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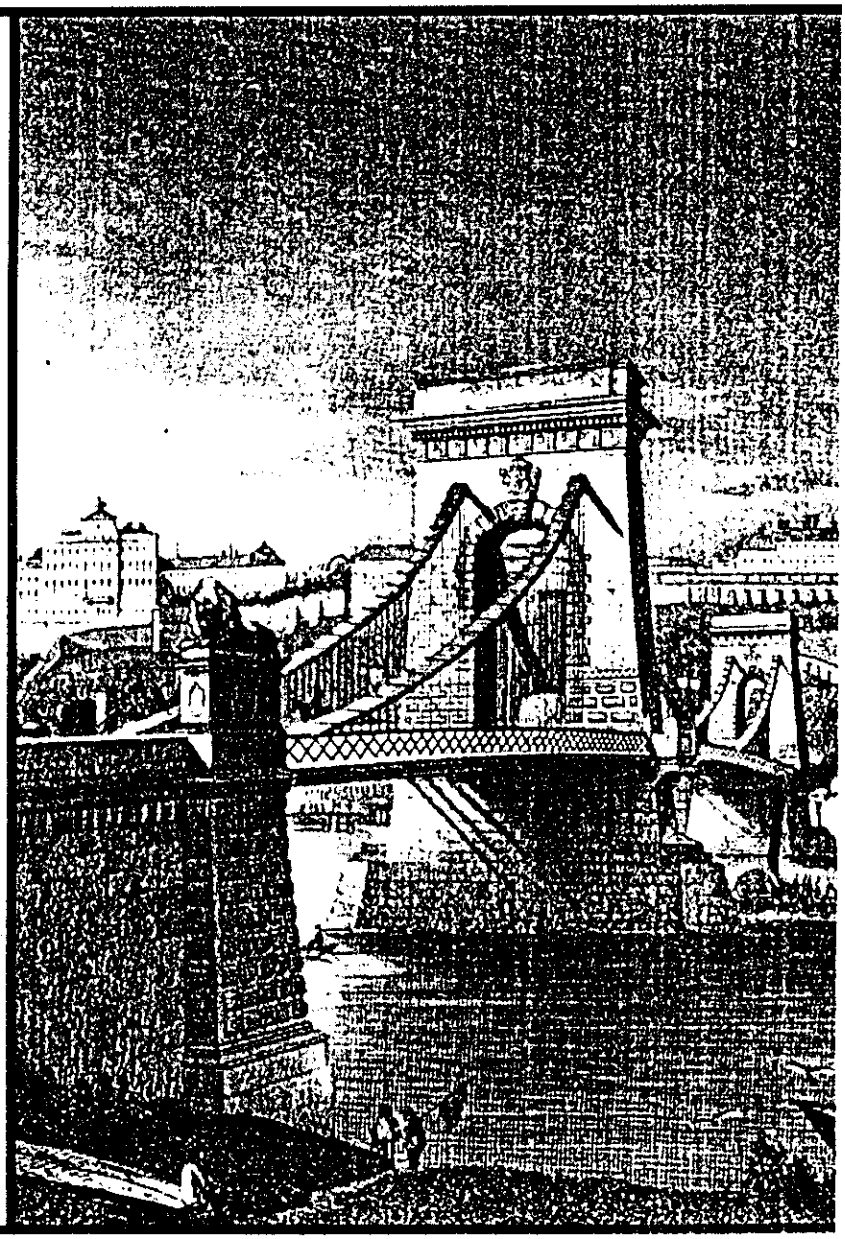

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A Fuzzy Legal Case-Based Reasoning System for the CISG

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Abstract

In legal case-based reasoning(CBR), there exist problems concerning fuzziness, e.g. representation of precedent cases and similarity measures. In our proposed fuzzy legal CBR system(FLCBR), a case is composed of issues, features and case rules. Issues and features of precedent are characterized on the basis of the facts of precedent and statutory rule. Case rules are used for interpreting the court judgment, which can not be obtained from the statutory rule directly. Fuzziness in the judgment of the features and case rules is represented by membership functions that is structured by membership and vagueness concepts. Cases similar to a query case are retrieved by issues and features, and case inference is made by case rules. The system proposed here will be used for education of law, where the target law of the system is contract, especially as it relates to the United Nations Convention on Contracts for the International Sale of Goods (CISG).

Keywords: Legal Reasoning, Fuzzy Theory, Case-Based Reasoning, CISG.

1 Introduction

It is known that there are vagueness and uncertainty in legal CBR, e.g. in knowledge representation, retrieval and inference of cases. For example, when dealing with the similarity assessment, it is difficult to find the cases from a case base that is completely the same as the query case. Fuzzy theory has already been employed in some legal expert systems [3] [7]. In [3] by using fuzzy database, legal judgment is performed based on the resemblance of legal knowledge and facts. In [7] a vague legal concept, i.e. the required period of waiting after traffic accidents is determined by fuzzy rule inference.

In above fuzzy modeling, the rule actions are generally associated with the assignment of a numeric value to variables. This situation allows the use of the aggregation techniques used in the control domain. It is known that, in legal case-based reasoning, similarity measure plays an important role. The similarity between the query case and the precedent cases are very useful to retrieve the cases similar to a query case, and infer whether they are applicable to the query case. For a need of satisfying this characteristic of legal reasoning, a new type of connection of legal reasoning and fuzzy theory, fuzzy legal CBR system(FLCBR) is proposed.

In FLCBR, to capture the fuzziness, fuzzy theory is applied in the all process of legal CBR. In case representation, fuzziness in the judgment is described by fuzzy set that is structured by the membership concept and vagueness concept. In retrieval and inference, similarity measures are made by fuzzy matching. This system allows the vague inputs, and bridges the gap between users and knowledge-based legal reasoning system.

Overview of the proposed system is introduced in section 2. Section 3 describes the fuzziness in case representation. Similarity measures between fuzzy sets is made in section 4. The retrieval of similar cases is presented in section 5. The case inference is discussed in section 6. An experiment is described in section 7.

2 Fuzzy Legal CBR System Overview

The presented system is composed of four parts, i.e. case base, retrieval, inference and interface module (Fig.1).

In the case based, a precedent case is represented by issues, features and case rules. A precedent includes several issues. The issue describes the legal judgment, e.g. whether the proposal is sufficiently definite. Each issue consists of an argument point and a court judgment. The argument point is represented by natural language and the judgment by "Yes" or "No". The issue can be further interpreted into features and case

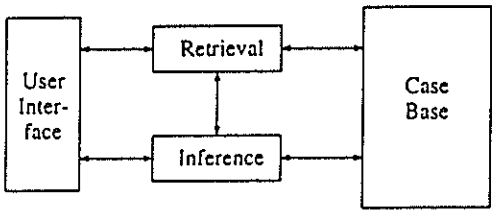

Figure 1: The Structure of Fuzzy Legal CBR System

rules by experts.

In terms of statute rule and facts of precedent, issues are characterized by features. These are regarded as the surface features of a precedent. Because the statute rule is usually not enough for solving any case, on the basis of statute rule and court judgment, referring to the theory proposed by experts, case rules are made by experts. It is used to interpret connections between the precedent and court judgment.

The features and case rules are represented by frame, stored in the case base.

For a query case, it is necessary to retrieve similar cases from the case base. The retrieval is made in terms of issues and features. What results can be gotten from retrieved cases, namely, whether the conclusion of query case is the same as the precedent's or not, is inferred by case rules.

The CISG is an international law, it has been used in many countries. To apply our system to international exchange, a user interface of this system is developed in several languages.

3 Fuzziness in Knowledge Representation

In a traditional legal reasoning system, the degree to which a feature is an element of a feature set that describes a case, is either 1 or 0. In other words, it is judged by users in the form of "Yes" or "No". But sometimes it is difficult to judge Yes/No because of vagueness and uncertainty of knowledge.

Here, the membership concept and the vagueness concept [4] are employed to represent it, where the adaptation that specific knowledge is described by limited words is represented by the concept of membership, and the uncertainty of knowledge is represented by the concept of vagueness.

There are five values for the input of the membership concept, and three values for input of the vagueness. The membership value is m, and the vagueness value is v. The correspondence between numerical representation and fuzzy linguistic representation is shown in Table 1.

Table 1: Values of linguistic variables

membership(m)	vagueness(v)
Completely No (CN) 0	Vague (V) 1
Probably No (PN) 0.25	Roughly (R) 0.5
More or Less (ML) 0.5	Clearly (C) 0
Probably Yes (PY) 0.75	
Completely Yes (CY) 1	

To represent such statute rules and cases, a hierarchical fuzzy frame is used to represent the fuzziness of legal knowledge judged by the membership concept and vagueness concept.

4 Similarity Measures for Fuzzy Sets

A triangular membership function can be used to represent the fuzziness in the Yes/No judgment. The vertices can be defined as:

$$mL = m - mv, \tag{1}$$

$$mH = m + (1 - m)v, \tag{2}$$

where m and v assume the values shown in Table 1, and mL and mH show the lower limit and upper limit of m, respectively.

There are several methods for the determination of similarity measures of fuzzy sets [2]·[6]. Because the fuzzy set used here becomes a singleton when judgment is crisp, and two fuzzy sets sometimes do not overlap, the methods in the literature cannot deal with these problems. Therefore, we propose a new approach discussed below.

Let the membership function of A be μ_A, The center of gravity of A can be calculated by

$$CG(A) = \frac{\int_{a_1}^{a_2} x\mu_A(x)dx}{\int_{a_1}^{a_2} \mu_A(x)dx}. \tag{3}$$

The distance between two centers of gravity, i.e. $| CG(A) - CG(B) |$, is used to describe the the similarity degree (Figure 2). To satisfy the conditions of similarity relations, the degree of similarity $S(A, B)$ is calculated by

$$S(A, B) = (1 - |CG(A) - CG(B)|). \tag{4}$$

5 Retrieval

For retrieving the most similar precedent case from a precedent case base, a method of two-stage retrieval is

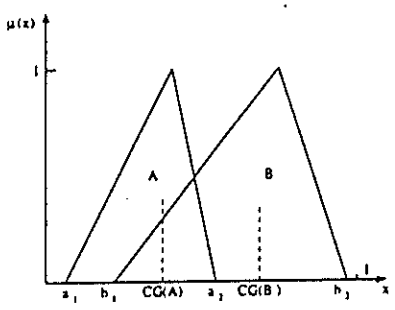

Figure 2: The Similarity Between Fuzzy Sets

proposed. In the first stage, called Issue Index, a set of precedent cases, in the precedent case base, which seems to be relevant to the query case, is hunt. In the second stage, that is based on the similarity measures between features, the most promising case is further retrieved from the collection of the retrieved cases. The two stages are based on the hierarchical representation of the cases.

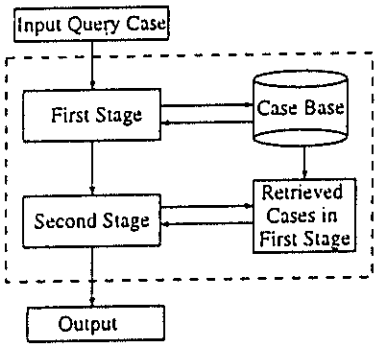

Figure 3: Similarity Measure in the Retrieval

Issues Index

According to the issue, and the conclusion of the issue that the user is interested in, the related cases can be retrieved. The issues index can improve the utilization of the index in case retrieval, especially since it can smoothly narrow down cases to a single issue, to meet the users' needs from different viewpoints.

In the first stage, the cases can be indexed by the article number and the names of issues, as well as the conclusion of cases. This stage uses a simple crisp matching.

Similarity Between Features

In the second stage, the similarity between issues is measured by the similarity between the features of the cases, that are represented by fuzzy frames. The similarity is measured in terms of similarity measure between fuzzy sets introduced in the last section.

Moreover, sometimes, not only a single issue is to be compared between two cases. The algorithm applied for more than one relevant issue should be considered. The similarity between cases is considered to be the weighted summation of the similarity between issues. The result of comparison between two cases is different if users address different aims. So, the weight is introduced in the case retrieval and the average similarity is calculated with weights.

6 Inference

Whether the retrieved precedent case is applicable to the query case should be known after the retrieval has been completed. The precedent conclusion is made by the case rule judgment.

It is known that, for rules, the more similar the antecedent, the more similar the conclusion. Therefore, the inference can be made by the degree of similarity in case rule judgments between the precedent case and query case.

Because there is fuzziness in the case rule judgment, the judgment is described as a fuzzy set here. Therefore, the similarity measures of case rule judgments become similarity measures of fuzzy sets.

The case rule about a point of argument is represented by several frames. Each frame of the precedent and query case can be described as follows:

precedent : $P = \{P_i\}_{i=1}^{n}$,

query case : $Q = \{Q_i\}_{i=1}^{n}$,

P: frame that represents the precedent case,

Q: frame that represents the query case,

P_i: fuzzy set that describes the judgment of case rule elements for the precedent,

Q_i: fuzzy set that describes the judgment of case rule elements for the query case,

n: quantity of slots in a frame.

Similarity measures will be performed as follows:

Let membership functions of P_i and Q_i be μ_{P_i}, μ_{Q_i}, respectively. The center of gravity of P_i and Q_i can be calculated by equation (3).

$S(P_i, Q_i)$ is the similarity degree of P_i and Q_i, and is defined by,

$$S(P_i, Q_i) = (1 - |CG(P_i) - CG(Q_i)|). \quad (5)$$

Let $S(P, Q)$ be the degree of the similarity of P and Q.

It can be calculated by

$$S(P, Q) = min(S(P_1, Q_1), ..., S(P_n, Q_n)). \quad (6)$$

If the degree of similarity is greater than the threshold given in advance, the query case conclusion is the same as that of precedent. If the degree of similarity is less than the given threshold, the conclusion of frame Q can't arrive at the same conclusion as that of precedent. This does not mean that the query case has the opposite conclusion of the precedent. It is necessary to infer it using other precedent or approach for this query case.

7 Experiment

The following eight precedents are selected as the precedent cases of the case base for the experiment.

case1: Experiment tube affair
case2: Screw affair
case3: Leather affair
case4: Jet Engine affair
case5: Car affair
case6: Shoes affair
case7: Tyre affair
case8: Electronic parts affair

All precedents selected here are relevant to the formation of a contract. These are all from CLOUT (Case Law on United Nations Commission on International Trade Law Texts).

A query case that is related to the vague concept "The proposal is sufficiently definite" is summarized as follows:

Event: proposal
Description of event:
The goods are cultivator.
The quantity of cultivator is one.
Concerning the price:
The price of the tractor is fixed.
The price of a set of cultivator is not fixed.
The cultivator contains a rake.

After the issue "The proposal is sufficiently definite" is selected and the corresponding features are judgment, the retrieval is made. In the first stage of the retrieval, pursuant to issue index, i.e. the cases dealing with the issue are picked from the precedent cases. As a result of this example, case2, case3 and case4 are searched. In the second stage, similarity is measured in search-for parts as mentioned in section 5. The similarities of case 2, case 3 and case 4 and the query case are assessed, respectively. For example, the case 4 (Jet Engine affair) may be the case most similar to the query case because the goods are composed of several parts.

The case rules of Jet Engine affair is then judged by users. In terms of the fact of the query case, users can select the fuzzy linguistic variables to answer the elements of case rules. On the basis of the judgment, whether the conclusion of the retrieved case is applicable to the query case is reasoned.

The result is different with the inputs selected by the user. It is helpful for users to know how results are changed by the different inputs. It also helps users (students) to understand CISG and the meaning of precedents and query case.

8 Conclusion

Fuzzy theory is applied to deal with the fuzziness of the legal CBR system. The CISG is selected as the target law. The precedent of the case base is comprised of issues, features and case rules. They are represented by a hierarchical fuzzy frame. The case retrieval and case inference are based on the similarity measure between fuzzy frames.

This work developed the study of the legal reasoning and provided a possibility to build more effective and efficient intelligent legal reasoning systems.

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