# An Artificial-Intelligence-Based Semantic Assist Framework for Judicial Trials•

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**Abstract**
Due to their success in routine tasks such as voice recognition, image classification, and text processing, extensive attention has been aroused on how to use artificial intelligence (AI)-based automation tools in the judicial-trial process to improve efficiency. Meanwhile, judicial trial is a complex task that requires accurate insight and subtle analysis of the cases, law, and common knowledge. Applying the results provided by AI-based automation tools directly to the judicial-trial process is controversial due to their irregular logic and low accuracy. Based on this observation, this article investigates the logic underlined in judicial trials and the technical characteristics of AI, and proposes an AI-based semantic assist approach for judicial trials that is logical and transparent to the judges.

**Keywords:** artificial intelligence, legal reason, fact extraction and verification, semantic similarity, sentencing prediction

## 1. INTRODUCTION

Artificial intelligence (AI)-based automatic tools have already demonstrated their power in routine tasks such as voice recognition, text processing, and image classification; many organizations around the world have introduced these automation tools in place of human labour to increase the efficiency of their systems, such as banking, retail, and transport.[1] Due to similar scenarios existing in judicial trials, law experts in academia and industry have considered applying AI-based automation tools in the judicial-trial process to improve efficiency.

While the judicial trial is a complex process that requires accurate insight and subtle analysis of the cases, law, and common knowledge, any misjudgments in the trial will not only have a serious impact on both parties, but also damage judicial justice and result in an adverse social impact. When applying the results provided by AI-based automation

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1. Zalnieriute, Bennett & Williams (2019).

tools to the judicial-trial process, there are two objectives: first, make the results accurate and logical for trial; second, work out how to find and correct the errors in the results. Based on this principle, this article reports a fine-grained analysis of cases deployed in court and progress in AI, and proposes an AI-based semantic approach to the judicial trial. This approach recurs throughout the trial process and does not aim to minimize the error deviation from the prediction to fit the logic underlined in judicial trials with AI characteristics. If the AI-benefit results are logical and transparent to judges, AI-based automation tools will be more likely to be trusted by legal experts and deployed in the trial system.

## 2. CASE-STUDIES OF AUTOMATION IN CHINA'S COURTS

In the following section, we describe and analyze the programs that Chinese courts have deployed in the trial system. These case-studies reflect Chinese judges' thoughts on AI and its assistance for trials.

### 2.1 An Intelligent Court System at an Intermediate People's Court of Suzhou

Suzhou is an important city in Jiangsu Province, China. Its gross regional product (GDP) has exceeded 1 trillion yuan since 2011. With the rapid development of the economy, the number of cases received by Suzhou Intermediate Court has continued to grow to a high level, which went up to 250,000 cases in 2016. Meanwhile, there are only 697 judges in Suzhou Intermediate Court, which results in prominent contradiction with the higher requirements for the quality and efficiency of the trial.

In the current context, Suzhou Intermediate Court has actively explored AI technologies to set up an intelligent court,[2] which effectively improves the quality and effectiveness of the trial.

#### 2.1.1 Case-Based Electronic-Files Generation
When the litigants submit their complaints, the filers will scan the relevant materials to generate electronic files for the first time, then relevant filing information will be automatically recognized and backfilled with intelligent applications. The speed of this process is about twice that of the traditional manual-input method. After manual verification, the case-based electronic files are arranged according to case-handling habit and circulated in the whole trial process, which accelerates the processing speed of the trial.

#### 2.1.2 Cross-Examination with Case-Based Electronic Files
Suzhou Intermediate Court revolutionized the traditional way of evidence-giving and cross-examination in court. The parties did not pass the evidence materials to the judges and the other parties one by one as before. All the evidence materials (electronic files) are broadcast and displayed synchronously and uniformly on the display before the trial bench and the parties, which greatly saves time in the linking of proof and cross-examination.

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2. Zhang & Zhou (2017).

At the same time, the "voice wake-up" function of the evidence-display system can auto-matically identify the specific instructions of the speaker in the trial, accurately retrieving the corresponding electronic documents, images, audio, video, and other electronic evidence in the electronic files, and displaying them on the computer screen in front of the parties in real time, which makes the trial rhythm much smoother than before.

### 2.1.3 Synchronized Transcription with Speech Recognition

Suzhou Intermediate Court introduced speech recognition into the trial-transcription process to increase the speed of court records. According to collected statistics, the voice transcrip-tion can reach 250–300 words/minute, which is much higher than the speed of traditional manual input (about 120–150 words/minute). Synchronized transcription with speech recognition can fully meet the court's hearing requirements and especially fit into the diffi-cult, game-playing, and antagonistic cases, which need to record the detailed views of both parties to better identify the facts, via voice transcription.

In fact, the transcription system can accurately identify and automatically annotate the speakers in the court and transform spoken language into written legal language, both of which increase the efficiency of the whole trial.

The intelligent court system in Suzhou Intermediate Court is an integrated solution of a wisdom trial covering the whole process of litigation, with the main content of "electronic files + court hearing voice + intelligent service." Since the deployment of the intelligent trial system, the judge's transactional work has been divested by about 40%, the clerk's transactional work has been reduced by about 50%, and the average trial efficiency of cases has been increased by about 30%.

### 2.2 The "206 System" in Shanghai High People's Court

"206 System" is a code name for the "Shanghai Intelligent Auxiliary System of Criminal Case Handling" in order to remember the start date of this project. On 6 February 2017, Meng Jianzhu, secretary of the Central Political and Judiciary Commission, investigated and surveyed in Shanghai High People's Court and gave the task of "Promoting the Reform Software of Litigation System Centered on Court Trial" to Shanghai High People's Court. This is an innovation judicial reform to integrate big data and AI technol-ogies into criminal-case handling.

Accompanied by social-structure transformation and civil-rights-enhanced awareness, the cases accepted by Chinese courts has grown sharply. The Report on the Work of the Supreme People's Court (2019)[3] showed that the people's courts at various levels concluded 1,198,000 criminal cases of first instance. How to accelerate the processing speed of material and data to relieve case backlogs is a big challenge for judges and courts.

In general, the court uses many different forms of information (such as handwritten text, audio, images, etc.) about cases and the gathering of case-related evidence by judges is time-consuming. Adopting new information technologies such as the Internet, big data, cloud computing, and AI to improve judicial efficiency is a natural solution.

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3. Xinhuanet.com (2019).

The main target of the "206 System" is to settle the inconsistent evidence and procedures that exist in the current trial system. The first step is to set up a unified evidence standard. Shanghai High Court has allocated more than 400 people from courts, procuratorates, and public security bureaus to investigate the most common criminal cases, including seven types and 18 specific charges. For example, the homicide-case group has investigated 591 homicide cases in the past five years and concluded seven stages, 13 verification matters, 30 types of evidence, and 235 evidence-verification standards for homicide cases. These expert experiences are gold standards for big data and AI algorithms. The second step is to supply AI tools to convert criminal-case-related documents into Shanghai Criminal Case's Big Data Repository, including the evidence-standard repository, electronic-file repository, case repository, judicative-document repository, and the judicial-interpretation repository of laws and regulations. Traditional criminal-case documents have many different information carriers such as text, audio, and images; current AI tools can convert these documents into electronic files with a unified standard. For text documents, the "206 System" has adopted optical character-recognition (OCR) technology and a deep neural network to train about 15,000 case files. At the end of 2017, the "206 System" could fully recognize all kinds of printed evidence and some kinds of handwritten text such as signatures and stamps, and extract and verify related information according to predefined rules. The total number of items in Shanghai Criminal Case's Big Data Repository was up to 16.95 million items, which would not be possible to achieve manually. The last step is to use translated parameters by predefined expert experience and a big-data repository to train AI models; the optimized results could be used to help the police and judges to reduce or eliminate inconsistent evidence. Finally, guidance on the evidence collection of 102 common cases has been programmed into the system, which can help police to reduce or eliminate flaws and omissions when they obtain evidence. It also has questioning models for different types of cases, providing guidance to police during questioning. The system can generate inquiry records automatically afterwards. The consistent evidence submitted in the trial will accelerate the case-processing speed of judges.

The "206 system" is the first system to embed evidence standards into the criminal justice system of public security organizations, procuratorial organizations, and people's courts. As stated before, this system has integrated many AI techniques, such as OCR, natural language processing (NLP), intelligent speech recognition, judicial entity identification, entity relationship analysis and automatic extraction of judicial elements, to exploit and analyze accumulated typical criminal cases, judicial-information resources, and case-handling experience. It can help judges to authenticate evidence with unified standards and sentence the trial impartially, so as to prevent wrongfully convicted cases.

As reported in Chinadaily,[4] AI assistive technology that was used at Shanghai No 2 Intermediate People's Court on 23 January 2019 was the first practice of it in a criminal trial in China. During the trial, the "206 System" translated voice into transcript precisely and displayed transcript and all related evidence on the screen, which all the people could see. Wu Haiyin, deputy head of the information department of Shanghai High People's Court, appraised that "The '206 system' realized full-course intelligence assistance and reviewed evidences comprehensively, playing an active role in impartial judgment."

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4. Chinadaily.com (2019).

In summary, the current AI-based court system is mainly focused on elementary electronic case-document management such as building electronic case files, voice transcriptions, and file examinations. While the main focus of a trial is legal facts and related law connections, how to extract the exact legal fact and provide law assistance from a huge volume of case-related electronic files for judges may be the next step in the application of AI-based automation tools in the trial system.

## 3. RESEARCH PROGRESS IN AI

Conviction with legal facts and related law provision is the core task of a trial. So, extract case-related legal facts from electronic files and connecting them with specific legal provisions are two key aspects of an intelligent trial system. In this section, we will review and analyze relevant research progress including two aspects of the information extraction of legal texts and trial-reason generation in the AI area.

### 3.1 Information Extraction from Legal Texts

Information extraction from legal texts, which can provide legal-fact information for judgment-reason generation and sentencing prediction, is a fundamental part of an intelligent trial system. Currently, information extraction from legal text can be mainly divided into three types of methods: the rule-based information-extraction method, the similar-case-based information-extraction method, and the machine-learning-based information-extraction method.

The rule-based information-extraction method constructs domain ontology or defines a large number of structured rules according to the features of legal texts, such as JAPE[5] and other rules, through which a specific kind of judicial texts can be reasoned. The biggest drawback of this method lies in its poor generalization ability.

The similar-case-based information-extraction method extracts the target case's information by using the extraction rule of similar cases. Therefore, the key to this method is the definition of similar-case classes. Early models usually used simple Euclidean distance to calculate similarity, then models for case reasoning proposed some similarity-calculation-optimization methods, such as a weighted heterogeneous-value distance, to measure similarity.[6] In order to enhance the effect of case-based reasoning, more models add ontology and fuzzy logic to the model to effectively ensure the accuracy of case learning.[7] While lacking enough legal explanation, the similar-case-based-reasoning method is effective in information extraction in many legal fields.

The machine-learning-based method can be divided into two categories: an end-to-end deep-learning method based on text embedding and a machine-learning method based on semi-structured features and a knowledge graph. In the end-to-end deep-learning method, there is no explicit information-extraction layer. This category of method classifies texts directly through deep neural networks, such as cyclic neural networks and convolutional

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5. Cunningham, Maynard, & Tablan (2000).

6. Gu, Liang, & Zhao (2017); Yan, Yu & Wang (2017).

7. El-Sappagh et al. (2018).

neural networks, and realizes an end-to-end decision-making system. It has been applied in many fields of civil and criminal judgments.[8] Due to its black-box feature, the end-to-end deep-learning method does not have any interpretability. The machine-learning method extracts the text-information structure according to the legal elements, labels them according to a knowledge graph, and constructs the supervised-learning-based model.[9] The interpretation of this category of method did not conform to the legal logic of the judicial-trial process and lacks judicial interpretability.

### 3.2 Trial-Reason Generation

The trial-reason generation includes two parts: fact verification and related law/regulation application. Research shows that there are problems in the practice of trial-reason generation due to the lack of legal-fact identification and the process of law/regulation application.

Research shows that the trial-element-representation method based on semantics can express the semantic information in text better. Early studies defined trial representation[10] by similar classes of cases. While reflecting partial semantic information to some extent, the representation made it hard to reveal the complex relationship between trial elements due to its coarse semantic-information feature. In recent years, more mainstream solutions have tried to describe the semantic features of trial elements through continuous space, such as a topic model[11] and word embedding[12] in continuous space. While these technologies have greatly expanded the semantic information in the trial field, fine-grained semantic-information representation in the legal domain need to be more logical for criminal judgments.

In summary, current AI-based semantic technologies have made some progress in the legal-text process. However, in order to achieve the representation of fine-grained semantic information in the trial field, we should consider applying trial-decision logic into AI-based semantic technologies.

## 4. DETAILS OF THE AI SEMANTIC TRIAL-ASSIST FRAMEWORK

### 4.1 Legal-Fact Extraction and Verification from Electronic Case Files

In a judicial trial, electronic files are the main data source to assist in sentencing decision-making. Electronic files include electronic documents and related electronic data with a specific format, which is based on digital-image technology, character-recognition technology, database technology, and other media technologies, produced before or during the case-acceptance process. Electronic files with different sources and formats should be extracted and expressed through uniform legal texts, which mainly constitute the evidence and related natural facts.

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8. Sulea et al. (2017); Xiao et al. (2017); Ye et al. (2018).
9. Katz, Bommarito, & Blackman (2017).
10. Ashley & Rissland (2003).
11. Cunningham, *supra* note 5.
12. Chalkidis & Kampas (2019).

Nowadays, direct information extraction from electronic files faces some technical obstacles: the rule-based extraction method has poor generalization ability and cannot be directly applied to complex electronic files; the machine-learning-based extraction method requires a lot of manual labelling and electronic files cannot provide enough learning samples because of their privacy. Meanwhile, there are a huge number of judgment documents that exist in the legal-information system. A judgment document is a legal document recording the process and result of the trial of a case. It is an important carrier of judicial cases and contains all the information needed to support the legal judgment. Compared with electronic files, judgment documents have huge data and the content of the text naturally contains annotated information, so they can provide samples for learning. However, electronic files and judicial documents have different structures and data distribution, which may result in a learning problem due to the different distribution of training data and prediction data. Luckily, a domain-adaptive model can solve this problem effectively by mapping different distribution data to the same distribution-feature space. Therefore, it is practical to use the massive judgment documents to construct an adaptive information-extraction model.

By analyzing the structure of judicial documents, the basic unit of information in legal texts is the legal fact. Different from an objective natural fact, a legal fact organizes legal elements logically through investigation results and evidence. Taking criminal cases, for instance, legal facts should include the time, place, victim, purpose, motivation, plot, means, consequence, attitude after the case, and so on. So, the legal fact is chosen as a basic unit of information in our proposed information-extraction model. Furthermore, we expand the concept of the legal fact, adding the evidence related to the fact into the legal fact, to form the extended legal fact. Therefore, fact extraction includes not only the extraction of event elements, but also the extraction of relevant evidence. In judicial logic, the extraction and identification of legal facts are the basis of interpreting the analysis results of legal documents such as judicial documents and electronic files, because legal facts ensure the retroactivity of the results, thus ensuring judicial interpretability.

In NLP, an event is highly similar to a legal fact as a form of information representation. An event can be defined as the objective fact, which includes the arguments such as person/thing, time, place, and their interaction. In general, events in NLP are made up of elements that include triggers, event types, arguments, and argument roles. Specifically, event triggers are the core words of the event. Event arguments are the participants of the event, which are mainly composed of entities, values, time, places, and so on. Argument roles refer to the role of arguments in events, which may exist in different types of events. Therefore, event representation and the related extraction method can be used as a reference for legal-fact representation and extraction. However, there are many differences between events and legal facts. On the one hand, there are only trigger words to trigger events, while legal facts may not have trigger words, or there are multiple trigger words to present facts jointly. On the other hand, legal facts may cover the description of multiple events or can be inferred from multiple events. Therefore, the traditional event-extraction method may capture events related to legal facts rather than legal facts. The legal fact needs to be inferred through many related events. The relationship between events and legal facts is shown in Figure 1.

Fact verification is the follow-up step after fact extraction. In the judicial field, fact verification refers to the process of inferring the facts of a case through evidence. The facts that need to be recognized include the identity of the defendant; the accused
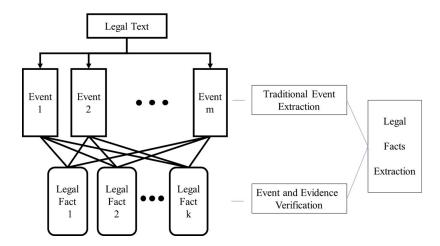
**Figure 1.** Event extraction and legal-facts extraction.

criminal act; whether the accused act was committed by the defendant; whether the defendant was guilty; the motive and purpose of the act; the time, place, means, consequences, and other circumstances of the act; the responsibility of the defendant; and the relationship with other accomplices, etc. In the computer field, fact verification can be defined as a mapping problem from evidence space to fact space. According to the judicial logic, this kind of mapping is not a direct mapping, but needs to be passed through the rules of evidence. Therefore, the first step of our two-step fact-finding model is to realize the matching of evidence and evidence rules, and to generate evidence features. The second step combines evidence features to infer the relationship between evidence and facts.

Based on the above analysis, we constructed a multi-stage machine-learning and deep-learning model for extracting and verifying legal facts from electronic files. To ensure the whole model performance, we integrated the agents defined by each stage through reinforcement learning and formed a framework for extracting and identifying facts based on reinforcement-learning multi-agent interaction. First, the framework can accurately extract and identify the facts needed by taking advantage of machine learning and deep learning to provide support for the generation of judgment reasons and sentencing prediction. Second, the operation mode of the framework conforms to the logic process of judicial judgment, ensures the traceability of intermediate results, and provides interpretability for an intelligent judicial system.

## 4.2 Trial-Reason Generation Based on Judgment Rules and Massive Judgment Documents

After extracting related legal facts, the judge needs to find out the matching laws and regulations to generate the judgment reasons.

In recent years, the emerging law and regulation-service systems have been providing law and regulation queries according to keywords. Most of these systems adopt mechanical matching, which matches specific law and regulations according to whether there are relevant keywords in them and may result in some laws and regulations without inputting

keywords being filtered out. That is to say, these methods did not consider the inherent semantic logic relationship between law/regulation and facts, which leads to insufficient consideration of the judgment reasons generated. To generate reasons from legal fact to decisions according to legal logic, abundant semantic logic-matching reasoning processes between events and laws and regulations are mandatory. In fact, there are abundant abstract semantic relations in laws and regulations. This semantic information needs to be fully considered and utilized, so we need to use AI to simulate the human understanding and reasoning of these semantics.

Combining the judgment rules and massive judgment documents, we propose an automatic reason-generation framework based on multiple-item embedding, which can effectively mine the potential semantic information from structured data (such as age) and unstructured data (such as text-description information), and integrate the multidimensional information by multiple-item embedding. By achieving semantic matching between legal facts and relevant laws/regulations by deep learning, this framework can generate the interpretable reasons for judgments. Specifically speaking, this framework can match related laws and regulations using legal facts and sentencing circumstances, then generate the reasons for judgments, including the reasons for the starting point of sentencing, the reasons for benchmark sentencing, and the reasons for pronouncing sentences.

Combined with multidimensional data and deep-learning algorithms, the proposed automatic reason-generation framework can identify semantic embedding vectors from legal facts, sentencing circumstances, and laws/regulations, and fully mine the potential semantic information of data to ensure that the judgment reasons contain rich logical relations. In the matching process, using the semantic similarity matching between legal facts and laws/regulations can better mimic a judge's logical inference between legal facts and laws/regulations, thus enhancing the reasoning of judgments.

The given reasons for conviction are classified and generated by a sentence start point, benchmark penalty, and pronouncing penalty, so as to ensure that the whole process of conviction and sentencing is lawful and reasonable.

## 5. CONCLUSION

With the development of AI technology, AI-based automation tools will get more and more involved in the intelligent judicial-information system.

This paper surveyed and analyzed the AI-base automation program deployed in China's court and pointed out that information extraction and reason generation for judges may be the next step in AI-based automation tools applied in the trial system.

Considering that the information in legal texts is mostly organized by legal facts, this paper proposed an AI-based semantic assist framework for judicial trials based on legal facts. First, we constructed a multi-stage machine-learning and deep-learning model for extracting and verifying legal facts from electronic files. Then, we use multidimensional data and deep-learning algorithms to identify semantic embedding vectors from legal facts and generate trial reason using semantic information on facts and their logical relations.

Different from traditional end-to-end machine-learning models, the proposed framework extracts legal facts; analyzes semantic logic between facts, sentencing circumstances, and

laws/regulations; and generates trial reason for judges. The whole process conforms to the internal logic of the judicial process and can better mimic a judge's logical inference between legal facts and laws/regulations, thus enhancing the reasoning of judgments.

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