Argumentation Theory for Reasoning with Inconsistent Ontologies (Extended Abstract)*

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Ontology languages are an important method to represent knowledge. A description logic has difficulty reasoning under inconsistent information, as well as providing an explanation of how a result of a query is reached and why it is acceptable. Justification has been shown to be an effective type of explanation to bring about changes in the system [7]. Formal argumentation, as a method for handling reasoning with inconsistent information, provides various ways to explain why a claim is justified, which makes it a promising tool to solve the problems above. $ASPIC^+$ [5, 6] is a rule based argumentation framework, in which (finite) arguments are constructed by strict or defeasible rules from the set of premises. Strict rules are applied to model certain inferences, while defeasible rules are applied to model uncertain inferences. $ASPIC^+$ can resolve conflicts between arguments by preferences, and can evaluate whether an argument is acceptable based on abstract argumentation frameworks and argumentation semantics [2]. For more details, please see [5, 6, 1, 2]. Compared with other applicable argumentation systems, such as *DeLP* [3], in this paper we chose $ASPIC^+$ because: 1) it supports modeling different types of attack relations between arguments (i.e., rebutting, undermining and undercutting), and hence can more flexibly express inconsistency; 2) it supports skeptical and credulous justification, which can reflect users' different attitudes. For the reasons above, we propose deriving an argumentation theory called *DL-AT*, which translates a DL ontology into ASPIC+. What's more, we propose a novel definition of explanation.

This paper considers ontology based on $\mathcal{ALC}$ expression. To translate a DL ontology into an argumentation theory (AT), the logical language $\mathcal{L}$ of AT represents concepts C as unary predicates $C(x)$, while the roles P are represented as binary predicates $P(x, y)$. For ABox assertions, x, y are individuals, and formulas in ABox are contained in the set of premises $\mathcal{K}$ in *DL-AT*. As for the TBox, inspired by [4], we interpret the declarations in it as strict/defeasible rules in the set $\mathcal{R}$ of AT as shown in Table 1, where C, D are basic concepts, P, Q are roles,

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x, y are individuals and α, β are free variables. $\rightarrow$ and $\Rightarrow$ denote strict rules and defeasible rules respectively. According to specified context, a formula can only be translated to one type of rule.

Table 1. Mapping from TBox of DL ontology to rules in the *AT*

TBox of DL	rules in $\mathcal{R}$ of AT
$C \sqsubseteq D$	$C(x) \rightarrow / \Rightarrow D(x)$
$C \equiv D$	$D(x) \rightarrow / \Rightarrow C(x)$ & $C(x) \rightarrow / \Rightarrow D(x)$
$C \sqsubseteq \forall P.D$	$C(x), P(x,y) \rightarrow / \Rightarrow D(y)$ & $C(x) \rightarrow / \Rightarrow P(x,\alpha)$
$P \sqsubseteq Q$	$P(x,y) \rightarrow / \Rightarrow Q(x,y)$
$P \equiv Q$	$P(x,y) \rightarrow / \Rightarrow Q(x,y)$ & $Q(x,y) \rightarrow / \Rightarrow P(x,y)$
$C \sqsubseteq \exists P.D$	$C(x) \rightarrow / \Rightarrow P(x,\beta)$ & $C(x), P(x,\beta) \rightarrow / \Rightarrow D(\beta)$
$C \sqcap D \sqsubseteq \emptyset$	$C(x) \rightarrow / \Rightarrow \neg D(x)$ & $D(x) \rightarrow / \Rightarrow \neg C(x)$
$C \sqsubseteq D \sqcup Z$	$C(x) \rightarrow / \Rightarrow D(x) \vee Z(x)$ & $C(x), \neg D(x) \rightarrow / \Rightarrow Z(x)$ & $C(x), \neg Z(x) \rightarrow / \Rightarrow D(x)$
$C \sqsubseteq D \sqcap Z$	$C(x) \rightarrow / \Rightarrow D(x)$ & $C(x) \rightarrow / \Rightarrow Z(x)$

Based on the translation, a *DL-AT* is defined as follows.

Definition 1. *Let $\Delta = (T, A)$ be a DL ontology, a DL-AT$_\Delta$= $(\mathcal{L}, \mathcal{R}^T, \mathcal{K}^A)$ is an argumentation theory constructed with Δ, such that $\mathcal{R}^T$ is the set of rules corresponding to T based on Table 1, and $\mathcal{K}^A$ is the set of premises based on A.*

Based on Definition 1, arguments can be constructed by rules in $\mathcal{R}^T$ from the set of premises $\mathcal{K}^A$.

According to paper [2], an extension E is a set of arguments that are collectively acceptable under certain argumentation semantics $\mathcal{S}$. An argument A is *acceptable* w.r.t. an extension $E_\mathcal{S}$ under $\mathcal{S}$ if $A \in E_\mathcal{S}$. A is *skeptically justified* under $\mathcal{S}$ if $\forall E_\mathcal{S} \in \mathcal{E}_\mathcal{S}$, $A \in E_\mathcal{S}$; A is *credulously justified* under $\mathcal{S}$ if $\exists E_\mathcal{S} \in \mathcal{E}_\mathcal{S}$, s.t. $A \in E_\mathcal{S}$. We use $Prem(A)$ to denote the set of all the premises that used to build an argument A, $Conc(A)$ to denote the conclusion of A, $Rule(A)$ to denote the set of all the rules used in A. The following Definition shows how to evaluate whether an assertion is acceptable.

Definition 2. *Given a DL-AT$_\Delta$ = $(\mathcal{L}, \mathcal{R}^T, \mathcal{K}^A)$, let $\mathcal{A}$ be the set of all the argument constructed based on it. An assertion X is skeptically/credulously acceptable under certain argumentation semantics $\mathcal{S}$, iff $\exists A \in \mathcal{A}$, s.t. A is skeptically/credulously justified w.r.t. $\mathcal{E}_\mathcal{S}$ and $Conc(A) = X$.*

Definition 2 translates the query about whether an assertion X is acceptable in *DL-AT* into the query about whether an argument A whose conclusion is X is acceptable. The evaluation of this assertion corresponds to the evaluation of argument A. Based on Definition 2, the following definition shows how to perform a traditional reasoning task (instances checking). Due to space restriction, definitions for other reasoning tasks are omitted.

Definition 3. *Let φ be an individual, skeptically or credulously, it holds that φ is an instance of class:*

- *C $(/\neg C)$, iff $\exists A \in \mathcal{A}$, s.t. A is skeptically/credulously justified w.r.t. $\mathcal{E}_{\mathcal{S}}$ and $Conc(A) = C(\varphi)(/\neg C(\varphi)$;*
- *$C \sqcap D$, iff $\exists A, B \in \mathcal{A}$ s.t. A and B are both skeptically/credulously justified w.r.t. $\mathcal{E}_{\mathcal{S}}$ and $Conc(A) = C(\varphi)$, $Conc(B) = D(\varphi)$;*
- *$C \sqcup D$, iff $\exists A, B \in \mathcal{A}$ s.t. at least one of A and B are skeptically/credulously justified w.r.t. $\mathcal{E}_{\mathcal{S}}$ and $Conc(A) = C(\varphi)$, $Conc(B) = D(\varphi)$;*
- *$\exists P.D$, iff $\exists A, B \in \mathcal{A}$ s.t. A and B are both skeptically/credulously justified w.r.t. $\mathcal{E}_{\mathcal{S}}$ and $Conc(A) = P(\varphi, x)$, $Conc(B) = D(x)$ (x is an individual);*
- *$\forall P.D$, iff 1) $\exists A \in \mathcal{A}$ s.t. $Conc(A) = P(\varphi, x)$; and 2) $\forall A \in \{A | Conc(A) = P(\varphi, x)\}$, $\exists B \in \mathcal{A}$, s.t. $Conc(B) = D(x)$.*

According to Definition 3, the query about whether an instance is a member of a complex concept can be divided into several queries about whether this instance is a member of some basic concepts, while these answers can be obtained based on Definition 2.

At last, we define the explanation of the acceptance of an assertion as follows.

Definition 4 (Explanation). *Assuming that X is a skeptically/credulously acceptable assertion under certain argumentation semantics $\mathcal{S}$, then $\exists A \in \mathcal{A}$ s.t. $Conc(A) = X$,*

- *the explanation of how this assertion is reached is $Prem(A) \cup Rule(A)$;*
- *the explanation of why this assertion is acceptable is $Prem(B) \cup Rule(B)$, s.t. $\forall C \in \mathcal{A}$, if C successfully attacks A, then B successfully attacks C.*

Definition 4 gives a formal explanation of why an assertion X concluded by argument A is acceptable, which consists of two parts. The first part explains how X is reached by presenting all the premises contained in $\mathcal{K}^A$ and all the rules contained in $\mathcal{R}^T$ that applied to construct argument A. In other words, it indicates all the declarations contained in the ABox and TBox of DL ontology that used to conclude X. The second part explains why this assertion is acceptable by presenting all the premises and rules applied to construct the arguments defend A. Similarly, this explanation indicates all the relevant declarations of DL ontology.

In summary, we propose an argumentation theory called *DL-AT* to handle reasoning with inconsistent ontology, and provide a formal definition of explanation. In future work, we will explore how to apply our approach to some more expressive description languages, such as SHI.

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