

# Survey on Legal Expert System using Fuzzy and Neural Networks

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**ABSTRACT:** Law can be defined as set of rules of a country and the way they are interpreted and implemented. The Objective of this survey is to explore different flavours of legal expert system available in Artificial Intelligence area in terms of reasoning, methodologies and legal domain. We start with rule base reasoning (RBR), Case Based Reasoning (CBR) and integrating RBR and CBR (Hybrid).Applying Fuzzy Logic to legal reasoning result in handling uncertainty during decision making process. Use of Neural Networks in legal expert system overcome difficulty arise in symbolic reasoning system and facilitate knowledge acquisition.

**KEYWORDS:** Legal Expert System, Fuzzy, Neural Networks, RBR and CBR

## I. INTRODUCTION

Legal reasoning can be consider as an process by which lawyers use rules(or statutes) and history cases (precedents) to resolve legal disputes. Lawyers and Judges in the common law use three forms of legal reasoning which are Inductive, deductive reasoning and reasoning by analogy. As per Dan Hunter [26], inductive reasoning is two stage process, in first stage: classification will be made from generalizing a category from number of isolated experiences. Rule can be derived from classification and in second stage: once rules have been induced, they may be applied to new situation in a deductive manner. Modelling inductive reasoning may require further investigation. Most of the systems in business market employ deductive or analogical reasoning or combination of both deductive and analogical. Constructing Legal Expert system (LES) for legal reasoning requires first and foremost legal analysis. The LES can play the role of judge, an adviser and act as a legal drafter. The logic of that system and operating methodology depends on role. There are different forms of legal analysis which includes Rule Base Reasoning (RBR), Case Based Reasoning (CBR) and combination of RBR and CBR. Basically reasoning engine in Legal Expert system (LES) incorporates various forms of legal analysis.

According to paper [12], model prescribes outcome of a new case is a weighted average of the results of prior cases, where the weights are a function of the fact similarity and precedential authority of the prior cases. Legal Expert System (LES) is capable of performing role of lawyer. System deals with both statute law and case law and directly related to knowledge representation. LES output should be *in* data form such that it can be the base of lawyer's legal argument. A LES must be based upon legal reasoning model. The main advantage of LES is that they are more precise than human experts, as they consider all legal precedents before drawing a conclusion, unlike lawyers, who basically focus on a limited set of information. Fig 1 shows traditional legal expert system inference mechanism and also called symbolic reasoning system. However, symbolic system has several limitations, which basically includes

- a) Entire knowledge cannot be represented symbolically.
- b) System maintenance is time consuming.

In modelling intelligence, neural networks adopt alternative approach where relationships between pieces of information are not explicitly stated in form of symbols.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 8, August 2017

Connectionist (Neural Network) paradigm is used in legal reasoning and employed in modelling situations that are characterized as open-textured. In the creation of LES, inclusion of neural network (NN) can overcome some of the limitations of the symbolic systems. One of limitation is knowledge acquisition bottleneck associated with symbolic system. NN can be used in situations where there is incomplete information and based on that make inferences and classify patterns.

Fuzzy logic can be incorporated in process of legal reasoning to define vague legal concepts simply called as Fuzzy reasoning .Fuzzy logic offers excellent feature of defining linguistic legal terms and to implement in Fuzzy Legal Expert System. Legal inference is realized as fuzzy inference.

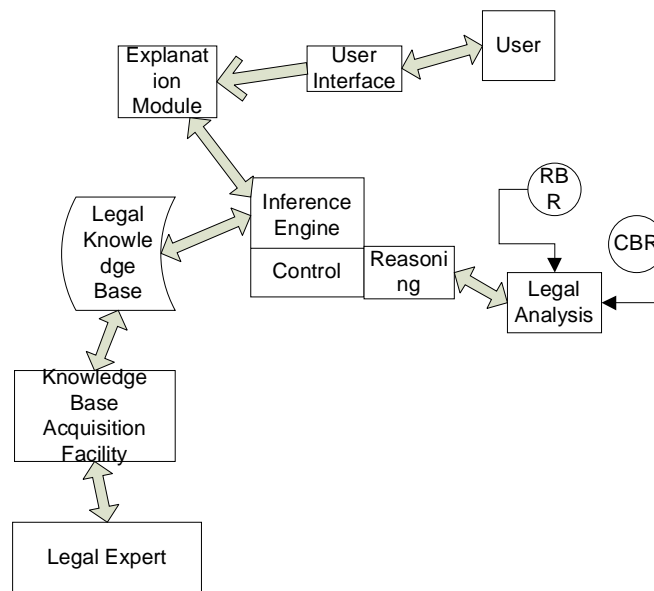


Fig 1: Components of Basic Legal Expert System

## II. LITERATURE STUDY

Elaborate literature study is done across inclusion of different AI technologies with in design of Legal Expert System. This section mainly focuses and summarizes on various research areas of legal expert system. The four important paradigms that have been successfully used in legal reasoning are rule-based reasoning approaches, case-based reasoning approaches, fuzzy theory and neural networks.

### A. Rule based expert system in Legal domain:

In a rule-based Legal expert system, knowledge base is constructed in form of deductive rules. Rule –Base Legal Expert System (RBLES) represents law using if-then rules. Judiciary System to some extent composed of rules. Rules need to be conceptualized in required format for knowledge representation. RBLES have been used to represent statutes and cases. Systems using rule-based reasoning called as ‘production system’. This kind of system usually consists of three main components. First component is rule-set. Second component is interpreter, which executes as recognise-act cycle for facts given to the system. The third component is working-memory which stores facts, goals and intermediate results.

There are several diverse areas in legal field where rule base expert system is deployed successfully. The **JUDITH** system was designed as Rule-Base legal reasoning system. Popp and Schlink’s JUDITH [2] system employs rules to construct parts of the German civil code. The methodology behind JUDITH is similar to those of the MYCIN system ( Rule-based medical expert system). **TAXMAN** [3] is rule-based reasoner deals with taxation of organizations. **Split Up**[1] is legal expert system designed using if-then rules to assist judges and lawyers. Apart from working as rule-base

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Vol. 6, Issue 8, August 2017

reasoner, Split up is built with neural network theory. The main functionality of Split Up is to make predictions about the distributions of marital property following divorce in Australia.

## **B. Case Based Expert system in legal domain**

Case-based reasoning (CBR) is a promising technique in AI, termed as reasoning by experience in the form of cases to represent knowledge. The basic principle behind CBR is that reasoning and resolving problem are based on the most specific experiences instead of general rules. For given problem, Case-based reasoner searches for past cases (precedents) and attempts to retrieve a case that has same problem specification as the present case based on similarity assessment criteria. Based on adaptation criteria, solution is proposed by adapting suitable case. Precedent plays important role in legal decision making process. Entire process can be formalized with two significant parts which are case-retriever and case-reasoner. CBR may be viewed as a particular form of analogical reasoning. Case-based legal expert system develops legal concepts by referencing similar old cases.

Few CBR systems are illustrated as: **FINDER** was modeled by Tyree, Greenleaf, and Mowbray. **FINDER** is based on law of trover. The law of trove is a common law based on the rights of finders of lost chattels. **FINDER** stores its domain knowledge of each of the cases in a vector of attribute values. **FINDER** operates using the nearest neighbor analysis. The **FINDER** system is simulated in **SHYSTER**. **HYPO** is a case-based reasoning (CBR) system deals with trade secrets law and is well documented CBR system. **Hypo** was developed by Kevin Ashley and Edwina Rissland at the University of Massachusetts and performs CBR in legal domain. Working model of **Hypo** is analyzing problem scenarios in the trade law area and retrieves suitable cases from its case base, forms them into legal arguments. Another System is **OPINE** (Office Practice INquiry Expert) a generic case-based reasoner for use in legal domains[15]. **OPINE** has a single function working methodology that results in likely case outcome in particular legal context. **Hirota** [9], developed a fuzzy Case based Reasoning system for legal inference. **JUDGE** [16] is a case based reasoner implemented for criminal law domain. System is designed to model the sentencing of criminals done by real-life judges by matching history cases to current case.

## **C. Hybrid-Based Expert Systems used in Legal Domain**

Hybrid Expert system mostly be design with best side of each methodology and compensates the limitation of rule based reasoning by case based reasoning due to the existence of 'open-textured' rule terms. Both RBR and CBR have their own weaknesses. CBR approach cannot easily take advantage of existing domain knowledge, while RBR approach need complete domain knowledge but lacks knowledge of past experiences. A hybrid legal expert system is one which integrates more than one method of reasoning to solve legal problem. Rules are usually based on legislation where as cases on precedents. Some of the hybrid legal expert systems are discussed here. **CABARET**[4] deals with (US) income tax law and use a RBR to acquire knowledge not only about the statutes, but also the common law.

**GREBE** ( Generator of Exemplar-Based Explanations) system deals with Texas workers compensation law. In **GREBE**, cases are represented both in rules and in a case-base. As previously discussed in **CABARET**, **GREBE** also use rule based reasoning to capture both types of knowledge. **PROLEXS** [van Opdorp et al.1991] is a Dutch system focused on the landlord-tenant law. Rule based reasoning is used for legislation knowledge and supports both forward and backward chaining. Case based reasoning is used for case law knowledge. **IKBALS** [19] uses a distributed AI approach and focuses in the area of credit law. Since system operates in a parallel nature, CBR and RBR are totally independent agents. **IKBALS II** [19] deals with accident compensation domain and is combination of RBR and CBR in order to determine if an injured employee is eligible to compensation only when worker falls under statutory rules. **SHYSTER-MYCIN** [5] is a legal expert system integrating **SHYSTER** (a legal expert system) and **MYCIN** (a medical expert system). The design of the system was mainly concentrated on the **MYCIN** ( rule-based ) part of the system and was modified to support requirements of the system. The **SHYSTER** (Case based) part was invoked on demand and was not modified. **Gun Ho Lee**[27] proposed integrated approach that is combination of RBR and CBR for bank auditing system. The knowledge base of RBR comprises of application specific domain rules and regulations. The CBR executes similarity-based matching to find the most similar case to the new problem in form of case. The hybrid system suggested by **Robert T.H.Chi and Melody Y.Kiang**[28] includes both a case base which stores past cases and an explanation mechanism which uses domain theory to generalize the old cases to cover a wide range of problems.

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Vol. 6, Issue 8, August 2017

## III. INTEGRATION OF LEGAL EXPERT SYSTEM WITH FUZZY LOGIC AND NEURAL NETWORKS:

### A. Legal Reasoning using Fuzzy Systems

Fuzzy logic is extensively used in development of legal expert system and this technology has great future in legal system. Few systems are summarized here. Usually fuzzy technique is employed to resolve uncertainty issues in problem domain. Vagueness and complex relations contained in legal knowledge can be implemented by constructing fuzzy relational database [7] which handled CISG (Contracts for International Sales for Goods) law. In this paper [9], fuzzy theory is applied for case representation and Case Base Reasoning (CBR) for legal inference. According to [6], vague legal concepts can be represented using fuzzy logic. Fuzzy logic presents the ability to examine the linguistic usage of legal concepts and to include them into a fuzzy expert system. **Kaoru Hirota, MingQiang Xu, Yasufumi Takama and Hajime Yoshino** [10] proposed Fuzzy Legal Expert System, where case base is composed of hierarchical fuzzy frames, Hausdorff distance-based similarity measure between fuzzy sets was used for case retrieval, case based reasoning used in legal reasoning. **Jong-Uk Choi** [8], systematically designed legal expert system where uncertainty issue is handled using fuzzy database. Ambiguity and vagueness of expression can be solved by fuzzy inference.

### B. Legal Reasoning using NN (neural networks):

**Yi.Gu, Guangming.Zhang**[11] proposed Legal expert system incorporating LVQ neural network for 'Analysis on children custody decision making model'. LVQ neural network works on basis of weight vector analysis on the set elements. **Jong-Uk Choi** [8] suggested legal expert system model in which neural networks was incorporated to analyze the weight of domain information. Weights associated with domain concepts mostly differ according to situation and domain experts. This type of scenario is best understood by NN. In this paper [8], neural network is applied to auto insurance domain to fine tune output and for handling uncertainty problem. And also author explains how neural networks handle changing situations in processing of auto insurance claim processing that mostly solved by restricted and fixed rules. Neural network approach best suited for availability of problem solving domain with consistent and relatively large database [6]. **John Zeleznikow and Andrew Stranieri** [1] suggested legal expert system model where problem space is split into two functional units, one functional block is modeled with rule set and another with neural network. Neural network is feasible approach when domain terms are open textured, uncertain and to deal with inputs which have more than one value[Project\_report\_Split-Up\_A\_Legal\_Expert\_S].

## IV. CONCLUSION

Expert systems in diverse domains are available in market. Majority of them are in medical area in field of diagnosis of various diseases, modelled and implemented with fuzzy and neural networks. But we can find very rare such systems in legal domain, that too for Indian legal system. There is need to develop legal expert system to automate legal tasks particularly in sub domains like auto-insurance claim process.

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