Argument-Based Negotiation in a Social Context

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1. INTRODUCTION

Autonomous agents usually operate as a multi-agent community performing actions within a shared social context to achieve their individual and collective objectives. In such a social context, their actions are influenced via two broad forms of motivations. First, the *internal influences* reflect the intrinsic motivations that drive the individual agent to achieve its own internal objectives. Second, as agents reside and operate within a social community, the social context itself influences their actions. Here, we categorise these latter forms as *social influences*. Now, in many cases, both these forms of influence may be present and they may give conflicting motivations to the individual agent. For instance, an agent may be internally motivated to perform a specific action, whereas, at the same time, it may also be subject to an external social influence not to perform it. Furthermore, agents usually have to perform their actions in environments with incomplete information. Thus, for instance, they may not be aware of the existence of all the social influences that could or indeed should affect their actions.

In such complex and uncertain environments the need for the agents to interact efficiently and effectively becomes paramount. Given this, *Argumentation-Based Negotiation* (ABN) has been advocated as a promising means of resolving conflicts within such agent societies [3, 5]. In more detail, ABN allows agents to exchange additional meta-information such as justifications, critics, and other forms of persuasive locutions within their interactions. These, in turn, allow agents to gain a wider understanding of the internal and social influences affecting their counterparts, thereby making it easier to resolve certain conflicts that arise due to incomplete knowledge. Furthermore, the negotiation element within

ABN also provides a means for the agents to achieve mutually acceptable agreements to the conflicts of interests that they may have in relation to their different influences.

Now, one of the central features required by an agent to engage in such arguments within a society is the capability to generate valid arguments during the course of the dialogue. We believe this demands four fundamental capabilities: (i) a schema to reason in social settings; (ii) a mechanism to identify a suitable set of arguments; (iii) a language and a protocol to exchange these arguments; and (iv) a decision making functionality to generate such dialogues. This paper focuses on the first two issues and formulates models to capture them. More specifically, we extend the basic notion of social commitment to develop a coherent schema that captures social influences emanating from the roles and relationships of a multi-agent society (see Section 2). Thereafter, we illustrate how agents can use this social influence schema to *systematically* derive arguments to negotiate and resolve conflicts within a social context. In doing so, we highlight two major ways that agents can use this schema. The first of these allows agents to argue about the validity of each other's social reasoning, whereas the second enables agents to exploit social influences by incorporating them as parameters within their negotiation (see Section 3).
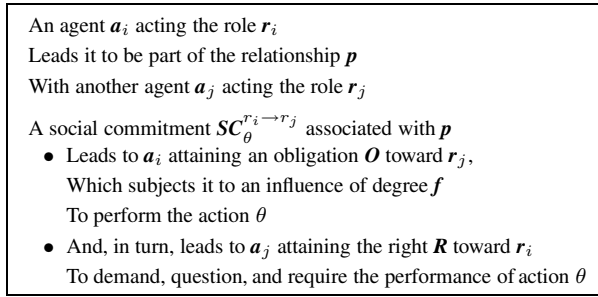
2. CAPTURING SOCIAL INFLUENCE

The notion of *social commitment* acts as our basic building block for capturing social influences. In essence, a social commitment ($\text{SC}_\theta^{x \to y}$) is a commitment by one agent x (termed the *debtor*) to another y (termed the *creditor*) to perform a stipulated action θ [2]. Having defined such, Castelfranchi further explains the consequences of a social commitment for both the agents involved. In detail, a social commitment results in the debtor attaining an *obligation* toward the creditor, to perform the stipulated action. The creditor, in turn, attains certain rights. These include the right to demand or require the performance of the action, the right to question the non-performance of the action, and, in certain instances, the right to make good any losses suffered due to its non-performance. We refer to these rights the creditor gains as the *rights to exert influence*. This notion of social commitment resulting in an obligation and rights to exert influence, allows us a means to capture social influences between two agents. Thus, when a certain agent is socially committed to another to perform a specific action, it subjects itself to the social influences of the other to perform that action. The ensuing obligation, on one hand, allows us to capture how an agent gets subjected to the social influence of another, whereas, the rights to exert influence, on the other hand, model how an agent gains the ability to exert such social influence upon another.

Given this basic building block for modelling social influence between specific pairs of agents, we now proceed to explain how this notion is extended to capture social influences resulting due to

An agent a_i acting the role r_i

Leads it to be part of the relationship p

With another agent a_j acting the role r_j

A social commitment $SC_\theta^{r_i \to r_j}$ associated with p
- Leads to a_i attaining an obligation O toward r_j,
  Which subjects it to an influence of degree f
  To perform the action θ
- And, in turn, leads to a_j attaining the right R toward r_i
  To demand, question, and require the performance of action θ

Figure 1: Schema of Social Influence.

factors such as roles and relationships within a wider multi-agent society (i.e., those that rely on the structure of the society, rather than the specific individuals who happen to be committed to one another). Specifically, since most relationships involve the related parties carrying out certain actions for each other, we can view a relationship as an encapsulation of social commitments between the associated roles. To illustrate this, consider the relationship between the roles supervisor and student. For instance, assume the relationship socially influences the student to produce and hand over his thesis to the supervisor in a timely manner. This influence we can perceive as a social commitment that exists between the roles supervisor and student (the student is socially committed to the supervisor to perform the stipulated action). As a consequence of this social commitment, the student attains an obligation toward the supervisor to carry out this related action. On the other hand, the supervisor gains the right to exert influence on the student by either demanding that he does so or through questioning his non-performance. In this manner, social commitment again provides an effective means to capture the social influences emanating through roles and relationships of the society (independently of the specific agents who take on the roles). Given this descriptive definition of our model, Figure 1 captures these notions as a schema of social influence (for a detailed formalisation refer to [4]).

3. CAPTURING SOCIAL ARGUMENTS

Having captured the notion of social influence into a schema, here we present how agents can use it to systematically identify arguments to negotiate within a society. We term these arguments *social arguments*, not only to emphasise their ability to resolve conflicts within a society, but also to highlight the fact that they use the social influence present within the system as a core means in changing decisions and outcomes within the society. Specifically, we have identified two major ways in which social influence can be used to change decisions, and, thereby, resolve conflicts between agents (see Figure 2).[1]

3.1 Socially Influencing Decisions

One way to affect an agent's decisions is by arguing about the validity of that agent's practical reasoning [1]. Similarly, in a social context, an agent can affect another agent's decisions by arguing about the validity of the other's social reasoning. In more detail, agents' decisions to perform (or not to perform) actions are based on their internal and/or social influences. Thus, these influences formulate the justification (or the reason) behind their decisions. Therefore, agents can affect each other's decisions indirectly by affecting the social influences that determine their decisions (see Figure 2(a)). Specifically, in the case of actions motivated via social influences through the roles and relationships of a structured society, this justification to act (or not to act) flows from the social influence schema

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[1]For a more comprehensive list of arguments, together with their formal representation, refer to [4].

(a) Socially Influencing Decisions

(b) Negotiating Social Influence
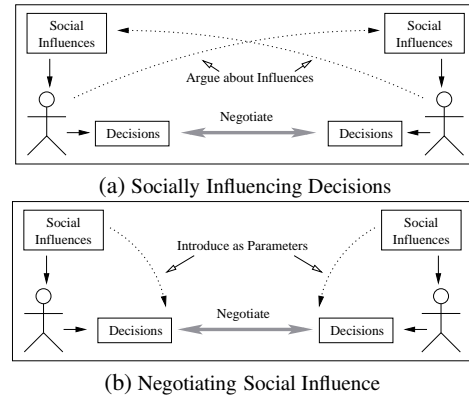
Figure 2: Interplay of Social Influence and Argumentation-Based Negotiation.

(see Section 2). Given this, we can further classify the ways that agents can socially influence each other's decisions into two broad categories:

1. Undercut the opponent's existing justification to perform (or not) an action by disputing certain premises within the schema that motivates its opposing decision (i.e., dispute a_i is acting role r_i, dispute SC is a social commitment associated with the relationship p, dispute θ is the action associated with the obligation O, etc.).

2. Rebut the opposing decision to act (or not) by,
   i. Pointing out information about an alternative schema that justifies the decision not to act (or act as the case may be) (i.e., point out a_i is also acting role r_i, point out SC is also a social commitment associated with the relationship p, point out θ is the action associated with the obligation O, etc.).
   ii. Pointing out information about conflicts that could or should prevent the opponent from executing its opposing decision (i.e., point out conflicts between existing *obligations*, *rights*, and *actions*).

3.2 Negotiating Social Influence

Agents can also use social influences within their negotiations. More specifically, instead of using social argumentation as a tool to affect decisions (as above), agents can use negotiation as a tool for "trading social influences". In other words, the social influences are incorporated as additional parameters of the negotiation object itself (see Figure 2(b)). For instance, an agent can promise to (or threaten not to) undertake one or many future obligations if the other performs (or does not perform) a certain action. It can also promise not to (or threaten to) exercise certain rights to influence one or many existing obligations if the other performs (or does not perform) a certain action. In this manner, the agents can use their obligations, rights, and even the relationship itself as parameters in their negotiations.

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