Information processing, rational beliefs and social interaction (10w2133)

Giacomo Bonanno (University of California Davis, USA),
James Delgrande (Simon Fraser University, Canada),
Randy Goebel (University of Alberta, Canada),
Jérôme Lang (Université Paris-Dauphine, France),
Hans Rott (University of Regensburg, Germany)

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1 Overview of the Field

The study of the mathematical aspects of belief formation, information processing and rational belief change is of central importance in a number of different fields, namely artificial intelligence, computer science, game theory, logic, philosophy and psychology. The area of belief change studies how a rational agent may maintain its beliefs about a possibly changing environment after obtaining or perceiving new information about the environment. This new information could include properties of the actual world, occurrences of events, and, in the case of multiple agents, actions performed by other agents, as well as the beliefs, preferences or actions (including communication acts) of other agents. Such agents could be acting and sensing in a dynamic world, coalescing information obtained from various sources, negotiating with other agents, or otherwise augmenting and revising their knowledge.

The most important question in Game Theory is how to rationally form a belief about other players' behavior and how to rationally revise those beliefs in light of observed actions. Traditionally Game Theory has relied mostly on probabilistic models of beliefs, although recent research has focused on qualitative aspects of belief change. A new branch of modal logic, called Dynamic Epistemic Logic, has emerged that investigates the effects of events that involve information being revealed to a group of agents in a variety of ways, such as through a public announcement or a private announcement. In artificial intelligence, the relatively recent emergence of the field of cognitive robotics, which is concerned with endowing artificial agents with cognitive functions that involve reasoning about goals, actions, the states of other agents, collaboration and negotiation, etc., has given impetus to the development of computational operators for belief change and the identification of issues arising from concrete, evolving sets of knowledge. Another, related, new field of research, called Social Software, maintains that mathematical models developed to reason about the knowledge and beliefs of a group of agents can be used to deepen our understanding of social interaction and aid in the design of successful social institutions. Social Software is the formal study of social procedures focusing on three aspects: (1) the logical and algorithmic structure of social procedures (the main contributors to this area are computer scientists), (2) knowledge and information (the main contributors to this area are logicians and philosophers) , and (3) incentives (the main contributors are game theorists and economists). The area of belief change is thus of interest to many research communities. To date, there has been limited interaction among these communities. The purpose of this 2-day workshop was to bring together researchers from these

different areas in an attempt to find some common ground and to identify general principles that underly the different approaches.

2 Recent Developments and Open Problems

The initial research in belief change came from the philosophical community, wherein belief change was generally studied from a normative point of view, providing axiomatic foundations about how rational agents should behave with respect to the information flux. Subsequently, computer scientists, especially in the artificial intelligence and the database communities, have been building on these results and relating them to computational systems. Belief change, as studied by computer scientists, not only pays attention to behavioral properties characterizing evolving databases or knowledge bases, but must also address computational issues such as how to represent beliefs states in a concise way and how to efficiently compute the revision of a belief state. More recently, the economics and game theory community, in particular the emerging field of cognitive economics, has become active in belief change research, adopting a normative point of view, like philosophers, but paying more attention to the ”cognitive plausibility” of the belief change operators.

Belief change is an area that leads to complex formal problems, not least of which is the problem of specifying an agent's epistemic state. That is, not only must an agent's beliefs be formally characterized, but so too must (effectively) the agent's strategy for responding to new information. The dominant approach to belief revision is known as the AGM theory, following the pioneering contribution of Alchourrn, Grdenfors and Makinson (1985). The AGM theory deals with the transition from a belief state to a new belief state in response to a piece of information. Information is treated as veridical and the ”success axiom” is assumed, which requires that information be believed. While belief revision is an active area of research, there are important open problems that remain to be addressed or further explored.

The first open problem concerns the notion of information. Belief revision is about incorporating reliable information into one's beliefs. What constitutes reliable information? Years ago, perhaps, a photograph could be taken as ”indisputable evidence”. Nowadays, with the advent of sophisticated image-editing software, photographs can be manipulated to misrepresent facts or to create the appearance of an event that did not happen. Videos and voice recordings are, nowadays, equally manipulable. What can one trust as a source of reliable information? The testimony of a witness? A newspaper article? A book? A television news report? A claim by the president of the USA? Many of us rely on the internet for information. Can material found on the internet be trusted as accurate? The theory of belief revision needs to address the issue of belief formation and revision in a world where no information can be fully trusted. Furthermore, in a social context, the incentives to convey wrong information need to be studied and incorporated into a theory of belief revision.

A second open problem is how to deal with sequences of items of information which are in partial or full contradiction with each other. This can happen when the same source, over time, provides contradicting information or when different sources (e.g. different experts) provide conflicting information or different opinions or assessments. To some extent, this issue has been studied in the literature on iterated belief revision, where various principles have been suggested (for example, the principle that the most recent item of information should prevail over earlier ones). However, the proposed principles seem rather *ad hoc* and in need of a firmer foundation.

A third problem concerns the notion of ”minimal” belief change. The AGM theory is often referred to as a theory incorporating the principle that beliefs should be changed in a minimal way, so as to ensure that there is minimal loss of prior beliefs. While this is true when new information is compatible with prior beliefs, in the case where the new information contradicts the earlier beliefs, there is really no constraint imposed by the AGM postulates in terms of preserving as many of the old beliefs as possible. Indeed one way of revising beliefs, which is consistent with the AGM postulates, if to form a new belief set consisting exclusively of the learned information and anything that can be logically deduced from it. More work needs to be done on what minimal belief change entails.

3 Presentation Highlights

This was a multidisciplinary workshop, covering different fields. Two participants were from economics and game theory (Giacomo Bonanno, University of California Davis, USA and Daniel Eckert, University of Graz, Austria), two from philosophy (Hansa Rott, University of Rotenburg, Germany and Bryan Renne, University of Groningen, The Netherlands), three from computer science and artificial intelligence (James Delgrande, Simon Fraser University, Canada, Ken Satoh, National Institute of Informatics, Japan and Thorsten Schaub, Technical University of Darmstadt, Germany), one from linguistics (Jeffry Pelletier, University of Alberta, Canada) and one from Information Science and Media Studies (Thomas Ågotnes, University of Bergen, Norway). There was also a graduate student in computer science (Mehrdad Oveisi, Simon Fraser University, Canada). The first day of the workshop was devoted to individual presentations. However, the speakers were encouraged to avoid focusing on narrow technical contributions and instead try to highlight approaches and issues that spanned more than one field. Each talk lasted 30 minutes. Giacomo Bonanno talked about using the AGM theory of belief revision developed in computer science and philosophy to gain new insights into game theory, in particular the solutions of dynamic games with imperfect information. Ken Satoh talked about the brand new field of Juris-informatics and the attempts to analyze principles of legal reasoning in terms of non-monotonic logic and counterfactuals. Thomas Ågotnes drew a connection between the methods and tools used to analyze cooperative or coalitional games and the relatively new field of dynamic epistemic logic. James Delgrande and Thirsten Schaub talked about new developments in the theory of belief revision, from both a theoretical and a computational perspective. Hans Rott talked about the connections between rational choice theory and principles of belief revision. Bryan Renne talked about attempts to model communication and exchanges of opinions in terms of justifying one's own beliefs. Daniel Eckert drew a connection between model theory and impossibility results in social choice theory. Jeffrey Pelletier talked about experiments aimed at understanding how well people reason from a logical point of view. Mehrdad Oveisi gave an overview of his thesis where he analyzes changes in belief bases. Each talk was followed by a lively discussion. The second and last day was devoted to two round-table discussions which spanned the topics touched upon in the previous day as well as new topics.

4 Scientific Progress Made

Given the very short length of this workshop (one and a half day) one could not expect to achieve much in terms of scientific progress. However, all the participants agreed that the workshop had been very fruitful, both in terms of exposure to new topics and issues and in terms of highlighting possible new avenues for research.

5 Outcome of the Meeting

It is expected that one of the outcomes of the meeting will be to stimulate interdisciplinary research. During the several informal discussions that took place during the one and a half day, some of the participants saw the possibility of establishing new connections between their areas of research and talked about possible joint projects. It was also agreed that the workshop had been very beneficial and that a follow-up or similar workshop would be highly desirable. However, it was also agreed that a longer workshop that spanned more than one and a half days would be better. Six out of the ten participants came from very far (five from Europe and one from Japan) and felt that a longer workshop would be needed in order to justify traveling such a long distance.

References

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