

# The Rationale and Approach of the Legal Expert System Construction

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## Abstract

Based on the interpretation on the evolution of theoretical basis of the construction of legal expert system as the clue, this article mainly analyzes and points out the dilemma faced by symbolism and connectionism as the algorithm on construction of legal expert system. Through defeasible reasoning, a contextual-based legal expert system could be realized. The legal expert system should be constructed with the judge as the center character, in which the personality of the judge could not necessarily be eliminated. As a result, the article provides a model of a legal expert system based on dual processing, including factual argumentation and legal argumentation.

## Keywords

Legal Expert System, Symbolism, Connectionism, Defeasible Reasoning

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## 1. Introduction

Since the first expert system DENDRAL was launched in 1965, the topic of establishing expert systems combined with expertise in various domains has become a hot field of artificial intelligence application research. In 1970, American scholars Buchanan and Headrick published “Some Speculation about Artificial Intelligence and Legal Reasoning”, which set off the cross-domain research of the artificial intelligence technology and the legal theory. Early integration of artificial intelligence and law mainly focused on the theoretical basis of the two legal systems, namely the statutory law system based on norms and deductive reasoning, and the case law system based on similar cases and analogical reasoning, thus, reasoning models in legal expert system—rule-based and cased-based modes, were mainly differentiated by the logic in both legal systems. In 1975, Walter and Bernhard introduced the JUDITH system, which was designed to assist lawyers in reasoning cases (Popp & Schlink 1975). They estab-

lished the relationship between specific concepts in various fields and their outward manifestations; by setting up a logical model of the reasoning process, the system could achieve its function. In 1977, McCarty, known as the “Father of Artificial Intelligence and Law,” introduced the TAXMAN system for basic legal reasoning by constructing concepts, rules and their relationships in the field of corporate tax law (Popple, 1996). The case-based artificial intelligence judicial application can be traced back to LDS, a system for assisting judgments developed by Waterman and Peterson in 1981, which compares characteristics to find similar values and then derives the liability ratio of specific cases (Cao, 2021). The most famous model in this field is the HYPO system applicable to the field of the Trade Secrets Act. Its designers Ashley and Rissland used “deconstructing factual-extracting elements-comparison” method to conduct analogical reasoning, by then drawing conclusions of the pending cases by comparing with selected similar cases. Based on the two basic studies above, other systems such as hybrid systems represented by CABARET, data-based legal argumentation systems, and defeasible and non-monotonic logic-based systems such as CABARET have also been proposed (Prakken & Vreeswijk, 2022).

Even though a boom in theories of constructing legal expert models appears currently, there is still a lack of an effective fusion model of artificial intelligence and law. The two systems still show their own operations and lack a deep understanding of the other party’s idea. While the artificial intelligence field is moving towards interpretable artificial intelligence, which seeks to solve the problem of uninterpretable in algorithms (Wu & Sun, 2021), most of the few legal -artificial intelligence studies in the field still rely on the theory of criticizing artificial intelligence intervention based on the principle of algorithm black box. However, the general trend is that the further integration of artificial intelligence and law has become a worldwide consensus.

The current legal expert system is mainly challenged from two aspects. One is from risk assessment tools such as COMPAS, by referring to the measurement of penalty database, and selecting specific elements among them, the possibility of the offender recommitting a crime while serving the sentence is obtained, and thus sent to sentence accordingly (Zuo, 2018). This kind of tools focuses on constructing a profile of criminals through experience to draw conclusions, but ignores the role of legal norms in it, or at most the restriction of rules can only be an indirect adjustment relationship realized through the constraints of previous sentencing experience. Therefore, this model has potential risks of overhead laws. The second is the insufficient response to the existing legal expert system. Several successful legal expert systems currently implemented in Chinese courts are facing such problems as proliferation of similar cases but lack of accuracy, the sentencing prediction does not shed light on its reference on the cases and it is far away from practical and the automatic generated context of judgment has only limited content (Ye, 2019). The way to deal with these two challenges points to the establishment of a practical legal expert system, rather than the combination of the perfect legal argumentation system and artificial intelligence.

## 2. The Dilemma of Symbolism and Connectionism Algorithms

A practical description for the legal expert model is that it is a deconstruction and replacement of the traditional judicial adjudication model. That is to say, the legal expert model is designed to make the same decision as the judge in some judgment procedures and thereby liberate the judge. The extent to which this goal can be achieved is the evaluation of the level of development of artificial intelligence, which includes three levels: Artificial Narrow Intelligence, which mainly engaged in providing support such as information retrieval in judicial judgments; Artificial General Intelligence that aims to replace judges to make judgments based on autonomous decision-making; and Artificial Super Intelligence that further evolved on this basis (Zhou & Wu, 2019). In current research, hardly any research published focuses on the latest, also, scholars have not drawn unanimous conclusions on the depth of artificial intelligence algorithms of the legal expert model and the degree of autonomous decision-making. Therefore, before discussing how the legal expert model should be established, it is in need to demonstrate the degree of intelligence in the system. That is, can or to what extent can artificial intelligence replace judges? There are also different proposals for Artificial General Intelligence legal expert systems, such as a Hart-style expert system, based on the diversion of tangled and simple cases and constructing a standardized reasoning model and a fuzzy and open consensus argumentation model (Ye, 2018), or a complete legal reasoning system argumentation model established with high-quality case database resources. The author believes that the current research level of artificial intelligence shows that it cannot respond to the value foundation and credibility in cases, therefore, it can only play a supportive roll in the judgement.

In the system, in order to ensure proper fusion of the artificial intelligence and the target field, it must be ensured that the artificial intelligence can appropriately respond to the knowledge of which, in other words, artificial intelligence must be integrated into the system of the target field with its cognitive activities, and the cognitive activities of artificial intelligence-also known as machine learning-are embodied in the expert system as the acquisition of knowledge. From a macro perspective, the machine learning methodology of artificial intelligence can be divided into five major categories: Symbolism, Connectionism, Evolutionism, Bayesianism, and Analogy. Among them, only semiotic and connectionist machine learning methodology are mainly used in legal expert systems.

The symbolist theory believes that all concepts can be represented by appropriate symbols, and by using symbols, rules and logic to represent knowledge and evolutionary logic for reasoning, it is possible to realize the relationship between human external behavior and internal ideas. An image of the representation system, by establishing rules database and using reverse deduction methods, including rule learning and decision tree algorithms, is formed (Sun & Fu, 2021). However, one of the insurmountable obstacles of symbolism is that it is unable

to possess a priori knowledge required to understand concepts of what human does—it is also called “uninterpretable” knowledge in hermeneutics, which is summarized by some scholars as “common sense” (Zuo, 2019). Therefore, it is difficult to distinguish the logical structure of the language in some sentences. For example, when a sentence is expressed as “Tom ran ten miles with Jerry on his back, he is exhausted”, the system cannot identify what “he” refers to. Since, Symbolism has also been given the title—Good Old-Fashioned AI.

Connectionism put forward different propositions against the system. With the scientific breakthroughs in neuroanatomy, neurophysiology, and neuron electrophysiological research, people have a better understanding of neurons and the structure of the human brain. The earliest connectionism design AI based on the previous study, and implement it through mathematical and statistical methods. Different from the linear logic of symbolism, connectionism advocates the realization of a parallel distributed processing by constructing neurons and assigning different weights to the connections between them, aiming to construct an information processing system by imitating the structure of the human brain (Zhu, 2004). The advent of Deep learning has made connectionism the most widely used machine learning methodology. By distinguishing the degree of abstraction of knowledge to construct a stepped structure, and through repeated training of big data, it reaches the most abstract concept. The most famous Deep learning product is Alpha GO, which through a combination of supervised learning and reinforcement learning of the game data and board positions, it focuses on local areas and performs exhaustive algorithms, and finally makes the most favorable placement decision for winning. However, connectionism also encounters the same difficulties as symbolism when it is applied to the transformation of natural language and the vague and informal life scenes, because deep learning is also constructed on the basis of representational knowledge, which needs precise inputs; however, our daily communication is characterized by a certain degree of ambiguity in expression and illogicalness in argumentation. But however vague language, human can deal with through marginal awareness, tolerance of ambiguity and ability of insight (Xu, 2018) to process information and understand meaning, which has not been clearly explained by people, so it is quite hard to be fed into machine learning. As some scholars have said: “Currently, advanced neural network technology barely relies on brain science’s imitation of the simple operation of human brain nerves. It is difficult to build just a few neurons for things like legal adjudication that require rich life experience.” (Zhou & Lü, 2021)

Yang enumerates the advantages and disadvantages of the two algorithms on which the above two classifications are based.

As shown in **Figure 1**, the ANN provides efficiency in processing parameters and self-learning ability to a certain extent, while it acquires complex operation process and long training time, moreover, the outcome is hard to explain, which means the process is not clear enough for us to assess. On the other hand, DT is equipped with operation system that is easy to implement, with good compatibility

Algorithm	Advantage	Disadvantage
ANN	High accuracy in classification, good learning ability; Strong Fault-tolerance and Robustness against noise data; The ability to associate; Good predictive and classification ability for untrained data.	Huge quantities of parameters (Metrics and Thresholds); Black box process; Long training time, which may fall into the local minimum; The neural network cannot be used directly to generate the rules; The input attribute value must be numeric.
DT	Simple structure that could analysis visually; Easy to extract classification rules; Suitable for processing relatively large data; Process label and numerical data at the same time; Relatively high computing speed; High accuracy in classification.	Hard to deal with missing data; Prone to overfitting; Neglect the correlation of attributes in the data set; Biased results when distinguishing with huge horizontal characteristics.

**Figure 1.** The comparative characteristic of the two algorithms (Yang, Qiao, Li, & Wang, 2019).

with different sorts of data and high speed in calculating, while it plays less than satisfactory in dealing with such data. In all, both algorithms do not suit the construction of legal expert system.

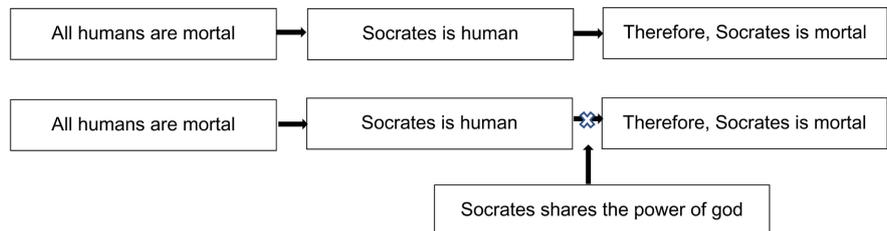
In addition, while both models are based on the study of large quantity of data, the proportion between the uploaded judgment and recorded judgements are merely around 50% in China, and other issues such as irregular examination of withdrawal, imperfect management and supervision systems, system incompatible between courts, and obvious regional differences in document disclosure, etc. that affecting the quality of the content of the judgment (Ma, Yu, & He, 2016). Under the constraints of these conditions, it is not realistic to construct the ideal of an “Artificial General intelligence” model that dominates the referee.

### 3. The Approach of Defeasible Reasoning Model

As mentioned above, the original artificial intelligence legal expert systems were built on the basis of cases or rules. Regardless of whether it is building a knowledgebase of rules or a case knowledgebase, the basis of these two models is to construct a knowledge base that can be reasoned or compared, and distinguishes two steps—knowledge construction and legal argumentation—in the legal process. Therefore, both are also collectively referred to as knowledge-based systems (Zhou, 2015). The knowledge system has faced the following difficult problems since the beginning of its application: How to guarantee the authenticity and integrity of its knowledge? How to realize its interpretability or trustworthiness? How does its operation ensure that some value in judicial processes in practice, such as the value of argumentations between the parties throughout the case, not be emptied? The system has never been able to solve these problems perfectly. As an alternative, an argument-based legal expert system that emphasizes defeasibility reasoning proposed.

### 3.1. Defeasible Reasoning Structure

The so-called “defeasibility” was originally a professional term in property law, but Hart expanded its concept to all fields. The concept of defeasibility refers to a rule: there is a universal concept, and when an exception occurs, such prima facie rule is broken (Hage, 2003). To describe it in a more familiar language, *i.e.*, a concept has its normal characterization and exceptions that disrupt its interpretation process, and the concept will no longer be valid when such exceptions occur. In other words, this is a statement about how a belief is broken.

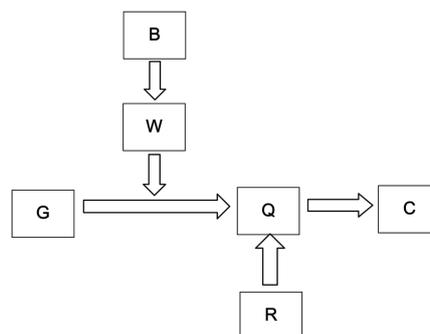


**Figure 2.** Monotonic reasoning and defeasible reasoning.

**Figure 2** shows an example of the function of the concept of defeasibility. When the traditional syllogism introduces such an exception, its proof is no longer valid, and defeasibility emphasizes the process of breaking the rules.

### 3.2. Toulmin’s “Rebuttal” Model of Interpretation

Defeasible reasoning structure, modified by Stephen Toulmin, transmitted to the “rebuttal” or exception element in the interpretation model, which indicates a situation where the warrant, guarantee the interpretation, has to be excluded (Song, 2019).



**Figure 3.** Toulmin model.

In this model (**Figure 3**), G stands for the background knowledge, W for the warrant, B for the background of the warrant, Q is used to represent the particular modal qualifier in an argument, and C is the proposition. Its process runs as follows: With basis G, we can claim W (relies on support B), in the absence of a special rebuttal or no disqualification (R), to prove claim C, or at least which could be a hypothesis (Q) (Toulmin et al., 1979). Through this defeasibili-

ty-rebuttal model, Toulmin no longer focuses on the monotonous reasoning based on knowledge, instead, on the support and rebuttal process of a claim. Thus, a model based on dual-subject and argumentation is realized, under which the legal interpretation is a dynamic, purposeful, multi-subjective, context-sensitive, and dialogic process, and the problem that the judicial process is emptied could be solved this way (Wu, 2006). The major point of the results adopted by such model is not whether we agree or disagree with the conclusion of the interpretation, or whether we accept the authenticity of the statement supporting the conclusion, the key is that we can effectively explain whether and why we agree or disagree. The only reason for disagreement is that we take the trouble to check all the claims and relations implicit in the argumentation, and face the problem honestly, whether all the facts are as stated, and whether they really have what the original speaker claims meaning (Toulmin et al., 1979).

### 3.3. Apart from the Structure: Judge's Agency in the Activity

However, the argumentation model represented by Toulmin's system also has its shortcomings. That is to say, legal argumentation is not just for putting a dispute between both parties, the ultimate goal of which is to persuade the judge to make a final judgment. However, in the argumentation model, the judge is placed on the periphery of the system and does not been properly considered. "As a neutral third party, on the one hand, judges play a role in regulating the order of argumentation, and on the other hand, they are also the audience specifically targeted by the parties..." (Wu, 2006) Since, the next research topic in the field should focus on the reduction of the value of argumentation, the participation of all the parties in judicial process, especially the judge.

The way that judge's power intervention in the court trial is manifested in the construction of the discourse order by mastering the power of, dominating the arguments and the argumentation process of the parties in the litigation activity, and stopping at the point where he wants to support the justification with. On the other hand, judges barely rely on their own will to dominate the trial process, but try to maintain "neutrality" in the process. Therefore, what the judge shows through his initiative to control the order of discourse is the tension between negotiation rationality and the power intervention in the trial process (Yang, 2018). Putting the arguments of the parties under the arrangement of the judge no longer just reflects the argumentation relationship between the parties, but also considers the debate structure that carries the argumentation and the judge that has the power to shape the order of the structure. In the past, the legal expert system was structured based on cases, rules, or argumentation, a reason for which was the distrust of judges' judgments. According to the opinions of social science, judges' judgments were subject to such background factors like the individual's gender, age, family, environment, political stance and even what they ate for breakfast. Rather than traditional legal norms, have a decisive influence on their judgment. Hence, these models share a same ideal of eliminating the per-

sonal factors of the judge and realizing the judgment of the case with the image of a non-presupposition judge while under certain cases, this ideal is consistent with Webber's propose of "automatic vending machine". In which, disputants enter the case into the machine, and the result of the judgment is a conclusion that is impersonalized and universally learnable in a form automatically drawn according to legal provisions, which shares the same context with the mirror image rule that the judgment corresponds strictly to the law and like cases treated alike (Ji, 2018). But what this proposition does not notice is that the current knowledge base for artificial intelligence learning, if it is not purely sticking to rules, will inevitably be affected by actual judicial practice and judgment documents. The trial process, after depriving judge's process of adopting and judging the results of the argument, is still not unrestricted. The judge's restraint on the trial process runs through the entire process, suppressing the parties' argument with the power of discourse, and intercepting the required parts of their own opinions as the reason for the judge's argument. This kind of micro-regulation is somehow ignored by the researchers.

#### **4. A Dual-Structure Model That Retains Judge's Personality**

While the defeasible reasoning structure could, generally, displays the process of debate and compromise, it ignores the agency holds by the judge that arranges the process in a subtle way, and thus such model does not successfully provide access to acknowledging the process of how judge adopts a decision. However, it does provide a constructive idea to focus on the factual argumentation.

Since, the machine learning in the construction of the legal expert system should include the normative fact part of the law and the personality value part of the judge, in response to this, the author advocates a legal expert system centered on the recognition and judgment of judges. The mission of the legal expert system is not to remove the personality factor of judges, but to strive for a "just" judgment. And what is justice? This is not only being questioned in the legal field, but also a topic of constant dispute in various fields. However, its function of promoting should not be restricted due to the disputes, since, we list three values that the artificial intelligence legal system should follow at this stage: 1) Formal justice, i.e. the same input will inevitably lead to the same output; 2) Openness and standardization, which means it is not only necessary to have a knowledge base capable of deep learning, but also to avoid the "halting problem" that cannot be solved within the system, such as the reflexivity of law, therefore, values outside the legal field need to be absorbed continuously to enrich this system; 3) Supportiveness, which reflected not only in the convenience for judges in judging cases, but also in promoting the "interpretability" of judges' decisions in the judicial adjudication process, in order to appropriately shift the "decision-argumentation" form intuitive judicial process (Ge, 2018). Since, we divide the argumentation model into two parts—fact argumentation model and legal argumentation model. In fact, the process of legal argumentation also needs

to include the process of value judgment, such as how well the judged case conforms to political and social respect. However, this step should not be handed over to artificial intelligence to make decisions in the current environment. Artificial intelligence can provide a reference result of the case, but its application or not should depend on the judge or judicial system.

The fact argumentation model mainly focuses on the extraction of the facts of the case, which is about what facts should be included in the legal evaluation and how it influences the legal judgments. Before discussing this issue, we need to pay attention to two points: 1) the cognition of facts has the characteristics of contextualization, and their influence on different facts depend on different situations; 2) the recognition of external knowledge can only be realized in the form of enumeration, which is subject to the level of development in this field.

Within the fact argumentation model, three kinds of facts need to pay attention to: natural facts, social facts and factum juridicum, as well as the relationship between the former two and the latter.

For the identification of natural facts, we can use some characteristics of the rules of physics to carry out as detailed enumeration as possible, e.g., if a “stone” is to be identified, it can be based on the material form, size, degree of shape regularity, mineral content, and filter it by those factors.

The recognition of social facts involves the knowledge category of psychology and ethics. A concept draws in social facts often shows the certainty of its core and the ambiguity of its extension, which means there are not only matters that undoubtedly belong to its category, but also fuzzy areas that intersect with other relationships. For example, how to judge whether parents punish their children is educational behavior or abusive? The answer depends on the social backgrounds, cultural backgrounds and even characteristics of the individual, but this part can at least be reduced to several behaviors and subjective aspects: the means of punishment, the purpose of punishment, the contingency of the punishment, and the severity of injury. A reasonable answer could be approached only with the joint efforts of experts in different fields.

The identification of factum juridicum is not based on the social knowledge base on which natural facts and social facts depend. Such facts are the representations of specific concepts stipulated by laws or legal documents. Therefore, their identification should rely on the legal knowledge base and are enumerated in accordance with the provisions of the law. For example, the identification of legal facts of “checks” can be divided into: bills, issued by the drawer, the payment obligor is the bank or other financial institution that handles the deposit business, the consideration is a certain quantity of money.

Since natural facts, social facts, and factum juridicum have different knowledge bases and standards of adoption, there may be situations in which an entity is identified as both a legal fact and a natural/social fact, which is possible if there is no contradiction between the identification standards. Still taking “checks” as an example, if we assume that the conditions for identifying the social facts of “checks” are: be honored by financial institutions, the amount equals

the number recorded on the bill, thus, it may lead to a situation in which there are two descriptions of an object (object A is both a factum juridicum m and a social fact n), which is neither consistent with common sense nor conducive to the subsequent legal reasoning process. We purpose that only factum juridicum should be output in this case. An initial difference between factum juridicum and social facts lies in their distinctiveness, the former is specially adjusted by the law, while the latter is not, since, outputting factum juridicum is conducive to the subsequent reasoning process; at the same time, factum juridicum do not negate the social or natural meaning of a concept, and even include which to an extent.

Converting the above conclusion into a logical sentence is that: all concepts that meet the requirements of natural/legal facts should be output, unless they are not at the same time in line with the standard of factum juridicum (Figure 4).

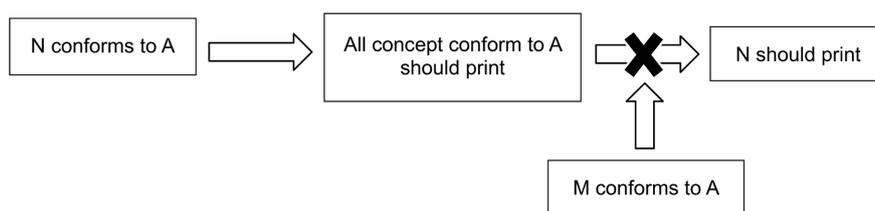


Figure 4. Defeasible reasoning in fact argumentation model.

Under the frame of legal argumentation, judge’s adjudication of cases is considered to be a process of interchanging between the law and the facts, and the cumbersomeness of this process heavily depends on the complexity of the case. In a simple case, the facts of the case are relatively clear, and the parties have hardly any dispute over the application of the law. At this time, the judge does not need to repeatedly review the law and the facts of the case. While in complex cases, the focus of disputes between the two parties often involves multiple marginal areas of legal concepts (such as robbery, intentional injury, or murder). At this time, the judge needs to constantly review the characteristics of the facts to meet the element requirement in law, which is also known as the subsumption model of legal argumentation (Figure 5).

In Figure 5, “T” represents “causing serious injury”, “R” means “imprisonment of over three years but less than 10 years”, “S” stands for “cut off one’s left thumb, forefinger and middle finger”, and “a” means Tom. The argumentation process can be reduced to three parts: constructing and comparing the equivalent transformation elements of case facts and factum juridicum, realizing the transformation of the former into the latter, realize the connection between the facts of the case and the consequences of the adjudication. In the fact argumentation model, the factum juridicum in the facts of the case have already realized the coverage and output of the natural/social facts. A series of reasoning about the legal concept of “serious injury” has been included in the aforementioned stage, therefore, there is no need to repeat the reasoning for the transformation of facts in the latter stage (Figure 6).

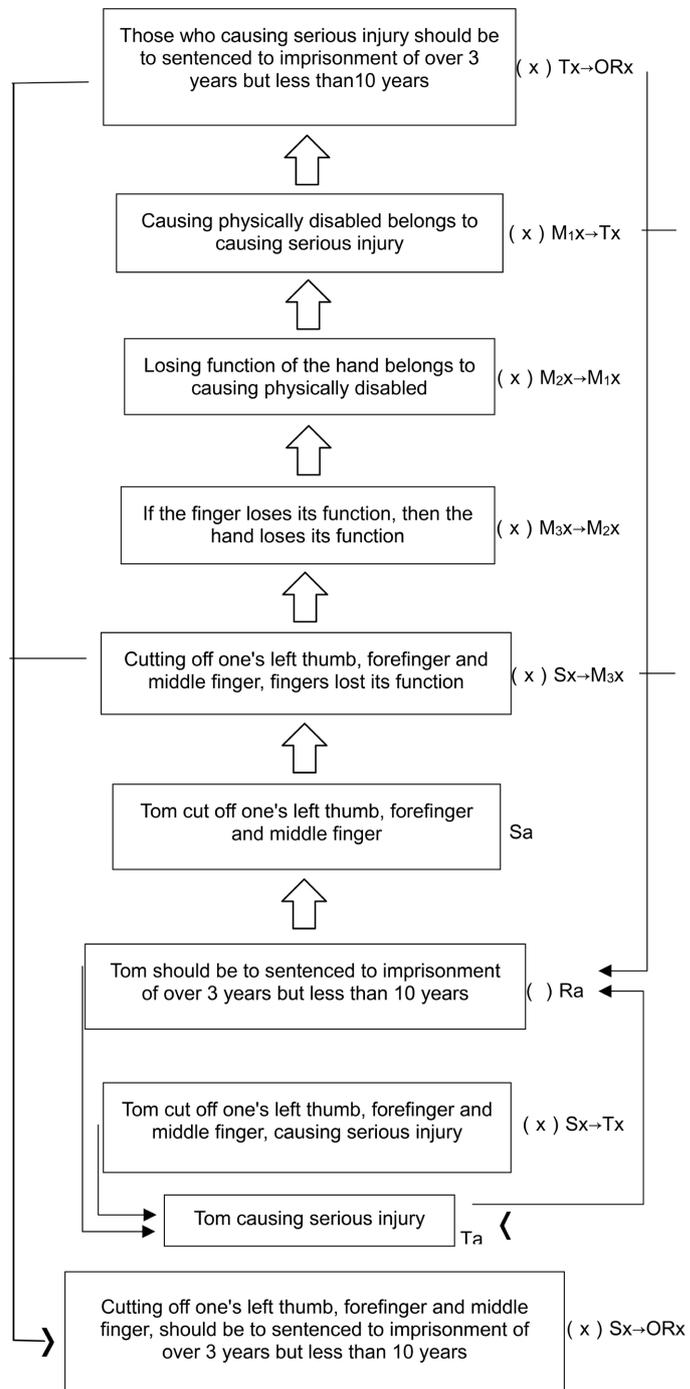


Figure 5. The subsumption model (Lei, 2016).

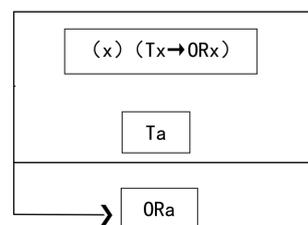


Figure 6. Legal argumentation model.

By constructing a dual-reasoning model of factual reasoning and legal reasoning, the process of applying law by judges is deconstructed. It can be seen that in this part, legal reasoning can be reduced to the truth transmission in the sense of formal logic between factum juridicum and legal norms, while the factual argumentation part contains a certain degree of openness. Judging the nature of facts will undoubtedly affect the subsequent reasoning process, so a question arose is that how to limit arbitrary and enable value factors to be transmitted in the judicial process at the same time? Unless artificial intelligence system can gain knowledge of moral logic, or its self-supervised learning will inevitably lead to mistrust in the artificial intelligence judicial process. At present, the best method of which is still to manually input the value. To make a summary, this model can be divided into three parts, for the first part is the fact argumentation model which outputs the final factual language. In the subsumption model, it deals with the natural description and transmits into legal logic form. In the end, the legal argumentation model would provide the decision conforming to deductive reasoning.

## 5. Conclusion

This article initially reviews the previous theoretical ideas for the construction of artificial intelligence legal expert systems, analyzing its characteristics and difficulties, and tries to construct a model based on a more mature legal reasoning theory. However, this model is still a sort of Artificial Narrow Intelligence, which requires manual input to ensure the acceptability of the results. Therefore, any theory proposed at this stage is only a medium-range. The realization of the transition from “humanoid” to “superhuman” needs to be based on the knowledge of many deterministic multi-disciplinary disciplines, such as whether inductive reasoning can be considered logically deterministic, while the background knowledge is still not plentiful. On the other hand, knowledge of the judicial process also requires higher degrees of completeness, which still remains insufficient.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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