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Dear Professor,

we are pleased to be able to inform you that the production of the monograph dedicated to Professor Ernest Czogała has been completed. We hope that the quality of both, its printing and presentation, will fulfill your expectations.

In conclusion, we would like to thank you for your excellent cooperation during the publication of the monograph.

Yours sincerely

DYREKTOR
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ZBIORY ROZMYTE I ICH ZASTOSOWANIA

Praca dedykowana
Profesorowi Ernestowi Czogale

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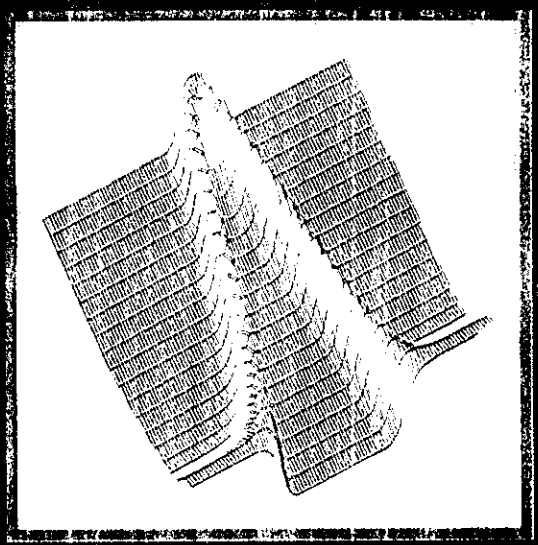
Jana Chojcana i Jacka Łęskiego



$$R_2 = \left\{ \left[(x,z), \sup_{y \in Y} T\left(\mu_{R_1}(x,y), \mu_{R_2}(y,z)\right) \right] \middle| x \in X, y \in Y, z \in Z \right\} \quad R_1 \circ R_2 = \left\{ \left[(x,z), \sup_{y \in Y} T\left(\mu_{R_1}(x,y), \mu_{R_2}(y,z)\right) \right] \middle| x \in X, y \in \right.$$

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DEVELOPMENT OF FUZZY LEGAL EXPERT SYSTEM (FLES) FOR CISG

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Abstract

A fuzzy legal expert system (FLES) based on similarity measure has been constructed, where the target law is the United Nations Convention on Contracts for the International Sale of Goods (CISG). It aims to classify vague legal concepts in the CISG and support the education for the beginners of international law. The FLES is composed of fuzzy legal case-based reasoning (FLCBR) module and fuzzy legal argument (FLA) module. The former provides a primary study on vague legal concepts. The latter is the extension of the former, and can make an argument between plaintiff and defendant. The fuzziness and context-sensitive effects are taken into account in the knowledge representation and similarity measures in these two modules. This work developed the basic study of the legal reasoning method, and established a foundation of intelligent legal reasoning system for the beginners of the field of international law.

1. Architecture of FLES

Statutory rules are different from the logical ones because statutory rules consist of vague legal concepts. Study of statutory rules is difficult for the beginner of law students. An intelligent fuzzy legal expert system (FLES) is constructed to support the law students in studying the vague concepts in the CISG. It explains what the meaning of vague legal concept in a query case is.

Study of legal vague concept is considered to be a two-stage process including the understanding of query case and the related statutory rules, as well as the basic skill of legal argument with cases. Similar precedents are very useful for the understanding of the vague concept. That is why case-based reasoning is used in legal reasoning. Argument is an important characteristic of human intelligence. Especially in law, which is an adversarial domain, for the development of the conventional case-based

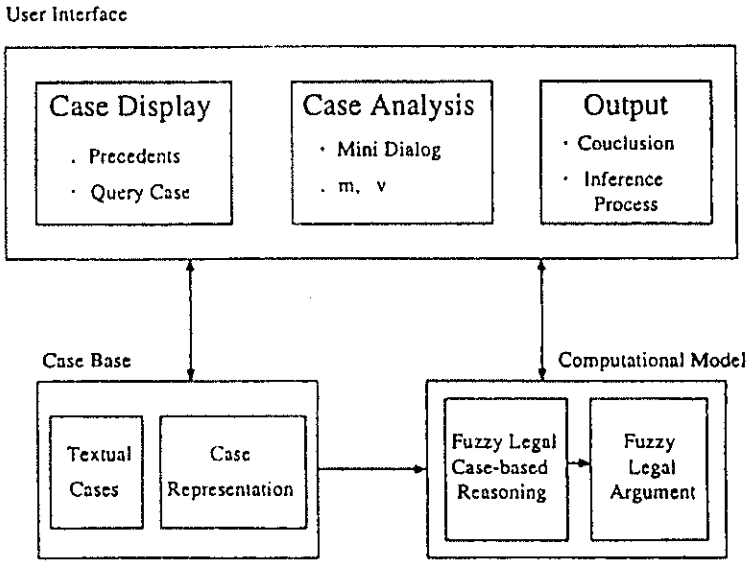

Fig. 1. Architecture of FLES

reasoning, an argument made from the viewpoints of plaintiff and defendant is very useful for the study of vague legal concepts. Therefore, the proposed FLES is composed of FLCBR and FLA modules. In the first stage, the fuzzy legal case-based reasoning (FLCBR) is used. After this stage, users can know the vague concepts and the related case and statutory rules to some extent, in the second stage, the fuzzy legal argument (FLA) is used to give a deeper interpretation. FLA is a high-level legal reasoning because it involves the legal argument. FLCBR is regarded to be the basis of FLA. But, if user has enough knowledge of vague concepts and query case, the first stage of FLES - FLCBR - is not necessarily performed. So, FLCBR and FLA are designed to be performed independently.

The architecture of FLES is shown in Figure 1.

- Case Base: contains the precedents selected from the CLOUT. They are represented by the textual case and case representation including the hierarchical fuzzy frame and the fuzzy factor hierarchy.
- User Interface: consists of integrated tools for case display, case analysis and output of explanation.
- Computational Model: includes the computational models in the two modules.

In the case base of FLES, the case representation is a hybrid knowledge representation that can be appropriate for the two kinds of legal reasoning.

The user interface of FLES offers a set of menu-driven input and output windows, displaying the case representation of the precedent in case base, the case analysis for query case, as well as the inference process.

- Case Display consists of precedents, in case base and query case. The case base is composed of a textual summary, hierarchical fuzzy frame and fuzzy factor hierarchy for each precedent. The textual cases of this system consist of eight precedents. All precedents selected here are relevant for the formation of a contract. All of these originate from CLOUT.
- Case Analysis is conducted by a Mini Dialog. A query case is given by making the judgment in terms of the membership and vagueness concepts that are represented by the linguistic expression introduced in the last chapter.
- Output consists of conclusion of the inference process and the final conclusion. It is of benefit to the students studying the legal reasoning by FLES.

The CISG is an international law, in order to apply our system to international exchange, the user interface of this system is developed in several languages.

The heart of the architecture of FLES is the legal reasoning approach in the computational model. FLES uses FLCBR in the model to retrieve similar precedents from the case base, and judge the adaptation of the retrieved case to the query case. Then, a legal argument is generated by FLA to deeply interpret the classification of vague legal concept from the viewpoints of plaintiff and defendant. The characteristics of the two kinds of legal reasoning used in this system will be further discussed in the next section. Structures of these two kinds of legal reasoning will be introduced in detail in sections 3 and 4.

2. Characteristics of the Two Reasonings

Two kinds of the legal reasoning approaches in FLCBR and FLA mentioned before are employed in the proposed system FLES. The characteristics of these two reasonings are summarized in Table 1.

FLCBR is a typical case-based reasoning, appropriate for retrieving a similar case form a large-scale case base, and knowing if the query case has a conclusion of the retrieved precedent. It is suitable for the case base from which the features and case rules can be obtained. It is useful for users to study the knowledge of the query case, the related precedents and the vague concepts.

Legal vague concepts have a clear kernel, and an uncertain border region, so there is room for argument. The fuzzy legal CBR. is further extended by considering the legal argument. The training of law education involves learning to make arguments for and against the application of statutory rules, and for and against the previous case with respect to the query case. Argument has long been the main topic of AI

Table 1. Characteristics of the Two Reasonings in FLCBR and FLA

	FLCBR	FLA
Knowledge Representation	Fuzzy Frame	Fuzzy Factor Hierarchy
Similarity	Distance-Based	Structural
Inference	Case Rules	Argument Moves
Function	Study of Rules, Cases	Skill of Arguments
Viewpoints	Goal-Driven	Plaintiff, Defendant
Structure	Simple	Complex

and Law researches. Two types of arguments usually exist. One is rule-based, while the other is case-based. Our study is focused on the case-based argument. FLA is a legal argument module based on the proposed structural similarity measure that is combination of similarity measure theory and fuzzy theory. The viewpoints of plaintiff and defendant are both considered, thus the conclusion is a set of the similarity and dissimilarity measures. It is applicable to let students know the legal knowledge from the sides of the plaintiff and defendant, and learn the skill of legal argument.

Generally, the fuzzy legal argument needs a fuzzy factor hierarchy that describes the issues in a adversarial way. Accordingly, a structural similarity is measured in both symbolic and numeric ways. So, the knowledge representation and the similarity measure are more complex in FLA than those of the FLCBR, usually are time-consuming.

3. Experiment of Fuzzy Legal Case-based Reasoning

The query case *Cultivator* [4], that is devised for the legal reasoning of the CISG, is cited for the experiment based on our fuzzy legal case-based reasoning.

The query case is as follows:

1. On April 1, company C in New York dispatched a letter containing an offer to the business branch of a Japanese company D in Hamburg, the content of which is that C sells a set of cultivator(the price of the tractor itself is $50,000 to D. The tractor should be equipped with a rake, which is product of company E. The farming machinery is delivered by a U.S. cargo ship).
2. The letter reached D on April 8.
3. On April 9, D telephoned C to tell "I accept your offer, but you should transport the machinery by a Japanese container"

There are several issues as to whether the contract is concluded. Whether the proposal from C is effective or not is one of them. On the condition that "The proposal is sufficiently definite," the proposal is effective.

According to the issue, this case can be simply described 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.

There are eight precedents in the case base for the experiment:

casel: 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

Articles of precedents can be read from precedents menu. All cases are also presented by a hierarchical frame structure that is composed of issues, features and case rules. The slot values of the frame are described with fuzzy membership value.

In the query case *Cultivator Case*, the controversy between the plaintiff and defendant i.e. whether a proposal is sufficiently definite, can be considered as an issue. The retrieval procedure is divided into two stages. In the first stage, pursuant to issue index, the cases dealing with CISG 14 are picked from the precedents. The precedents in the case base are narrowed down to a part of the precedents. As a result of this example, case2, case3 and case4 are searched for in the first stage.

In the second stage, similarities between the query case and the retrieved precedents in the first stage are measured by the method introduced in section 3.3, are shown in the "Selected Precedent" windows. For example, the case 4 (*Jet Engine case*) is the most similar to the query case (cf. Figure 2).

Then the case rules of *Jet Engine Case* is judged by users.

In terms of the fact of query case, users can select the fuzzy linguistic variables to answer the case rules (cf. Figure 3). The conclusion on the basis of the judgment is derived and displayed in "inference window".

The result is different with the inputs selected by the user. A user can see how small changes in the problem could lead to different results. It is helpful for users to know that results are changed by the different inputs. It also helps users to understand

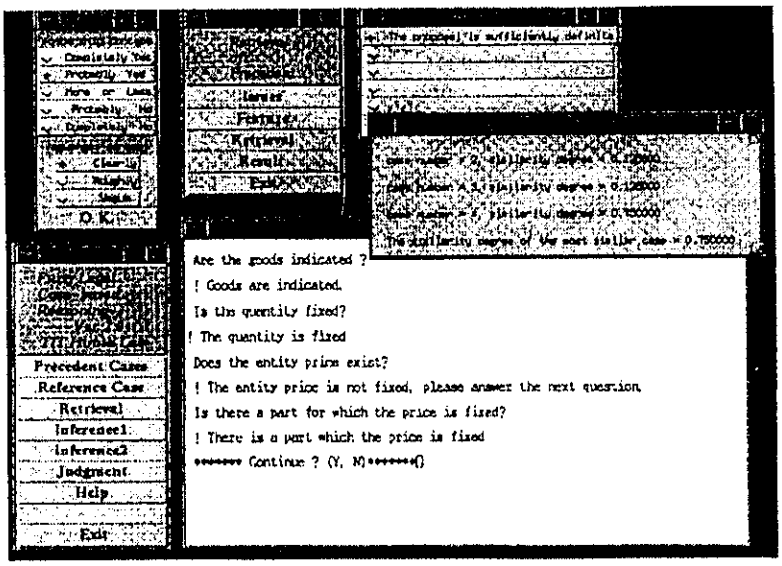

Fig. 2. The Retrieval of Precedents

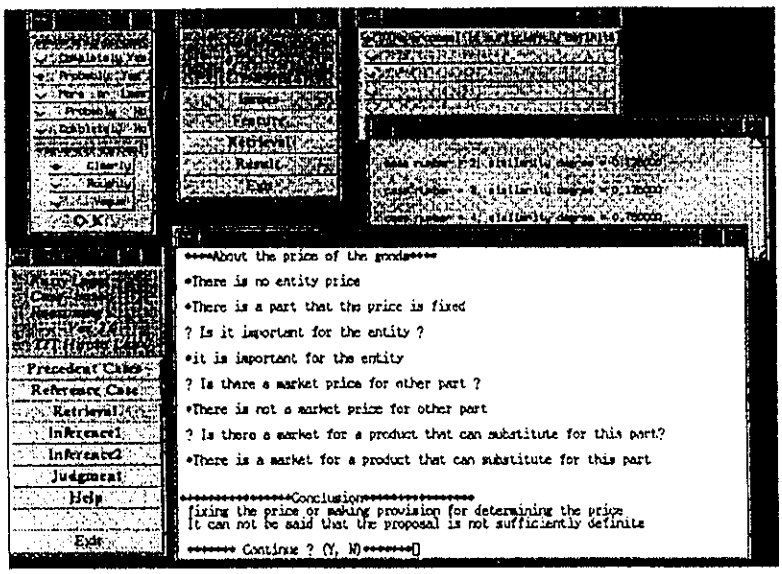

Fig. 3. The Inference by Case Rules

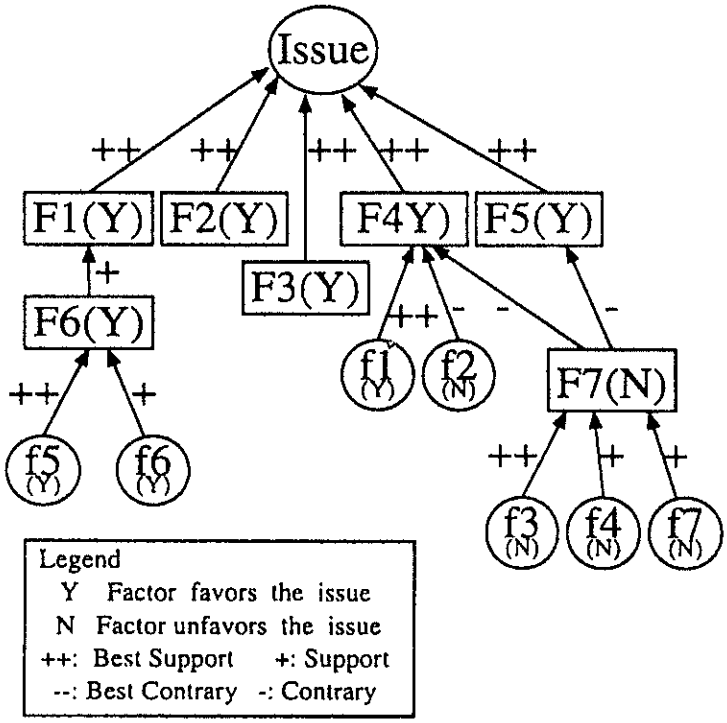

Fig. 4. An Example of Fuzzy Factor Hierarchy in the CISG

the meaning of the statutory rules of the CISG and the meaning of precedents and query case.

FLCBR is constructed on the basis of the comments of the researchers on the legal domain and the law students [4].

The viewpoints of plaintiff and defendant are not emphasized in FLCBR. Legal argument made by plaintiff and defendant is also an important reasoning method in law. A fuzzy legal argument considering the viewpoints of both plaintiff and defendant is proposed in the next section.

4. Experiment of Fuzzy Legal Argument

This experiment is based on the vague concept and the cases of the CISG. The vague concept "*The proposal is sufficiently definite*" in the CISG is employed to illustrate how to make a legal argument by the proposed approach. The fuzzy factor

hierarchy of this vague concept that is focused in the fixing of price is shown in Figure 4.

The query case *Cultivator Case* mentioned in section 3 is used again here.

The description of "The proposal is sufficiently definite" concerning the price in the query case is the following:

The price of the tractor is fixed.
The price of a set of *Cultivator* is not fixed.
The *Cultivator* contains a rake.

Students can at first decide the degrees that this query case has the factors by referring to the atomic factors of the fuzzy factor hierarchy, then in the light of the output of the legal argument to learn the argument skill and further comprehend the meaning of the vague concept and the query case by comparing with the argument made by himself.

In the case base that is used in this module, there are 8 precedents that are the same as the precedents in FLCBR module. They are represented again by the fuzzy factor hierarchy, for example, the atomic factors of *Jet Engine Case* related to the issue are as follows:

f_1: The important part has a price
f_2: The attachment has no price
f_3: The attachment is not sold in market
f_5: There is an important part in the goods
f_6: There is an attachment
f_7: There is no similar product for the attachment.

If the following atomic factors are considered to be the properties of the query case *Cultivator Case*, an example of the output of this system for the query case is shown in Figure 5.

f_1: The important part has a price
f_2: The attachment has no price
f_3: The attachment is not sold in market
f_4: There is no product that can substitute the attachment
f_5: There is an important part in the goods
f_6: There is an attachment.

The explanation for the process of the argument is as follows.

Plaintiff's Claim

The proposal of the query case is not sufficiently definite, because it has the most

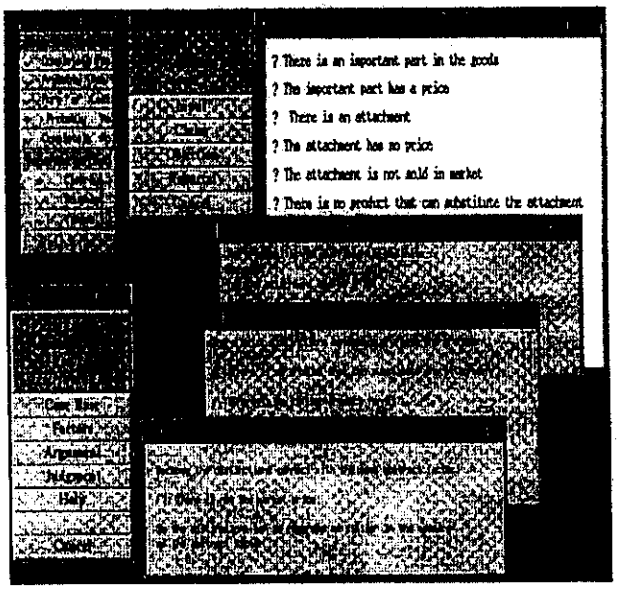

Fig. 5. An Example of the Legal Argument

high similarity degree with the *Jet Engine Case* that has the conclusion: the proposal is not sufficiently definite, because the query case has the factors f_2, f_3.

Defendant's Objection

Jet Engine Case case is not applicable to the query case, because there is f_4 in the query case, and f_7 in the precedent.

Plaintiff's Rebuttal

Jet Engine Case case is still applicable to the query case, even though there is f_4 in the query case, but it is the same as the f_7 in the *Jet Engine Case* under the meaning of the abstract factor F_7. They both support the abstract factor F_7: there is not the market price. So, the proposal is not sufficiently definite.

The output of the system is different with the judgments selected by the user. It is helpful for users to know that results are changed by the different inputs. It also helps users to learn the skill of making legal argument. And, it is also helpful for students to understand the meaning of the statutory rules of the CISG and the meaning of the precedents and query case from the viewpoints of plaintiff and defendant.

5. Discussion

5.1. Comparison with the Related Work with FLCBR

(1) Comparison with L. Philipps's Work

The legal domain is a challenge for the fuzzy theory because it is unlike the other domains where the fuzzy theory is sufficiently applied. L. Philipps proposed a fuzzy legal reasoning system that deals with the vague concept [3]. In his system, the fuzzy rule inference is used to determine the required period of waiting after traffic accidents.

In the determination of the required period of waiting after traffic accidents, such the following rules are included:

If light damage occurs, a short period of waiting is required,
If medium damage occurs, a medium period of waiting is required.

Having constructed such a rule base, the next step is to use it in obtaining the values for the consequences or actions. The firing levels of the rules for the query case are calculated. After the calculation, these firing levels are used to do a weighted aggregation of the individual rule consequences.

However, in legal reasoning system, not only numeric features exist, but also many symbolic features exist. The features having numeric values are few. Fuzziness exists not only in a numeric value, but also in a judgment on the existence of a feature. In the conventional fuzzy inference, after the rule actions are generally associated with the assignment of a numeric value to variables, the aggregation techniques that are applied in the control domain just can be used on the decision of quantity in the vague concept. On the other hand, because there is no explanation of the inference process, the importance of the conventional fuzzy inference in the legal reasoning is restricted.

Compared with L.Philipps's work, in this dissertation, fuzzy theory is applied in legal case-based reasoning. In legal case-based reasoning, the consequences are more complex. There does not exist a simple aggregation technique that can be used

Table 2. Comparison with L. Philipp's Work

	Knowledge Representation	Retrieval	Explanation	Inference
Philipp's Work	Fuzzy Rule	×	×	Center of Gravity
FLCBR	Hierarchical Fuzzy Frame	○	○	Similarity Measure

for different domains. The similarities and distinctions between a query case and precedents are different with the precedents. On the other hand, it is difficult for users to give exact judgments on a query case in terms of their knowledge. The presented system is helpful for the beginner of the law, where a query case with vague legal concept is represented by issues, features and case rules. The existences of the features and case rules is judged with membership and vagueness concepts that can be selected by users easily. when a query case is dealt, at first, after the selection of the issue and the judgment on the features of the query case, the precedents similar to the query case are retrieved according to the requirement of users, and the understanding of the query case and the related statutory rules. Then, whether the most similar precedent retrieved is applicable to the query case is further inferred by the judgment of the case rules. The case retrieval and inference in FLCBR are based on the similarity measure between the fuzzy frames. It agrees with the cognition process of human beings in legal case-based reasoning. In L.Philipps's work, it is lack of retrieving the precedents similar to the query case from a case base, and a comparison between the cases.

(2) Comparison with GREBE

GREBE(GeneratoR of Exemplar-Based Explanations) [2] is a system for legal analysis determining whether a legal classification applies to a new case and explaining this determination. It uses detailed knowledge of the facts and reasoning of specific past cases, together with legal rules and common-sense knowledge to determine and justify the legal consequence of the query case.

GREBE describes a process of legal reasoning that is the complementarity of rules and precedents in the classification task. GREBE can apply either case-based reasoning or rule-based reasoning to goals. But case-based reasoning is the central in GREBE, and statutory rules just assist case-based reasoning through rule moves. So the main similarity between FLCBR and GREBE is that case-based reasoning is used in them. The main difference between FLCBR and GREBE is related to the fuzziness existed in the case representation and the similarity measure. GREBE is established on the basis of the case representation is crisp, while the fuzziness is considered in FLCBR. Besides the fuzziness, the other comparison is simply discussed as below.

The legal knowledge representation in GREBE is composed of issues, features and statutory rules, while in FLCBR it is composed of issues, feature and case rules. In FLCBR, even though the statutory rule isn't used directly, the relation between it and precedents is emphasized, moreover, the relation is concluded as case rule that can be used again in the classification of the vague concepts like statutory rule.

In the view of the function, GREBE performs the legal analysis composed of the retrieval, adaptation and explanation, while FLCBR is mainly focused in retrieval and adaptation. In GREBE, two types of rule-based inference: *Term Reformation* and *Case Elaboration*, are used, while in FLCBR, distance-based similarity measure is used in the retrieval and adaptation. The function of explanation in FLCBR is not stronger than GREBE's. But it is compensated with the FLA that is able to generate

Table 3: Comparison with GREBE

	Representing Fuzziness with Fuzzy Set	Knowledge Representation	Inference	Function
GREBE	×	Issues, Features, Statutory Rules	Rule-based	Legal Analysis
FLCBR	○	Issues, Features, Case Rules	Similarity Measure	Retrieval, Adaptation

the legal argument where a more complex explanation than that generated by the *Term Reformation and Case Elaboration* in GREBE.

5.2. Comparison with the Related Work with FLA

(1) Comparison with HYPO

Ashley and Rissland's HYPO system is a famous legal argument system in the legal domain. The presented system is compared with it in the following ways.

a. Fuzziness

In HYPO, a *dimension* is used to represent the property of a precedent. A dimension is applicable if all of its prerequisites are satisfied, and is a near miss if all of its prerequisites are satisfied except several items. The objective judgment of a human being is not considered. For example, the focal slot *Number-discloses* of a dimension in HYPO, is a crisp value, and the criteria of comparison are only Greater-than and Less-than. Moreover, the fuzziness exists not only in the numeric value, but also in the judgment, and the relations between the dimensions. However, these are not considered in HYPO.

b. Representation and Integration of Multiple Knowledge Types

The knowledge representation in HYPO is a dimensional structure. The problem of dimensional or featural representation is that they fail to capture the conceptual content in detail, and it is difficult to represent the inferential knowledge. The main advantage is its simplicity. Through the abstraction mechanism in the fuzzy factor hierarchy, it is possible to tightly integrate inferential knowledge with more atomic

Table 4: Comparison with HYPO and CATO

	HYPO	CATO	FLA
Knowledge Representation	Dimension	Factor Hierarchy	Fuzzy Factor Hierarchy
Representing Fuzziness with Fuzzy Set	×	×	○
Similarity Measure	Feature, Distance	Feature, Context	Structural
Argument	Symbolic, Numeric	Symbolic	Symbolic, Numeric

factors that correspond to the dimension in HYPO. This leads to the similarity measure in accordance with their contextual bias.

c. Similarity Measure

The similarity measure in HYPO is the conventional feature-based similarity measure. The distance-based similarity is neither included in the argument, nor related to the evaluation of the significance of the similarity and distinction. In particular, HYPO is concentrated on the research of law, while the similarity measure is not systematically analyzed, e.g. the properties of the similarity measure are not involved. In order to deal with this problem, the structural similarity measure, based on the context-sensitive effects and fuzziness, integrated by the distance-based similarity, feature-based similarity as well as the context-based similarity, is proposed in the presented system.

(2) Comparison with CATO

Aleven's CATO [1] is also a legal argument system. The presented system is compared with it in the following ways.

a. Knowledge Representation

In the structure of knowledge representation, both two systems use the factor hierarchy, but, the component of a factor hierarchy, i.e. the meaning of a factor, is not the same. The biggest distinction is that the fuzziness that exists in precedents and query cases is not considered in the knowledge representation as the reason of the argument in CATO. The fuzzy factor hierarchy proposed here contains the factor hierarchy in CATO, namely, the knowledge representation in CATO is a subset of the fuzzy factor hierarchy. Therefore, CATO was not able to make the argument that

is generated by the fuzziness. In addition, the magnitude of a factor, i.e. the factor value, is not considered in the factor representation as well as the legal argument in CATO.

b. Similarity Measure

Even though in CATO the significance of the similarity and distinction is assessed, it is restrictive, and is not studied systematically. In the presented system, by considering the fuzziness and context, and integrating the distance-based and features-based similarities and the proposed context-based similarity measure, a framework of structural similarity measure is proposed. The proposed context-based similarity is studied thoroughly from the ways of classification and property. The retrieval and evaluation functions in the context-based similarity measure are studied. By a structural similarity, a legal argument that symbolic expressions and numeric values are involved, is structured.

(3) Limitations of our system

Even though both HYPO and the presented system apply the "three-ply" arguments, the argument moves in HYPO are more complex. HYPO was able to make an argument by generating hypothetical modifications of a precedent. In that way, how hypothetical changes in a problem could lead to different results can be seen to some extent, e.g. how an argument could be strengthened if there are additional facts in the query case. Realizing this function means that more cases are necessary.

As a whole, the similarity-based fuzzy legal expert system is of benefit to the students to study the vague legal concepts in the CISG. Compared with the other legal expert systems, capturing the fuzziness and considering context-sensitive effects are the features of this system.

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