Towards Efficient Context-Sensitive Deliberation

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1 Introduction - Simple vs Complex Models

The trade-off between many simple agents, where patterns emerge from many interactions and fewer complex agents, where patterns emerge due to both internal deliberation as well as interactions, is of high importance in social simulations (see [3] for a good overview of this KIDS vs. KISS debate). As we have shown in [5] there is no winner for all cases. Going for many simple agents makes it often easier to replicate statistical findings, however with more complex agents we can often have a more in-depth analysis of what causes changes in behaviour and incorporate critical aspects that require a certain complexity. For example, the ASSOCC model [5] contains complex need-based agents with a rich social life. This allowed for detailed analysis of the effectiveness of new restrictions. However, this complexity came at the cost of a limit of about 2000 agents since going above this number slowed down the simulation significantly. Contrast this with a mathematical model such as the Oxford model [6] which runs 1 million agents, where on the other hand the agents only have a simple deliberation system and the effects of changes in the situation are not easily explained.

The Consumat framework [7] tried to offer a solution for adapting the deliberation to the situation. This could also provide a basis for dynamically compromising between quality and computational costs of decisions, using a utility-driven form of metacognition [8]. This framework unfortunately lacks social concepts such as normative behavior (e.g. wanting to be part of a group) or theory of mind (i.e. thinking about intentions, needs, goals, etc. of other agents). The deliberation selection mechanism is rational, while the ideas we propose in this extended abstract are based on a more human deliberation selection mechanism that is influenced by the physically and socially relevant aspects i.e. the context in a broad sense. In this paper we start from the Contextual Action Framework for Computational Agents (CAFCA) [4], which has clearer analytical concepts than the Consumat with a richer representation of social concepts. We will explain this framework and its relevance in the next section. In that section we also describe the main new idea of iterating deliberation steps with context discovery. Rather than first establishing a context and then deciding on a deliberation method, the two aspects are linked and interrelated. We use the smoking ban

		SOCIALITY DIMENSION		
		INDIVIDUAL	**SOCIAL**	**COLLECTIVE**
REASONING DIMENSION	**HABITUAL**	Repetition	Imitation	Joining-in
	STRATEGIC	Rational choice	Game theory	Team reasoning
	NORMATIVE	(institutional) rules	(social) norms	(moral) values

Fig. 1. Adopted from [4], it shows the categorization of deliberation methods

model [1] as a running example and as basis for our proof of concept implementation that indicates how this dynamic model can move from complex to simple deliberations based on the context.

2 Context-Sensitive Deliberation

The fact that context is important for the deliberation is not new. The relation between time scales and deliberation was posed by Newell in [10]. But, although Newell shows there is some connection between types of deliberation and context, he does not show how an agent can dynamically connect context and deliberation. Similarly there is quite some work on defining aspects of contexts in Human-Computer Interaction. Notably [11] gives a very usable definition of contexts when one considers the use of a software system in a context. However, all this work on context does not consider the deliberation of the agent itself in it's context in a dynamic way. The closest formal model on context recognition influencing deliberation is discussed in [2], but it remains a complex concept to define, even though humans use it in everyday life. The main fallacy that the approaches seem to have is that it is assumed that we first determine the context we are in and subsequently determine the best fitting deliberation method. We propose a method where we essentially start from the architecture proposed by Kahnemann [9]. In this architecture Kahnemann assumes that people have a system 1 for simple and quick thinking and a system 2 for elaborate and slow thinking. We assume a bit more elaborate system where the agent can slowly slide from simple and quick deliberation to elaborate and slow deliberation using the CAFCA framework shown in figure 1.

This matrix gives a broad categorization of agent deliberation methods. The matrix contains a social axis (horizontal) which has increased social deliberation when moving from left to right. In the first column the deliberation methods only consider the physical properties of other agents, they are just seen as obstacles or objects rather than social beings with their own behavior and goals. Moving to the second column, theory of mind becomes important, e.g. game theory requires the agent to be aware of other agents' actions. Finally the third column includes all of the aspects mentioned before in addition to group affiliation aspects. The reasoning axis (vertical) requires more effort when going from top to bottom and goes (usually) from short term simple to long term planning like deliberation.

The assumption is that agents in a known, normal situation will try to exhibit some habitual behavior by repeating previous behavior in the same situation. When this behavior is not possible or seen as inappropriate, the agent will move

from top-left in the matrix to bottom-right in the matrix. These steps can be initiated by some trigger from the context or by an internal trigger on the motivations (or goals) of the agent. In order to illustrate this idea of drawing slowly on more aspects of the context and on more deliberation aspects we use a case study on the smoking ban. Smoking is both an individual, habitual behavior as well as a social behavior. The introduction of the smoking ban in restaurants and bars creates a change in context that will (possibly) trigger a change of behavior. As there are already simulations on the changes triggered by the smoking ban [1] we can compare a simulation based on our deliberation principles with existing simulations to check its validity and differences in deliberation activities.

A smoker can enter a bar he visits regularly. For him this is a normal context allowing for the repetition deliberation method, leading him to smoke inside. However sometimes the context can have changed slightly, leading to different considerations. E.g. if the bartender is different from normal this might signal a change in management and thus a different smoking policy. Similarly, the introduction of a smoking ban leading to signs that it is forbidden to smoke inside. Note that these elements of the context are related to the intention of smoking. Thus this intention leads to picking up certain cues from the context that might influence the intent! Given the change in context the smoker can now take a social view and draw in the presence of the other people present in the bar and see what they are doing. When many other people still smoke as normal he might just imitate them and also smoke. However, if he notices his group of friends, that he usually meets in the bar, all not smoking, he might move to a deliberation including the value of group affiliation and complying to what friends are doing. All of this behavior is still determined by the first row in the CAFCA matrix. Notice that we first look at the other people as people that have a similar goal of being in the bar and at second instance look at people that one has a special relation to that is worth taking into consideration. Thus the deliberation changed of nature while taking in more aspects of the context.

It can become even more interesting when a person walks up to the smoker and tells it is forbidden to smoke. This will trigger more context exploration as now the smoker has to consider the other person as well, leading to for example game theoretical or (social) norm deliberation methods. If he does not know the other person he might consider a strategic way out of the situation. Comply and give up smoking in the bar, go outside to have a smoke, stir up his friends to join in smoking. These possibilities again lead to deliberation methods going from left to right in the second row of the CAFCA matrix.

Finally, the smoker also might consider whether the smoking ban should be followed and thus lead to a more long term change of behavior. This is the kind of deliberation taking place on the normative row of the CAFCA matrix. Note that this normative reasoning can take place in parallel or even after the deliberation taking care of the present situation. Thus the deliberation methods are not all exclusive! The more elaborate ones are triggered when more aspects of the context are taken into consideration. And reversely, more social and normative aspects of the context are taken into consideration when more long term

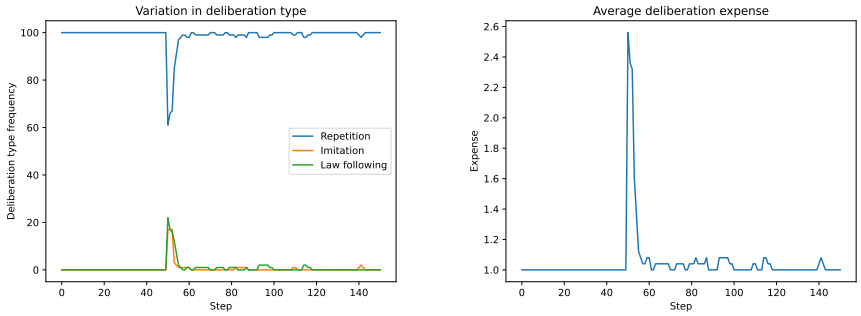

Fig. 2. The effect of the introduction of the smoking ban (step 50) on deliberation type (left) and deliberation expense (right)

influences are expected on the agent's intentions and goals. This flexibility in deliberation processes and interaction with the context is very much like human deliberation. We do most things automatically whenever we can (being quick and efficient in deliberation) but in almost any situation we can change to a more complex deliberation if the situation requires.

3 Discussion and Prospects

We have made a first, relatively simple implementation of the above context-sensitive deliberation in a social simulation that models agents reacting to the smoking ban. The agents follow default behavior until there is a contextual cue or trigger. The introduction of the smoking ban will influence the agents to use other deliberation types rather than going for the default action, as there is a relevant change in context which needs to be processed. In the case of the smoking ban, the smokers action of smoking is suddenly illegal causing them to imitate or follow the law. While this model is only a proof of concept it already shows the potential of our approach in terms of performance.

Figure 2 clearly shows a dramatic bump in deliberation expenses right after the introduction of the smoking ban (step 50). This bump is caused by a shift from reasoning using low-expense repetition to higher-expense imitation and law-abidance, until the new status-quo is becomes integrated as a new (repetition) habit. Most of the time, agents use low-cost deliberation while allowing for more complex deliberation, only when required.

This simple implementation does not incorporate the actual interplay between context and deliberation, which should depend e.g., on the type of activity and aspects relevant for the context for that activity. We are still investigating whether and which patterns of this interplay can be modeled. Location and time (e.g., morning or afternoon) appear to be intuitive starting points. However what comes next? How do people in unfamiliar situations deliberate, look at signs or people or asks for help? We will explore these aspects next.

Research on such frameworks also can lead to advances in social science, beyond scalable advanced agent models. E.g. which deliberation system to focus on when building a policy to bring about the best effect? Would imitation or changing rules achieve the highest impact?

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