Norm's Benefit Awareness in Open Normative Multi-agent Communities: A Conceptual Framework

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Abstract. In open normative multi-agent communities, agents adopt new norms to increase their utilities. Several studies have developed mechanisms for agents to adopt new norms. These mechanisms are based on sanction, imitation, or social learning. The limitation of these mechanisms is that over time all agents follow the new norms, while in a real situation, usually there is a number of agents that persistently violate the norms for their benefits. We consider that intelligent agents should adopt new norms based on their awareness of the norms' expected benefits on their utilities and not only by sanctions or imitating other agents. Consequently, this paper presents a conceptual framework for agents' awareness of norms' benefits in open normative multi-agent communities. In the proposed framework, four components constitute agents' awareness of norms' benefits which are Norm's Adoption Ratio; Norm's Yields; Norm's Trust, and Norm's Morality. Using these components, however, agents would be able to evaluate the benefits of detected norms and subsequently determine whether the norms increase or decrease their utilities for eventual adoption or rejection.

Keywords: Social Norm, Normative Systems, Norms Benefit Awareness, Normative Multi-agent Systems, Software Agents.

1 Introduction

Norms and normative multi-agent systems have become the subjects of interest for many researchers [1, 2]. The term norm is used to characterize the behaviors of community members and is generally accepted as efficient means to normalize their behaviors [2]. Recently, numerous models on multi-agent systems have been investigated and this includes norms in agent architectures [3, 4, 5]. Boella et al. [6] claimed that researchers of moral and legal philosophy have studied traditional normative systems [7].

In open normative multi-agent communities, agents adopt new norms to increase their utilities [8]. Several studies have developed mechanisms for agents to adopt new

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norms, which are based on sanction [9, 10], imitation [11, 12, 13], or social learning [14, 15]. The limitation of these mechanisms is that over time all agents comply with the norms. Such agents possess inferior autonomies as their decisions are influenced by external powers, which they subsequently comply. In real situations, there is always a number of agents that persistently violate the norms for their benefits (i.e., deviant agents). For more advanced ability, we stress that intelligent agents should adopt new norms based on their awareness about the expected benefits on their utilities and not only by sanctions [9, 10] or imitating other agents [11, 12, 13]. In the real world, we occasionally see some people violate the norms despite the influence of such external powers due to their awareness of the expected benefits of such violations. Consequently, this paper addresses this issue for investigation by introducing a conceptual framework of agents' awareness of norms' benefits in open normative multi-agent communities where norms are adopted based on their expected benefits.

The concept of norms' benefits awareness enables agents to recognize the benefits or gains arising from complying or violating the norms. Agents' that interact with internal and external environments need to be aware of the norms' benefits and use their abilities and motivations to exploit these benefits for achieving their goals. However, to achieve coordination and cooperation in open communities, Criado et al. [16] suggested that norms should represent an effective tool and agents must be able to adopt norms autonomously based on the yields gained.

This paper, which reports the work-in-progress of our research in norms, presents a conceptual framework for agents' awareness of norms' benefits. In this framework, we discuss, first, the components that constitute the norms' benefits awareness and subsequently present the proposed framework. Four components are observed from the literature that constitute norms' benefits awareness which are Norm's Adoption Ratio (they referred to it as norm strength) [13]; Norm's Yields [17]; Norm's Trust [18], and Norm's Morality [9]. Using these components, agents evaluate the benefits of the norms and subsequently determine whether the norms increase or decrease their utilities for eventual adoption or rejection.

The objectives of this study are, (i) to highlight the issues of norms' benefits awareness in open multi-agent communities of online-designed norms, and (ii) to develop a norms' benefit awareness framework. This paper is the first research attempt of its kind that analyzes and formulates the phenomenon of norms' benefits awareness in a multi-agent community. Our contribution in this paper is three-fold. Firstly, we analyze the components that constitute norms' benefits awareness. Secondly, we develop a framework for norms' benefits awareness. Thirdly, we propose an approach that can be used to calculate the benefits of a particular norm.

The next section dwells upon the related work on norms adoption. Section 3 discusses the components of norms' benefits awareness. Section 4 details out the framework of norms' benefits awareness and propose a norms' benefits calculation method. Section 5 concludes the paper.

2 Related Work

Norms and normative systems have received greater attention due to their ability to coordinate agents' interactions [1, 2]. In general, norms are integrated with multi-agent systems to guide agents to behave in a socially harmonious way. Consequently, research on norms identification and detection have recently appeared in the literature expounding issues and techniques on this research domain [9, 13, 19, 20, 21]. For example, Savarimuthu et al. [19, 20] proposed a norm identification technique in which a visitor agent infers the norms of an agents' community without the norms being explicitly given to the agent. The agent infers the norm based on a sanctioned agent and after inferring, the agent adopts the norm. In another work by Mahmoud et al., [9] they proposed an algorithm to detect obligation and prohibition norms which they called the Obligation and Prohibition Norms Mining algorithm (OPNM). The algorithm exploits the resources of the host system, implements data formatting, filtering, and extracting the exceptional events, i.e. those that entail rewards and penalties of the obligation and prohibition norms.

Mahmoud et al. [13] presented a self-enforcing agent which detects norms based on beliefs that are triggered by emotions of imitating the majority and the agent extracts the norms using a norms mining algorithm.

Sen and Airiau [14] proposed a social learning theory, in which every agent in a community learns simultaneously from repeated interactions with randomly selected neighbors. Bosse et al. [15] presented a dynamic agent-based approach to simulate and formally analyze the process of social learning of agents' behaviors. The general mechanism is based on behavior changes by influence of peers. The approach involves the influence of three types of agents groups which are peers, parents, and school.

From the above works, we notice some deficiencies in the approaches that are based on sanctions, imitations or interactions. In this paper, we extend a further refinement to these approaches by enabling agents to evaluate the benefits of norms' awareness that would improve agents' decisions in adopting or rejecting a particular norm.

3 Norm's Benefit Awareness Components

We propose the concept of norms' benefits awareness to enhance the ability of normative agents in norms compliance or violation. Such ability to recognize the norms' benefits would greatly improve the agents' performance in achieving their goals. We define, initially, the underlying elements that constitute this concept.

Definition 1: Norm's Awareness is the ability of an agent to recognize the norms in open agent communities, in which norms are not explicitly given to agents.

Definition 2: Norm's benefits awareness is the ability of an agent to determine the gains or losses from adopting or violating a particular norm in open agent communities.

Definition 3: An agent's utility is a measure of its usefulness in a particular domain.

From the literature, we identify the components that constitute the norms' benefit awareness, which are, Norm's Adoption Ratio, Norm's Yield, Norm's Trust, and Norm's Morality. We justify the significance of these parameters in developing the framework by assessing the influence of each parameter on the decision of agents to adopt or reject a norm.

- Norm's Adoption Ratio (N_{AR}): A Norm's Adoption Ratio is the ratio of agents practicing a particular norm to the population of agents in a community. If P is the agents' population, and N_a is the number of agents practicing a particular norm, then $N_{AR} = N_a{:}P$. This ratio is high when a norm is enacted by a majority of agents, which experience the norm's benefits. Such experience reinforces an agent's decision to enact the norm and gain the expected benefits or violate the norm to avoid expected losses. For example, in an elevator scenario, if the majority practices the norm of *excusing* oneself when exiting the elevator, an agent expects that the benefits from adopting such norm avoids it from a sanction and/or increases its reputation.
- Norm's Yield (N_Y): To adopt a norm, an agent should consider the expected yield of that norm. A norm's yield refers to the gain received from adopting a norm arising from the norm's return on an agent's utility. When an agent discovers the yield value of a particular norm, it infers the benefits of adopting the norm. If the norm possesses high yield, it attracts agents to adopt it. For example, reading news online becomes the norm of many communities because it is inexpensive and convenient.
- Norm's Trust (N_T): Another parameter that motivates an agent to adopt a norm is when the agent is able to evaluate a norm's trust value. A norm's trust refers to the degree of an agent's belief in a norm that influences other agents to adopt the norm. If the trust value of a particular norm is high, it increases the possibility of adopting the norm. Andrighetto et al. [18] provided an example of a bus stop scenario of a particular community, in which when people arrive at the bus stop, the norm is, they do not form a queue but instead they sit on a bench and memorize who came earlier than them. In such situation, because people highly trust the norm, they adopt the norm.
- Norm's Morality (N_M): A norm's morality refers to the state of a norm (good or bad) in comparison with a morality reference. The morality value of a norm allows an agent to check whether the norm conforms to its morality reference. If it conforms, the probability of adopting the norm is high and vice versa. For example, talking loudly or shouting is a low morality norm for many communities. But if it is detected as a strong norm in a particular community, in this case, the agent has the option to accept or reject the norm basing on its awareness about the norm's expected benefits.

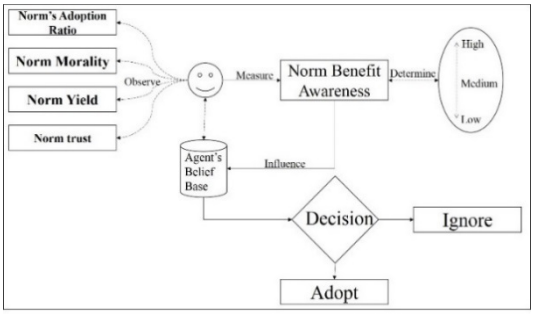

Fig. 1. Evaluating the Norm's Benefit Awareness

If an agent is able to determine the values of the above parameters, it can evaluate the Norm's Benefit Awareness. As shown in Figure 1, the agent becomes aware of the norm's benefit from observing and evaluating the parameters values (Norm's Adoption Ratio, Norm's Yield, Norm's Trust, and Norm's Morality). Having determined the parameters' values, e.g. high; medium; or low, the agent's belief is influenced by these values, which in turn influence its decision to adopt or reject the norm.

4 A Conceptual Framework for Norm's Benefit Awareness

In the first section we present the conceptual design of this framework. The second section discusses the framework formalization.

4.1 Conceptual Design

In this framework, we introduce the concept of Norm's Benefit Awareness in an open normative multi-agent community, in which agents recognize the benefits of adopting the norms and subsequently decide whether to adopt or reject the norm. In this work, we propose a Norm's Benefit Evaluator, N_BE that enables agents' awareness of the benefits of adopting or rejecting a particular norm. The Norm's Benefit Evaluator, evaluates the parameters, Norm's Adoption Ratio, Norm's Yield, Norm's Trust, and Norm's Morality. Having evaluated the parameters, the Norm's Benefit Evaluator determines whether the result increases or decreases an agent's utility. The agent's belief is influenced by the output of the Norm's Benefit Evaluator (increase; decrease). When the agent's belief is updated with the expected benefit, it decides whether to accept or reject the norm.

As shown in Figure 2, an agent first detects a norm (1). The agent then launches the Norm's Benefit Evaluator (2). The Evaluator evaluates the parameters' values, Norm's Adoption Ratio, Norm's Yield, Norm's Trust, and Norm's Morality (3). It then determines the effect of the detected norm on the agent's utility (increase; decrease) (4) which in turn influences the agent's belief (5). From its belief, the agent is aware of the benefits of the detected norm (6). The agent then decides (7) whether to accept and comply with the detected norm (8a) or reject and violate the norm (8b).

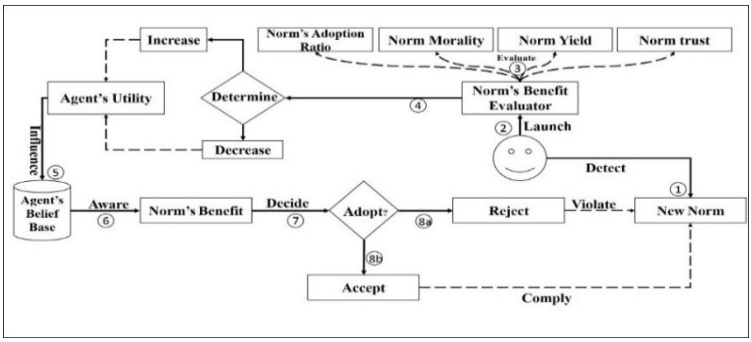

Fig. 2. A Proposed Framework for Norm's Benefit Awareness

4.2 Formalization

We introduce here the proposed approach for evaluating the Norm's Benefit Awareness (N_BA) via the Norm's Benefit Evaluator (N_BE). As mentioned earlier, for an agent to determine the N_BE, it needs to evaluate the parameters, Norm's Adoption Ratio, N_{AR}; Norm's Yield, N_Y; Norm's Trust, N_T; and Norm's Morality, N_M. The output of the N_BE either increases or decreases the agent's utility.

Let δ be the value of adoption ratio parameter, N_{AR}; λ be the value of yield parameter, N_Y; σ be the value of trust parameter, N_T; and μ be the value of morality parameter N_M. The parameters' values (δ, λ, σ, μ) are assumed to be positive, neutral, or negative. If the highest value of N_BE is 1, and the lowest value is 0, there is a range of threshold value, T, bounded between a and b; a maximum value, Max > a; and a minimum value, Min < b. If X is the result of N_BE, then,

$$N_BE = \begin{cases} \text{Max (Increase)} & 1 \geq X \geq a \\ \text{T (Threshold Value)} & a > X \geq b \\ \text{Min (Decrease)} & b > X \geq 0 \end{cases}$$

which means that the Norm's Benefit Evaluator (N_BE) equals Max (increase an agent's utility) when its result, X, is bounded between 1 and a; equals T when X is bounded between a and b (increase or decrease an agent's utility), or equals Min when X is bounded between b and 0 (decrease an agent's utility).

The parameters' (N_{AR}, N_Y, N_T, N_M) proposed evaluation procedure is as follows. Let E_P be a norm's positive effect, E_N the neutral effect, E_G the negative effect; n the norm; and α an agent with a utility, u_α. If E_P is bounded between 0 and 1 (positive effect), E_N equals 0 (neutral effect), E_G is bounded between 0 and -1 (negative effect), Table 1 shows the parameters' N_{AR}, N_Y, N_T, and N_M evaluation.

Table 1. The Parameters' (N_{AR}, N_Y, N_T, N_M) Evaluation

Parameters	Positive Effect (E_P)	Neutral Effect (E_N)	Negative Effect (E_G)
N_{AR}	$1 \geq \delta > 0$	$\delta = 0$	$0 > \delta \geq -1$
N_Y	$1 \geq \lambda > 0$	$\lambda = 0$	$0 > \lambda \geq -1$
N_T	$1 \geq \sigma > 0$	$\sigma = 0$	$0 > \sigma \geq -1$
N_M	$1 \geq \mu > 0$	$\mu = 0$	$0 > \mu \geq -1$

As mentioned earlier,

$N_BE = \delta(N_{AR}), \lambda(N_Y), \sigma(N_T), \mu(N_M)$
For the norm n, $N_BE = \delta(n), \lambda(n), \sigma(n), \mu(n)$

The parameters' $\delta(n), \lambda(n), \sigma(n), \mu(n)$ evaluations are as follow:

$$\delta(n) = \begin{cases} E_P(u_\alpha) & 1 \geq \delta > 0 \\ E_N(u_\alpha) & \delta = 0 \\ E_G(u_\alpha) & -1 \geq \delta > 0 \end{cases} \qquad \lambda(n) = \begin{cases} E_P(u_\alpha) & 1 \geq \lambda > 0 \\ E_N(u_\alpha) & \lambda = 0 \\ E_G(u_\alpha) & -1 \geq \lambda > 0 \end{cases}$$

$$\sigma(n) = \begin{cases} E_P(u_\alpha) & 1 \geq \sigma > 0 \\ E_N(u_\alpha) & \sigma = 0 \\ E_G(u_\alpha) & -1 \geq \sigma > 0 \end{cases} \qquad \mu(n) = \begin{cases} E_P(u_\alpha) & 1 \geq \mu > 0 \\ E_N(u_\alpha) & \mu = 0 \\ E_G(u_\alpha) & -1 \geq \mu > 0 \end{cases}$$

$$\text{If } \delta(n), \lambda(n), \sigma(n), \mu(n) = \text{Max} \Rightarrow N_BE = \text{increase}(n, u_\alpha)$$
$$\text{If } \delta(n), \lambda(n), \sigma(n), \mu(n) = T \Rightarrow N_BE = (\text{increase}(n, u_\alpha) \vee \text{decrease}(n, u_\alpha))$$
$$\text{If } \delta(n), \lambda(n), \sigma(n), \mu(n) = \text{Min} \Rightarrow N_BE = \text{decrease}(n, u_\alpha)$$

Table 2 shows the sample results of N_BE.

Table 2. Sample Results of NBE

δ	λ	σ	μ	N_BE	Agent's Utility (u_α)
E_P	E_P	E_P	E_P	Max	increase
E_P	E_P	E_G	E_G	T	critical (increase \ decrease)
E_P	E_G	E_G	E_G	T	critical (increase \ decrease)
E_G	E_P	E_P	E_G	T	critical (increase \ decrease)
E_G	E_G	E_G	E_G	Min	decrease

Hence, we define the Norm's Benefit Awareness (N_BA) of the agent, α, on the norm, n, as follow:

$$N_BA(\alpha, n) = \begin{cases} (\text{adopt } (\alpha, n)) \Leftrightarrow \text{increase } (n, u_\alpha) & N_BE = \text{Max} \\ (\text{ignore } (\alpha, n)) \Leftrightarrow \text{decrease } (n, u_\alpha) & N_BE = \text{Min} \end{cases}$$

This means that Norm's Benefit Awareness for the agent, α, on norm, n, is either α adopts the norm, n, if and only if it increases its utility (N_BE = Max), or α ignores the norm, n, if and only if it decreases its utility (N_BE = Min).

5 Conclusion and Future Work

In this paper, we present initial findings on norm's benefits awareness in an open multi-agent community where norms are adopted based on their expected benefits.

We observe that four components constitute the norm benefit awareness which are Norm's Adoption Ratio, Norm's Yields, Norm's Trust, and Norm's Morality.

This paper also proposes an approach to calculate the norm's benefits awareness via a norm's benefit evaluator. For an agent to determine the norm's benefit evaluator, it needs to evaluate the parameters' values, i.e., adoption ratio, yield, trust, and morality. The output of the N_BE either increases or decreases the agent's utility.

In our future work, we shall develop a method to calculate the absolute values of the parameters. From these values, an agent is able to calculate the norm's benefit and decide whether to adopt or reject a detected norm. When the norm's benefit is high, it motivates the agent to adopt it and vice versa.

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