A legal reasoning system based on a collective situation model

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Studies of legal reasoning is notable, because not only that it is an integration of various technology of AI, but also that it is an application of computers to the real world. Recently, in this domain, situation dependency for both static and dynamic aspects, that is, representation and inference respectively, has been regarded as an important factor. In legal reasoning, various situations around the current case should be concidered to reach a proper conclusion. A cognitive agent (occasionally, human being) brings background conditions from various aspects into the inference. Background conditions contains common sense around the agent, its values, its standpoint, and so on. On the other hand, in the target case of the inferece, we can see temporal scenes or spacial locations as situations. In the analysis of legal cases, we have observed necesity to consider especially temporal situations which articulates the progress of time in the current case. In the earlier studies of legal reasoning, they study the formalization of legal reasoning based on situation theory because situation theory provides us logical foundation for situation dependency and information flow from one situation to the other. One of their purposes is to enhance the efficiency of representation and to execute inference on that representation according to uniform form of situations. That is also our primary purpose.

Almost their works deal with situations like modules which are collections of facts and rules. they, however, does not treat properties of situations themselves. Therefore, we propose a formal situation model to treat such properties. To put it concretely, we consider a situation not as a primitive, but as a set of more primitive elements. We assume an existence of that primitive elements, we call it a *particle of situation; pos*, and we specify relations between *pos*s, we call them *neighborhood relation*s. We represent a situation as a set of *pos*s connected each other by neighborhood relations. We call that model a

collective situation model. In this model, situations hold their properties depending on a species of situation by relating situations each other, and they have a set of elements of information(called *infon*s). Moreover, we distinguish *support relations*, which are relations which specify if a situation support infons, into three parts. According to that, we provide one solution for persistency of infons which is one of conciderable problems in situation theory. We have two advantages in this model. Firstly, a *support map*, which is a set of infons supported by a certain situation, can be calculated constructively. Secondly, we can have a flexible world structure because situations can be constructed from a graph composed of neighborhood relations and *pos*s.

Using that situation model, we show uniformity of representation of various kind of situations. In that, we especially concider temporal situations. It is so effective to represent temporal information as situations becuase of frequency of change of konwledge according to transition from one temporal scene to the other. We provide a model that has *situations* which stands for point- or interval-like entity on the temporal axis. Situations are related each other by such ordinary temporal relations as 'during', 'meet', 'overlap' and so on, and they hold eventualities as *infons*. The main advantage of this model is that we only need to consider temporal relations between situations, and can disregard temporal properties of each *infon*; thus, this model allows us to consider only useful temporal information, and clearly defines a temporal stage in a case as a situation as well. We have three reasons why situations are used to represent temporal information. Firstly, it makes us describe universal properties about temporal aspect of assertions to detach temporal information from assertions. Secondly, we can take two viewpoints for situations, exterior and interior ones. In an exterior viewpoint, we can represent various temporal relation between situations as entities. On the other hand, we can see the situations as the set of infons in an interior viewpoint. Thirdly, according to uniformity of situation representation, constrains between temporal situations and other type of situaions can be described efficiently.

Furthermore, we formalize an inference mechanism based on the collective situation model. According to examining coginitive agent, we devide situations into two domains, a target domain and a reasoning domain. In the target domain, we define reasoning mechanism which specify the situation, depending on given goal, with constraint solving between situations. Thanks to representing situations as sets, constraint solver makes situations which apear in the constraint suit with the correspond set-theoritic relations such as it subset, *union*, *intersection*, and so on. On the other hand, for reasoning domain, we apply *defeasible reasoning* to our situation model. Defeasible reasoning is one of inference mechanizms for obtaining an consistent solution from an inconsistent rule-set. We also examine an unification mechanism not only for infons but also for situations. In solving a goal, the given goal has two meanings. If a situation of the goal is specified, the goal asks whether the infon of the goal is supported in the situation or not. Otherwise, if the situation is not specified, that is, it is a variable, then the goal asks whether any situation which holds the infon exists and, if it exists, asks what the situation is.

In this thesis, We designed a language/system based on the collective situation model. This system has following features:

- definitions of inference rules, facts, support maps and relations between situations by user,
- an unification function which distinguishs events and properties,
- an inference mechanism as extended resolution mechanism, which has a constraint solver to specify situations dynamically in the process of the inference, and
- a user interface that provides a query system, displaying data.

We believe the system can be applied not only to legal reasoning but more general problem solving. We showed that the system works well for representing and infering cases where we had to deal with complex temporal relations.