Contextual rational closure for defeasible $\mathcal{ALC}$ (Extended Abstract)

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Abstract. Description logics have been extended in a number of ways to support defeasible reasoning in the KLM tradition. Such features include preferential or rational defeasible concept inclusion, and defeasible roles in complex concept descriptions. Semantically, defeasible subsumption is obtained by means of a preference order on objects, while defeasible roles are obtained by adding a preference order to role interpretations. In this paper, we address an important limitation in defeasible extensions of description logics, namely the restriction in the semantics of defeasible concept inclusion to a single preference order on objects. We do this by inducing a modular preference order on objects from each modular preference order on roles, and using these to relativise defeasible subsumption. This yields a notion of contextual rational defeasible subsumption, with contexts described by roles. We also provide a semantic construction for rational closure and a method for its computation, and present a correspondence result between the two.

Keywords: description logics, non-monotonic reasoning, defeasible subsumption, preferential semantics, rational closure, context

Given the special status of concept inclusion in description logics (DLs), and the historical importance of entailment in logic in general, past research efforts to extend DLs with non-monotonic reasoning capabilities have focused primarily on accounts of defeasible subsumption and the characterisation of defeasible entailment. Semantically, the latter usually takes as point of departure an ordering on a class of first-order interpretations [16, 18], whereas the former usually assume a preference order on objects of the domain [5, 14].

Recently, we proposed a new direction to introduce defeasibility to DLs [6, 7]. This built on previous work to resolve two important ontological limitations of the preferential approach to defeasible DLs — the assumption of a single preference order on all objects in the domain of interpretation, and the assumption that defeasibility is intrinsically linked to arguments or conditionals [8, 9].

We achieved this by introducing defeasibility in the concept language via an intuitive notion of normality for roles [6]. This parameterised the idea of preference while at the same time introducing the notion of defeasible class membership — defeasible subsumption allows for the expression of statements

of the form "C is usually subsumed by D", for example, "Chenin blanc wines *are usually* unwooded". In the extended language, one can also refer directly to, for example, "Chenin blanc wines that *usually have* a wood aroma". These notions can also be combined seamlessly, as in: "Chenin blanc wines that *usually have* a wood aroma *are usually* wooded". This cannot be expressed in terms of defeasible subsumption alone, nor can it be expressed w.l.o.g. using typicality-based operators [2, 14, 15, 20] on concepts, because the semantics of the expression is inextricably tied to the two distinct uses of the term 'usually'.

Nevertheless, even this generalisation left open the question of different, possibly incompatible, semantic characterisations of defeasibility in subsumption. A single ordering on individuals, as is usually assumed, does not suffice when preferences depend on context. In this paper, we therefore propose to induce multiple preference orders on objects derived from preference orders on role interpretations, and use these to relativise defeasible subsumption. This yields a notion of contextual defeasible subsumption, with contexts indicated by role names.

Building on previous work in the KLM tradition, we show that restricting the preferential semantics to a modular semantics allows us to define and compute a notion of rational entailment from a defeasible knowledge base. Rational closure is a form of inferential closure studied by Lehmann and Magidor [19], which is based on modular entailment but it extends its inferential power. Our proposal is a generalisation of the DL version of propositional rational closure. We present a proof-theoretic characterisation, based on the work of Casini and Straccia [13], as well as a semantic characterisation, based on the work of Booth and Paris [3] in the propositional case, and of Britz et al. [4] and Giordano et al. [17, 18] in the DL case. We then state and prove a correspondence result which relates the computation of rational closure to the semantic construction.

Defeasibility introduces a new facet of contextual reasoning not present in *deductive* reasoning in that preference orders can be used to indicate context. While an account of deductive reasoning with contexts in knowledge representation is not intrinsically linked to defeasible reasoning, its integration with contextual defeasible description logics warrants further investigation [1]. The present paper [11] is a revised and extended version of a paper presented at FoIKS 2018 [10]. In related work [12], we address another important open question, namely the creation of a tableau-based proof procedure for defeasible $\mathcal{ALC}$.

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