A Precedent-based Legal Judgement System using Fuzzy Relational Database

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Abstract

In the domain of law, various real situations are expressed as relations and/or combinations of legal knowledge items (legal concepts, articles of law, etc). Such knowledge items (legal facts, events) can not be precisely defined. Legal judgement is performed based on resemblance of legal knowledge and facts. In our system, vague legal knowledge is saved in the fuzzy relational database, and legal inference is realized as fuzzy inference. The target law for this system is United Nations Convention on Contracts for the International Sale of Goods (CISG).

1 Introduction

In the domain of law, various ever-changing real situations can not be clearly expressed and managed. The problem is to give judgements about examples and events in the domain of law by combining articles and concepts from law, expert knowledge, previous examples and other legal knowledge.

However, the amount of such knowledge is not infinite. On the contrary, when making judgements about various real situations we use quite scarce knowledge. Articles and concepts from law permit for vagueness and indecisiveness. Since they represent various real situations, they can be understood and interpreted in a broad sense. Therefore, vagueness and indecisiveness play an important role when making legal judgements about examples and events from various real situations.

In our system, we process vagueness and indecisiveness by using fuzzy theory, and build a system for legal judgement (legal inference) by using legal knowledge which contains vagueness and indecisiveness.

2 Legal inference (explanation by analogy)

First we will discuss explanation by analogy as a basic inference method in law. In figure 1 we show this inference method.

As shown in figure 1, logic based on analogy assumes that A and B agree on the point α, and also, what is actually permitted by a law regulation A $->$ X is that since A contains α, and since B contains the same α, a legal effect X is allowed to follow from such B.

Law/Regulation : A(x) − > X(x)
Case : a
Case description : B(a)
Judgement : X(a)

A − > X A and B agree on the important point α.
B − > X

Figure 1: Explanation by analogy

At this point, to make the explanation by analogy possible, we pick up all the candidate elements for the important point α, and carry out matching among them.

3 Legal knowledge with vague expressions

An example of vague expressions contained in the articles of law is shown in table 1.

Table 1: An example of vague expression from an article from CISG

Article No.	Article Content
16-2b	if it was <u>resonable</u> for the offeree to rely on the offer as being irrevocable and the offeree <u>has acted in reliance on the offer</u>.

Expressions as **reasonable** and **has acted in reliance on the offer** in table 1 show that clearly regulated matters actually don't exist in the domain of law. However, in the process of legal inference this kind of vague expressions play a very important role.

We implement vagueness contained in the articles from law and other legal knowledge by using concepts of membership and vagueness from [1], and the concept of possibility distribution. This results in the fuzzy relational database[2] which houses vague legal concepts.

4 Building fuzzy relational database with legal knowledge

Matters from law can be expressed as a collection of relations among various elements from law. To build a fuzzy relational database, we analyze and decompose the concept of *the formation (conclusion) of the contract* from CISG. We show an example of relational scheme in table 2.

Table 2: An example of relational scheme

offer([offeror],[content of the offer])
offeror(specific person,[general person])
content of the offer([clear enough])
clear enough([goods],quantity,price,[add matters])
offer effective([send out],[cancel],[arrival])
.....

When decomposed and presented in the form of relational scheme, legal knowledge forms a network structure shown in figure 2.

5 Knowledge representation

Vague knowledge from law resides in the fuzzy relational database in the form shown in table 3. This knowledge is specified in the form of triangular membership functions.

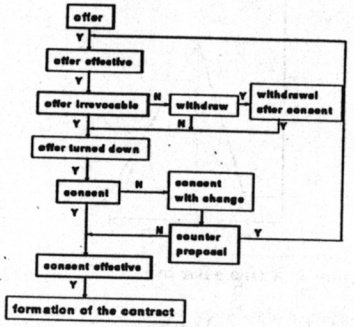

Figure 2: Network structure of legal knowledge

Table 3: . An example of expression of vague knowledge
(1) Goods

No.	Goods	m	v
c0001	sugar	Completely True	Clearly
c0002	handicraft machines	Very True	Roughly
c0003	cotton	True	Roughly

(2) Price

No.	Price	m	v
c0001	100	Unknown	Vague
c0002	5000	True	Clearly
c0003	1500	Very True	Roughly

Three vertices of the triangular membership function are computed using concepts of membership and vagueness. Membership value is m, and vagueness value is v, and the vertices are computed using:

$$mL = m - m \times v \quad (1)$$

$$mH = m + (1 - m) \times v \quad (2)$$

Membership value and vagueness value represent numerically expressed linguistic values ([3]) shown in table 4. Membership function specified by mL, mH, m and v from (1) and (2) is shown in figure 3.

Table 4: . Values of linguistic variables

membership	t	vagueness	t'
Unknown	0	Vague	1
More or Less True	0.25	Roughly	0.5
True	0.5	Clearly	0
Very True	0.75		
Completely True	1		

Vague legal knowledge resides in the knowledge base in the form of relational scheme. However, crisp knowledge, or knowledge which explicitly does not contain vagueness, also exists in the domain of law. In our system, we represent this kind of knowledge as a fuzzy singleton. We often encounter a situation in which, in order to satisfy existing concept or matter or affair crisp knowledge is neccessary. However, in the cases when it is not absolutely neccessary, but to a certain degree (for example about 0.6), it is advantageous to represent this kind of crisp knowledge by using fuzzy singleton. This kind of crisp knowledge can be also described by means of IF-THEN rules.

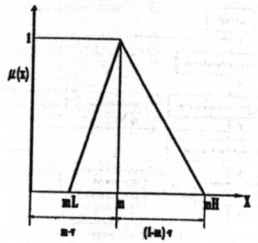

Figure 3: A triangular membership function

6 Handling of judicial precedents

In our system it is still not possible to include judicial precedents from reality. Instead, we use previous reasoning results as judicial precedents. Previous reasoning results are decomposed in the form of relations from the knowledge base, and saved there for future reference. Thereby, the reasoning result in the form of computed numerical value is also added to the knowledge base.

7 Legal reasoning and fuzzy reasoning

Legal reasoning is implemented as reasoning by analogy. First, an event or case from reality is matched against the specific article description. We perform here crisp pattern matching between two legal concepts. If the description from the article matches completely the event, a crisp conclusion is established.

However, since crisp matching against article description is practically not possible, descritpion of an event or case from reality is matched against legal knowledge by means of analogy. This matching is actually vague matching.

The process of legal reasoning is shown in figure 4.

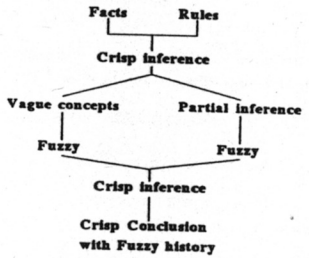

Figure 4: Legal reasoning flowchart

As shown in figure 4, we first employ crisp reasoning. In the case when vague concepts appear, or crisp matching is not possible, fuzzy reasoning is carried out. In the last stage, using the result from fuzzy reasoning, we carry out crisp reasoning. The result from fuzzy reasoning is used as the intermediate result which shows the progress of reasoning (fuzzy history). From this result, we obtain crisp reasoning result, which represents the final judgement.

8 Fuzzy reasoning

Fuzzy reasoning is carried out using vague legal concepts. Vague legal knowledge is represented by means of fuzzy relational scheme (table 2), and specified in the form of triangular membership functions (figure 3).

Input data given in the form of membership functions, and knowledge from the knowledge base are matched, and the matching value is computed by using the method of numerical inverse truth restriction given in expression (3).

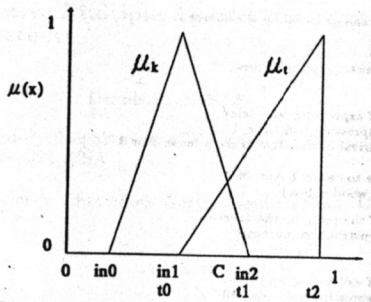

Figure 5: Matching of input data and knowledge from the knowledge base

$$m = \frac{1}{2}\{sup(\mu_t \bigwedge \mu_k) + inf(\mu_t \bigvee \neg\mu_k)\} \tag{3}$$

In order to use this matching result for the continuation of reasoning, we save the x coordinate of the intersection point of the membership function representing input data, and the membership function representing knowledge from the knowledge base (C in figure 5). We also save the matching value m as a height of a singleton membership function positioned at C.

When the all input data are matched against appropriate knowledge items from the knowledge base this way, we compute the result of matching as the center of gravity G of the obtained matching result (membership function). Value G represents the result of the fuzzy reasoning. It is computed using:

$$G = \frac{\sum C_i \cdot x}{\sum C_i} \tag{4}$$

In short, since vague data are represented as a relation of schemes, we look for the matching value with respect to each relation. When the reasoning results from all relations are collected, we produce the result of the relational scheme as a whole. Then, the final result of the system is decided by comparing the result of the relational scheme (center of gravity G) and the threshold value set by a rule. The final result of the system is crisp, and is given in terms of truth or falsehood.

9 Reasoning simulation

A result of one reasoning simulation is given in figure 6. The final reasoning result is given in terms of truth or falsehood, and the intermediate reasoning results are saved as fuzzy judgements.

10 Conclusion

Legal knowledge with vague and complex relations is saved in the fuzzy relational database, and legal reasoning system using this database is built. This work is part of the research sponsored by the Ministry of Education of Japan as the important research area "Legal Expert Systems".

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```
<Input of the proposal by the offeror>
Offeror: A
Offeree: B
Goods: construction machines
Quantity:
Price:
Method of expressing will: telex
Date of expressing will: Apr, 1
Date of arrival of the offer to the offeree: Apr,8
Other:
Impossible to cancel ( Apr, 30)
Packing ( wooden box)

<Input of the reply by the offeree>
Goods: construction machines
Quantity:
Price:
Method of expressing will: letter
Date of expressing will: Apr, 10
Date of arrival of the reply to the offeror: Apr, 17
Other:
 Packing (wooden box) strong

******REASONING******
The content of A's proposal is:
goods( construction machines)
quantity( NULL)
price( NULL)
Quantity and price are not given.
Any implications? (Y/N) n
Following theories are available:
1)official explanation
2)Theory of Honolld
3)Theory using general price
4)Theory using implicit knowledge
Theory No.: 2

Content of A's proposal is clear enough, according to article 14-1.
Therefore, the proposal constitutes an offer.
The offer arrives to B on Apr, 8
The offer is not withdrawn.
Therefore, the offer is effective.
B's reply to A is
packing(wooden box) -> strong,packing(wooden box)
 There is no essential change
Therefore, B's reply to A means consent, according to 18-1.
B's reply to A arrived on Apr, 17
Therefore, the consent is effective.

<Conclusion>
According to the content of A's offer, the contract is concluded.
<Remarks>
Judicial precedence : NO
Theory : YES
<Fuzzy judgement>
The content of the offer is clear enough -> 0.521
Essential change -> 0.121
wooden box — strong wooden box
```

Figure 6: The simulation result of legal reasoning