Ethical Decision-Making in Multi-Agent Systems

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ABSTRACT

Developing socially beneficial multi-agent systems (MAS) necessitates addressing the capacity of agents to make decisions of an ethical nature. Ethics is inherently multi-agent, involving one's concern for another. To make ethical decisions, agents should consider the needs of different stakeholders. Principles from normative ethics, the philosophical study of morality, provide practical guidance to determine right from wrong. My work implements normative ethics principles in artificial agents to foster ethical decision-making.

KEYWORDS

normative ethics, social norms, sociotechnical systems

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1 INTRODUCTION

Multi-agent systems (MAS) are collections of multiple agents acting and interacting in a shared environment [40]. As MAS commonly do not exist in isolation but alongside humans, it is important to consider the wider social implications of decisions made in MAS and capacity of agents to make decisions of an ethical nature [11].

Ethics is multi-agent insofar as it involves one party's concern for another [29]. In MAS with different interacting agents, decisions have varying effects on outcomes for relevant stakeholders. For many environments, individual agents do not share the same goals as the society, or there are limitations on resources [37]. Agents may negatively impact others if they prioritise solely their own interests and do not consider others in their decisions. To be beneficial to the system, agents should consider the needs of relevant stakeholders.

Developing agents capable of making ethical decisions thus enhances the capacity of MAS to be socially beneficial. In my work, I argue that operationalising principles from normative ethics, the philosophical study of practical means to determine right from wrong [4], is a step towards developing agents with ethical decision-making capacities. Normative ethics principles denote and justify morally good or right action [19]. Principles guide decision-makers in making evaluative judgements and determining moral permissibility of courses of actions, facilitating choosing amongst actions by considering their moral implications [23, 26].

Normative ethics principles are justified in philosophical theory; normative in the sense that they are prescriptive, denoting how things ought to be, rather than descriptive, denoting how things are. As what is the case might not be ethical, using independently justified principles has the benefit of addressing the *is-ought* gap: just because something *is* the case, doesn't mean it *ought* to be [20]. Implementing normative ethics principles makes explicit the reasons underlying ethical choices, as to explain why a decision was made, one can refer to the reasons that justify the relevant principle [11, 16]. Operationalising normative ethics thus provides a mechanism to systematically assess the rightness and wrongness of actions in a range of situations, and justify decisions by reference to the principles used [3]. How can we operationalise normative ethics to support ethical decision-making in MAS?

In pursuit of operationalising normative ethics for ethical decision-making in MAS, I identify three key research questions to address:

RQ$_{\text{identification}}$ *What ethical principles have previously been implemented in computer science literature?*

Understanding how to apply principles, and which principle is appropriate to a situation, is aided by identifying how computer science literature has previously utilised normative ethics. To address this question, we surveyed computer science literature and developed a taxonomy of 21 principles operationalised in AI [43].

RQ$_{\text{operationalisation}}$ *How can ethical principles be operationalised in decision-making capacities?*

Operationalising ethical principles in decision-making assists in choosing amongst possible actions [7, 23]. We addressed this question by implementing maximin (a well known fairness principle prioritising the least advantaged [32]) [45], and combining multiple principles in learning agents [44].

RQ$_{\text{incorporating context}}$ *How does context interplay with the application of ethical principles to MAS?*

Different settings may have contextual requirements that influence the relevancy of various factors and outcomes of decisions. Continuing work pursues questions regarding how context influences ethical decision-making and how agents with ethical decision-making capacities can be implemented in the real world.

2 PRINCIPLE IDENTIFICATION

In normative ethics, there are many different theories about morality with varying strengths and weaknesses. All good theories have some useful truths, yet different principles lead to distinct solutions, and all principles have some counter-intuitive implications [11, 34]. To support ethical reasoning in the face of imperfect principles, a reasonable response is to use each principle where it is most effective [5]. Discerning which principle is appropriate for an application is aided by identifying which principles have previously been used in literature and how they have been operationalised. In Woodgate and Ajmeri [43], we survey computer science literature and develop a taxonomy of 21 normative ethical principles previously operationalised. We define a new mapping of each principle to how they have previously been operationalised, key themes practitioners should be aware of to implement principles, difficulties that may arise, and existing gaps.

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3 PRINCIPLE OPERATIONALISATION

Implementing principles in reproducible ways requires consistent methodologies that make explicit the principles being used [9]. To investigate how to implement normative ethics in decision-making capacities in MAS, we (1) operationalise Rawlsian ethics to foster fair norm emergence; (2) combine multiple principles to reconcile difficulties arising with individual principles.

3.1 Operationalising Rawlsian Ethics

Social norms are standards of expected behaviour harness in MAS to regulate behaviour [27]. However, exploitative norms may emerge when agents act solely out of self-interest. In Woodgate et al. [45] we present RAWL·E, a novel method to design socially intelligent norm-learning agents that consider others in decision-making by operationalising maximin, a fairness principle advanced by Rawls [32]. Maximin states that in a society with unequal distribution not to the benefit of all, the least well-off should be prioritised. Previous literature utilises principles to aggregate value preferences [22, 36], make normative decisions [2], and optimise learning policies [12, 38]. We advance previous literature by applying maximin to learning agents in norm emergence settings. We find a society of RAWL·E agents has higher fairness and social welfare, and more emerged cooperative norms, compared to a society of agents not implementing maximin.

3.2 Operationalising Multiple Principles

There are difficulties with individual principles and the application of a single principle may lead to unintuitive outcomes [5]. Implementing multiple principles in decision-making helps to see problems from different perspectives [26] and balance the strengths and weaknesses of each principle [6]. Principles have been implemented in MAS, however, prior work does not combine principles, combines principles in a single way, or presumes a central authority, which may not be feasible in all environments [8, 12, 25, 30, 46]. To mitigate weaknesses with individual principles, in Woodgate and Ajmeri [44] we propose PriNE, an agent architecture combining multiple principles in individual decision-making. To evaluate PriNE, we compare a society of PriNE agents to societies implementing individual principles in a berry harvesting scenario. We find societies of PriNE agents have higher fairness and sustainability than societies implementing single principles [44].

4 INCORPORATING CONTEXT

Challenges arise with implementing ethical decision-making in the real world as there are varying factors that affect outcomes of decisions and how to apply principles. There are different ways to choose between or combine principles, people may reasonably disagree about morality, decisions are made within historical contexts with varying power dynamics, and decisions should be interpretable to stakeholders. Planned work and future directions investigate how to integrate context into ethical decision-making.

4.1 Planned Work

Deciding which principles to encode in decision-making is a challenging task: there are issues with individual principles, and different principles may have conflicting recommendations [31]. In Woodgate and Ajmeri [44], we investigated how combining principles into a single answer mitigates weaknesses with individual principles. We found different ways of combining principles may be appropriate for different scenarios. Directions include examining the influence of context on which principles or combination of principles is appropriate. Directions also involve combining promotion of ethical behaviour with explicit prevention of unethical outcomes.

Even if it were possible to identify one principle that held true in any situation, humans hold a variety of reasonable and contrasting beliefs [33]. Rational people may disagree about descriptive facts (the mechanics of a situation), preferences (agree about descriptive facts but want different things), or what is of moral value (what is right or wrong) [34]. Designing AI with one moral doctrine may therefore impose beliefs upon people who do not agree with them [17]. Directions involve investigating how ethical decision-making can take into account beliefs and preferences of stakeholders.

We simulated abstracted berry harvesting scenarios to evaluate the methods developed in Woodgate et al. [45] and Woodgate and Ajmeri [44]. To work towards implementing ethical decision-making in the real world, directions include applying methods to more complex and real-world scenarios.

4.2 Future Directions

Ethical MAS should promote fairness, broadly understood as the mitigation of bias and discrimination against marginalised groups [18]. There has been extensive research into algorithmic fairness, however, focusing on algorithms alone can subvert actual fairness by taking too narrow a stance [16]. What counts as discrimination or fairness may depend on the task [21], and structural inequalities influence the design and implementation of tools [39]. To support fairness in MAS, future directions include exploring how broader social constructs influence outcomes through a sociotechnical lens that appreciates interacting social and technical tiers [29, 42].

People often have differing and potentially conflicting preferences, and multiple-user social dilemmas may arise when values (deeply held beliefs and preferences [35]) or norms conflict [10, 41]. Previous research has explored dilemmas where one principal makes a decision affecting others (one-to-many) [15]. However, there are several ways in which power dynamics affect how agents act and interact. Interactions could involve one agent affecting another (one-to-one), many agents affecting one (many-to-one), or many agents affecting many others (many-to-many). To improve fairness considerations, future directions include investigating various types of multiple-user social dilemmas. Dilemmas may arise in mundane settings, and do not have to be extreme trolley-problem cases [14].

In social contexts, decisions should be interpretable insofar as stakeholders can infer some sort of qualitative understanding [13]. Interpretability is important as the reasons for a decision help evaluate that decision [24, 28]. Qualitative understanding may be aided through explanations, illocutionary acts uttered with the intention to make something understandable [1]. Agents should have the ability to justify their decisions so that stakeholders can understand why those decisions were made. Future directions include examining how ethical decision-making in STS can be made interpretable, and how explanations can be harnessed to improve interpretability.

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