ESSLLI 2016 Course Proposal: Introduction to Non-Monotonic Logic

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1 Personal information of the proposers

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`http://homepage.ruhr-uni-bochum.de/defeasible-reasoning/index.html`

Mathieu Beirlaen Mathieu Beirlaen obtained his PhD in philosophical logic at Ghent University in 2012, under the supervision of Joke Meheus and Christian Straßer. He worked as a postdoctoral researcher at Ghent University until February 2013, after which he became postdoctoral fellow at the National Autonomous University of Mexico (UNAM) in Mexico City. In January 2015, he moved to Bochum to join Christian Straßer's new research group on non-monotonic logics and formal argumentation at RUB. Mathieu has worked on adaptive logics and their applications in deontic logic and philosophy of science, and on the relations between adaptive logics and other formal frameworks such as dialogical logic and input/output logic. He has collaborated extensively with Christian Straßer, and continues to do so.

Christian Straßer Christian Straßer holds master degrees in both philosophy and computer science. He obtained a PhD in philosophical logic at Ghent University in 2011. An extended version of his PhD thesis was recently published in the 'Trends in Logic' series on Springer. In 2014 he was awarded a Sofja Kovalevskaja research prize by the Humboldt foundation. This enabled him to start a research group at RUB on a formal and argumentative account of defeasible reasoning. In 2015 he became a junior-professor at the Institute for Philosophy II at RUB. He is also a visiting professor at Ghent University.

Christian Straßer has published both on the meta-theoretic foundations and on applications of a broad scope of sub-domains of non-monotonic logic, such as adaptive logics, default inferences, defeasible deontic logic, argumentation frameworks, and preferential semantics. He is the co-author and maintainer of the entry on non-monotonic logic at the Stanford Encyclopedia of Philosophy (`http://plato.stanford.edu/entries/logic-nonmonotonic/`).

2 General proposal information

Title of the course: Introduction to Non-Monotonic Logic

Category: introductory course

Level: we presuppose a basic understanding of propositional logic.

3 Contents information

3.1 Abstract

Informally, a logic is non-monotonic if under the addition of new premises we may lose some consequences which were previously derivable. This means that some of our inferences are defeasible: in view of additional information they may get retracted.

In this course, we present, discuss, and compare some of the principal formalisms for representing defeasible inferences via non-monotonic logics. We introduce the framework of inheritance networks, Reiter's default logic, argumentation frameworks, preferential semantics, and adaptive logics. Each of these frameworks is representative of a large research tradition within the field of non-monotonic logic. In our course the interested student gets equipped with a basic understanding that will enable her to dig deeper into the literature and to understand similar techniques in formalisms that are not covered in the course.

3.2 Motivation and description

Ideally, the set of information on the basis of which we make an inference is both complete and consistent: it is conflict-free, and it contains everything that is relevant. In practice, it is often impossible to meet this standard. Decisions need to be made on the basis of the information at hand, and this set of information is often incomplete and/or inconsistent. The resulting inferences are *defeasible*: they are drawn tentatively, and are open to retraction in the light of further information. Examples of defeasible reasoning are numerous: induction, inference to the best explanation, inferences on the basis of expert opinions, reasoning in the presence of inconsistencies, reasoning with priorities, etc. In our everyday practice as well as in the practice of experts (e.g. medical diagnosis) or scientists, defeasible inferences are abundant.

The field of non-monotonic logic, which took off in the later decades of the previous century, covers a variety of formalisms devised to capture and represent defeasible reasoning patterns. Informally, a logic is *non-monotonic* if under the addition of new premises we may lose some of our previous consequences. This means that some of our inferences are defeasible: in view of additional information they may get retracted. Formally, a logic **L** is non-monotonic if it lacks the *monotonicity* property (where '$\vdash$' denotes **L**-consequence, Γ and Γ'

are sets of **L**-formulas, and φ is an **L**-formula):

$$\text{If } \Gamma \vdash \varphi, \text{ then } \Gamma \cup \Gamma' \vdash \varphi$$

The aim of this course is to introduce some of these formalisms to students interested in defeasible or non-monotonic reasoning. In our selection, we pay importance to the impact, scope, generality, and accessibility of the formalisms in question, as well as to their present-day importance in the continuing endeavours made by non-monotonic logicians. We will present the following formalisms in our course:

(i) *Inheritance networks* permit a gentle and natural familiarization with non-monotonic logic. Inheritance nets were devised to represent taxonomically organized bodies of knowledge [17]. The network is seen as a collection of nodes and signed, directed links representing taxonomic information (e.g. 'x is a y'). Non-monotonicity comes in whenever conflicts can be generated between paths in the network. Conflicts are resolvable in case one of the paths provides more specific information than the other(s). For instance, from the fact that Dumbo is an elephant we may infer that Dumbo is grey; but given the more specific information that Dumbo is a royal elephant, it follows that Dumbo is not grey.

The formal language underlying the theory of inheritance networks is rather inexpressive. In Reiter's *default logic* [13] this limitation is overcome. Defeasible conditionals are interpreted as inference tickets of the form $(\gamma : \theta)/\tau$ where γ, θ and τ may be complex formulas. The idea behind such rules is that if γ is known, then it follows that τ *unless* θ is false. In other words, the inference from γ to τ is warranted unless θ is inconsistent with our current beliefs.

Jointly consistent consequences of a knowledge base and a set of default rules are placed into extension sets of the knowledge base. The defeasible consequences of a default theory are then selected on the basis of these extensions, depending on one's reasoning strategy. On a credulous approach, formulas belonging to any extension set are considered derivable. On a more skeptical approach, only formulas belonging to all extension sets are derivable.

A recent application of default logic is Horty's conception of reasons in practical reasoning as default rules [7].

(ii) An actively researched approach to non-monotonic inference is based on argumentation frameworks. In his seminal contribution [5], Dung presents an abstract perspective on argumentative defeat by means of attack diagrams where nodes represent arguments and arrows represent attacks. Argumentation semantics are then applied to these graphs to determine sets of acceptable arguments. Several criteria for such selections have been proposed, such as the requirement that the selected sets are conflict-free and the requirement that they contain a defense against attacks on their members. In structured argumentation [11, 4, 2], more logical structure is added to arguments, and attacks (such as rebuttals and undercuts) can be defined in terms of syntactic properties of arguments.

(iii) A different, very influential perspective on non-monotonic entailment is that of selecting a certain preferred subset of the models of a given premise set [14]. The resulting set of models is studied as subject to certain constraints on the consequence relation, such as the properties of reflexivity, cut, and cautious monotonicity [8]. It is one of the most remarkable insights in the theory of non-monotonic logics that various independently developed and differently motivated semantics (ranging from qualitative [8] to quantitative considerations [1, 10]) give rise to the very same core properties of non-monotonic consequence relations.

(iv) Finally, we turn to *adaptive logics* a formalism which combines various features already present in the aforementioned points [3, 15]. Adaptive logics come with a dynamic proof theory for making inferences conditionally, subject to future retraction. Their semantics is a specific version of the selection semantics from (iii) in the sense that models are now selected with respect to a standard of normality. This standard may – but need not – be classical logic, resulting in an adaptive logic which interprets the premises 'as consistently as possible'. The standard in question may also be stronger, resulting in logics for modeling ampliative reasoning patterns such as inductive generalization or abductive inference.

Each of the approaches in (i)-(iv) offers a specific angle on the formal modelling of defeasible reasoning. There are essential differences, but also lots of parallels between the formalisms in question. In the final session, we will compare the approaches and discuss their (dis)similarities and (dis)advantages.

In this course, students will get a grasp of some of the central formalisms in the domain of non-monotonic logic. Moreover, they will be familiarized with techniques and basic notions that are also central to formalisms that we cannot cover in the course due to time restrictions. For instance, the fixed point constructions used in default logic are similar to those e.g. in autoepistemic logic, and the semantic minimization technique in adaptive logics is similar to the ones in circumscription.

3.3 Tentative outline

Day 1: Presentation and discussion of inheritance networks and default logic (point (i) above).

Day 2: Presentation and discussion of argumentation frameworks (point (ii) above).

Day 3: Presentation and discussion of preferential semantics (point (iii) above).

Day 4: Presentation and discussion of adaptive logics (point (iv) above).

Day 5: Recapitulation and comparison of the various formalisms presented during the previous days.

3.4 Expected level and prerequisites

We have chosen to introduce a number of different formalisms to give the students a general flavor and survey of the field of non-monotonic logics. A basic understanding of first-order logic is already sufficient to get a general idea of how these formal systems work.

3.5 Relevant references

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4 Practical information

We would like our course to be considered for sponsorship by the EACSL.