One Formalization of Virtue Ethics via Learning

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December 3, 2021

Abstract

Given that there exist many different formal and precise treatments of deontological and consequentialist ethics, we turn to virtue ethics and consider what could be a formalization of virtue ethics that makes it amenable to automation. We present an embryonic formalization in a cognitive calculus (which subsumes a quantified first-order logic) that has been previously used to model robust ethical principles, in both the deontological and consequentialist traditions.

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1 Introduction

Separate from the two main camps in ethics, deontological ethics ($D$) and consequentialism ($C$), there is virtue ethics ($V$). While there has been extensive formal, computational, and mathematical work done on deontological ethics and consequentialism, there has been very little or almost no work done in formalizing and making rigorous virtue ethics. Proponents of $V$ might claim that it is not feasible to do so given $V$’s emphasis on character and traits, rather than individual actions or consequences. From the perspective of machine and robot ethics, this is not satisfactory. If $V$ is to be considered to be on equal footing with $D$ and $C$ for the purpose of building morally competent machines, we need to start with formalizing parts of virtue ethics. (After all, machines don’t yet understand that which is informal; witness e.g. Siri.) We present one such formalization based on learning and using one version of virtue ethics presented by Zagzebski in [16]. The goal in this paper is to present a simple formalization of a virtue ethics theory in a formal calculus that has been used to model deontological and consequentialist principles [6, 7].

The plan for the paper is as follows. First, we present a very quick overview of virtue ethics. Then we cover related work that can be considered as formalizations of virtue ethics. We then present one version of virtue ethics, $V_z$, that we seek to formalize fully. Then our calculus and the formalization itself ($V_f$) are presented. We conclude by discussing future work and challenges.

2 An Overview of Virtue Ethics

In simple forms of $C$, actions are evaluated based on their total utility to everyone involved. The best action is the action that has the highest total utility. In $D$, the emphasis is on inviolable principles, and reasoning from those principles to whether actions are obligatory, permissible, neutral, etc. In contrast to $D$ and $C$, some forms of virtue ethics can be summed up by saying the best action in a situation is the action that a virtuous person would do. A virtuous person is defined as a person that has learnt and internalized a diverse set of virtuous habits or traits. For a virtuous person, virtuous acts become second-nature, and hence are performed in many different situations. Note that unlike $D$ and $C$, it is not entirely straightforward how one could translate these notions into a form that is precise enough to be realized in machines.

3 Related Prior Work

Hurka [9] presents an ingenious formal account involving a recursive notion of goodness and badness. Hurka starts with a given set of primitive good and bad states of affairs. Virtues are then defined as love of good states of affairs or hatred of bad states of affairs. Vice is defined as love of bad states of affairs or hatred of good states of affairs. Virtues and vices are then themselves taken to be good and bad states of affairs, resulting in a recursive definition (See Figure 1). While there are rectifiable issues [8] with Hurka’s recursive definition, we feel that Hurka’s definition might not capture
central aspects of virtue [11]. We feel that it still has to be shown that this account is different from rigorous and formal accounts of C. Moreover, it is not clear how this account can be exploited for automation (Note: This is not Hurka’ goal).

Proposed Recursive Clarification by Hurka

• Some issues:
  • Technical issues with the system (rectifiable)
  • Needs base good and bad specified
  • Seems reducible to consequentialism

Figure 1: Hurka’s account

4 Exemplarist Virtue Theory

Exemplarist virtue theory (V_z) builds on the direct reference theory (DRT) of semantics and has the emotion of admiration as a foundational object. In DRT, the meaning of a word is constructed by what the word points out. For example, to understand the meaning of “water”, a person need not understand and possess all knowledge about water. The person simply needs to understand that “water” points to something which is similar to that (with that pointing to water).

In V_z, moral terms are assumed to be understood similarly. Moral attributes are defined by direct reference when instantiated in exemplars (saints, sages, heroes) that one identifies through admiration. The emotions of admiration and contempt play a foundational role in this theory. Zagzebski posits a process very similar to scientific or empirical investigation, Exemplars are first identified and their traits are studied. Exemplars are then continously further studied to better understand their traits, qualities, etc. The status of an individual as an exemplar can change over time. Below is an informal version that we seek to formalize:

| Informal Version V_z          |
|-------------------------------|
| I_1  | Agent or person a perceives a person b perform an action α. This observation causes the emotion of admiration in a |
| I_2  | a then studies b and seeks to learn what traits (habits/dispositions) b has. |
5 The Goal

From the above presentation of $V_z$, we can glean the following distilled requirements that should be present in any formalization.

| Requirements |
|--------------|
| $R_1$ A formalization of emotions, particularly admiration. |
| $R_2$ A notion of learning traits (and not just simple individual actions). |

6 Building the Formal Machinery

The computational logic we use is the deontic cognitive event calculus ($DCEC$). This logic was used previously in [6,7] to automate versions of the doctrine of double effect $DDE$, an ethical principle with deontological and consequentialist components. While describing the calculus is beyond the scope of this paper, we give a quick overview of the system. Dialects of $DCEC$ have also been used to formalize and automate highly intensional reasoning processes, such as the false-belief task [2] and akrasia (succumbing to temptation to violate moral principles) [3]. Arkoudas and Bringsjord [2] introduced the general family of cognitive event calculi to which $DCEC$ belongs, by way of their formalization of the false-belief task. $DCEC$ is a sorted (i.e. typed) quantified modal logic (also known as sorted first-order modal logic) that includes the event calculus, a first-order calculus used for commonsense reasoning. The calculus has a well-defined syntax and proof calculus; see Appendix A of [6]. The proof calculus is based on natural deduction [5], and includes all the introduction and elimination rules for first-order logic, as well as inference schemata for the modal operators and related structures.

6.1 Syntax

As mentioned above, $DCEC$ is a sorted calculus. A sorted system can be regarded analogous to a typed single-inheritance programming language. We show below some of the important sorts used in $DCEC$.

| Sort      | Description |
|-----------|-------------|
| Agent     | Human and non-human actors. |
| Time      | The $Time$ type stands for time in the domain. E.g. simple, such as $t_i$, or complex, such as $birthday(son(jack))$. |
| Event     | Used for events in the domain. |
| ActionType| Action types are abstract actions. They are instantiated at particular times by agents. Example: eating. |
| Action    | A subtype of $Event$ for events that occur as actions by agents. |
| Fluent    | Used for representing states of the world in the event calculus. |

The syntax has two components: a first-order core and a modal system that builds upon this first-order core. The figures below show the syntax and inference schemata of $DCEC$. The first-order core of $DCEC$ is the event calculus [12]. Commonly used function and relation symbols of the event calculus are included. Fluents, event and times
are the three major sorts of the event calculus. Fluents represent states of the world as first-order terms. Events are things that happen in the world at specific instants of time. Actions are events that are carried out by an agent. For any action type $\alpha$ and agent $a$, the event corresponding to $a$ carrying out $\alpha$ is given by $\text{action}(a, \alpha)$. For instance if $\alpha$ is “running” and $a$ is “Jack”, $\text{action}(a, \alpha)$ denotes “Jack is running”. Other calculi (e.g. the situation calculus) for modeling commonsense and physical reasoning can be easily switched out in-place of the event calculus.

The modal operators present in the calculus include the standard operators for knowledge $K$, belief $B$, desire $D$, intention $I$, etc. The general format of an intensional operator is $K(a, t, \phi)$, which says that agent $a$ knows at time $t$ the proposition $\phi$. Here $\phi$ can in turn be any arbitrary formula. Also, note the following modal operators: $P$ for perceiving a state, $C$ for common knowledge, $S$ for agent-to-agent communication and public announcements, $B$ for belief, $D$ for desire, $I$ for intention, and finally and crucially, a dyadic deontic operator $O$ that states when an action is obligatory or forbidden for agents. It should be noted that DCEC is one specimen in a family of easily extensible cognitive calculi.

The calculus also includes a dyadic (arity = 2) deontic operator $O$. It is well known that the unary ought in standard deontic logic lead to contradictions. Our dyadic version of the operator blocks the standard list of such contradictions, and beyond.\footnote{A overview of this list is given lucidly in [10].}

### 6.2 Inference Schemata

The figure below shows a fragment of the inference schemata for DCEC. First-order natural deduction introduction and elimination rules are not shown. Inference schemata $R_K$ and $R_B$ let us model idealized systems that have their knowledge and beliefs closed under the DCEC proof theory. While humans are not deductively closed, these two
rules lets us model more closely how more deliberate agents such as organizations, nations and more strategic actors reason. (Some dialects of cognitive calculi restrict the number of iterations on intensional operators.) \(R_4\) states that knowledge of a proposition implies that the proposition holds \(R_{13}\) ties intentions directly to perceptions (This model does not take into account agents that could fail to carry out their intentions). \(R_{14}\) dictates how obligations get translated into known intentions.

### Inference Schemata (Fragment)

| Rule | Description |
|------|-------------|
| \(K(a, t_1, \Gamma), \Gamma \vdash \phi, t_1 \leq t_2\) \[R_{KC}\] | \(K(a, t_2, \phi)\) |
| \(B(a, t_2, \phi)\) | \(B(a, t_2, \phi)\) |
| \(K(a, t, \phi)\) \[R_4\] | \(B(a, t, O(a, t, \phi, \chi))\) \(O(a, t, \phi, \chi)\) \[R_{13}\] |
| \(t < t', I(a, t, \psi)\) | \(P(a, t', \psi)\) |

### 6.3 Semantics

The semantics for the first-order fragment is the standard first-order semantics. The truth-functional connectives \(\land, \lor, \rightarrow, \neg\) and quantifiers \(\forall, \exists\) for pure first-order formulae all have the standard first-order semantics. The semantics of the modal operators differs from what is available in the so-called Belief-Desire-Intention (BDI) logics [15] in many important ways. For example, DCEC explicitly rejects possible-worlds semantics and model-based reasoning, instead opting for a proof-theoretic semantics and the associated type of reasoning commonly referred to as natural deduction [5,4]. Briefly, in this approach, meanings of modal operators are defined via arbitrary computations over proofs, as we will see for the counterfactual conditional below.

### 6.4 Formalizing Emotions

To formalize emotions, we build upon the OCC model. There are many models of emotion from psychology and cognitive science. Among these, the OCC model [14] has found wide adoption among computer scientists. Note that the model presented by [14] is informal in nature and one formalization of the model has been presented in [1]. The formalization by [1] is based on propositional modal logic, and while comprehensive and elaborate, is not expressive enough for our modelling, which requires at the least a quantified modal logic.

In OCC, emotions are short-lived entities that arise in response to events. Different emotions arise based on whether the consequences to events are positive (desirable) or negative (undesirable), whether the event has occurred, whether the event has consequences for the agent or for another agent. OCC assumes an undefined primitive notion of an agent being pleased or displeased in response to an event. We represent this notion by \(\Theta\) defined later. Though OCC has twenty two emotion types, we consider only the following handful of emotions shown below. An agent can be pleased or displeased in response to an event’s consequences that hold either for the agent or for
another agent. The following table summarizes the OCC definitions for six emotion types that we deem hold immediately for us here.

| Emotion Type | Response | Agent | Consequences  |
|--------------|----------|-------|---------------|
| Joy          | Pleased  | Self  | Desirable     |
| Distress     | Displeased | Self  | Undesirable   |
| HappyFor     | Pleased  | Other | Desirable     |
| Gloating     | Pleased  | Other | Undesirable   |
| PityFor      | Displeased | Other | Undesirable   |
| Resentment   | Displeased | Other | Desirable     |

Central to the formalization of below is a utility function $\mu$ that maps fluents and time points to utility values.

$$\mu : \text{Fluent } \times \text{Time } \rightarrow \mathbb{R}$$

The above agent-neutral function suffices for classical $\mathcal{DDE}$ but is not enough for our purpose. We assume that there is another function $\nu$ (either acquired or given to us) that gives us agent-specific utilities.

$$\nu : \text{Agent } \times \text{Fluent } \times \text{Time } \rightarrow \mathbb{R}$$

We can then build the agent-neutral function $\mu$ from the agent-specific function $\nu$ as shown below:

$$\mu(f, t) = \sum_a \nu(a, f, t)$$

For an event $e$ that happens at time $t$, let $e_I^t$ be the set of fluents initiated by the event, and let $e_T^t$ be the set of fluents terminated by the event. If we are looking up till horizon some $H$, then $\bar{\mu}(e, t)$, the total utility of event $e$ happening at time $t$, is then:

$$\bar{\mu}(e, t) = \sum_{y=t+1}^{H} \left( \sum_{f \in e_I^t} \mu(f, y) - \sum_{f \in e_T^t} \mu(f, y) \right)$$

Similarly, we have $\bar{\nu}(a, e, t)$, the total utility for agent $a$ of event $e$ that happens at time $t$:

$$\bar{\nu}(a, e, t) = \sum_{y=t+1}^{H} \left( \sum_{f \in e_I^t} \nu(a, f, y) - \sum_{f \in e_T^t} \nu(a, f, y) \right)$$

Emotions are fluents comprised of (i.) one or more agents; (ii.) an event; and (iii.) the time at which event took place.

We now define emotion fluents in terms of the machinery we have defined above. The general template for an emotion is that an emotion is equivalent to conditions stated in the OCC formalization and an addition $\Theta$ condition that is specific to the agent and time. Not all agents respond in the same way emotionally to the same conditions. $\Theta$ takes care of this variation. If $\Theta$ always holds, then we have an agent that is easily
swayed by events. If \( \Theta \) never holds, we have an agent that is never emotional. (Free variables in the following definitions are considered to be universally quantified.) To set the stage for defining admiration below, we present the following straightforward definitions for the four simplest emotions in OCC theory.

**Joy** The agent believes that the total utility of the event for itself is positive and that there are no negative consequences.

\[
\text{holds}(\text{joy}(a, e, t), t') \leftrightarrow \begin{cases} 
\Theta(a, t') \land \hat{\nu}(a, e, t) > 0 \land \\
B \left( a, t', \left[ \neg \exists f, t', \left( \text{initiates}(e, f, t) \land \hat{\nu}(a, f, t') < 0 \right) \right] \right) 
\end{cases}
\]

**Distress** The agent believes that the total utility of the event for itself is negative and that there are no positive consequences.

\[
\text{holds}(\text{distress}(a, e, t), t') \leftrightarrow \begin{cases} 
\Theta(a, t') \land \\
B \left( a, t', \left[ \neg \exists f, t', \left( \text{initiates}(e, f, t) \land \hat{\nu}(a, f, t') > 0 \right) \right] \right) 
\end{cases}
\]

**Happy For** The agent \( a \) believes that the total utility of the event for agent \( b \) is positive and that there are no negative consequences. The agent also believes that it is different from \( b \)

\[
\text{holds}(\text{happyFor}(a, b, e, t), t') \leftrightarrow \begin{cases} 
\Theta(a, t') \land \\
\left( a \neq b \right) \land \hat{\nu}(b, e, t) > 0 \land \\
B \left( a, t', \left[ \neg \exists f, t', \left( \text{initiates}(e, f, t) \land \hat{\nu}(a, f, t') < 0 \right) \right] \right) 
\end{cases}
\]

**Admiration For** In standard OCC, an agent \( a \) is said to admire another agent \( b \)'s action \( \alpha \), if agent \( a \) believes the action is a good action.
holds(admires(a, b, α, t), t')

⇔

Θ(a, t')∧

B(a, t',

(a ≠ b) ∧ μ(action(α, b), t) > 0 ∧

¬∃f, t'. (initiates(action(α, b), f, t) ∧

μ(f, t') < 0)

6.5 Learning Method

Note that when we look at humans learning virtues by observing others or by reading from texts or other sources, it is not entirely clear how models of learning that have been successful in perception and language processing (e.g. the recent successes of deep learning/differentiable learning/statistical learning) can be be applied. Learning in these situations is from one or few instances or in some cases through instruction and such learning may not be readily amenable to models of learning which require a large number of examples.

The abstract learning method that we will use is generalization. If we have a set of set of formulae \{Γ₁, ..., Γₙ\}, the generalization of \{Γ₁, ..., Γₙ\}, denoted by \( g(\{Γ₁, ..., Γₙ\} ) \) is a Γ such that \( Γ ⊢ ∧Γᵢ \). See one simple example below:

**Example 1**

\[
Γ₁ = \{talkingWith(jack) → Honesty\}
\]

\[
Γ₂ = \{talkingWith(jill) → Honesty\}
\]

**generalization** \( Γ = \{∀x.talkingWith(x) → Honesty\} \)

One particularly efficient and well-studied mechanism to realise generalization is anti-unification. Anti-unification that has been applied successfully in learning programs from few examples. In anti-unification, we are given a set of expressions \{f₁, ..., fₙ\} and we need to compute an expression \( g \) that when substituted with an appropriate term \( θᵢ \) gives us \( fᵢ \). E.g. if we are given \( hungry(jack) \) and \( hungry(jill) \), the anti-unification of those terms would be \( hungry(x) \).

**Example 2**

\[
likes(jill, jack)
\]

\[
likes(jill, jim)
\]

**anti-unification** \( likes(jill, x) \)

In higher-order anti-unification, we can substitute function symbols and predicate symbols. Here \( P \) is a higher-order variable.

---

\(^2\)This discipline known as inductive programming seeks to build precise computer programs from examples [13].
Example 3

\[
\begin{align*}
\text{likes}(jill, jack) \\
\text{loves}(jill, jim)
\end{align*}
\]

\[\text{anti-unification } P(jill, x)\]

6.6 Defining Traits

We need agents to learn traits and not just single actions. We define below what it means for an agent to have a trait. First, a situation \(\sigma(t)\) is simply a collection of formulae that describes what fluents hold at a time \(t\) along with other event calculus constraints and descriptions. An action type \(\alpha\) is said to consistent in a situation \(\sigma(t)\) for an agent \(a\) if:

\[
\sigma(t) + \text{happens}((\alpha, a), t) \not\vdash \bot
\]

Trait

An agent \(a\) is said to have an action type \(\alpha\) as a trait if there are at least \(m\) situations \(\{\sigma_1, \sigma_2, \ldots, \sigma_n\}\) in which there are unique alternatives \(\{\alpha_1, \ldots, \alpha_m\}\) available but instantiations of \(\alpha\) is performed in a large fraction \(\gamma \gg 1\) of these situations.

6.7 Learning from Exemplars and Not Just From Examples

We start with a learning agent \(l\). An agent \(e\) is identified as an exemplar by \(l\) iff the corresponding emotion of admiration is triggered \(n\) times or more. A learnt trait is defined below:

Learnt Trait

A learnt trait is simply a situation \(\sigma(t)\) and an action type \(\alpha\): \(\langle \sigma(t), \alpha \rangle\)

Once \(e\) is identified, the learner then identifies one or more traits of \(e\) by observing \(e\) over an extended period of time. Let \(\{\sigma_1, \sigma_2, \ldots, \sigma_n\}\) be the set of situations in which instantiations \(\{\alpha_1, \alpha_2, \ldots, \alpha_n\}\) of a particular trait \(\alpha\) are triggered. The learner then simply associates the action type \(\alpha\) with the generalization of the situations \(g(\{\sigma_1, \sigma_2, \ldots, \sigma_n\})\). That is the agent has incorporated this learnt trait:

\[\langle g(\{\sigma_1, \sigma_2, \ldots, \sigma_n\}), \alpha \rangle\]

For instance, if the trait is “being truthful” and is triggered in situations: “talking with alice.”, “talking with bob”, “talking with charlie”; then the association learnt is that “talking with an agent” should trigger the “being truthful” action type.
7 Example

We present a simple example. Assume that we have a market place where things that are broken or unbroken can be bought and sold. A seller can either honestly state the condition of the item \{\textit{broken}, \textit{unbroken}\} or not correctly report the state of the item. For an honest seller, we have the following two situations that can be observed:

**Situation 1**

\[
\sigma_1 \equiv \textit{holds}(\textit{broken}, t) \\
\alpha \equiv \textit{happens}(\textit{utter}(\textit{broken}), t)
\]

**Situation 2**

\[
\sigma_2 \equiv \textit{holds}(\textit{unbroken}, t) \\
\alpha \equiv \textit{happens}(\textit{utter}(\textit{unbroken}), t)
\]

The learnt trait is then given below. The trait says that one should always correctly utter the state of the item.

\[
\langle \textit{holds}(x, t), \textit{happens}(\textit{utter}(x), t) \rangle
\]

8 Conclusion

We have presented an initial formalization of a virtue ethics theory in a calculus that has been used in automating other ethical principles in deontological and consequentialist ethics. Many important questions have to be addressed in future research. Among them, are questions about the nature and source of the utility functions that are used in the definitions of emotions. We also need to apply this model to realistic examples and case studies. The lack of such formal examples and case studies is a bottleneck here.

References

[1] Carole Adam, Andreas Herzig, and Dominique Longin. A Logical Formalization of The Oce Theory of Emotions. \textit{Synthese}, 168(2):201–248, 2009.

[2] K. Arkoudas and S. Bringsjord. Toward Formalizing Common-Sense Psychology: An Analysis of the False-Belief Task. In T.-B. Ho and Z.-H. Zhou, editors, \textit{Proceedings of the Tenth Pacific Rim International Conference on Artificial Intelligence (PRICAI 2008)}, number 5351 in Lecture Notes in Artificial Intelligence (LNAI), pages 17–29. Springer-Verlag, 2008.

[3] Selmer Bringsjord, Naveen Sundar Govindarajulu, Daniel Thero, and Mei Si. Akratic Robots and the Computational Logic Thereof. In \textit{Proceedings of ETHICS
• 2014 (2014 IEEE Symposium on Ethics in Engineering, Science, and Technology), pages 22–29, Chicago, IL, 2014. IEEE Catalog Number: CFP14ETI-POD.

[4] Nissim Francez and Roy Dyckhoff. Proof-theoretic Semantics for a Natural Language Fragment. *Linguistics and Philosophy*, 33:447–477, 2010.

[5] Gerhard Gentzen. Investigations into Logical Deduction. In M. E. Szabo, editor, *The Collected Papers of Gerhard Gentzen*, pages 68–131. North-Holland, Amsterdam, The Netherlands, 1935. This is an English version of the well-known 1935 German version.

[6] Naveen Sundar Govindarajulu and Selmer Bringsjord. On Automating the Doctrine of Double Effect. In Carles Sierra, editor, *Proceedings of the Twenty-Sixth International Joint Conference on Artificial Intelligence, IJCAI-17*, pages 4722–4730, Melbourne, Australia, 2017. Preprint available at this url: [https://arxiv.org/abs/1703.08922](https://arxiv.org/abs/1703.08922).

[7] Naveen Sundar Govindarajulu, Selmer Bringsjord, Rikhya Ghosh, and Matthew Peveler. Beyond the doctrine of double effect: A formal model of true self-sacrifice. International Conference on Robot Ethics and Safety Standards, 2017.

[8] Avram Hiller. The Unusual Logic of Hurka’s Recursive Account. *Journal of Ethics and Social Philosophy*, 6(1):1–6, 2011.

[9] Thomas Hurka. *Virtue, Vice, and Value*. Oxford University Press, Oxford, UK, 2000.

[10] P. McNamara. Deontic Logic. In Edward Zalta, editor, *The Stanford Encyclopedia of Philosophy*. 2010. McNamara’s (brief) note on a paradox arising from Kant’s Law is given in an offshoot of the main entry.

[11] JK Miles. Against the Recursive Account of Virtue. *Theoretical & Applied Ethics*, 2(1):83–92, 2013.

[12] E. Mueller. *Commonsense Reasoning: An Event Calculus Based Approach*. Morgan Kaufmann, San Francisco, CA, 2006. This is the first edition of the book. The second edition was published in 2014.

[13] Shan-Hwei Nienhuys-Cheng and Ronald De Wolf. *Foundations of Inductive Logic Programming*, volume 1228. Springer Science & Business Media, 1997.

[14] Andrew Ortony, Allan Collins, and Gerald L Clore. *The Cognitive Structure of Emotions*. Number 0521353645. Cambridge [England] ; New York : Cambridge University Press, 1988.

[15] A. S. Rao and M. P. Georgeff. Modeling Rational Agents Within a BDI-architecture. In R. Fikes and E. Sandewall, editors, *Proceedings of Knowledge Representation and Reasoning (KR&R-91)*, pages 473–484, San Mateo, CA, 1991. Morgan Kaufmann.

[16] Linda Zagzebski. Exemplarist Virtue Theory. *Metaphilosophy*, 41(1-2):41–57, 2010.