

07351 Abstracts Collection
Formal Models of Belief Change in Rational
Agents
— **Dagstuhl Seminar** —

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Abstract. From 26.08. to 30.08.2007, the Dagstuhl Seminar 07351 “Formal Models of Belief Change in Rational Agents” was held in the International Conference and Research Center (IBFI), Schloss Dagstuhl. During the seminar, several participants presented their current research, and ongoing work and open problems were discussed. Abstracts of the presentations given during the seminar as well as abstracts of seminar results and ideas are put together in this paper. The first section describes the seminar topics and goals in general. Links to extended abstracts or full papers are provided, if available.

Keywords. Belief change, rational agents, information economy, information processing

07351 Executive Summary – Formal Models of Belief Change in Rational Agents

From August 26, 2007 to August 30, 2007, the Dagstuhl Seminar 07351 "Formal Models of Belief Change in Rational Agents" was held at the International Conference and Research Center (IBFI), Schloss Dagstuhl. During the seminar, several participants presented their current research, and ongoing work and open problems were discussed.

The Executive Summary describes the seminar topics and goals in general. Abstracts of the presentations given during the seminar as well as abstracts of seminar results and ideas are put together in the Proceedings. Links to extended abstracts or full papers are provided, if available.

Keywords: Belief revision, iterated belief revision, update, merging, dynamic logic, epistemic logic, conditionals, social choice, game theory

Joint work of: Bonanno, Giacomo; Delgrande, James; Lang, Jérôme; Rott, Hans

Extended Abstract: <http://drops.dagstuhl.de/opus/volltexte/2007/1201>

A logical formalism for the subjective approach in a multi-agent setting

Guillaume Aucher (IRIT - Toulouse, F)

Representing an epistemic situation involving several agents depends very much on the modeling point of view one takes. In fact, the interpretation of a formalism relies quite a lot on the nature of this modeling point of view. Classically, in epistemic logic, the models built are supposed to represent the situation from an external and objective point of view. We call this modeling approach the objective approach. In this paper, we study the modeling point of view of a particular agent involved in the situation with other agents. We propose a logical formalism based on epistemic logic that this agent can use to represent ‘for herself’ the surrounding world. We call this modeling approach the subjective approach. We then set some formal connections between the subjective approach and the objective approach. Finally we axiomatize our logical formalism and show that the resulting logic is decidable.

Keywords: Epistemic logic, multi-agent system

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2007/1200>

Iterated Dynamic Revision of Multi-Agent Higher-Level Beliefs: A Semantic Approach

Alexandru Baltag (Oxford University, GB)

I present a semantic, qualitative approach, in the tradition of Dynamic-Epistemic Logic (DEL), to the problem of (iterating) dynamic belief revision of multi-agent higher-level beliefs (i.e. beliefs, not only about ontic facts, but also about other agents’ beliefs etc). This presentation is primarily based on my own work with S. Smets, and on J. van Benthem’s closely related work, but it is also connected to other DEL-based approaches to belief revision, by G. Aucher, H. van Ditmarsch and others.

There are seven main ingredients that are combined in this approach.

The first is the distinction (clearly formulated by J. van Benthem and simultaneously by Baltag and Smets, but anticipated by others) between “static” and “dynamic” belief revision, distinction of primary importance when dealing with higher-level beliefs.

The second ingredient is the well-known semantic representation (due, in various forms, to Lewis, Grove and Spohn) of conditional (i.e. revisable) beliefs in terms of plausibility-ordered models.

The third ingredient is the idea that a complete belief revision theory should deal, not only with the revision of "beliefs", but also with revising other "doxastic attitudes": conditional belief, knowledge, "safe belief", entrenched (or "strong") belief etc. Formalizing this idea gives rise to a number of complete modal logics, with modalities for each type of doxastic attitude.

The fourth ingredient is the idea that new information does not come only in propositional form, but also in dynamic form: besides the propositional content of learning, there are the specific informational-doxastic aspects of the learning action itself. In other words, dynamic belief revision is not simply triggered by learning "propositions", but by the specific "doxastic events" through which learning is achieved: e.g. "hard" (inherently truthful) public announcements, "soft" (inherently believable) announcements, "secret" learning (whose possibility is unsuspected by outsiders), "legal" private learning (commonly known to be possible, although its content is private) etc.

The fifth ingredient (first introduced by G. Aucher and H. van Ditmarsch, as an adaptation to belief revision of the DEL approach of Baltag, Moss and Solecki) consists of modeling (the informational-doxastic features of) these various learning events using the same type of (plausibility-ordered) models that were used to represent static beliefs.

The sixth ingredient (due to Baltag and Smets) is the "Action-Priority" Rule, an update rule giving the simplest and most convincing generalization of AGM-type revision to arbitrary doxastic events.

Finally, the last ingredient consists of using a Dynamic Logic syntax, and so-called "Reduction Axioms", to formalize and completely axiomatize various logics for dynamic revision of (multi-agent higher-level) doxastic attitudes.

Keywords: Dynamic belief revision, plausibility models, action models, dynamic logic, modal logic

Enhanced Contractions and (In)dependence

Alexander Bochman (Holon Academic Inst. of Techn., IL)

We introduce a number of contraction operations that allow us to preserve more information in the process of belief contraction and revision of our epistemic states. One of them, choice contraction, will be argued to characterise basic (in)dependence relations among propositions belonging to the epistemic state.

Keywords: Contractions, dependence

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2007/1204>

Semantic structures for one-stage and iterated belief revision

Giacomo Bonanno (Univ. of California at Davis, USA)

Semantic structures for belief revision and iterated belief revision are proposed. We start with one-stage revision structures that generalize the notion of choice function from rational choice theory. A correspondence between these one-stage structures and AGM belief revision functions is established. We then add branching time and consider more general structures that accommodate iterated revision. AGM temporal belief revision structures are defined and a syntactic axiomatization is provided.

Keywords: Iterated belief revision, choice functions, Kripke semantics, branching time, modal logic

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2007/1205>

Equilibrium in social contraction

Richard Booth (Mahasarakham University - Thailand, SAS)

In a previous work we introduced *social contraction* operators as an intermediate stage in defining multi-agent belief merging operators, the idea being each agent manipulates their beliefs into a form in which they may be consistently conjoined. One notion which traditionally plays a prominent role in studies of multi-agent interaction is that of *equilibrium*.

We look at one way to describe what it means for the outcome of a social contraction operation to be in equilibrium. For this we assume each agent comes equipped with its own individual belief *removal* operation. Then, roughly, an equilibrium outcome is one which results from every agent simultaneously removing exactly enough beliefs to be consistent with all the others. Under this notion, we may examine questions such as: Are such equilibria always guaranteed to exist? And, if yes how do we find them? We also show how this notion of equilibrium may be seen as a generalisation of the notion of maximally consistent subsets of agents.

Keywords: Merging, social contraction, equilibrium, belief removal

Defeasible Acceptance, Assumptions, and Conditionals

John Cantwell (KTH Stockholm, S)

A theory of defeasible acceptance is presented with the ambition to capture acceptance conditions appropriate for the indicative conditional.

A central component of the theory is the separation of the role of what is *accepted* and what is *assumed* and an analysis of the relationship between propositions that are accepted and propositions that are assumed. Soundness and completeness results are presented for a non-bivalent semantics. A general characterisation is also given in the form of plausibility functions.

Belief Change and Cryptographic Protocol Verification

James Delgrande (Simon Fraser University, CA)

Cryptographic protocols are structured sequences of messages that are used for exchanging information in a hostile environment. Many protocols have epistemic goals: a successful run of the protocol is intended to cause a participant to hold certain beliefs. As such, epistemic logics have been employed for the verification of cryptographic protocols. Although this approach to verification is explicitly concerned with changing beliefs, formal belief change operators have not been incorporated in previous work.

In this paper, we introduce a new approach to protocol verification by combining a monotonic logic with a non-monotonic belief change operator. In this context, a protocol participant is able to retract beliefs in response to new information and a protocol participant is able to postulate the most plausible event explaining new information. We illustrate that this kind of reasoning is particularly important when protocol participants have incorrect beliefs.

Keywords: Belief change, belief evolution, cryptographic protocol verification

Joint work of: Hunter, Aaron; Delgrande, James

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2007/1206>

Judgment aggregation and multi-agent belief revision

Daniel Eckert (Universität Graz, A)

Relations between belief revision and the aggregation of preferences or judgments have long been noted (see e.g. Kfir-Dahav and Tennenholtz 1996, Konieczny and Pino Peres 2002, Gabbay, Pigozzi and Rodriguez 2006).

This note extends on a recent result by Christian List (2007) on multi-agent belief revision in the framework of judgment aggregation. In this framework the dictatorship result for judgment aggregation functions translates into the impossibility of a non-trivial multi-agent belief revision function under even weaker conditions than those in the spirit of Arrovian social choice.

Keywords: Judgment aggregation, multi-agent belief revision

Propositional Merging Operators based on Set-Theoretic Closeness

Patricia Everaere (Université d'Artois - Lens, F)

Belief merging operators aim at defining the beliefs/goals of a group of agents from a profile of bases, gathering the beliefs/goals of each member of the group. In the propositional setting, a widely studied family of merging operators are the distance-based ones: the models of the merged base are the interpretations considered as close as possible to the given profile; closeness is often measured as a number resulting from the aggregation of the distances to each base of the given profile. In this work we propose a new family of propositional merging operators, close to such distance-based merging operators, but relying on a set-theoretic definition of closeness, namely the diff measure already at work in several revision/update operators from the literature. We study a specific merging operator of this family, obtained by considering set product as the aggregation function. We focus on three important criteria: logical properties, strategy-proofness and complexity.

Keywords: Intelligence artificial, logic, merging, set of conflict

Joint work of: Everaere, Patricia; Konieczny, Sébastien; Marquis, Pierre

Isn't it time to apply belief revision?

Randy Goebel (University of Alberta, CA)

The study of belief revision has continued to elaborate a theoretical framework for understand belief accumulation, but hasn't had much impact in practical applications. We present some application problems which could feasibly benefit from belief revision theories, and offer back application constraints that stretch those theories. Among the issues revealed include the need for resource constrained reasoning, and a demand for further work on the trade offs between maintaining belief flocks. Application areas include online data mining of data streams, and software engineering revision management.

Keywords: Belief revision applications

Optimal Regression for Reasoning about Knowledge and Actions

Andreas Herzig (IRIT - Toulouse, F)

We show how in the propositional case both Reiter's and Scherl & Levesque's solutions to the frame problem can be modelled in dynamic epistemic logic (DEL), and provide an optimal regression algorithm for the latter.

Our method is as follows: we extend Reiter's framework by integrating observation actions and modal operators of knowledge, and encode the resulting formalism in DEL with announcement and assignment operators.

By extending Lutz' recent satisfiability-preserving reduction to our logic, we establish optimal decision procedures for both Reiter's and Scherl & Levesque's approaches: satisfiability is NP-complete for one agent, PSPACE-complete for multiple agents and EXPTIME-complete when common knowledge is involved.

Keywords: Reasoning about action and change, reasoning about knowledge, situation calculus, frame problem, dynamic epistemic logic

Joint work of: van Ditmarsch, Hans; Herzig, Andreas; de Lima, Tiago

See also: Proc. AAI 2007

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2007/1207>

A conceptual framework for revision, update, and nonmonotonic reasoning

Gabriele Kern-Isberner (Universität Dortmund, D)

It is well-known in the NMR & BR community that belief revision, belief update and default inference are closely related operations (referred to as belief operations in the following), and that there are lots of similarities between them, but also subtle or crucial differences. Axiomatic frameworks have been set up for each of these operations which help clarifying characteristics, but which, e.g., also stress the importance of distinguishing between revision and update. The human mind, however, seems to adopt and use new (even uncertain) information quite easily, without complicate analyses which operation is the most appropriate.

The point this talk aims to make is that human beings may realize all belief operations by making use of one basic belief change operation in different ways. This would explain similarities as well as differences between the belief operations, and provide the grounds for a really unifying approach to belief change and default reasoning. A methodological framework for all belief operations will be sketched, together with some basic postulates for belief change and nonmonotonic reasoning. Moreover, an example of a powerful belief change operator in a probabilistic environment will be presented.

Keywords: Conceptual framework, belief revision, iterated revision, belief update, nonmonotonic reasoning

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2007/1208>

A conceptual framework for (iterated) revision, update, and nonmonotonic reasoning

Gabriele Kern-Isberner (Universität Dortmund, D)

This paper makes a foundational contribution to the discussions on the very nature of belief change operations. Belief revision and belief update are investigated within an abstract framework of epistemic states and (qualitative or quantitative) conditionals. Moreover, we distinguish between background knowledge and contextual information in order to analyse belief change more appropriately. The rich epistemic representation framework allows us to make a clear conceptual distinction between revision and update on the one side, while revealing structural similarities on the other side. We propose generic postulates for revision and update that also apply to iterated change. Furthermore, we complete the unifying picture by introducing universal inference operations as a proper counterpart in nonmonotonic reasoning to iterated belief change.

Keywords: Belief revision, belief update, nonmonotonic inference, epistemic states, conditionals

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2007/1208>

Inconsistency Measures and their Application to Belief Change

Sebastien Konieczny (Université d'Artois - Lens, F)

This talk is about inconsistency measures. We recall the two main families of inconsistency measures and show their respective weaknesses. Then we introduce Shapley Inconsistency Measures (SIV), that allow to express how much inconsistency brings each formula of a belief base. This also allows to define inconsistency measures for belief bases that take both into account the distribution of the conflicts amongst the formulae of the base, but also the proportion of the language concerned by the inconsistencies. We then explain how such measures can be used for reasoning tasks, and more specifically for belief change operators: we focus on inference relations, belief revision, belief merging, conciliation (negotiation) operators.

Keywords: Inconsistency measures, paraconsistent logics, belief change, reasoning under inconsistencies

From belief change to preference change

Jérôme Lang (IRIT - Toulouse, F)

There is a huge literature on belief change. In contrast, preference change has been considered only in a few recent papers.

There are reasons for that: while there is to some extent a general agreement about the very meaning of belief change, this is definitely not so for preference change. We discuss here the possible meanings of preference change, arguing that we should at least distinguish between four paradigms: preferences evolving after some new fact has been learned, preferences evolving as a result of an evolution of the world, preferences evolving after the rational agent itself evolves, and preferences evolving per se. We then develop in more detail the first of these four paradigms (which we think is the most natural). We give some natural properties that we think preference change should fulfill and define several families of preference change operators, parameterized by a revision function on epistemic states and a semantics for interpreting preferences over formulas.

Keywords: Beliefs, preferences, decision making, agents, preference revision

Joint work of: Lang, Jérôme; van der Torre, Leon

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2007/1209>

Why Indeterminacy in Probability Judgment?

Isaac Levi (Columbia Univ. - New York, USA)

When an agent fails to rule out probability distributions as permissible to use in assessing expected utility, the agent is in a state of doubt or suspense concerning probability judgment. Such doubt differs from doubt concerning judgments of truth as in states of full belief.

Keywords: Doubt, suspense, probability judgment, serious possibility, permissibility, consensus

Probability Logic and Logical Probability

Isaac Levi (Columbia Univ. - New York, USA)

Authors like Keynes, H. Jeffreys and Carnap advocated using a concept of "logical probability". Logical probability had the following properties: (a) it was representable as a function from potential states of full belief (or "evidence") to states of subjective or credal probability judgment. (b) Such functions were alleged to be constrained by principles of probability logic. (c) All rational agents were supposed to be obliged to adopt the standard function that probability logic prescribed. In this essay, it is argued that these three requirements could be satisfied only if probability logic prescribed that credal probability should be numerically determinate. Keynes denied that it should numerically determinate and Carnap abandoned the idea that probability logic could supply a determinate function from states of full belief to numerically determinate credal states that all rational agents ought to adopt. The paper explains that once this is conceded, logical probability ought to be interpreted rather differently than it is customarily is.

Keywords: Probability, full belief, logic, evidence

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2007/1210>

Character and Coherence - Belief Dynamics as a Guide for Modelling in Ethics

Guido Löhrer (Universität Bern, CH)

Revising moral beliefs is a fundamental operation in ethics. Revisions of moral beliefs are generally considered to require one fixed point of reference: that is, a stable moral character of the person revising his or her moral beliefs. Without this requirement, these alterations of beliefs, decisions and actions could not be seen as accountable in respect to the persons in question. Thus, meta-ethical generalists on the one hand, and particularists on the other, argue that fixed moral principles, (i.e. a fixed moral sensitivity), are constitutive to character stability. Both positions see moral rightness in the sense of synchronic coherency of lower moral beliefs, (e.g. maxims), as the goal of the revision of moral beliefs. The critical findings are that the static ability to always be right in moral issues does not form a moral character capable of exceptional imputation. Therefore, this article argues first of all that character stability should be seen as diachronic coherency of our moral beliefs. Secondly, it argues for a point of view that sees iterative revisions of moral beliefs not only as constituted in accordance to moral principles, but that these revisions influence the respective moral principles, an influence that can also lead to moderate changes of these principles. The final point of argument will discuss the strategies by which such revisions should take place.

Revisionen moralischer Überzeugungen erfordern nach allgemeiner Auffassung einen festen Bezugspunkt: einen stabilen moralischen Charakter der umdenkenden Personen. Andernfalls können diesen ihre Überzeugungen, Entscheidungen und Handlungen nicht zugerechnet werden. So lehren metaethische Generalisten einerseits und Partikularisten andererseits, für Charakterstabilität seien fixe Moralprinzipien bzw. eine fixe moralische Feinfühligkeit konstitutiv. Beiden Positionen zufolge zielen Revisionen auf moralische Richtigkeit im Sinne synchroner Kohärenz niedrigstufiger moralischer Überzeugungen (z.B. Maximen). Der kritische Befund: Das statische Vermögen, in moralischen Dingen immer richtig zu liegen, bildet keine einer besonderen Zurechnung fähigen moralischen Charaktere aus; das dynamische Vermögen, sich selber auf angemessene Weise korrigieren zu können, dagegen wohl. Darum argumentiert der Beitrag erstens dafür, Charakterstabilität als diachrone Kohärenz unserer moralischen Überzeugungen aufzufassen. Zweitens wird für eine Sicht plädiert, nach der iterative Revisionen moralischer Überzeugungen nicht nur Moralprinzipien gemäß vorgenommen werden, sondern diese auch affizieren und deren maßvolle Veränderung nach sich ziehen können. Zuletzt wird diskutiert, nach welchen Strategien sich Revisionen dieser Art vollziehen sollten.

Keywords: Coherence, radical vs. moderate revision

Propositional Relevance through Letter-Sharing: Review and Contribution

David Makinson (London School of Economics, GB)

The concept of relevance between classical propositional formulae, defined in terms of letter-sharing, has been around for a very long time. But it began to take on a fresh life in 1999 when it was reconsidered in the context of the logic of belief change. Two new ideas appeared in independent work of Odinaldo Rodrigues and Rohit Parikh. First, the relation of relevance was considered modulo the belief set under consideration, Second, the belief set was put in a canonical form, known as its finest splitting. In this paper we explain these ideas; relate the approaches of Rodrigues and Parikh to each other; and briefly report some recent results of Kourousias and Makinson on the extent to which AGM belief change operations respect relevance. Finally we suggest a further refinement of the notion of relevance by introducing a parameter that allows one to take epistemic as well as purely logical components into account.

Keywords: Belief change, relevance, letter-sharing, splitting

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2007/1212>

Forgetting and Update – an exploration

Abhaya Nayak (Macquarie Univ. - Sydney, AU)

Knowledge Update (respectively Erasure) and Forgetting are two very different concepts, with very different underlying motivation. Both are tools for knowledge management; however while the former is meant for accommodating new knowledge into a knowledge corpus, the latter is meant for modifying \bar{U} in fact reducing the expressivity \bar{U} of the underlying language. In this paper we show that there is an intimate connection between these two concepts: a particular form of knowledge update and literal forgetting are inter-definable. This connection is exploited to enhance both our understanding of update as well as forgetting in this paper.

Keywords: Knowledge Update, Erasure, Forgetting, Dalal Distance, Winslett Distance

Joint work of: Nayak, Abhaya; Chen, Yin; Lin, Fangzhen

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2007/1213>

A Method for Reasoning about other Agents' Beliefs from Observations

Alexander Nittka (Universität Leipzig, D)

Traditional work in belief revision deals with the question of what an agent should believe upon receiving new information.

We will give an overview about what can be concluded about an agent based on an observation of its belief revision behaviour. The observation contains partial information about the revision inputs received by the agent and its beliefs upon receiving them. We will sketch a method for reasoning about past and future beliefs of the agent and predicting which inputs it accepts and rejects. The focus of this talk will be on different degrees of incompleteness of the observation and variants of the general question we are able to deal with.

Keywords: Belief revision, iterated revision, non-prioritised revision, non-monotonic reasoning, rational closure, rational explanation

Joint work of: Nittka, Alexander; Booth, Richard

Extended Abstract: <http://drops.dagstuhl.de/opus/volltexte/2007/1214>

Distance Semantics for Relevance-Sensitive Belief Revision

Paulos Peppas (University of Patras, GR)

Parikh's axiom (P) for relevance-sensitive belief revision is studied. Sound and complete semantics for axiom (P) is provided in the form constraints on system-of-spheres.

Keywords: Belief Revision, System of Spheres

Joint work of: Peppas, Pavlos; Chopra, Samir; Foo, Norman

Extended Abstract: <http://drops.dagstuhl.de/opus/volltexte/2007/1215>

See also: P. Peppas, S. Chopra, and N. Foo, "Distance Semantics for Relevance-Sensitive Belief Revision", Proceedings of the 9th International Conference on the Principles of Knowledge Representation and Reasoning, Whistler, AAAI Press, 2004

Minimal Change

Laurent Perrussel (IRIT - Toulouse, F)

Most of the belief revision and update operators are based on a minimal change postulate. This postulate states that the resulting belief base should be as close as possible of the initial belief base. This closeness notion entails a notion of distance between belief bases. In order to define such distances, Dalal has proposed a criterion based on the number of propositional symbols that have changed their truth values. However, it could be that changing one symbol may lead to significant change if this symbol frequently appears in the clauses of the initial belief base.

In this talk, we propose to represent the belief base in conjunctive and disjunctive normal forms in order to represent prime implicants and implicates.

Based on the conjunctive and disjunctive normal forms and an explicit link between literal and prime implicates, we propose a new change metric based on the numbers of prime implicates that are unchanged when a new information is inserted. This new notion of minimal change enables to revisit existing belief change operators and to propose new change operators which reflects our notion of minimal change.

Joint work of: Marchi, Jerusa; Perrussel, Laurent; Bittencourt, Guilherme

Premise Independence in Judgment Aggregation

Gabriella Pigozzi (University of Luxemburg, L)

Judgment aggregation studies how agent opinions on logically interconnected propositions can be mapped into a collective judgment on the same propositions, and is plagued by impossibility results.

In this paper we study the central notion of independence in these impossibility results. First, we argue that the distinction between the premises and conclusions play an important role in the benchmark examples of judgment aggregation. Second, we consider the notion of independence in judgment aggregation frameworks, and we observe that the distinction between premises and conclusion is not taken into account. Third, based on our analysis, we introduce independence assumptions that distinguish premises from conclusion.

We show that, by introducing new operators that satisfy our independence assumptions, the problematic impossibility results no longer hold.

Keywords: Judgment aggregation, social choice theory

Joint work of: Pigozzi, Gabriella; van der Torre, Leendert

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2007/1216>

Multiple Contraction: State of the Art and Future Works

Mauricio Reis (University of Madeira - Funchal, P)

We survey the existing approaches on multiple contraction and present our plan for future research topics on this subject.

Joint work of: Reis, Maurício; Fermé, Eduardo

Connections between belief revision, belief merging and voting

Odinaldo Rodrigues (King's College - London, GB)

In this paper, we consider a number of different ways of reasoning about voting as a problem of conciliating contradictory interests.

The mechanisms that do the reconciliation are belief revision and belief merging. By investigating the relationship between different voting strategies and their associated counterparts in revision theory, we find that whereas the counting mechanism of the voting process is more easily done at the meta-level in belief merging, it can be brought to the object level in base revision. In the former case, the counting can be tweaked according to the aggregation procedure used, whereas in base revision, we can only rely on the notion of minimal change and hence the syntactical representation of the voters' preferences plays a crucial part in the process. This highlights the similarities between the revision approaches on the one hand and voting on the other, but also opens up a number of interesting questions.

Keywords: Belief revision, belief merging, social choice, voting problem

Joint work of: Gabbay, Dov; Pigozzi, Gabriella; Odinaldo Rodrigues

Common Foundations for belief revision, belief merging and voting

Odinaldo Rodrigues (King's College - London, GB)

In this paper, we consider a number of different ways of reasoning about voting as a problem of conciliating contradictory interests. The mechanisms that do the reconciliation are belief revision and belief merging. By investigating the relationship between different voting strategies and their associated counterparts in revision theory, we find that whereas the counting mechanism of the voting process is more easily done at the meta-level in belief merging, it can be brought to the object level in base revision. In the former case, the counting can be tweaked according to the aggregation procedure used, whereas in base revision, we can only rely on the notion of minimal change and hence the syntactical representation of the voters' preferences plays a crucial part in the process. This highlights the similarities between the revision approaches on the one hand and voting on the other, but also opens up a number of interesting questions.

Keywords: Belief revision, belief merging, voting, social choice theory

Joint work of: Gabbay, Dov; Pigozzi, Gabriella; Odinaldo, Rodrigues

Extended Abstract: <http://drops.dagstuhl.de/opus/volltexte/2007/1217>

Two-Dimensional Belief Change

Hans Rott (Univ. of Regensburg, D)

The idea of two-dimensional belief change operators is that a belief state is transformed by an input sentence A in such a way that A gets accepted with at least the strength or certainty of a sentence B (the reference sentence).

The input of such a transformation may alternatively be conceived as ' $B \leq A$ ' [B less-than-or-equal-to A]. This notation makes explicit that the process induced is basically one of doxastic preference change. The principal case of two-dimensional belief change obtains when B is a prior belief which is more strongly accepted than both A and $\neg A$, but the non-principal cases are interesting in their own right. Various two-dimensional revision operators were studied by Cantwell (1997, 'raising' and 'lowering'), Fermé and Rott (2003, 'revision by comparison'), and Rott (2007, 'bounded revision'). Special choices of a fixed input sentence A or a fixed reference sentence B lead to some well-known unary operators of belief change: 'irrevocable' (aka 'radical') revision, 'severe withdrawal' (aka 'mild contraction'), 'natural' (aka 'conservative') and 'lexicographic' (aka 'moderate') revision. The talk gives a survey of several variants of two-dimensional belief change and their representations. I argue that two-dimensional belief change operators offer an interesting qualitative model with an expressive power between (all too poor) unary operators and (all too demanding) quantitative models of belief change.

Keywords: Belief revision, radical revision, conservative revision, moderate revision, severe withdrawal, preference change, qualitative vs. quantitative change

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2007/1240>

See also: John Cantwell, 'On the Logic of Small Changes in Hypertheories', *Theoria* 63 (1997), 54-89. Eduardo Fermé and Hans Rott, 'Revision by Comparison', *Artificial Intelligence* 157 (2004), 5-47. Hans Rott, 'Revision by Comparison as a Unifying Framework: Severe Withdrawal, Irrevocable Revision and Irrefutable Revision', *Theoretical Computer Science* 355 (2006), 228-242. —, 'Shifting Priorities: Simple Representations for Twenty-seven Iterated Theory Change Operators', in: *Modality Matters: Twenty-Five Essays in Honour of Krister Segerberg*, eds. Henrik Lagerlund et al., Uppsala Philosophical Studies, Vol. 53, Uppsala Universitet 2006, pp. 359-384. —, 'Bounded Revision: Two-Dimensional Belief Change Between Conservatism and Moderation', in: *Homage à Wlodek. Philosophical Papers Dedicated to Wlodek Rabinowicz*, eds. Toni Rønnow-Rasmussen et al., Lunds Universitet 2007, <http://www.fil.lu.se/hommageawlodek/site/papper/RottHans.pdf>.

A blueprint for deontic logic in three (not necessarily easy) steps

Krister Segerberg (Uppsala University, S)

The famous AGM paradigm for the analysis of theory change drew its inspiration from two sources: belief change and norm change. But very early on, interest in the former eclipsed the interest in the latter. Now, many years later, it is appropriate once again to raise the question about norm change. In the author's terminology, given the current work in Dynamic Doxastic Logic, what might Dynamic Deontic Logic look like?

Keywords: Belief change, norm change, Dynamic Doxastic Logic, Dynamic Deontic Logic

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2007/1218>

Dynamic Interactions Between Goals and Beliefs

Steven Shapiro (University of Toronto, CA)

Shapiro et al. [2005], presented a framework for representing goal change in the situation calculus. In that framework, agents adopt a goal when requested to do so (by some agent reqr), and they remain committed to the goal unless the request is cancelled by reqr. A common assumption in the agent theory literature, is that achievement goals that are believed to be impossible to achieve should be dropped. In this paper, we incorporate this assumption into Shapiro et al.'s framework, however we go a step further. If an agent believes a goal is impossible to achieve, it is dropped. However, if the agent later believes that it was mistaken about the impossibility of achieving the goal, the agent might readopt the goal. In addition, we consider an agent's goals as a whole when making them compatible with their beliefs, rather than considering them individually.

Keywords: Goal Change, Belief Change, Situation Calculus

Joint work of: Shapiro, Steven; Brewka, Gerhard

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2007/1199>

Full Paper:

<http://www.ijcai.org/papers07/Papers/IJCAI07-422.pdf>

See also: Steven Shapiro and Gerhard Brewka: Dynamic Interactions between Goals and Beliefs. In Manuela M. Veloso, ed.: Proceedings of the 20th International Joint Conference on Artificial Intelligence, 2625-2630.

Measuring Ranks via the Complete Laws of Iterated Contraction

Wolfgang Spohn (Universität Konstanz, D)

Ranking theory delivers an account of iterated contraction; each ranking function induces a specific iterated contraction behavior. The paper gives a complete axiomatization of that behavior, i.e., a complete set of laws of iterated contraction. And it shows how to reconstruct a ranking function from its iterated contraction behavior uniquely up to multiplicative constant and thus how to measure ranks on a ratio scale.

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2007/1239>

Ranking Revision Reloaded

Emil Weydert (University of Luxemburg, L)

We propose a belief revision strategy which, in a nutshell, combines an extension of Spohn's ranking-based revision with Lehmann's sequential belief change philosophy. Epistemic states are sequences consisting of a prior ranking measure and a sequence of ranking constraint sets, from which the actual belief valuation is extracted through a sophisticated iterated JLZ-shifting procedure. Revision is just concatenation. This is an instance of the epistemic projection paradigm.

Keywords: Ranking measures, iterated belief revision

Extended Abstract: <http://drops.dagstuhl.de/opus/volltexte/2007/1202>

The Logic of Bargaining: a Survey of Belief-Revision-Based Bargaining Theory

Dongmo Zhang (Univ. of Western Sydney, AU)

This paper provides a survey of belief-revision-based bargaining theory. We shall show how the AGM theory can be used to contribute a solution to the bargaining problem. A solution to the n-person bargaining problem is presented based on the maxmin rule over the degrees of bargainers' satisfaction. The solution is uniquely characterized by four axioms: collective rationality, scale invariance, symmetry and mutually comparable monotonicity in conjunction with three other fundamental assumptions: individual rationality, consistency and comprehensiveness. The Pareto efficient solutions are characterized by the axioms: scale invariance, Pareto optimality and restricted mutually comparable monotonicity along with the basic assumptions. The relationships of these axioms and assumptions and their links to belief revision postulates and game theory axioms are discussed. The framework would help us to identify the logical reasoning behind bargaining processes and would initiate a new methodology of bargaining analysis.

Keywords: Belief Revision, Bargaining Theory, Game Theory, Multiagent Systems

The Logic of Bargaining

Dongmo Zhang (Univ. of Western Sydney, AU)

This paper reexamines the game-theoretic bargaining theory from logic and Artificial Intelligence perspectives.

We present an axiomatic characterization of the logical solutions to bargaining problems. A bargaining situation is described in propositional logic with numerical representation of bargainers' preferences. A solution to the n-person bargaining problems is proposed based on the maxmin rule over the degrees of bargainers' satisfaction. The solution is uniquely characterized by four axioms: collective rationality, scale invariance, symmetry and mutually comparable monotonicity in conjunction with three other fundamental assumptions: individual rationality, consistency and comprehensiveness. The Pareto efficient solutions are characterized by the axioms: scale invariance, Pareto optimality and restricted mutually comparable monotonicity along with the basic assumptions. The relationships of these axioms and assumptions and their links to belief revision postulates and game theory axioms are discussed. The framework would help us to identify the logical reasoning behind bargaining processes and would initiate a new methodology of bargaining analysis.

Keywords: Bargaining theory, belief revision, game theory

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2007/1203>

Input and Output in Judgment Aggregation

Leon van der Torre (University of Luxemburg, L)

We argue that input and output must be distinguished in judgment aggregation.

Keywords: Judgment aggregation

Joint work of: Pigozzi, Gabriella; van der Torre, Leon