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International Neural Network Society (INNS)

SOFT Japan Society for Fuzzy Theory and System (SOFT)

JNNS Japan Neural Network Society (JNNS)

Kyushu Institute of Technology (KIT)

FLSI Fuzzy Logic System Institute (FLSI)

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Learning a Vague Concept and Making Argument from Examples by Fuzzy Factors Hierarchy in the Legal Reasoning System

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Abstract

An argument model considering the fuzziness of cases is proposed. A notion of fuzzy factors hierarchy is employed to represent the cases with fuzziness. The argument model is based on the measures of similarity and dissimilarity of cases according to the viewpoints of agents. The similarity and dissimilarity measures are made by the distance-based and set-theoretic-based methods. The system proposed here is made for the education of law, especially for the United Nations Convention on Contracts for the International Sale of Goods(CISG).

1 Introduction

It is known that there exist vague concepts in knowledge-based system. Usually there is no single explicit representation of an entire concept or class, but only representation of the examples on the vague concept. For a query case, by learning from the examples, it can be known whether the query case belongs to the vague concept. Many methods have been developed to address this issue. The argument seems to attract the interest of researchers from various areas, especially from legal reasoning, decision theory, philosophy, psychology and cognitive science[3][7]. In these domains, an argument system can act as assistant and advisor, by facilitating communication and recommending solutions, but leaving the final enforcement of decisions to the agents.

The factors of a case are usually employed to represent the case[3]. We know that there are uncertainty and vagueness information in cases, a case has not always the explicit and specific factors. So there exists a room for argument made by agents, namely, fuzziness generates argument.

In the argument made by human beings for dealing with the fuzziness, the similarity and dissimilarity play an important role. If one side analogies the query case to a precedent case, the other side will distinguish them. If one side emphasizes the similarity, the other side will diminish it, namely, will emphasize the dissimilarity of them[8].

Our goal is to develop a computational and representational model of argument based on the similarity and dissimilarity measures.

Case representation is the basis of argument. The fuzzy factors hierarchy in three layers is applied to represent cases. The similarity and dissimilarity are measured by the distance-based and set-theoretic-based methods. Based on the similarity and dissimilarity measures, an argument model is proposed. Considering the vague concept in the CISG (United Nations Convention on Contracts for the International Sale of Goods), an experiment on legal argument is made.

The fuzzy factors hierarchy is introduced in section 2. The similarity measure is described in section 3. The argument model is presented in section 4. The result of the experiment on the vague concept of the CISG is illustrated in section 5.

2 Fuzzy Factors Hierarchy

Concept representation by factors is an approach often used in legal expert system. In order to represent the complex relations between a concept and its factors, factors hierarchy is also used[8]. A factor is either an element of a case or not in the literature. Whether a query case belongs to a concept is judged by the common and distinct factors between the query case and precedent cases.

But the factors of a case are not always all crisp, namely, a factor is probably not either an element of a case or not, sometimes is an element of a case only in some extent. The value of a factor may be also fuzzy linguistic representation. So traditional factors hierarchy is not appropriate to be used to model human internal representation of cases. A fuzzy factors hierarchy is proposed to represent the legal cases.

Definition 1 A fuzzy factor is composed of Name, Degree, Values, Relations and Agent, is denoted by < N, D, V, R, A>, where

N: Name, describing the facts of cases,

D: Degree, indicating what the extent that a case has the factor,

V: Factor Values, representing how extreme the factor is in a case to which it applies,

R: Relations, representing the level of the action of support or opposition for other factors,

A: Agent, representing that a factor is which side's viewpoint of the agents.

The names of factors usually are symbolic expressions describing the facts of cases.

A vague concept is usually a set of these factors, which its dimension being the number of factors that belongs to this case and elements are these factors. In traditional legal expert system, the degree that a factor is an element of a factor set that describes a case is either 1 or 0, in other words, is the Yes/No form. But it is sometimes difficult to judge Yes/No because of vagueness and uncertainty.

There are several methods to describe the degree, here the membership concept and vagueness concept are employed to represent the fuzzy Yes/No[4], where the adaptation that specific knowledge described by limited words is represented by the concept of membership, and the uncertainty of knowledge is represented by the concept of vagueness.

The values of a factor are magnitudes of a factor that are often represented by quantity. Quantitative property is related with numeric data, it is an important term in argument system. It usually has three types of representations, including crisp-data, interval-data and fuzzy-data.

The relation between factors could be strengthened or weakened with qualifiers, they could be crisp set or fuzzy set. In different domains, there exist different relational expressions. For example, in the case of the CISG it could be the expression like as {Best support, Support, Contrary, Best Contrary}.

Each factor represents the viewpoint of one of the agents who take part in the argument. In legal argument system, usually agents only includes a defendant and a plaintiff.

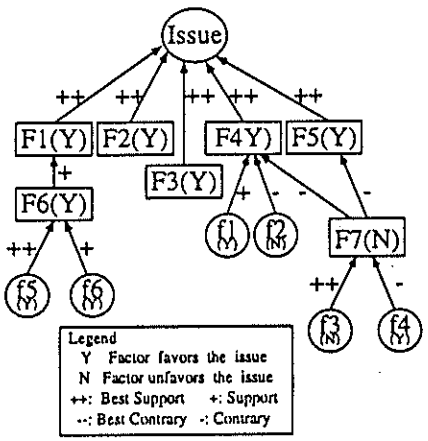

Figure 1: An Example of Fuzzy Factors Hierarchy in the CISG

Fuzzy factors are divided into fuzzy atomic factors and fuzzy abstract factors.

The fuzzy atomic factors represent the surface facts of a case. The abstract factors are the connections between the claim of a vague concept and the fuzzy atomic factors.

The claim of a vague concept is called *Issue* here.

A fuzzy factors hierarchy can be defined in the definition 2.

Definition 2 A factors hierarchy is structured by three layers.

Top level: Issue

Middle level: Abstract factors

Bottom level: Atomic factors

The top level of a fuzzy factors hierarchy is constructed by only one node, that represents the claim of a vague concept. The bottom level is the fuzzy atomic factors.

The factors of the middle level are structured by fuzzy abstract factors. A node can be explained by *and* and *or* of the sub-nodes. The number of nodes in the middle level is usually more than one.

The fuzzy factors hierarchy itself represents a causal connection between an *Issue* and the related fuzzy atomic factors and fuzzy abstract factors.

Figure 1 shows an example of a fuzzy factors hierarchy of the legal reasoning system for the CISG. The top level *Issue* is a claim of the vague concept "The proposal is sufficiently definite". The F1, F2, F3, F4, F5, F6, F7 are abstract factors, and f1, f2, f3, f4, f5, f6 are atomic factors. The meaning of these factors will be explained in section 5.

3 Similarity Measure

Similarity measures are defined at three levels: atomic factors, values of atomic factors, aggregation of similarities and dissimilarities. Appropriate similarity measures are chosen and applied based on the requirements. The notion of similarity is based on the distance(metric) and the set-theoretic[10]. The comparisons of factors values are measured by the distance-based similarity. The fuzzy atomic factors comparisons are measured by the fuzzy T-norms. Aggregation of similarities and dissimilarities is based on the extension of set-theoretic similarity measure proposed by Tversky[1].

3.1 Comparisons of Factors Values

A triangular membership function can be used to represent the fuzziness of factors values. For example, the magnitudes of the importance of the important part in the vague concept "*The proposal is sufficiently definite*" in the CISG can be described as fuzzy membership function.

There are several methods for the determination of similarity measures of fuzzy sets[2]. Because the fuzzy set used here becomes a singleton when the factors values become crisp data, and two fuzzy sets sometimes do not overlap, the methods in[2] can not deal with these problems. The difference between the centers of gravity of two membership functions A, B is used to measure the similarity.

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

$$S(A, B) = 1 - |CG(A) - CG(B)|. \quad (1)$$

3.2 Set-Theoretic Similarity Measure

The similarity based on the representation of factors can be measured by their common and distinct features[1][10].

Let $CB=\{P_1, P_2, ...P_i...P_n\}$ be the case base, Q be a query case.

Each case is represented by a set of factors. $P_i=\{m^1_{P_i}, ...m^k_{P_i}...m^t_{P_i}\}$, $Q=\{m^1_Q, ...m^k_Q...m^t_Q\}$, where $m^k_{P_i}, m^k_Q$, denote the degrees that case P_i and Q have the factor k, $(k = 1, ...t)$, respectively.

The similarity S and dissimilarity DS between a query case and a precedent case are:

$$S(Q, P_i) = f(Q \cap P_i), \quad (2)$$

$$DS(Q, P_i) = g(Q - P_i) + g(P_i - Q). \quad (3)$$

They are computed further as below in fuzzy T-norms.

$$f(Q \cap P_i) = \sum_{k=1}^{t} Min(m^k_Q, m^k_{P_i}), \quad (4)$$

$$g(Q - P_i) = Max\{Max(m^k_Q - m^k_{P_i}, 0)\}^t_{k=1}, \quad (5)$$

$$g(P_i - Q) = Max\{Max(m^k_{P_i} - m^k_Q, 0)\}^t_{k=1}. \quad (6)$$

The degree that a factor is an element of a case is determined here by the center of the gravity of membership function.

Tversky describes this kind of similarity measure as a features-set-matching process [1]. Similarity among objects is expressed as a linear combination of the measure of their common and distinct features.

$$S(P_i, Q) = \theta f(P_i \cap Q) - \alpha g(P_i - Q) - \beta h(Q - P_i), \quad (7)$$

where θ, α, β are weight parameters.

In legal reasoning system, it involves the argument made by plaintiff and defendant, the similarity and dissimilarity are measure from different viewpoints. The aggregation of them is not simple as (7). Argument between plaintiff and defendant forms the aggregation process.

4 Making Argument

Because interpretation of a vague legal concept in a case is related to the debates made by plaintiff and defendant. Whether a precedent case is similar to a query case, usually is debated by these two sides.

In an argument, if one side analogies the query case to a precedent case, the other side will distinguish them, and if one side emphasizes the similarity, the other side will downplay it, namely, emphasizes the dissimilarity of them. So both similarity and dissimilarity should be measured. A factor has different values in different cases. It should also be considered that every factor has a pro or con direction in reasoning process.

The proposed argument model in legal reasoning system consists of three steps:

1. One Side's Claim

The similar cases are retrieved from a set of examples. The case that has the most high similarity degree of facts to that of the query case is as the most on point case P_{mopc}. If the conclusion of case P_{mopc} favors the one side, the conclusion is regarded as the one side's claim I_{claim}.

I_{claim}={ The conclusion of the case P_{mopc})} ∪ { The factors that support the conclusion of the case P_{mopc}}.

$S(Q, P_{mopc})$ should satisfy

$$S(Q, P_{mopc}) = Max\{f(Q \cap P_i)\}^n_{i=1}. \quad (8)$$

2. Another Side's Objection

Another side finds the distinction from the query case and the case P_{mopc}, and emphasizes it. The distinction includes the difference between the shared factors, and the unshared factors. The former is the difference between the values of shared factors, the later is to find the factor that favors this side from the unshared factors.

$I_{objection}$={ The pro factor that has the most high dissimilarity degree $DS1(Q, P_{mopc})$} ∪ { The pro factor that has the most high dissimilarity degree $DS2(P_{mopc}, Q)$} ∪{ Comparisons of values of the shared factors }

$$DS1(Q, P_{mopc}) = g(Q - P_{mopc}), \quad (9)$$

$$DS2(P_{mopc}, Q) = g(P_{mopc} - Q). \quad (10)$$

3. One Side's Rebuttal

The first side downplays the dissimilarity, by finding the factors that can disregard the difference emphasized by the other side in the levels of the *Relations* between the factors.

$I_{rebuttal}$={ The factor that can downplay the difference by the *Relation* }

In these 3 steps, if there are relevant cases supported it they should be cited.

By these 3 steps, a context-sensitive interpretation $I_{inference}$, namely, the output of the proposed argument model, can be formed as

$$I_{inference} = I_{claim} \cup I_{objection} \cup I_{rebuttal}. \quad (11)$$

5 Experiment

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 model them by the proposed approach. The factors hierarchy of this vague concept that is focused in the fixing of price is shown in Figure 1.

Let us suppose a plaintiff claims that the proposal is not sufficiently definite in order to deny the conclusion of the contract.

In statute rule 14 there exists a definition on this concept, but there are not the explicit criterion for the judgement of the definition. The main content of the statute rule 14 is as a part of the abstract factors, and is shown as following:

{F1: Indicating the goods} *and* ({F2: Fixing the quantity } *or* {F3: Making provision for determining the quantity}) *and* ({F4: Fixing the price} *or* {F5: Making provision for determining the price}).

The other two abstract factors existed in case *Malev*[9] are shown at below:

F6: The goods are composed of several parts.

F7: There is not the market price.

The atomic factors of case *Malev* are as following:

f_1: The important part has a price

f_2: There is a part that no price

f_3: The goods are not sold in market

f_4: There is a substitute part

f_5: There is an important part

f_6: There is a affix part

The description of "The proposal is sufficiently definite" concerning the price in a query case *Cultivator case*[9] is the following:

The pri ce 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 factors hierarchy, then in the light of of the output of the argument system to learn the argument skill and comprehend the meaning of the vague concept and the query case by comparing with the argument made by himself.

The following is an example of the output of this system for the query case.

Plaintiff's Claim

The proposal of the query case is not sufficiently definite, because it has the most high similarity degree with the *Malev case* that has the conclusion that the proposal is not sufficiently definite. Because the query case has the factors f_1, f_2, f_5, f_6.

Defendant's Objection

Malev case is not applicable to the query case, because there is f_4 in the query case, it indicates that a substitute part supports the abstract factor that making provision for determining the price.

Plaintiff's Rebuttal

Malev case is still applicable to the query case, even though there is f_4 in the query case, but the relation of this factors to F7 is not stronger than that of f_3. So the proposal is not sufficiently definite.

6 Conclusion

By the fuzzy factors hierarchy, the uncertainty and vagueness of concepts are represented. The similarity and dissimilarity are used to represent the debates between agents. The argument based on the similarity and dissimilarity measures is modelled. In terms of factor hierarchy and the organization of the argument model, a vague concept can be learned from examples. An example on legal reasoning system is used to verify the effectiveness of this model. Extending the case base, and considering hypothesis in the argument are the future work.

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