Argumentation-based defeasible reasoning

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Abstract: Argumentation is an alternative approach for defeasible reasoning. It is based on the idea of justifying plausible conclusions by “strong” arguments. Starting from a knowledge base encoded in a logical language, an argumentation system defines arguments and attacks between them using the consequence operator associated with the language. Finally, it uses a semantics for evaluating the arguments. The plausible conclusions to be drawn from the knowledge base are those supported by “good” arguments. In this talk, we present two families of such systems: the family using extension semantics and the one using ranking semantics. We discuss the outcomes of both families and compare them.

Belief Change in a Preferential Non-monotonic Framework

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Belief change and non-monotonic reasoning are usually viewed as two sides of the same coin, with results showing that one can formally be defined in terms of the other. In this talk we will discuss that it also makes sense to analyse belief change within a non-monotonic framework, and in particular we take under consideration a preferential non-monotonic framework. We consider belief change operators in a non-monotonic propositional setting with a view towards preserving consistency. We show that the results obtained can also be applied to the preservation of coherence— an important notion within the field of logic-based ontologies. We adopt the AGM approach to belief change and show that standard AGM can be adapted to a preferential non-monotonic framework, with the definition of expansion, contraction, and revision operators, and corresponding representation results.

Applying Meta-heuristics to Decision Making Under Uncertainty*

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Abstract

Meta-heuristic methods represent a widely used tool to deal with various real-life optimization problems [1]. They represent computational methods that optimize problems by iteratively generating new or improving the existing solutions with respect to the given objectives. They do not guarantee the optimality of the obtained solution, however, they usually provide high quality solutions within reasonable CPU time. Meta-heuristics are general methods in a sense that they do not use *a priori* knowledge about the problem being optimized. They are actually recipes that should be tailored for each particular problem in order to obtain the efficient heuristic methods. Meta-heuristic methods usually apply some form of stochastic search and can be roughly divided into two categories: mathematically inspired and these that found the inspiration in nature. Typical examples of mathematically founded meta-heuristics are [2]: Tabu Search and Variable Neighborhood Search. Among methods inspired by natural processes the most famous are Simulated Annealing, Genetic Algorithms, Ant Colony Optimization [2], Particle Swarm Optimization [3], and Artificial Bee Colony [4].

The main goal of this talk is to introduce these powerful methods to wider audience dealing with stochastic decision making processes and to illustrate how they can be applied for these problems. The

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decision problems usually do not belong to the class of optimization problems. However, their parts can be formulated as optimization tasks and meta-heuristics could be used to efficiently resolve these parts.

For example, meta-heuristics can be used to generate incomplete solvers of the well known satisfiability problem [5, 6] whose applications are very important in many fields. Another example that will be illustrated here is related to the decision making in medicine. The appropriate diagnosis is required to adequately treat patients in hospitals. Diagnostic process could be viewed as classification problem based on the performed analyzes. The application of meta-heuristics in this case is an ongoing joint research with Nataša Glišović and Miodrag Rašković and the preliminary results will be presented.

Keywords: Optimization methods; Nature-inspired computing; Decision support systems; Reasoning under uncertainty.

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On Probability and Preferences in Argumentation Frameworks

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Abstract argumentation is nowadays a vivid field within artificial intelligence and has seen different developments recently. The simplest objects used in abstract argumentation are Dung's argumentation frameworks (AFs). They are just directed graphs where vertices represent the arguments and edges indicate a certain conflict between the two connected arguments. The goal is to identify jointly acceptable sets of arguments for which a large selection of different semantics is available. Apart from relations going beyond binary attack, AFs do not handle varying levels of uncertainty This calls for augmenting AFs with probabilities and due to various interpretations of what the probability of an argument or relation is and how it should be used, different methods have been proposed. In this talk, I give an overview of probabilistic argumentation frameworks of Li, Oren and Norman, and I relate this approach to the generalization of abstract argumentation, where preferences are added in order to take into account the strength of arguments.

Implementation of a Modern Dyadic Deontic Logic in Isabelle/HOL

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Abstract

A shallow semantical embedding of a dyadic deontic logic (by Carmo and Jones) in Isabelle/HOL is presented. First experiments provide evidence that this logic *implementation* fruitfully enables interactive and automated reasoning at the meta-level the object-level.

1 Introduction

Normative notions such as obligation and permission are the subject of deontic logics [5, 7], and conditional obligations are addressed in so called dyadic deontic logic.

A particular dyadic deontic logic has recently been proposed by Carmo and Jones [4]. This dyadic deontic logic comes with a neighborhood semantics and a weakly complete axiomatization over the class of finite models. Their framework is immune to some well known contrary-to-duty issues which can still be found in many other, related approaches.

As a first contribution we present an *"implementation"* of the Carmo-Jones-Logic (CJL) in Isabelle/HOL. This implementation utilizes the shallow semantical embedding approach that has been put forward by Benzmüller as a pragmatical solution towards universal logic reasoning (see [3, 1]). This approach uses classical higher-order logic as (universal) meta-logic to specify, in a shallow way, the syntax and semantics of various object logics, in our case CJL. Because of its neighborhood semantics and since it provides and combines modal and conditional operators, CJL constitutes a non-trivial object logic to implement in the shallow semantical embedding approach.

As a second contribution we employ our implementation to study some meta-logical properties of CJL in Isabelle/HOL. This also includes questions about the relationship of dyadic deontic fragment of CJL to other deontic logics, for example, Input/Output logic [6]. For this, we analysis a list of normative inference patterns that have been suggested by Parent and van der Torre [8]. A particular focus of our experiments is on nested dyadic obligations and we show that nested dyadic obligations in CJL can be eliminated. Moreover, we investigate the relationship of this dyadic obligation operator to standard conditional operators.

As third contribution we illustrate how our implementation supports the reasoning at object-level. More precisely, we show how classical deontic reasoning examples from the literature can now be represented in Isabelle/HOL and we examine how our implementation performs when being applied to these examples.

Future work includes a formal proof of the faithfulness of the shallow semantical embedding along the lines of related proofs for standard conditional logics [2] and quantified modal logics [1]. Moreover, the proposed embedding may provide a clue to turn CJL weak completeness theorem into a strong one.

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System for Decision Making when reasoning is under uncertainty

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Abstract - Decision making is definitely the most important task in every situation and it is very difficult. The domain of decision analysis models falls between two extreme cases. This depends on the degree of knowledge we have about the outcome of our actions. This paper offers a decision-making procedure for solving medical problems clustering data when data is missing. It gives a proposition of distance in such circumstances, as well as determining the weight of each analysis. The system was implemented in the programming language c # and demonstrated on a specific case of autoimmune diseases.

Keywords: Decision making, uncertainty, metrics, missing data.

The description of the problem

The clustering is a technique of researching the data which reveals the object of the data (which are described with attributes) with similar characteristics and divides them into clusters making them clearer and more useful. The cluster analysis, in fact, represents finding out the groups of objects such so that the objects in the group are mutually similar (or connected) and that the objects in different groups are mutually different (or unconnected).

The problem of clustering can be defined in the following way: a wanted number of the cluster K is given, a set of data from N points and the functions for measuring the distances. The sets of points should be found so that the value of the function for measuring the distance is minimized.

The methods based on the distance are very popular in literature because they can be used for any type of data. Therefore, the problem of clustering the data can be led to the problem of finding out the function of the distance for that type of data. From this comes out that finding out the function of the distance has become an important area of research for processing the data and their accurancy. Certain methods are often adapted to the specific domain of variables such as categorial or time series.

In this research, a suggestion of the new distance function is given which will be applied in the clustering of the medical data as well as the suggestion of calculating the importance of the analyses which are carried out with the patients. The advantage of the proposed distance is that the distances among the patients are calculated even when the data are missing. Also, the proposed importance of calculating the analyses, which we had suggested in this study, uses the probabilities of the presence, that is, the absence of the positive findings and it is determined which if the analyses is “more important” for an illness.

Methodology

The data, which we wanted to classify (the patients’ base with the analyses) are coded, so there was an idea of calculating the distance which uses Hamming’s distance. In order to define the proposed distance, we define Hamming’s distance. Let F be a final set with q elements.

Definition: Hamming’s distance $d(x,y)$ between two vectors $x, y \in F^{(n)}$ is a number of places at which these two vectors differ.

The proposed distance uses Hamming’s distance and the stated formulas. Using the stated formulas in the definition of the distance is because of the generality of the distance.

Let φ and ψ be two sets of the stated formulas to which the formulas belong, the formulas which represent the conjuction of the literals. The proposed distance between these two sets of the stated formulas is defined as:

$$D(\varphi,\psi) = \frac{\max\limits_{A\in\varphi}\min\limits_{B\in\psi} d(A,B) + \max\limits_{B\in\psi}\min\limits_{A\in\varphi} d(A,B)}{2} \qquad (1)$$

Where $d(A,B)$ is Hamming’s distance.

Research results

Results comparisons are to be the worst in the clustering method showed mean values, and linear regression that was significantly better than the mean value and almost the same performance as the proposed distance. Percentages of performance are given in Table 1. The results are obtained from the database that contains the 45 patients with 89 parameters.

Method of filling in missing data	Middle value	Linear regression	The proposed distance
Performance as a percentage	82%	89%	93%

Table 1. The performance results of different methods. Optimization problem is given the best results when applying the proposed distance.

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Formal proofs using natural deduction for modal logic of social choice

Tin Perkov

Social choice is about calculating a group decision based on individual judgments. In particular, preference aggregation is about aggregating the society's preference based on individual preferences, e.g. rankings of candidates in elections.

Judgments can be formalized as consistent sets of logical formulas. Mathematical framework for judgment aggregation consists of a set N of n individuals (agents, judges, voters), and the *agenda* – a set of formulas of a fixed underlying logic. In the case of preference aggregation, this can be the first-order theory of strict linear orderings.

A *profile* is an n-tuple $\{R_1, \ldots, R_n\}$, where R_i is a judgment set of agent i. In the case of preference aggregation, R_i is a strict linear ordering of candidates, as ranked by agent i. A *judgment aggregation rule* (JAR) is a function which maps each profile to a judgment set. In the case of preference aggregation, a JAR is called a *social welfare function* (SWF). Given a particular profile as the input, a SWF produces a strict linear ordering of candidates, representing the society's preference (the result of elections). Social choice theory studies properties of social welfare functions, with a motivation to determine which properties make a SWF "fair" or "unfair".

A sound and complete modal logic of judgment aggregation is given in [2], using a Hilbert-style axiomatization. The authors state that it is of additional interest to provide a formal proof of Arrow's Theorem, a famous impossibility result in social choice, and make some steps towards it. I propose an alternative approach, a Jaśkowski-Fitch-style natural deduction system in which proofs are more intuitive, with a particular motivation to formalize a classical proof of Arrow's Theorem adapted from [3], as presented in [1].

The Judgment Aggregation Logic (JAL) is defined w.r.t. a fixed set N of individuals and a fixed agenda $\mathcal{A}$. The atomic symbols are a propositional variable p_i for each individual $i \in N$, a propositional variable q_A for each agenda item $A \in \mathcal{A}$, and a propositional variable σ representing the aggregated judgment. The truth of a formula is defined relative to a JAR, a profile R and an agenda item A, e.g. p_i means that agent i judges A, while σ means that A is the resulting group judgment of R under this JAR. The logic has two modalities $\square$ and $\blacksquare$, which are read "for all profiles" and "for all agenda items", respectively.

The proofs of the natural deduction system for JAL are sequences of contextualized formulas. A context is a pair of a profile and an agenda item. The rules concerning introduction and elimination of Boolean connectives are classical and do not depend on a context. The rules concerning modalities are defined similarly as it is usually done in natural deduction systems for modal logics using contexts. Additional rules are needed to reflect logical consequence relation of the underlying logic, and the *universal domain assumption*, that is, that any consistent profile is admissible. In the case of preference aggregation this means that each individual can choose any strict linear ordering of candidates, independently of other individuals' choices.

Soundness of the system is proved directly (basically, it follows by induction from the apparent soundness of rules), while the problem of completeness is reduced to proving the axioms and simulating the inference rules from [2].

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Completeness vs cardinality of the object language in probability logics

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Through several examples we show various noncompactness / noncompleteness phenomena for probability logics with uncountable object languages.

Towards Relevant Justifications
(ongoing work)

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Justification logic replaces the $\Box$-operator of modal logic by explicit justifications [2, 5]. That is justification logic features formulas of the form $t : A$ meaning A *is believed for reason* t; hence we can reason with and about explicit justifications for an agent's belief. The framework of justification logic has been used to formalize and study a variety of epistemic situations [3, 6–8, 10].

However, traditional justification logic is based on classical logic, which can lead to the following paradoxical situation. Consider a person A visiting a foreign town, which she does not know well. In order to get to a certain restaurant, she asks two persons B and C for the way. Person B says that A can take path P to the restaurant whereas person C replies that P does not lead to the restaurant and A should take another way. Person A now has a reason s to believe P and a reason t to believe $\neg P$. We can formalize this in justification logic by saying that both

$$s : P \qquad \text{and} \qquad t : \neg P \tag{1}$$

hold. However, then there exists a justification $r(s, t)$ such that

$$r(s, t) : (P \wedge \neg P)$$

holds. Now this implies (under certain natural assumptions) that for any formula F, there is a justification u such that

$$u : F \tag{2}$$

holds. That means for any formula F, person A has a reason to believe F, which, of course, is an undesirable consequence.

It is the aim of this paper to introduce a justification logic, RJ, in which situations of this kind cannot occur, in particular, that means a logic in which (2) does not follow from (1). We achieve this by combining the relevant logic R with the justification logic $\mathsf{J4}$.

Relevant logics are non-classical logics that avoid the paradoxes of material and strict implication and provide a more intuitive deductive inference. The central systems of relevant logic, according to Anderson and Belnap [1], are the system of relevant implication R, as well as the logic of entailment E.

Meyer [12] proposed the logic NR, which is the relevant logic R equipped with an $S4$-style theory of necessity, in order to investigate whether the resulting theory coincides with the theory of entailment provided by Anderson and Belnap [1]. Adapting the semantics for the logic R [13], Routley and Meyer provided a complete semantics for the logic NR [14].

Our logic RJ is similar to NR but instead of the $\Box$-operator, we use explicit justifications and since we deal with beliefs, we do not include the truth principle $t : A \to A$ in the list of axioms.

Conjecture 1 (Soundness and Completeness). Let CS be any constant specification. For each formula A we have

$$\mathsf{RJ}_{\mathsf{CS}} \vdash A \quad \text{iff} \quad A \text{ is } \mathsf{CS}\text{-valid.}$$

There is a close relationship between NR and our logic of relevant justifications. Let RLP be the system RJ plus the axiom $t : A \to A$ based on the total constant specification, i.e., every constant justifies every axiom (including $t : A \to A$). A *realization* is a mapping from modal formulas to formulas of justification logic that replaces each $\Box$ with some expression t: (different occurrences of $\Box$ may be replaced with different terms).

Conjecture 2 (Realization). There is a realization r such that for each modal formula A

$$\mathsf{NR} \vdash A \quad \text{implies} \quad \mathsf{RLP} \vdash r(A).$$

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Ramsey tests and Ramsey's test: what has remained of the original footnote?

The aim of this paper is to show that there is no agreement in the interpretation of one of the most fundamental notion in conditional reasoning: *the Ramsey test*. Furthermore, it is suggested that in what currently goes under the label *Ramsey test* almost nothing has remained from Ramsey's original footnote and, in certain cases, the interpretation given to the original text diverges substantially from Ramsey's view about conditionals. Instead, it is claimed that what nowadays is usually called *Ramsey test* is either Stalnaker's version and interpretation of the footnote or Gärdenfors' formalization.
In his unpublished paper *General propositions and causality* F. P. Ramsey states in a footnote what is currently known as *The Ramsey test*, a procedure which is supposed to explain how we evaluate conditional statements. The footnote:

> If two people are arguing 'If p will q?' and are both in doubt as to p, they are adding p hypothetically to their stock of knowledge and arguing on that basis about q; so that in a sense 'If p, q' and 'if p, $\overline{q}$' are contradictories. We can say they are fixing their degrees of belief in q given p. If p turns out false , these degrees of beliefs are rendered <u>*void*</u>. If either party believe $\overline{p}$ for certain, the question ceases to mean anything to him except as a question about what follows from certain laws and hypotheses[1]
>
> F. P. Ramsey *General propositions and causality*, 1929[2].

Since the posthumous publication, Ramsey's footnote has gained remarkable recognition, being acknowledged as "the test" to evaluate conditional statements. However the acknowledgement is not that straightforward. It is argued that the footnote has been interpreted differently accordingly to different authors and their goals. Of course, such a small piece of text, out

[1] The stress on *void* is original by Ramsey.

[2] p. 247 in *The foundations of mathematics and other logical essays*, 1931, re-printed in Martino Publishing 2013

of its original context, can easily be interpreted as desired.
It is not even trivial whether the test is meant for indicative conditionals alone or whether it can be applied to counterfactual conditionals too. Different accounts are considered: the most shared and accepted interpretations claim that the footnote speaks only about indicatives where the value of the antecedent is unknown and that it has to be extended to counterfactuals. This is due partly to the vagueness of Ramsey's statement and partly to an overlooking of Ramsey's complete work.
Through a comparison between the different tests proposed along the past century, it is shown what remains of the original notions in Ramsey's footnote, if any, and what has changed, thus enlightening the directions research on conditional statements has taken. Starting from the original footnote, attention is paid to relevant notions in it, turning then to an analysis of some of the most influential versions of it. From the very first acknowledgement of Ramsey as giving a procedure to evaluate conditionals (Chisholm, 1941), particularly counterfactuals, to Stalnaker's "expansion" of the test, to Gärdenfors' formalization and triviality result and related ways out (e.g. Lindstrom and Rabinowicz 1992), passing through Adams, Levi and some recent works (e.g. Leitgeb's). Focusing on the interpretation of the footnote could throw light on the triviality result. In doing so, it comes out that the relationship between the tests proposed in the last 50 years and belief revision is not so uncontroversial.
Finally, conditional reasoning has gained a leading role also in psychological investigations, therefore a brief overview of some of the prominent works in this field and their treatment of the Ramsey test (e.g. Johnson-Laird) is presented. Indeed, the importance of disambiguating the footnote and of finding a shared agreement, if we want to use it to evaluate conditionals, is underlined also by cognitivists (cf. Johnson-Laird, 2015).
Understanding the meaning of the footnote is of great interest and further work towards the Ramsey interpretation of the *Ramsey test* is needed in order to reach agreement on a so controversial, but still relevant notion. Indeed, the study of the test is relevant from different points of view: philosophical, logical and, of course, historical and this paper is an attempt in that direction.

Using a Semantic Web Language to Model Complaints

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Scalability, reusability and end user-centered approaches are being taken into account to model specific legal domains, mainly e-commerce, e-administration, e-governance, criminal law, consumer law, mediation, drafting, business processes and contracting, through semantic Web languages (RDF, RDFS, OWL DL, SKOS), with an increasing preference for W3C standards. The European Data portal recently launched the Application Profile for Data Portals in Europe using a metadata vocabulary, a common schema for harmonising descriptions about public sector datasets in Europe, reusing, among others, Eurovoc thesauri now available as OWL ontologies. EUR-Lex and the Publication Office has also made great improvements recently: there is a freely accessible EU Metadata Registry; CELLAR, the new EU portal, serves on average some 5 million requests per day. It contains 200 million identifiers and 1100 million triples in its Oracle RDF store. These kinds of initiatives are taken at local, regional, and national governments, showing how the adoption of Semantic Web technologies in the administrative and industry domains is widespread even for concrete uses and applications. In my interdisciplinary talk, I want to spend a few words on examples of applications of Semantic Web technologies to the legal domain, in particular, modelling a real life setting of complaints. I will present a jointly developed work on an ontology design pattern to conceptualize complaints. The proposed Complaint Design Pattern has been designed based on the analysis of free text complaints from available complaint datasets (banking, air transport, automobile), among other knowledge sources. Knowledge engineers can further model complaints for specific domains and processes.

Dynamic argumentation semantics

Leon van der Torre

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Dung introduced so-called argumentation semantics as a function from argumentation frameworks to sets of acceptable arguments. The handbooks on formal argumentation describe how this general framework for non-monotonic reasoning has been extended in many different ways over the past two decades. In this presentation I introduce a dynamic agenda going beyond dialogue, and in particular I introduce two new dynamic extensions of Dung's approach. The first dynamic argumentation semantics is based on an update relation removing attacks and arguments from argumentation frameworks. The fixpoints of this update semantics are the extensions of Dung's static approach. The second dynamic argumentation semantics builds on input/output argumentation frameworks, which have been introduced three years ago. We introduce dynamics in this compositional approach to formal argumentation by considering input streams of arguments.

Postulates and Acceptability Semantics for Weighted Argumentation Frameworks

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We study the semantics that evaluate arguments in argumentation graphs, where each argument has a basic strength, and may be attacked by other arguments. We start by defining a set of principles, each of which is a property that a semantics could satisfy. We provide the first formal analysis and comparison of existing semantics. Finally, we define three novel semantics that satisfy more principles than existing ones.