompassing "generation-extraction-ranking" phases. During the generation phase, atomic relations are generated based on internal model knowledge, following predefined rules, which are then used for extraction in the next phase. The extraction phase involves extracting relationship triples from the generated atomic relations. In the ranking phase, a new language model is trained to score and rank candidate query atoms based on their validity. By incorporating human value judgments, the model produces a ranked list of reasonable query results. Reinforcement learning, based on human feedback, is used to iteratively optimize the model further.

It is worth noting that while handling large volumes of sensitive data, such as personal privacy and corporate confidential information, data security and privacy protection mechanisms are critical. However, this is not the primary focus of our current research. Our system is used within an enterprise's internal network with a robust risk management framework. Data protection measures, such as encryption, access control, and security auditing, comply with national laws and regulations and have passed rigorous corporate compliance reviews, ensuring the safety of data during transmission, storage, and processing.

4.2 Research on Text Understanding and Case Recommendation

Research Approach.

By integrating natural language processing (NLP) and intelligent document processing techniques, the aim is to ensure that machines can accurately understand the

key data information in grid-related cases, enabling case recommendation technologies. The focus is on understanding text content, constructing text network structures, and retraining document label models, all enhanced through NLP techniques to facilitate case recommendations. These technologies will be orchestrated through algorithms, combining semantic retrieval to produce final recommendation results that sort and push case materials according to the characteristics of grid cases.

Key Technologies.

The research aims to optimize the foundational capabilities of NLP for grid enterprise cases. Initially, legal documents are collected and processed to eliminate noise and anomalies, followed by tokenization, stemming, stopword removal, and part-of-speech tagging. The NLP models are then fine-tuned using machine learning and deep learning algorithms, such as logistic regression, support vector machines, decision trees, and neural networks. Techniques like grid search, random search, and Bayesian optimization are employed to adjust hyperparameters for improved model performance. Finally, models are evaluated using cross-validation and leave-one-out methods.

Next, document processing technologies for grid enterprise legal documents are studied. This involves optimizing document label models to directly output document labels for individual legal documents. Text clustering capabilities group similar cases together, forming a basis for constructing text network structures. Ultimately, the text network structure is built.

The research also explores automatic case recommendation technologies. NLP capabilities are utilized alongside semantic retrieval to recall all similar data based on input data, establishing the material scope. Subsequently, precise recommendations are generated tailored to the characteristics of grid enterprise cases, necessitating retraining of the ranking model to complete the case recommendations.

4.3 Research on Case Disposal Strategy Mining

Research Approach.

The case disposal strategy mining study consists of four parts: intelligent construction of complex case element relationships for grid enterprises, mining disposal strategies for similar cases, abstracting disposal strategy patterns, and intelligently generating legal documents based on disposal strategies. Through these studies, a system will be developed for the automatic generation of legal documents for newly arising cases based on existing similar cases, addressing the underutilization of existing cases and poor understanding of case elements.

Key Technologies.

The research focuses on intelligently constructing complex case element relationships for grid enterprise legal cases. Initially, case elements are extracted from legal documents to provide candidate elements for relationship construction. Given the unique complexities in the grid and judicial fields, a knowledge injection model for

document-level case element relationship extraction is designed, incorporating a knowledge injection layer between encoding and prediction layers that considers both unstructured and structured knowledge.

The research also addresses disposal strategy mining technologies for relevant grid enterprise cases. This includes event extraction and relationship identification techniques to mine disposal strategies for specific cases, followed by aggregating similar legal events for abstract expression. The evolution of specific legal events is statistically analyzed based on their interconnections to form generalized disposal strategies.

Lastly, the study investigates the generation of disposal text for newly arising cases. This involves developing prompt templates based on disposal strategies and employing large-scale language models for generating disposal texts.

4.4 Research on System Development and Application

Research Approach.

In the system development phase, the first step is to collect requirements, followed by analysis, evaluation, confirmation, and documentation of these needs. Next, system design and implementation are carried out, leading to system development and integration. By utilizing natural language processing and optical character recognition technologies, historical cases are collected and categorized. The system will interface with information security management systems to achieve unified access control and security. It will also incorporate previous research outcomes to enhance its application capabilities, improving management efficiency and risk management levels for grid enterprises. Finally, application demonstrations will be conducted. After the system is developed and deployed, selected grid companies will test the system, and adjustments will be made based on user feedback. Once the system meets user requirements, it will be promoted for broader use.

Key Technologies.

The research focuses on system integration and application construction techniques. Initially, requirements gathering and system design will be conducted. By engaging with users through communication, surveys, and observations, user needs and expectations will be collected and analyzed in detail, assessing their importance, priority, and feasibility, including technical, economic, and time evaluations. Subsequently, system development will implement functionalities such as case classification, retrieval, online editing, categorization, and alert notifications. Finally, system integration will take place.

The research will also investigate demonstration applications in relevant projects. Based on the outcomes of system development, application promotion will be initiated by selecting grid business companies with comprehensive operations and sufficient business volume for system trials. Adjustments will be made according to user feedback, with satisfaction levels and opinions collected to continually refine the system until it meets user requirements, leading to effective result promotion.

5 Conclusion

This paper presents an AI-based judicial case management information system for power grid enterprises, building a high-performance enterprise case database. It explores key technologies such as intelligent legal text processing, large-scale open semantic retrieval, case handling strategy mining, and legal document generation. These innovations enable rapid case management responses and real-time decision support. On this basis, system integration and application have been implemented, significantly improving case management efficiency, reducing case handling costs, and effectively addressing the traditional management model's reliance on individual experience. This system provides strong support for enterprise decision-making.

As AI technology continues to advance rapidly, there is still much room for further research and improvement in our system. For instance, using more advanced AI processes and large models for similar case recommendations and strategy mining will be the focus of our future work.

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