2008 IEEE/WIC/ACM International Conference on Web Intelligence and Intelligent Agent Technology

Ethical Trust and Social Moral Norms Simulation: A Bio-Inspired Agent-Based Modelling Approach

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Abstract

The understanding of the micro-macro link is an urgent need in the study of social systems. The complex adaptive nature of social systems adds to the challenges of understanding social interactions and system feedback and presents substantial scope and potential for extending the frontiers of computer-based research tools such as simulations and agent-based technologies. In this project, we seek to understand key research questions concerning the interplay of ethical trust at the individual level and the development of collective social moral norms as representative sample of the bigger micro-macro link of social systems. We outline our Computational Model of Ethical Trust (CMET) informed by research findings from trust, machine ethics and neural science. Guided by the CMET architecture, we discuss key implementation ideas for the simulations of ethical trust and social moral norms.

1. Introduction

It is a widely acknowledged concern that the micro-macro link (thereafter known as M-M link) or multi-level analysis constitutes a fundamental discussion in the study of sociology and social systems. This M-M issue or concern is also a concern in multi-agent system (MAS) simulation especially from the perspective of distributed artificial intelligence (DAI) where agency coordination and scalability can become problematic [51]. At the macro level of the M-M link, concerns are also framed in terms of emergence of macro phenomena from individual actions; emergence of structure; and emergence of norms from individual beliefs and behaviour. At the micro level, concerns are framed in terms of social causation as well as whether macro effects are transferred uniformly to all individuals or whether they are transferred in a non-uniform manner (See [61, 51, 50, 22]). Along these concerns are other related concerns of top-down or bottom-up influence for example do institutions influence individual behaviours or individual behaviours influence institutions?[12]; structure versus agency; and actor versus network debates. These dichotomies have very similar veins in that it all concerns the interplay of levels.

In order to gain a better understanding of the interplay of levels, our group have selected to investigate the interplay of individual ethical trust and collective social moral norms as a representative sample of the bigger M-M concern of social systems. We advocate the use of agent-based simulation as appropriate computer-based research tools that can mediate and help shed light in a bi-level analysis.

We see a form of moral reasoning comprising the ethical or moral consideration of others and a willingness to accept the risk by exercising trust. We see this form of ethical trust mapping to the notion of a "leap of faith" as mentioned by [37] and influcenced by the "sociation" process of [54]. Hence, the research questions that our project seeks to understand are:

- How can computer-based investigative techniques (for example agent-based computing and simulation) assist in the understanding of the interplay of ethical trust behaviors at the individual and the group level?
- How information processing affect moral judgement and actions?
- How do moral judgments and actions at the individual level affect the collective social moral norms? When does one's moral action become a collective moral norm for a group? and does a group moral norm constraint decision and behavior at the individual level?

Section 2 reviews important research on trust and machine ethics and highlight the significance of simulation and agent-based modelling paradigms for the investigation of this M-M link. Section 3 outlines the conceptual notion of a bio-inspired Computational Model of Ethical Trust

978-0-7695-3496-1/08 $25.00 © 2008 IEEE
DOI 10.1109/WIIAT.2008.184

(CMET). Based on this two-tier architecture, salient aspects of the agent-based model design considerations are discussed. Key features of this project are bio-inspired neural agent-based processes in ethical trust reasoning and in the evolution of social moral norms. Section 4 provides concluding discussions that lead to works including the application of CMET to investigate the interplay of ethical trust and moral norms.

2. Selected works

Here we analyze selected developments in trust and ethics research.

2.1. Trust and ethics research

According to Luhmann, "trust is a basic fact of life" and "to show trust is to anticipate the future" [30]. For sure, trust and ethics are necessary for social order and hence the effective functioning of social systems [30, 27, 20]. They have received active attention of researchers in many different fields. For good overview on trust, see [54, 30, 27, 39, 38, 48, 26, 32]. For overview of both eastern and western ethics, see [59, 60, 41, 62].

Two important developments are noted as trust and ethics research mature. First is the framing of trust and ethics as multi-dimensional constructs where researchers introduced the social, affective, emotional and computational dimensions of trust and moral judgments in the attempt to arrive at a deeper understanding (See [27, 10, 33, 6, 26, 23]). The other development is machine ethics research. Machine ethics is a field of study that is concerned with the ethical behaviours of machines towards human and other machines. Recent research in machine ethics include ethical reasoning and computational ethics (See [31, 4, 35, 5]) and suggest that, in addition to traditional philosophical inquiry, a computational approach for ethics is emerging.

2.2. Significance

These developments together with advances in simulation and agent-based technologies are important aspects of research findings. On the one hand, they inform us on modelling of "sociability" aspects of social systems namely the social interactions and the system feedback; and on the other hand, simulation and agent-based technologies provide the required modelling tools to model and study the intended social systems. According to [44], "Simulation is a ground-breaking tool to study the core problem of the micro/macro relations".

From these seminal papers of 'ascribing mental qualities to machines' [34] and 'agent-orient programming' [53] to Axelrod's view of simulation research as the 'third way of doing science' [9], the synergistic link (in terms of object-oriented usefulness and ease of computer experimentations) between simulation and agent-based paradigm can be mapped. As a result, agent-based simulation received popular attention from researchers working in diverse fields and disciplines (See [19, 17, 9, 24, 43, 63, 47, 55, 15]). We see simulation and agent-based modelling as a useful tool for the study of ethical trust and social moral norms within social systems. We subscribe to the three reasons [25] gave as to why agent-based modelling software and simulation is easy to use:

1. Agent-based simulation provides insight and intuition;
2. Agent-based simulation forces us to think more clearly about our problems;
3. Simulation allows us to perform experiments that would be difficult or impossible to perform on real subjects;

In addition, relative to the context of ethical trust modelling, we offer two other important considerations, namely:

4. Agent-based simulation allows us to test sociological theories;
5. Agent-based simulation facilitates the adaptive learning for complex adaptive system;

The findings from these research confirmed the appropriateness of agent-based simulation for investigations of complex adaptive systems, wherein social systems are prime candidates. Hence, it is the strengths of agent-based simulation combined with elements of bio-inspired neural agent-based processes that lead us to adopt the agent-based modelling approach for the development of a computational model of ethical trust (CMET). This model will be used to investigate the interplay of ethical trust and social moral norms.

3. Computational model of ethical trust (CMET)

We present the design considerations of CMET to allow simulation and investigations of the interplay of individual ethical trust and collective social moral norms.

3.1. Bio-inspired CMET architecture

A series of neural-related research inform and inspire our CMET model design. These developments include:

- The generic neuron network. The neuron is a brain cell that has functional control over many of our physical

and cognitive activities. The term neuron was coined in 1891 by Heinrich Wilhelm Gottfired von Waldeyer-Hartz and later, Cajal established the neuron doctrine and the principle of connection specificity. Artificial neural networks (ANN) are the computerized counterpart of the bio-based neurons. ANN is useful for pattern recognition and classifications. This ANN and MAS is deployed in tier-1 of CMET. (For overview on these areas see [11, 18, 29]).

- The mirror neuron system (MNS) comprising 'canonical neuron' and 'mirror neuron' are equipped with mirroring and adaptive learning abilities. (See [45, 46, 16]). In particular, the features of the shared manifold hypothesis [16] – wherein the canonical neuron simulates the "best programmed plan" and provides a copy to the mirror neuron for action have strong influence on the CMET design. This idea is closely related to other recent studies in the area of theories of mind (ToM). ToM suggest that we "mind read" social situations and this ability allow us to form a mental model within us (See [16, 1]; this idea that we carry 'a small-scale mental model of the real world inside our head' is also mentioned by Craik, Simmel and Bandura (see [54, 64, 10]). We use this mental model to reason and evaluate, to empathize and thereafter to form and to project social judgments. This form of mental model can be perceived as a form of system feedback and map closely to Rosen's anticipatory system. This idea is modelled at tier-2 of CMET.

- Recent neural research findings suggest that social and moral reasoning are related to various areas of the human brain - "a network of brain regions" (See [7, 3, 42]). In addition, [21] suggest that moral thinking involve two types of processes: "domain-specific, social-emotional responses and domain-neutral reasoning processes".

Based on these considerations, the CMET architecture is designed as a two-tier architecture as shown in Figure 1. Tier-1 in CMET models the ethical trust reasoning and tier-2 addresses the collective social moral norms. (For a more detailed discussion on CMET and its components see [28])

3.2. From CMET to agent-based simulation

We cite two studies: one on moral norms by [52] and the other on the promotion of norms by [8] as a start and a departure point for our discussion on the moral norms simulation. Both studies employed a behaviorial perspective towards norms.

For [52],

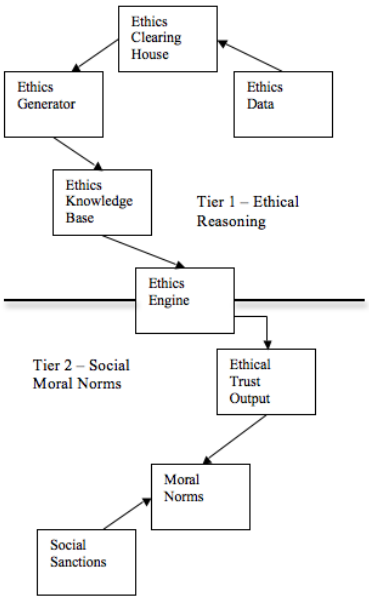

Figure 1. CMET 2-Tier Architecture.

> "The relationship of moral norms to behavior depends upon how a person defines the moral choice situation. If a person construes a decision he faces to be a moral choice, relevant moral norms he holds are likely to be activated and to affect his behavior" ([52]: p 355).

For [8],

> "A norm exists in a given social setting to the extent that individuals usually act in a certain way and are often punished when seen not to be acting in this way" ([8]: p 47")

We can say that the study by [52] is a traditional social science study that follows closely to the "deductivism" path (for a discussion of different research methodologies, see [2]) while [8] uses evolutionary game theoretic approach in a simulation to study how "norms can change over time or to the growth and decay of norms" ([8]: p 47). The approach taken can be summarized as follows:

Develop Model – Model the relationship of moral norms with suitable independent variables;

Measure or Simulate – Measure the independent variables as ordinal data type or simulate the rules or the decision-making processes to derive the strategies and values for the ordinal data type;

Apply Adaptation – Deploy learning, adaptation or evolutionary algorithms;

Observe Pattern – Observe for patterns and interactions;

For our project, we deploy this approach and in addition to a behavior-based definition of "moral norms", we include selected key social processes as discussed in the next section.

3.3. Discussion

The issues of micro-macro effects and macro-micro impacts within social systems are closely related to the notions of emergence, downward causation and sociation. According to [54] "...it is sociation which synthesizes all human interests, contents and processes into concrete unit" ([54]: p 4). These sociation processes include social interactions, learning and adaptation. Hence, in most social systems, on the one hand, when agents interact at the micro level, based on social signals, protocols and rules, macro phenomena such as formation of institution or behavior patterns at the collective level can be observed, giving rise to notion of "emergence" and these macro phenomena once formed, can in turn impact or constrain individual agent's behaviors through rules, conventions, norms, cases or law. (For more discussion on emergence and downward causation, see [14, 15, 40, 49]). Our project models key "sociation" processes in the form of social interaction, cognizance and information processing such as the effects as well as the acceptance of social information. An example of the effects of social information is the impact of sanctions and an example of the acceptance of social information is the agreement or transfer or copying of social beliefs. These processes are supported by key implementation ideas of "demons and agent ensemble grouping". We see these ideas being operationalized as follows:

Demons and MAS. Agents in the MAS will be equipped with"demon-like capabilities" for the selection and deployment of simulation parameters such as rules and variables. The idea of "demon" was first introduced circa 1872 by James Clark Maxwell as a form of thought experiment on issues of heat flow and the second law of thermodynamics. This idea was later popularized by [57] and is now commonly known as Maxwell's demons. Maxwell's demon is an imaginary "being with certain well-defined powers of actions" ([58]: p 126) and as part of his thought experiment, Maxwell conceived of this demon as a "sorting demon" who guarded the trapdoor between two containers and will open the trapdoor to allow a faster travelling molecules to pass through from one side to the other (See [13, 56]). [36] also used the idea of "demon" as "recognition-agents (that) lurk silently; to intervene only in certain circumstances" ([36]: p 274). CMET will have agents with "demon-like" roles to allow agents to be able to response to changing roles and environment, for example to allow for additional rules, meta-rules or different combinations of independent variables. When an agent encounters a given case, it "looks" out for the feature that belongs to his own class. Once the agent "observes" this feature, he will "broadcasts" his observation. The other agent will "listen" to the "broadcast" and based on the "loudest broadcasts", it will select and assigned the set of rules or "generics" to the corresponding level within the simulation.

Ethical trust reasoning. Tier-1 will provide for an ethical knowledge base that will aid in the development of rules for decision-making. The underlying mechanisms are designed as neural-based network and rule-based system (See Figure 2). These mechanisms will provide the required decision-making and rules during the simulation. This neural network rule-based system is differentiated from the evolutionary game theory approach deployed in [8]. We deploy this approach as an initial effort to allow for context-related, social influences and certain level of pragmatism to be exogenously modeled instead of endogenous accommodation within a game-theoretic pay-off matrix. In this sense, this approach may be considered to be more contextualized and behavioral then the game-theoretic approach. Tier-1 architecture can be further improved to incorporate role-playing games and to collect real time data. This will allow for more realistic representation and a move towards the trend of participatory simulation.

Social moral norms Tier-2 allows for operationalization of models with changing independent variables and rules. This is inspired by the concept of mirror neuron system (MNS) found in human system. Agents will be equipped with the roles of "canonical and mirror" neurons and will allow for copying and forming of collective moral practices. Tier-2 will include moral norms visualiser (MNV). Underpinning this notion of the MNV is the working mechanisms of MNS as well as the concept of an ensemble of agents and models. Each MNV agent has an ensemble of three types of agents namely the MNS agent - this is the agent subsystem that translates the moral judgment from a mental state to a defined state as well build a mental model to allow for second order system feedback; the ethical output (EO) agent - this agent contains cases as output from the tier-1 of CMET; and the memory (MEM) agent - contains the rules for adaptive learning and interactions. This agent ensemble grouping is shown in Figure 3

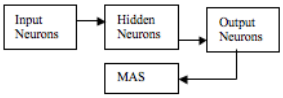

Figure 2. Neural Network and MAS.

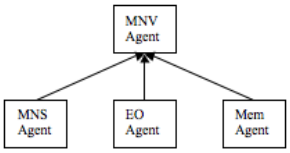

Figure 3. Agent Ensemble Grouping.

4. Conclusion

Neural mechanisms from the study of neural science and human brain have excellent properties that inspire design of computational models of ethical trust. Specifically the generic neuron network can be used for classification of rules and cases; MAS with "demon" capabilities allows for case recognition and management while agent ensemble grouping that support a "mirror neuron-like" system can be mapped for the modelling of ethical trust reasoning and for the study of social moral norms. We believe that such inspirations can be extended to other computational systems.

Agent-based modelling and simulation with its strong link to object-oriented paradigm is a useful tool for the study of micro-macro concerns of social systems. Beyond the initial investigations, it also allows testing and validating of essential social theories. We believe that an appropriate and cautious deployment of agent ensemble coupled with chosen simulation techniques can serve as another avenue of research and allow for model-to-model comparison. Due to space limitation, this area of model-to-model comparison was not addressed in this paper. However, we acknowledge that it is an important area to be addressed in future research work.

We are now in the phase of refining our model. This includes development of the simulation rules, variables' representation, cases and ethical knowledge base. The next phase is running the simulation and analyzing the outcomes. These results will be reported once they are available.

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