Representing Deontic Concepts for CNLs

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1 Introduction

The deontic concepts, *obligation*, *permission*, and *prohibition*, express what an individual *ought* to do, *may* do, or *should not do*; they ascribe a property to an action that an individual or collective performs, what we refer to here as *deontic specifications*. For brevity, we focus on obligation. We can say that the purpose of the concepts is to help the agent to *guide* his behaviour in the sense that the agent *prospectively* considers the consequences of his actions relative to some deontic ascription to an action, where the consequences follow from the fulfillment or violation of the obligation. The nature of the deontic concepts is that violations may arise, but we can reason with them.

For controlled natural languages (CNLs), it would be useful to be able to write deontic specifications for legal documents. However, to create a CNL with deontic concepts, one must address a range of unusually complex and as yet unresolved issues in natural language syntax and semantics ([1], [2] and [3]).

In this paper, we outline some key points from [4], which discusses the natural language syntax and and formal semantics of deontic concepts. This presentation serves as a high level departure point and framework for CNLs which aim to extend the expressivity of the language to the deontic concepts. While this paper does not itself present novel research, it is nonetheless novel and relevant to the CNL research community.

2 Linguistic Considerations

The wide-range of problems and issues found in the literature must be considered in the requirements analysis for the design of a CNL with deontic concepts. In many deontic logics, the deontic concepts are represented as sentential modal operators syntactically and semantically analogous to alethic modal operators *Necessity* and *Possibility*. However, the analogy gives rise to numerous problems. We argue that some of the issues can be addressed by making linguistically well-grounded observations and adopting linguistic theories. Some key bullet points are:

- Modal operators such as "ought" in *Bill ought to have left by now* have epistemic and non-epistemic interpretations, where the former has a *quantificational* meaning (in most contexts what happens), while the latter has a meaning where violation and fulfillment arise. We are primarily interested in the non-epistemic interpretation.
- A range of logical paradoxes arise, where the paradoxes are counter-intuitive inferences which arise from a the logical representation of a set of sentences such as *Bill*

ought to leave the house. If Bill leaves the house, then Bill ought to visit Jill. If Bill doesn't leave the house, then Bill ought not to visit Jill. Bill leaves the house. We argue that the deontic operators have a restricted semantic distribution.
- Two specific forms of the paradoxes, the *Gentle Murderer Paradox* and the *Good Samaritan Paradox*, can be can resolved by applying linguistic theory – *focus*, *adverbial semantics*, *discourse representation*, and *generalised quantifiers*.
- Deontic operators on *stative* expressions and *agentive actions* are distinguished, where statives ought to be analysed to have an implicit agentive action.
- Temporal operators and deadlines are often claimed to be intrinsic to an analysis of the deontic operators [5]. We argue they are not, but rather they are one of a number of interactions between operators of different sorts.
- *Action negation* should be construed in lexical semantic terms as antonyms, allowing some actions to be undefined with respect to obligation.

3 Theoretical Development

We base our analysis on a modal action logic [6, 7], where the deontic operators are reduced to actions and violation/fulfillment markers. Novel to our approach, the markers are fine-grained, complex expressions that are compositionally derived from the expression the operator applies to. We focus the discussion on the difference between sequences of obligations in contrast to obligations on sequences. The problem illustrates a general point that deontic operators are sensitive to the fine-grained linguistic structure of the expression they apply to.

We briefly review the proposal for the purposes of the abstract. In modal action logics, actions are state-changing functions. Given an action name α and a proposition ϕ, we may form the proposition $[\alpha]\phi$. Where an action is executed (the preconditions are satisfied), it results in a state in which the postconditions, whatever they are, hold along with ϕ. The negation of an action α, $\overline{\alpha}$, denotes the complement set relative to α [8]. Complex action combinators puts two actions in sequence ';'.

Deontic operators apply directly to action names of atomic or complex actions. They are reduced to actions and a violation marker V

$\sigma \models \mathbf{OB}\alpha$ iff $[\overline{\alpha}](\mathrm{V})$
It is *obligatory* to do α in σ iff doing *anything other* than α leads to a violation.

However, the single marker of violation does not make any fine-grained distinctions, though these parameters can be added. A key point of this approach is that violation leads to a state marked as having a property V rather than being false. Thus, the agent can reason with respect to the violation rather than ruling out such circumstances as is the case with *static system constraints*.

In our analysis, the markers are formal analogs to the natural language expressions.

a. Bill is obligated to move the left toggle up.
b. Were Bill to move the left toggle down, there is a violation of an obligation with respect to Bill on the movement of the left toggle up. Were Bill to move the left toggle up, there is a fulfillment of an obligation with respect to Bill on the movement of the left toggle up.

We *decompose* the *verbal* form of obligation into a correlated *nominal* form which expresses violation and fulfillment. In other words, there is an abstract object with the requisite properties (similar to [9]).

To formalise the analysis, we postulate several sorts of abstract objects along with functions to relate them. We give an example and describe it. The nominal portion of the deontic specification is:

$\exists$ x $\in$ DS [deonticOpF(x) = "obligation" $\wedge$ actionF(x) = "α" $\wedge$ agentF(x) = "Bill" $\wedge$ deonticFlagF(x) = "violation"].
There is a deontic specification x which has as deontic operator the "obligation", the action "α", the agent "Bill", and the deontic marker "violation".

Where $\overline{\alpha}$ is executed, this "flag" arises; where α is executed, a fulfillment "flag" arises.

On complex actions such as sequences, we have several alternative definitions. We provide the *collective* interpretation of"It is obligatory that Bill move the left toggle up, and then Bill move the right toggle left." Here, the deontic operator applies to the *sequence itself* as in a *procedure*; the consequences of violating the procedure are distinct from those which follow from violating any one action which comprise the procedure.

$\mathbf{OB}_{coll}((\alpha;\beta),\iota) =_{def}$
$[\overline{\alpha;\beta}]$(∃ds3 (deonticOpF(ds3) = "obligation" $\wedge$ actionF(ds3) = "$\alpha;\beta$" $\wedge$ agentF(ds3) ="ι" $\wedge$ deonticFlagF(ds3) = "violation")) $\wedge$
$[\alpha;\beta]$(∃ds4 (deonticOpF(ds4) = "obligation" $\wedge$ actionF(ds4) = "$\alpha;\beta$" $\wedge$ agentF(ds4) = "ι" $\wedge$ deonticFlagF(ds4) = "fulfillment"))

We must give a *generative* definition of action *antonym* for complex actions (see [4]).

The language is highly flexible and extensible. While the theoretical development focused on issues bearing on sequences of actions, which in turn supports an analysis of a key *Contrary-to-Duty Paradox*.

With respect to CNLs, the translation of deontic specifications now takes on the flavour of a translation to event-theoretic semantics [9]. The main challenge is to construe the actions as dynamic, context-changing functions.

4 Discussion

The literature on the deontic concepts is very extensive. We have not defended our position with respect to the many varieties. We remark on one particular line of research stemming from the Event Calculus [10], [11], [12]; these are rich systems which clearly warrant further development. Given our analysis of violations and fulfillments, it may be rather straightforward to express them in these logics (suitably extended and modified). We did not adopt these approaches since (depending on the approach) they did not take into account: Contrary-to-Duty Paradoxes, constraints on deontic operators, statives, complex violation and fulfillment markers, deontic operators on complex actions, and action negation as lexical semantics. Nor did we adopt theories where temporality is central [12]. [13] is a recent effort to incorporate deontic concepts into a CNL with an

Event Calculus. However, it also does not address these issues and contains no violation markers, but has a semantics with truth values; deadlines are assumed to be central.

Our approach must provide notions of interdefinability of the expressions with the operators, consistency among them, nor implication from them. However, this is not an issue unique to our proposal, but is a common problem [8]. Indeed, the paradoxes arise due to over-generation, which does not occur in our approach. Moreover, we could impose 'meaning postulates' to account for relevant properties in a more 'local' sense.

We have not, in this short overview, outlined the implementation. It should be noted that the implementation is designed to address the issue of obligations on sequences and the related Contrary-to-Duty paradoxes. It includes a detailed, but abstract development of the lexical semantics of antonyms for *abstract actions* comprised of explicit pre and post conditions. Whether actions from natural language can be reduced in such a way is an open question. [4] also includes a range of other topics such as contract updates.

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