

Progress Report 02
ConsRel, Fapesp Project 2004/14107-2
Logical Consequence and Combinations of Logics
— Fundamentals and Efficient Applications

Period: April 1st, 2006 to March 30th, 2007

Main Researcher: Walter Carnielli (CLE/IFCH-UNICAMP)

Abstract

This is the second report of CONSREL Project covering activities developed during the period from April 1st, 2006 to March 30th, 2007. As the initial proposal of this project was written in English, we believe it appropriate to present the corresponding progress reports in English as well. The first section contains a brief summary of this report in Portuguese.

Sumário

O Projeto CONSREL trata da investigação acerca das relações de consequência, enfocando diversas vertentes:

1. estudo da questão da expressividade das relações de consequência dentro de padrões específicos, tais como aspectos qualitativos versus quantitativos;
2. investigação das formas gerais de semânticas formais (isto é, semânticas formuladas com precisão matemática e para as quais se possa dispor de métodos ou técnicas de caráter formal, em particular algébrico ou categorial);
3. investigação dos métodos e técnicas de combinação (síntese) de sistemas lógicos ou de relações de consequência;
4. investigação dos métodos e técnicas de decomposição (análise) de sistemas lógicos.

O Projeto, em resumo, se constitui dos seguintes módulos:

- Módulo 1: Fundamentos de Combinação de Sistemas Lógicos (*Task 1: Fundamentals of Combining Logics*);
- Módulo 2: Aspectos Computacionais das Combinação de Sistemas Lógicos e Demonstração Automática de Teoremas (*Task 2: Computational Aspects of Combinations of Logics and Theorem Proving*);
- Módulo 3: Lógicas Quânticas e Algoritmos (*Task 3: Quantum Logics and Algorithms*).

Informações adicionais encontram-se disponíveis nas páginas do Projeto:
<http://www.ime.usp.br/~consrel>

e

<http://consrel.incubadora.fapesp.br/portal/project-members>

Fazemos aqui uma breve descrição, quantitativa e qualitativa, a respeito dos principais resultados atingidos dentro de cada “Task” no período de 01/04/2006 até 30/03/2007. Para uma avaliação qualitativa deve-se consultar a Seção 2. Para uma descrição das atividades organizadas a partir dos membros componentes do Projeto deve-se consultar a Seção 3.

Dentro da **Task 1: Fundamentals of Combining Logics**, coordenada por Marcelo Coniglio, foram publicados ou submetidos 12 artigos e uma dissertação de mestrado em tópicos relativos às diferentes linhas de pesquisa deste módulo. Além disso, foi concluído o livro “Analysis and Synthesis of Logics”, pelos autores W.A. Carnielli, M.E. Coniglio, D. Gabbay, P. Gouveia e C. Serenadas, que reflete alguns dos avanços do projeto no período dedicados a esta Task.

Parte dos artigos produzidos no período são devotados à investigação de certas questões básicas concernentes aos processos de combinação de lógicas e à própria definição de tradução entre lógicas. Outros artigos tratam de outros aspectos mais específicos das combinação entre lógicas, tais como a combinação de lógicas algebrizáveis e o desenvolvimento de quantificadores modulados. A característica de se utilizar teoria de categorias como pano de fundo para o desenvolvimento teórico foi mantida; isto pode ser apreciado na maior parte das produções desta Task.

Com relação à **Task 2: Computational Aspects of Combinations of Logics and Theorem Proving**, coordenada por Marcelo Finger, foram elaborados 11 artigos e uma tese de doutorado, todos eles relevantes às linhas de pesquisa desta Task: aproximação de lógicas, provadores automáticos eficientes de teoremas e inferência sensível a recursos. Uma das características principais da pesquisa desenvolvida nesta Task foi a procura de aplicações, principalmente no contexto de robótica, através do desenvolvimento de jogos educativos baseados na noção prática de inferência.

Finalmente, no que concerne à **Task 3: Quantum Logics and Algorithms**, coordenada por Walter Carnielli, três artigos e uma dissertação de mestrado foram elaborados. Dois artigos foram aceitos para publicação: o

primeiro investiga o uso de representações do tipo polinomial como estratégia heurística, e discute como idéias de G. Boole a respeito da unificação de lógica, álgebra e cálculo diferencial e integral podem ser recuperadas e revistas a partir desta perspectiva.

O segundo artigo tem como intenção principal a proposta de circuitos lógicos baseados em lógicas não-standard de forma a embasar modelos de computação não-convencionais. Embora se trate de uma nova visão sobre a questão que pode ser adaptada para diversas lógicas alternativas, os modelos particulares que se tem em vista dizem respeito à computação quântica e suas relações com as máquinas de Turing paraconsistentes. O artigo foi muito bem avaliado pelos pareceristas, e aceito para publicação e para apresentação no evento.

Temas correntes de investigação (assuntos de trabalhos em preparação, além destes citados) incluem o estudo do problema dos estados quânticos emaranhados através da perspectiva lógica (lógicas não-adjuntivas) e possibilidades de se estender o Teorema de Cook para circuitos lógicos não-standard (definidos por meio de cálculos de polinômios com variáveis ocultas).

Na nossa avaliação o segundo ano do Projeto foi, assim como o primeiro, muito produtivo em termos dos avanços substantivos alcançados, totalmente de acordo com os objetivos iniciais.

Continuando com a notação adotada no primeiro relatório, $\boxed{\text{[Ref]}}$ denota que a referência [Ref] corresponde a uma publicação produzida pelos membros do Projeto durante o período.

1 Introduction

The second year of the CONSREL Project, analogously to the first one, has been a very productive period. A good amount of papers, as well as a research book, were published or submitted for publication; an improved version of the open source theorem prover developed by a member of the Project has been released; finally, one MSc and one PhD students have finished their theses in the context of the Project. Additionally, other graduate students certainly will have their final defense happening in the coming years, within the lifetime of the Project.

At the Project webpages :

<http://www.ime.usp.br/~consrel>

<http://consrel.incubadora.fapesp.br/portal/project-members>

most of the papers published within the context of the Project can be found.

The structure of this Report is as follows: The rest of this section recalls the Project's setting, describing its domain, goals and the structure in which the Project tasks were divided. Section 2 reports the achievements in each of the Project tasks. Section 3 details the personal contribution of each member to the Project's goals. Finally, Section 4 discusses work in progress, plotting the directions of the Project in its continuation. Using the same notation as in the previous report, $\boxed{\text{[Ref]}}$ denotes that the reference [Ref] corresponds to a publication produced by Project members within the reported period .

1.1 The Project domain

The Project CONSREL deals with the topic of Logical Consequence and Combinations of Logics. This wide topic allows us to deal with many subjects, and we have chosen to concentrate on the following:

- The study of methods for combining logics. This encompasses the ways logics can be put together to generate more complex systems, as well as the ways a logic can be decomposed into simpler ones. The combination procedures can generate a single logic, as in the fibring or in the possible-translations approach, or the process can be asymptotic and generate a class of logics, as in the families of logics that approximate classical logic.
- The study of practical applications of combinations of logics, which covers the fields of theorem proving, AI, belief revision and the study of novel models of computation, such as quantum computation and quantum algorithms.

To cover this wide spectrum we face the problem of combining logics from the mathematical, computational, conceptual and philosophical points of view.

1.2 The Project goals

As we have stated in the Project proposal, the aims of this Project are directed towards the following aspects of combination of logics:

1. To study the fundamental issues of combining logics, covering the following points:
 - Specific methods for combining logics, such as *fusion*, *products* and *fibring*.
 - Algebraic and categorial aspects of logic combinations, such as *Blok-Pigozzi algebraization*.
 - Formal semantics for logic combination, such as *possible-translations semantics* and *society semantics*.
2. The study of computational aspects of logical combination, addressing the following topics:
 - Approximations of classical logic and the development of approximate theorem provers.
 - Belief Revision and its relation with the notions of relevance generated by approximation processes.
 - Logics *with* uncertainty, as opposed to logics that reason *about* uncertainty. These logics of practical interest can be modeled as a combination of classical logics with probability theory or with fuzzy logics.

3. The study of particular logics of interest resulting from combination of logics, namely:
 - Quantum Logics, which are connected to mathematical questions on Hilbert Spaces, Lie Algebras and Topology.
 - Quantum algorithms which, from the standpoint of combination mechanisms, can be seen as superpositions of classical models.

1.3 The Structure of the Project

To achieve the above mentioned goals, the Project is divided into three main tasks, each of which by its turn subdivided into several subtasks, as follows.

Task 1: Fundamentals of Combining Logics, coordinated by Marcelo Coniglio. Subtasks:

- Subtask 1.1: Combinations of Logics and their Applications
- Subtask 1.2: Splitting and Algebraizing Logics
- Subtask 1.3: Algebraic Semantics for Modal Logics
- Subtask 1.4: Algebraic and Categorical Aspects of Logical Consequence

Task 2: Computational Aspects of Combinations of Logics and Theorem Proving, coordinated by Marcelo Finger. Subtasks:

- Subtask 2.1: Approximations of Classical Propositional Logic
- Subtask 2.2: First-Order Approximate Inference¹
- Subtask 2.3: Resource Sensitive Inference
- Subtask 2.4: Automatizing Paraconsistent Inference

Task 3: Quantum Logics and Algorithms, coordinated by Walter Carnielli. Subtasks:

- Subtask 3.1: Quantum Computation and Quantum Logics
- Subtask 3.2: Polynomial Ring Proof Procedures
- Subtask 3.3: Paraconsistent Turing Machines

1.4 Human Resources of the Project

As it is usual in projects of wide range involving people from different institutions and from several levels and distinct backgrounds, there is a continuous adjustment in the human resources component of the Project:

- Adolfo Gustavo Serra Seca Neto has finished his PhD and is now a Post-Doc Student.

¹This Subtask was cancelled, see Section 2 below.

- Alberto Leopoldo Batista Neto has finished his Master's Thesis and he is applying for a PhD in the same Program, to be started in 2008.
- New Master students were incorporated into the Project: Samir Gorsky, Newton Marques Peron and Leandro Suguítani, all from IFCH- UNICAMP.

The updated group of researchers consists from now on of the following people:

Project Coordinator

- Walter Carnielli (IFCH and CLE – UNICAMP)

Task Coordinators

- Marcelo Coniglio (IFCH and CLE – UNICAMP)
- Marcelo Finger (DCC-IME-USP)

Researchers

- Itala D'Ottaviano (IFCH and CLE – UNICAMP)
- Hércules de Araujo Feitosa (MAT-UNESP-Bauru)
- Odilon Otávio Luciano (MAT-IME-USP)
- João Marcos (DIMAp/ CCET- UFRN)
- Hugo Mariano (MAT-IME-USP)
- Flavio Correa da Silva (DCC-IME-USP)
- Renata Wassermann(DCC-IME-USP)
- Angela Weiss (MAT-IME-USP)

Post-Doc Members

- Milton Augustinis de Castro (IFCH – UNICAMP)
- Adolfo Gustavo Serra Seca Neto (DCC-IME-USP)

PhD Students

- Juan Carlos Agudelo Agudelo (IFCH-UNICAMP) (name in publications: Juan Carlos Agudelo)
- Juliana Bueno (IFCH-UNICAMP) (name in publications: Juliana Bueno-Soler)
- Rodrigo de Alvarenga Freire (IFCH-UNICAMP)
- Carlos Hifume (IFCH-UNICAMP)
- Joselyto Riani (DCC-IME-USP)
- Luís Sbardellini (IME- USP)

- Luiz Henrique Silvestrini (IFCH- UNICAMP)

MSc Students

- Alberto Leopoldo Batista Neto (IFCH- UNICAMP)²
- Anderson de Araujo (IFCH- UNICAMP)
- Samir Gorsky (IFCH- UNICAMP)
- Newton Marques Peron (IFCH- UNICAMP)
- Rodrigo Podiack (IFCH- UNICAMP)
- Guilherme Rabello (MAT-IME-USP)
- Teófilo de Sousa Reis (IFCH- UNICAMP)
- Leandro Suguitani (IFCH- UNICAMP)
- Rafael Rodrigues Testa (IFCH-UNICAMP)

External Participants

- Jean-Yves Béziau (Université de Neuchâtel, Switzerland)
- Carlos Caleiro (IST, Lisbon)
- Alexandre Costa-Leite (Université de Neuchâtel, Switzerland)
- Eduardo Fermé (Department of Mathematics and Engineering, Universidade da Madeira, Portugal)
- Dov Gabbay (King's College, London)
- Paulo Mateus (IST, Lisbon)
- João Rasga (IST, Lisbon)
- Amílcar Sernadas (IST, Lisbon)
- Cristina Sernadas (IST, Lisbon)
- Jorge Petrucio Viana (IM-UFF, Rio de Janeiro)

2 Report by Tasks

Task 1: Fundamentals of Combining Logics

Task coordinator: Marcelo Coniglio

This task is mainly dedicated to the study and the development of a general theory of combination of logic systems, from a theoretical and conceptual point of view.

During the period under analysis we can say that a more than satisfactory bulk of results were obtained in the scope of this Task. It is worth noting

²Master's Thesis concluded in April 2007. He is applying for a PhD in the same Program, to be started in 2008.

that most of the research topics proposed in Section 5 of the previous Research Report (“Future Work: Next Steps and Work in Progress”) were attained, as described below.

One of the main achievements of the team was the completion of a lengthy book about combination of logics, including conceptual issues and covering the main techniques on combining logics, with a good amount of original contribution. This book involves two main researchers of the project, as well as other external members.

Additionally, a good amount of papers were produced by the team members, some of them in collaboration with external project members and other researchers. Some of these papers were published or accepted for publication, others have been submitted for publication, and some have been released as electronic preprints, with the purpose of being submitted in the near future.

On the other hand, a Master dissertation elaborated by a student member of the team with a grant from FAPESP was concluded. This dissertation concerns topics of this project Task.

The research developed in the reported period covered the four corresponding subtasks. In a similar way to the first year of the Project, the advancements can be classified into two main lines: the first line concerns to the study of general conceptual issues about combination and representation of logic systems. The second is about the analysis of specific techniques for composing (splicing) and decomposing (splitting) logic systems.

Subtask 1.1: Combinations of Logics and their Applications

One of the main achievements concerning this subtask is the completion of the book:

[CCGGS07] W.A. Carnielli, M.E. Coniglio, D. Gabbay, P. Gouveia, and C. Sernadas. **Analysis and Synthesis of Logics**. Submitted to *Applied Logic Series*, Kluwer, 2007.

This book reflects the efforts of team members dedicated to the development of general techniques for composing and decomposing logics (see the preface and table of contents attached to this report). We briefly describe the most relevant developments obtained during the period under evaluation:

1. An uniform notation was introduced, in order to cope with the different applications of fibring developed by the authors since 1999. This notation allows to represent logic systems and their fibring at both syntactical and semantical levels, starting from propositional languages and going naturally through first-order and higher-order (modal) languages.
2. Different notions of interpretation systems, each one adequate for the different truth-functional logic systems defined over the languages mentioned above, have been related. This enables to cope with a more uniform semantical theory for truth-functional logic systems.

3. All the papers from which the book was based were entirely revised and corrected. New interesting examples and results were added. In particular, Chapter 9 (“Splitting Logics”) concerning the decomposition of logics systems by means of possible-translations semantics (PTS’s) contains several new results with respect to the categorial representation of PTS’s.

With respect to the last item above, we intend to generalize the categorial results concerning PTS’s through the research of the MSc student Teófilo Reis, a member of the Project team endowed with a FAPESP grant. Specifically, a broader notion of signature morphism (using multifunctions) is being considered. It is worth noting that this work has impact on the research being developed in the Subtask 1.2 (see below). Some interesting results were already obtained, which are to be presented by Reis in a Conference this year.

Another MSc student, Alberto Leopoldo Batista Neto, also member of the Project and a FAPESP grantee, has finished his Master’s Thesis at Unicamp under supervision of Marcelo Coniglio:

[B07] Alberto L. Batista-Neto. *Representação e Combinação de Lógicas: Questões Conceituais (Representation and Combination of Logics: Conceptual Questions*, in Portuguese). Master’s Thesis. IFCH-UNICAMP, 2007.

In this thesis, several interesting questions concerning the notion of translations between logics by means of different formalisms such as meta-translations, transfers and conservative translations were outlined (within the framework of combining logics).

On the other hand, several articles concerning this subtask are under elaboration, and we hope to finish and to submit them in the next months. One of such articles deals about the possibility of obtaining ‘bridge principles’ (that is, interaction laws between connectives of logics being combined) and the philosophical significance of this phenomenon. This discussion relates the subject of combining logics with a well-known philosophical discussion, Hume’s ‘is-ought problem’.

With respect to the general theory of translations between logics, starting from the representation of logic systems as being constituted by a set and a consequence operator (in the same lines as Béziau’s *Universal Logic*), some new interesting translations between logic systems were obtained. Arguably, these functions can be considered as an instrument to look for a general concept of duality between logics and between other formal systems. The results obtained in this research are contained in the following paper:

[DF07] Itala M.L. D’Ottaviano and Hércules A. Feitosa. Deductive systems and translations. In J.-Y. Béziau, editor, *Directions in Universal Logic*. Birkhuser, to appear.

Additionally, the possibility of obtaining conservative translations from Łukasiewicz logics into classical logic was analyzed. Thus, it was shown, using facts

about algebraic semantics, that there is a conservative translation from every finite Łukasiewicz's logic into classical logic. However, the proof of the existence of such translations is not constructive. The results obtained are reported in the paper:

[DF06] Itala M.L. D'Ottaviano and Hércules A. Feitosa. Translation from Łukasiewicz logics into classical logic: Is it possible? In J. Malinowski and A. Pietruszczak, editors, *Essays in Logic and Ontology*. Poznan Studies the Philosophy of the Sciences and the Humanities, v. 91, p. 157–168, 2006.

Finally, some attention was dedicated to non-classical logics. On the one hand, in the paper

[M06] João Marcos. Ineffable inconsistencies. In J.-Y. Béziau and W.A. Carnielli, editors, *Paraconsistency with no Frontiers*. North-Holland/Elsevier. To appear.

it is shown that for any given consistent tarskian logic it is possible to find another non-trivial logic that allows for an inconsistent model yet completely coincides with the initial given logic from the point of view of their associated single-conclusion consequence relations.

On the other hand, logics of formal inconsistency (paraconsistent logics which permit the internalization of the concepts of consistency and inconsistency inside the object language) has been applied to abductive logics. The concept of abduction or retrodution was introduced by C.S. Peirce in the double sense of searching for explanatory instances and providing an explanation. There is, however, an inferential step from the *explanandum* to the (one or more) abductive *explanans*. Whether this inferential step can be captured by logical machinery depends upon a number of assumptions, but in any case it suffers in principle from the triviality objection: any time a singular contradictory *explanans* occurs, the system collapses and stops working. The paper

[C06a] W. Carnielli. Surviving Abduction. *Logic Journal of the IGPL*, 14:237–256, 2006.

shows that the robust logics of formal inconsistency provide simple yet powerful techniques for automatic abduction. Moreover, the whole procedure is capable of automatization by means of the tableau proof-procedures available for such logics. Several examples are discussed in the paper above.

A method for of obtaining a (possibly non-truth-functional) 2-valued semantics for finite-valued matrix logics was obtained as a result of a research involving members of the team, producing a paper published as a book chapter in 2005. A second edition of that book was published in 2007, including a revised version of the above mentioned paper:

[CCCM07] C. Caleiro, W. A. Carnielli, M. E. Coniglio, and J. Marcos. Two’s company: “The humbug of many logical values”. In J.-Y. Béziau, editor, *Logica Universalis*, Second edition, pages 169–189. Birkhäuser Verlag, 2007 (in print).

Subtask 1.2: Splitting and Algebraizing Logics

Several interesting new results were obtained in the context of this subtask.

The question of combining by fibring logics in the so-called *Leibniz hierarchy* was outlined. This is related to a more general issue on combinations of logics: the preservation by fibring of certain properties of propositional logics. In the research developed this period, three important classes of logics within the Leibniz hierarchy were studied: protoalgebraic, equivalential and algebraizable logics. The study involved the definition of the respective categories of logic systems. On the other hand, new categories of deductivizable quasi-varieties were introduced, and a new isomorphism between this category and the category of algebraizable logics was obtained. This result is a simpler alternative to a similar result found in the literature. This research line has generated the following article:

[FC07] Víctor L. Fernández and Marcelo E. Coniglio. Fibring in the Leibniz Hierarchy. *Logic Journal of the IGPL*. To appear.

On the dual side, that is, from the viewpoint of decomposition of algebraizable logics into simpler ones, the technique of obtaining a kind of algebraization for a logic through a possible-translations semantics whose factors are algebraizable has been significantly improved. The description of the method, as well as several interesting examples of its application, can be found in the following paper:

[BCC07] Juliana Bueno-Soler, Marcelo E. Coniglio and Walter A. Carnielli. Possible-translations algebraizability. In J.-Y. Béziau and W.A. Carnielli, editors, *Paraconsistency with no Frontiers*. North-Holland/Elsevier. To appear.

As planned in the last Report, a formal and very general study of possible-translations semantics was initiated, with the aim of obtaining general results of preservation of properties of the factor (component) logics through the combination process. As mentioned above, a MSc student is working on this subject, and some promising results were obtained. By applying the resulting know-how on algebraizing logics by means of possible-translations semantics obtained through the results mentioned above, it is expected that new interesting applications can be obtained.

Subtask 1.3: Algebraic Semantics for Modal Logics

The goal of this subtask is the study of abstract consequence operators and generalized (or modulated) quantifiers (such as ‘generally’, ‘rarely’, ‘most’, etc.),

and their relationship to other logics, in particular, to modal logics. One aspect of the Project is to study algebraic semantics for such logics.

There was some relevant advance concerning this task during the last year, and some articles were produced.

A classification for (first-order) quantifiers was proposed, separating between “classical quantifiers” (which are defined from the ‘classical’ quantifier \forall by means of boolean combinations) and “non-classical quantifiers”, which are conceived as primitive ones. As a case-study, the non-classical quantifier “many” was introduced within a formal framework, obtaining a new logical system, the so-called *Logic of Many*. However, some paradoxes concerning the proposed notion are pointed-out. Some of the results of this research are contained in the paper below.

[GF07] Maria C. Cabrini Grácio, Hércules A. Feitosa and Mauri Cunha do Nascimento. “Muitos”: Formalizando um conceito impreciso (“*Many*”: *Formalizing an imprecise concept*, in Portuguese). Accepted for publication in *Revista Eletrônica Informação e Cognição* (REIC).

In what concerns the philosophical studies of da Costa’s theories of truth and quasi-truth, some new results were obtained. Peirce’s semiotic conception of knowledge was analyzed, taking into account his conceptions of truth and reality as well as his metaphysics, with the aim of obtaining a more coherent way of representing knowledge and cognitive processes, in alternative to the atomist–deductivist developments of formal sciences. Instead of being exclusively involved with the conception of truth (as developed by Tarski) a conception of the Peircean pragmatic truth and a formal definition of pragmatic truth (the quasi-truth previously introduced by da Costa and collaborators) was proposed. By defining the mathematical concept of partial structure and by using a special semantical approach, a suitable logic that can be used as the underlying logic for theories whose truth conception is the quasi-truth was analyzed. The results obtained can be found in the paper below.

[HD07] Carlos Hifume and Itala M.L. D’Ottaviano. Peircean pragmatic truth and da Costa’s quasi-truth. In Magnani, L.; Li, P., editors. *Proceedings of “Model-Based Reasoning in Science and Medicine 2006” (MBR’06)*, Guangzhou (Canton), P. R. China, July 3-5, 2006, “Studies in Computational Intelligence”, Springer Series. In print.

Finally, continuing with the study of abstract consequence operators already started, a class of ordered algebras associated to Tarski’s consequence operators (the *TK-algebras*) was defined. Together with this, a modal logic associated to TK-algebras was introduced. By adapting the classical techniques on algebraic logic, the corresponding soundness and completeness theorems were obtained. These results are described in the paper below.

[FCG07] Hércules A. Feitosa, Mauri Cunha do Nascimento and Maria Claudia Cabrini Grácio. A propositional logic for Tarski's consequence operator. *CLE e-Prints*, vol. 7, n. 1, 2007.
<http://www.cle.unicamp.br/e-prints/vol7,n1,2007.html>

Subtask 1.4: Algebraic and Categorical Aspects of Logical Consequence

This subtask was originally designated to obtain applications for the subject of combining logics by using tools from category theory, with emphasis in fibring and possible-translations semantics. Several new results were obtained in this direction, as will be described below.

The application of accessible categories in the study of categories of logics has been continued, and the results contained in a previous preprint were improved. These results are described in the following paper:

[AFLM07] Peter Arndt, Rodrigo A. Freire, Odilon O. Luciano and Hugo L. Mariano. A global glance on categories in Logic. *Logica Universalis*, vol. 1(1), p. 3-39, 2007.

The idea of generalized ultrafilters with applications to the study of first-order logics was fully explored. Specifically, a version of Łós' ultraproduct theorem for forcing in Kripke structures has been obtained in the context of first-order languages with equality. Additionally, ultrafilters in topologies (naturally associated to partial orders) were analyzed. The results obtained in this line of research are contained in the paper below.

[MM06] Hugo L. Mariano and Francisco Miraglia. Logic, Partial Orders and Topology. *Manuscrito*, v. 28, n. 2, p. 449-545, 2005.³

Finally, an article in which is proved that profinite L-structures, the cofiltered limits of finite L-structures, are retracts of ultraproducts of finite L-structures, was entirely revised and accepted for publication:

[MM07] Hugo L. Mariano and Francisco Miraglia. Profinite Structures are Retracts of Ultraproducts of Finite Structures. *Reports on Mathematical Logic*, no. 42, 2007 (in print).

Task 2: Computational Aspects of Combinations of Logics and Theorem Proving

Task coordinator: Marcelo Finger

This task deals with the study of the computational and practical aspects of combination of logic systems.

³This volume was in fact completed and published in 2006.

This task has continued to see notable progress in several of its subtasks, which includes the acceptance for publication of papers in good journals and conferences as well as the production of the first version of an open source theorem prover for logics of formal inconsistency.

Subtask 2.1: Approximations of Classical Propositional Logic

The results in this area continue the expansion of the frontiers of logical approximation. Until very recently, all forms of approximation processes in logic concerned some form of redefinition on the notion of classical negation. This was in conformity of the paraconsistent nature of those approximations, namely that all intermediate logics that approximated classical logic admitted some form of non-trivializing inconsistency.

Our previous report [FW06] already mentioned the fact that approximations had expanded this horizon to admit approximations of classical logic by weakening any set of classical connectives, not only negation.

We have now made two other expansions in the field:

- Almost all previous approximations were “approximations from below”, in which the family of logics that processed the approximation was a sub-classical, that is, its set of theorems were a subset of the set of theorems from classical logic. We now introduce a method for “anytime approximation of classical logic from above” [FW07].
- Approximations from above consisted of weakening the semantics of some connective. We have shown that we can also obtain several approximations of classical logic by controlling the use of inference rules. In particular, we can obtain an approximation process that respects the uniform substitution property, something that is very rare in approximation processes and paraconsistent logics as well [FG06].

Unfortunately, one of the lines of this task, namely that of approximating first-order classical logic, was cancelled: due to personal problems, the student in charge of this development had to quit her doctoral program and, consequently, she also left the project.

The paper studying approximations from above is:

[FW07] Marcelo Finger and Renata Wassermann. Anytime approximations of classical logic from above. *Journal of Logic and Computation*, 17(1):53–82, 2007.

The paper dealing with approximations through the control of Cut, a method called *cut-and-pay*, is presented in:

[FG06] Marcelo Finger and Dov Gabbay. Cut and pay. *Journal of Logic, Language and Information*, 15(3):195–218, October 2006.

The work on approximating modal logics has appeared in a volume of Electronic Notes in Theoretical Computer Science:

[FR06] Marcelo Finger and Guilherme Rabello. Approximations of modal logic **K**. In *Electronic Notes in Theoretical Computer Science*, volume 143: *Proceedings of the 12th Workshop on Logic, Language, Information and Computation (WoLLIC 2005)*, pages 171–184, January 2006.

It is important to note that an expanded version of approximations of modal logic is about to appear in a journal version.

Subtask 2.2: First-Order Approximate Inference

This subtask has not been developed due to the fact that the student assigned to it, Eudenia Menezes, has left the Project for personal reasons.

We believe that the excellent work being done in other subtasks is able to compensate for the fact that this subtask is cancelled.

Subtask 2.3: Resource Sensitive Inference

On this topic, several works related to robotics and use of inference in practical cases have been developed, as well as in the practical implementation of belief revision. We continue to stress the application of this line of research in the area of computer and educational games which has generated several papers in several national and international conferences, involving many of the Project participants.

In the area of computer and educational games, the following papers were produced:

[CV06] F. S. Correa da Silva and W. Vasconcelos. Rule schemata for game artificial intelligence. In *Brazilian Symposium of Artificial Intelligence SBIA*, 2006.

[YC06] F. S. Yamamoto and F. S. Correa da Silva. Ambientes virtuais contextualizáveis baseados em jogos de computador em educação. In *Workshop sobre Educação em Computação WEI*, 2006.

In the area of reasoning for robotics, we have published the following paper:

[TBC06] F. W. Trevisan, L. N. Barros, and F. S. Correa da Silva. Designing logic-based robots. *Inteligencia Artificial*, 10:11–22, 2006.

In the area of reasoning applied to belief revision and reasoning based on ontologies, we have:

[RW07] Marcio Moretto Ribeiro and Renata Wassermann. Base revision in description logics. In *Proceedings of the International Workshop of Ontology Dynamics*, 2007. Vienna, Austria.

[RW06] Márcio Moretto Ribeiro and Renata Wassermann. First steps towards revising ontologies. In *Proceedings of the Second Workshop on Ontologies and their Applications (WONTO 2006)*, 2006.

[KPRRVNW06] Fábio Kepler, Christian Paz-Trillo, Joselyto Riani, Márcio M. Ribeiro, Karina Valdivia-Delgado, Leliane Nunes de Barros, and Renata Wassermann. Classifying ontologies. In *Proceedings of the Second Workshop on Ontologies and their Applications (WONTO 2006)*, 2006.

Finally, we had some application of reasoning with uncertainty and trust applied to computer grids.

[BVKF06] Jr José de R. P. Braga, Alexandre C. T. Vidal, Fabio Kon, and Marcelo Finger. Trust in large-scale computational grids: an SPKI/SDSI extension for representing opinion. In *MCG '06: Proceedings of the 4th international workshop on Middleware for grid computing*, page 7, New York, NY, USA, 2006. ACM Press.
<http://doi.acm.org/10.1145/1186675.1186683>.

Subtask 2.4: Automatizing Paraconsistent Inference

The productive work of this subtask has proceeded forward. It had thus produced the following papers:

[SnF06] Adolfo Gustavo Serra Seca Neto and Marcelo Finger. Effective prover for minimal inconsistency logic. In *IFIP 19th World Computer Congress, TC-12 IFIP AI 2006*, volume 217, pages 465–477, Santiago, Chile, 2006. IFIP International Federation for Information Processing.

The doctoral thesis of Adolfo Gustavo Serra Seca Neto also counts as a contribution to this area [Sn07].

[Sn07] Adolfo Gustavo Serra Seca Neto. *A Multi-Strategy Theorem Prover*. PhD thesis, Department of Computer Science, DCC/IME/USP, University of São Paulo, 2007.

Finally, continuing the research about the development of tableaux systems for da Costa's paraconsistent logics, some new results were obtained, and the methods proposed in [DC05] were improved. This results are described in the following paper:

[DC06] Itala M.L. D’Ottaviano and Milton A. de Castro. Analytical tableaux for da Costa’s paraconsistent logics. *Electronic Notes in Theoretical Computer Science*, volume 143: *Proceedings of the 12th Workshop on Logic, Language, Information and Computation (WoLLIC 2005)*, pages 27–44, January 2006.

Task 3: Quantum Logics and Algorithms

Task coordinator: Walter Carnielli

This task has the purpose of studying Quantum Logics and Quantum Computation, and their application to the modeling of quantum computation in a wide range.

– **Subtask 3.1: Quantum Computation and Quantum Logics**

This task is dedicated to investigate the relationship between logic systems and models of quantum computation, with the intention to investigate the role of distinct underlying logics in models of computation. A related output of the task is the analysis of the role the essential quantum characteristics play in the development of efficient quantum algorithms. After finishing his MSc thesis, the student Juan Carlos Agudelo Agudelo is now working under a Ph.D. grant from FAPESP and part of his research interests are related to all subtasks of this Task (thanks to some new results on non-standard logic circuits, as explained below). Some encouraging first results have been obtained in all the subtasks of this Task, revealing the intended connections between them.

– **Subtask 3.2: Polynomial Ring Proof Procedures**

The approach of the “polynomial ring proof procedures” is a new and innovative idea which relates questions of theorem proving in classical and non-classical logics, algebraization of logics and applications to quantum gates in quantum computation. From a more conceptual perspective, it is also related to some philosophical discussion on the work of G. Boole and in the inheritance of G. Leibniz in formalizing logic.

– **Subtask 3.3: Paraconsistent Turing Machines**

The intention behind this subtask is to refine the models of Paraconsistent Turing Machines proposed in previous steps of the Project in such a way as to get closer of the models of quantum computing. In particular, a promising research line is to study the role of non-adjunctive logics and its (possible) relationship with entangled quantum states. Another promising line of attack consists in extending the polynomial ring proof procedures (as described in Subtask 3.2) with the aims of application in non-standard logic circuits.

Results from research and production

The following points have been completed as a result of the research efforts around the Task. Since the results have to do with the integration of the three subtasks, we present them in block:

1. Detailed study of the polynomial ring calculus over finite fields with hidden variables, and the proposal of a paraconsistent circuit model.
2. Investigation on the relationship between paraconsistent circuit models and quantum circuits.
3. Analysis of some quantum algorithms in order to gain intuition on the distinctions between quantum and classical algorithms, namely: Dan Simon's algorithm to find function periods; Peter Shor's algorithm to factor integer numbers in polynomial time, and Grover's search algorithm.

The following items represent the results of the work developed within the present Task within the reported period:

1. The paper

[AC07] J.C. Agudelo and W.A. Carnielli. Unconventional Models of Computation through Non-Standard Logic Circuits.

was accepted for presentation in the "UC'07- International Conference on Unconventional Computation" (Organized by the School of Computing, Queen's University, Kingston, Canada and the Centre for Discrete Mathematics and Theoretical Computer Science, The University of Auckland, Australia). Further references at <http://www.cs.queensu.ca/uc07>.

2. The same paper was also accepted (after two positive referee reports) to appear in the conference proceedings to be published in the Lecture Notes in Computer Science (LNCS), Springer-Verlag, 2007.
3. The communication "Máquinas de Turing Paraconsistentes não Adjuntivas e Simulação de Algoritmos Quânticos" was presented by Juan Carlos Agudelo in the XIV Encontro Brasileiro de Lógica <http://www.tecmf.inf.puc-rio.br/EBL06> held between 24 -28 April 2006 in Itatiaia, RJ.
4. The communication "Perspectives on algebraizing logics" was presented by Juliana Bueno in the XIV Encontro Brasileiro de Lógica <http://www.tecmf.inf.puc-rio.br/EBL06> held between 24 -28 April 2006 in Itatiaia, RJ.
5. The communication "Polynomial Formulations of Non-Deterministic Semantics for Logics of Formal Inconsistency" was presented by Marcelo Coniglio in the XIV Encontro Brasileiro de Lógica <http://www.tecmf.inf.puc-rio.br/EBL06> held between 24 -28 April 2006 in Itatiaia, RJ.

6. The invited conference “Boole’s Algebraic Logic in Polynomial Form” was imparted by Walter Carnielli in the XIV Encontro Brasileiro de Lógica <http://www.tecmf.inf.puc-rio.br/EBL06> held between 24 -28 April 2006 in Itatiaia, RJ.
7. The invited conference “Polynomizing: Using Polynomial Forms as Reasoning Models” was imparted by Walter Carnielli in the conference “Model-Based Reasoning in Science and Medicine” (MBR’06) held between 03-05 July 2006 at the Sun Yat-Sen University in Guangzhou , China.
8. The communication “Circuitos Lógicos via Cálculo de Anéis de Polinômio” was presented by Juan Carlos Agudelo at the XII Encontro Nacional de Filosofia da ANPOF <http://www.anpof.org.br/encontros/12/> held between 23- 27 October 2006 in Salvador da Bahia.
9. The communication “Prova por polinômios: uma nova abordagem para algebrizar lógicas?” was presented by Juliana Bueno at the XII Encontro Nacional de Filosofia da ANPOF <http://www.anpof.org.br/encontros/12/> held between 23- 27 October 2006 in Salvador da Bahia.
10. The conference titled “Combinations of Logics: Paradoxes, Problems and Perspectives was delivered at the “Colloque international sur les Attitudes et l’Action dans le Discours” (within the ACFAS Conference), 9 - 11 May 2007, Trois-Rivières, Quebec, Canada.
11. The following paper has also been worked out:

[C07] W. Carnielli. Polynomizing: Using Polynomial Forms as Reasoning Models. In Model-Based Reasoning in Science, Technology, and Medicine, Series “Studies in Computational Intelligence” (eds. L. Magnani and P. Li), Vol. 64, Springer, Berlin/New York, 2007 (in print).

It is a revised and improved version of the preprint

[C06b] W. Carnielli. Polynomizing: Logic Inference in Polynomial Format and the Legacy of Boole. *CLE e-Prints*, vol. 6, n. 3, 2006. <http://www.cle.unicamp.br/e-prints/vol.6,n.3,2006.html>

12. A more ambitious paper “Quantum Computation via Paraconsistent Computation” is being prepared for publication in an international journal. A first draft was posted as a preprint in:

[AC06] J.C. Agudelo and W.A. Carnielli. Quantum Computation via Paraconsistent Computation. Available at <http://arxiv.org/abs/quant-ph/0607100>

and in:

<http://wslc.math.ist.utl.pt/ftp/pub/CarnielliWA/06-AC-qcvpc.pdf>

3 Report by Members

We now expose, for each member of the Project, which were their main contributions to the Project.

Project Coordinator

- Walter Carnielli (IFCH and CLE – UNICAMP)

Journal papers: [C06a].

Conference papers: [AC07].

Book Chapters: [CCCM07, BCC07, C07].

Books: [CE06, CCGGS07].

Preprints: [C06b, AC06].

Student supervision: (Ongoing) Juan Carlos Agudelo Agudelo (PhD), Rodrigo de Alvarenga Freire (PhD), Anderson de Araujo (MSc), Samir Gorsky (MSc), Rodrigo Podiack (MSc).

(Finished) Juan Carlos Agudelo Agudelo [A06] (MSc)

Talks, mini-courses and seminars:

- Talk as Invited Speaker in the “XIV Encontro Brasileiro de Lógica”, Itatiaia, RJ, April 24-28, 2006:
Boole’s Algebraic Logic in Polynomial Form.
- Talk as Invited Speaker in the conference “Model-Based Reasoning in Science and Medicine” (MBR’06), Guangzhou (Canton), P. R. China, July 3-5, 2006:
Logic Inference in Polynomial Format and the Legacy of Boole.
- Talk in the “X Colóquio Cone Sul de Filosofia das Ciências Formais”, Santa Maria, RS, November 15-18, 2006, as a part of the mini-course “Modalidades”:
Multimodalidades e o Inquérito Filosófico.
- Talk as Invited Speaker in the “Colloque international sur les Attitudes et l’Action dans le Discours” (as a part of ACFAS), Trois-Rivières, Quebec, Canada, March 9-11, 2007:
Combinations of Logics: Paradoxes, Problems and Perspectives.

Reviews:

- Review of the book *Alfred Tarski: Life and Logic*, by Anita Burdman Feferman and Solomon Feferman, Cambridge University Press, Cambridge, UK, 2004. “Logic and Logical Philosophy” volume 15 (2006), 91–96.

Other publications:

- Entry “Lógica Paraconsistente, Sistemas de” (*Paraconsistent Logics, Systems of*, in Portuguese), in João Branquinho, Desidério Murcho and Nelson Gonçalves Gomes, editors, “Enciclopédia de Termos Lógico-Filosóficos”. São Paulo: Martins Fontes, 2006.
- Preface to the book “The Magic Garden of George B. And Other Logic Puzzles”, by Raymond Smullyan. Polimetrica Publisher, *Contemporary Logic* series, 2007.
- Preface to the book “An Introduction to Partially Ordered Structures and Sheaves”, by Francisco Miraglia. Polimetrica Publisher, *Contemporary Logic* series, 2006.

Task Coordinators

- Marcelo Coniglio (IFCH and CLE – UNICAMP)

Journal papers: [FC07].

Book Chapters: [CCCM07, BCC07].

Books: [CCGGS07].

Student supervision: (Ongoing) Luiz Henrique Silvestrini (PhD), Newton Marques Peron (MSc), Teófilo de Sousa Reis (MSc), Rafael Rodrigues Testa (MSc).

(Finished) Wagner Sanz (PhD), Alberto Leopoldo Batista Neto [B07] (MSc).

Talks, mini-courses and seminars:

- Talk in the “XIV Encontro Brasileiro de Lógica”, Itatiaia, RJ, April 24-28, 2006:
Polynomial Formulations of Non-Deterministic Semantics for Logics of Formal Inconsistency.
- Talk in the “XIV Encontro Brasileiro de Lógica”, Itatiaia, RJ, April 24-28, 2006:
An Introductory Study about the Many-valued Hierarchy InPk.
- Visit to the Center for Logic and Computation, Instituto Superior Técnico, Lisbon, July 2006, developing research activities. Seminar in the “Logic and Computation Seminar”:
Fibring in the Leibniz hierarchy.
- Talk as Invited Speaker in the “XIII Latin American Symposium on Mathematical Logic”, Oaxaca, México, August 7-12, 2006:
Combining and Uncombining Logics.
- Talk in the “XII Encontro Nacional de Filosofia da ANPOF”, Salvador, BA, October 23-27, 2006:
Combinar e decompor lógicas: como e por quê?.

- Talk in the “X Colóquio Cone Sul de Filosofia das Ciências Formais”, Santa Maria, RS, November 15-18, 2006, as a part of the mini-course “Modalidades”:
Alguns Paradoxos Modais.
 - Visit to the Center for Logic and Computation, Instituto Superior Técnico, Lisbon, January 2007, developing research activities. Seminar in the “Logic and Computation Seminar”:
I1 and P1 are (and are not) algebraizable with the same quasi-variety.
- Marcelo Finger (IME – USP)
 - Journal papers:** [FW07, FG06, FW06].
 - Conference papers:** [FR06, SnF06, BVKF06].
 - Student supervision:** (Ongoing) Fábio Natanael Kepler (PhD), André Piza (PhD), Christian Paz-Trillo (PhD), Danilo Conde (MSc), Fernando Corrêa Lima (MSc).
(Finished) Adolfo Gustavo Serra Seca Neto [Sn07] (PhD), Germano Capistrano Bezerra (MSc).
 - Talks, mini-courses and seminars:**
 - Invited speaker in the “Escola de Verão”, Depto de Matemática, UnB. Brasília, 2006:
Raciocínio Aproximado.
 - Talk in the “XIV Encontro Brasileiro de Lógica”, Itatiaia, RJ, April 24-28, 2006:
End the discrimination: Equal rights for the CUT.
 - Invited speaker in “Propor 2006 — Computational Processing of Portuguese”, Itatiaia, RJ, May 13-17, 2006. Mini-course:
Applications of Machine Learning to Computational Linguistics.
 - Talk in IBERAMIA-SBIA 2006 — 2nd International Joint Conference. 10th Ibero-American Conference on AI. 18th Brazilian AI Symposium, 2006.
 - Visit to Depto de Matemática, UnB, Brasília, 2006, developing research activities.
 - Visit to Departamento de Informática da UFMA, São Luís, MA January 2006, developing research activities. Mini-course:
Resolvedores SAT.

Researchers

- Flavio Soares Correa da Silva (IME – USP)
 - Journal papers:** [TBC06].
 - Conference papers:** [YC06, CV06].

- Student supervision:** (Ongoing) Gustavo Enrique Salazar Torres (MSc), Tiago Motta Jorge (MSc), Igor Ribeiro Sucupira (MSc), Christian Alberto Noriega Guerra (MSc), Filipe Correa Lima da Silva (MSc). (Finished) Antonio Luiz Basile (MSc).
- Hércules de Araujo Feitosa (MAT-UNESP-Bauru)

Journal papers: [GF07].

Book Chapters: [DF06, DF07].

Preprints: [FCG07].

Student supervision: Maria Matulovic da Silva Fadel (MSc).

Talks, mini-courses and seminars:

 - Talk in the “XIV Encontro Brasileiro de Lógica”, Itatiaia, RJ, April 24-28, 2006:
Espaços quase topológicos e lógicas modais associadas.
 - Talk in the “XII Encontro Nacional de Filosofia da ANPOF”, Salvador, BA, October 23-27, 2006:
Acerca dos quantificadores naturais e seus modelos.
 - Talk in the “VII Encontro Brasileiro Internacional de Ciência Cognitiva”, São Paulo, 2006:
Quantificadores generalizados para o ‘muito’.
 - Talk in the “V Encontro da AFIHC”, Florianópolis, 2006:
Sobre os quantificadores generalizados.
 - João Marcos (UFRN, Natal)

Book Chapters: [M06, CCCM07].

Talks, mini-courses and seminars:

 - Talk in the “II International Colloquium on Metaphysics”, Natal, 2006:
Essential and accidental propositions
 - Talk in the “II International Colloquium on Metaphysics”, Natal, 2006:
Some countable families of multi-valued logics and their conjunctive and disjunctive normal forms
 - Talk in the “XIV Encontro Brasileiro de Lógica”, Itatiaia, RJ, April 24-28, 2006:
Beyond truth-functionality

Reviews:

 - Referee report for the *Symposium on Logical Foundations of Computer Science*, 2007
 - Referee reports for “Studia Logica”, 2006.
 - Referee report for the *Brazilian Symposium on Formal Methods (SBMF-2006)*, 2006.

- Referee report for the “Mathematical Logic Quarterly”, 2006.
- Hugo Luiz Mariano (MAT-IME-USP)
 - Journal papers:** [AFLM07, MM06, MM07].
 - Talks, mini-courses and seminars:**
 - Talk in the “XIV Encontro Brasileiro de Lógica”, Itatiaia, RJ, April 24-28, 2006:
On the category of algebraizable logics.
 - Reviews:**
 - Referee report for “Logic Journal of the IGPL”.
 - Referee report for “Logica Universalis”.
- Itala D’Ottaviano (IFCH and CLE – UNICAMP)
 - Conference papers:** [DC06].
 - Book chapters:** [DF06, DF07, HD07].
 - Student supervision:** Juliana Bueno (PhD), Carlos Hifume (PhD), Mauro Scheer (PhD), Leandro Suguitani (MSc).
 - Post-doc supervision:** Milton Agustini de Castro.
 - Talks, mini-courses and seminars:**
 - Talk in the “XIV Encontro Brasileiro de Lógica”, Itatiaia, RJ, April 24-28, 2006:
On da Costa’s paraconsistent differential calculus and a transference theorem.
 - Talk in the conference “Model-Based Reasoning in Science and Medicine” (MBR’06), Guangzhou (Canton), P. R. China, July 3-5, 2006:
Peircean pragmatic truth and da Costa’s quasi-truth.
 - Talk in the “XIII Latin American Symposium on Mathematical Logic”, Oaxaca, México, August 7-12, 2006:
On da Costa’s paraconsistent differential calculus and a transference theorem.
 - Seminar in the “Seminarios de Posgrado en Filosofía de la Ciencia”, Instituto de Investigaciones Científicas, Universidad Autónoma de México, Ciudad de México, August 2006:
Paraconsistent logics.
- Odilon Otavio Luciano (MAT-IME-USP)
 - Journal papers:** [AFLM07].
 - Talks, mini-courses and seminars:**
 - Talk in the “XIV Encontro Brasileiro de Lógica”, Itatiaia, RJ, April 24-28, 2006:
On the category of algebraizable logics.

Reviews:

- Referee report for “Logica Universalis”.

- Renata Wassermann (IME – USP)

Journal papers: [FW07].

Conference papers: [KPRRVNW06, RW06, RW07].

Student supervision: (Ongoing) Joselyto Riani (PhD), Eduardo Ribeiro de Castro (PhD), Marcio Moretto Ribeiro (MSc), Rodrigo Rage Ferro (MSc).
(Finished) Thiago Carvalho de Sousa (MSc).

Post-Doc Students

- Milton Augustinis de Castro (IFCH – UNICAMP)

Journal papers: [DC06].

Talks, mini-courses and seminars:

- Talk in the “XIV Encontro Brasileiro de Lógica”, Itatiaia, RJ, April 24-28, 2006:

Sistemas de Dedução Natural para as Hierarquias de Lógicas Paraconsistentes C_n e C_n^ de da Costa.*

PhD Students

- Juan Carlos Agudelo Agudelo (IFCH-UNICAMP)

Conference papers: [AC07].

Theses: [A06].

Preprints: [AC06].

Talks, mini-courses and seminars:

- Talk in the “XIV Encontro Brasileiro de Lógica”, Itatiaia, RJ, April 24-28, 2006:

Máquinas de Turing Paraconsistentes Não Adjuntivas e a Simulação de Algoritmos Quânticos.

- Talk in the “XII Encontro Nacional de Filosofia da ANPOF”, Salvador, BA, October 23-27, 2006:

Circuitos Lógicos via Cálculo de Anéis de Polinômios.

- Juliana Bueno (IFCH-UNICAMP)

Book chapters: [BCC07].

Talks, mini-courses and seminars:

- Talk in the “XIV Encontro Brasileiro de Lógica”, Itatiaia, RJ, April 24-28, 2006:
Perspectives on algebraizing logics.
- Talk in the “XII Encontro Nacional de Filosofia da ANPOF”, Salvador, BA, October 23-27, 2006:
Prova por polinômios: uma nova abordagem para algebrizar lógicas?

Reviews:

- Review of the book *Computabilidade: Funções Computáveis, Lógica e os Fundamentos da Matemática*, by Walter Carnielli and Richard L. Epstein, Editora da UNESP, 2005. SIRCA, Publicações Acadêmicas, pp. 174–179, Córdoba, Argentina.

- Rodrigo de Alvarenga Freire (CLE-UNICAMP)

Journal papers: [AFLM07].

Talks, mini-courses and seminars:

- Talk in the “XIV Encontro Brasileiro de Lógica”, Itatiaia, RJ, April 24-28, 2006:
On the category of algebraizable logics.

Reviews:

- Referee report for “Logic Journal of the IGPL”.

- Carlos Hifume (IFCH-UNICAMP)

Book chapters: [HD07].

- Joselyto Riani (DCC-IME-USP)

Conference papers: [KPRRVNW06].

- Adolfo Gustavo Serra Seca Neto (DCC-IME-USP)

Conference papers: [SnF06].

Theses: [Sn07].

Sites:

- KEMS - Um provador de teoremas multi-estratégia baseado no método KE.
<http://kems.iv.fapesp.br>

- Luiz Henrique Silvestrini (IFCH- UNICAMP)

Talks, mini-courses and seminars:

- Talk in the “XIV Encontro Brasileiro de Lógica”, Itatiaia, RJ, April 24-28, 2006:
Tableaux para uma lógica modulada.

MSc Students

- Alberto Leopoldo Batista Neto (IFCH-UNICAMP)
Alberto has concluded his Master's Thesis in April 2007. He is applying for a PhD in the same Program, to be started in 2008.
Theses: [B07].
Talks, mini-courses and seminars:
 - Seminar organized by the “Group for Theoretical and Applied Logic” (GTAL), CLE-UNICAMP, Campinas, November 11, 2006:
Combinations between Logics: Conceptual Questions (Combinações entre Lógicas: Questões Conceituais, in Portuguese).
- Anderson de Araujo (IFCH- UNICAMP)
Talks, mini-courses and seminars:
 - Talk in the “XII Encontro Nacional de Filosofia da ANPOF”, Salvador, BA, October 23-27, 2006:
Paradoxo do mentiroso: Um problema para a teoria da verdade como correspondência?.
- Guilherme Rabello (MAT-IME-USP)
Conference papers: [FR06].
- Rafael Rodrigues Testa (IFCH-UNICAMP)
Talks, mini-courses and seminars:
 - Talk in the “XII Encontro Nacional de Filosofia da ANPOF”, Salvador, BA, October 23-27, 2006:
Uma análise de algumas lógicas deônticas para a representação de normas jurídicas.

External Participants

- Carlos Caleiro (IST, Lisbon)
Book chapters: [CCCM07].
- Dov Gabbay (King's College, London)
Books: [CCGGS07].
Journal papers: [FG06].
- Cristina Sernadas (IST, Lisbon)
Books: [CCGGS07].

4 Future Work: Next Steps and Work in Progress

Task 1: Fundamentals of Combining Logics, coordinated by Marcelo Coniglio.

- Subtask 1.1: Combinations of Logics and their Applications.

With respect to this subtask, we expect, on the one hand, to develop a generalization of possible-translation semantics by using a wide notion of signature morphism. The research concerning the possibility of recovering a logic from its fragments will be continued. In particular, the phenomenon of spontaneous generation of ‘bridge-principles’ by means of metafibring will be investigated and connected to some philosophical discussion about the famous Hume’s ‘is-ought-thesis’ and with other aspects in philosophical logic .

- Subtask 1.2: Splitting and Algebraizing Logics.

The generalization of possible-translation semantics mentioned above is expected to be applied to the study of algebraizing logics.

- Subtask 1.3: Algebraic Semantics for Modal Logics.

We expect to continue our research on the quasi-truth theory. On the other hand, new concepts and applications of modulated quantifiers are expected to be developed.

- Subtask 1.4: Algebraic and Categorical Aspects of Logical Consequence.

This subtask is mainly devoted to the use of tools from category theory for representation and combination of logics. We plan to continue the different lines of research already initiated. Specifically, we intend to continue the development of a wide notion of signatures and logic systems based on the theory of multi-graphs.

- **Task 2: Computational Aspects of Combinations of Logics and Theorem Proving**, coordinated by Marcelo Finger.

- Subtask 2.1: Polynomial-Time Approximations of Classical Propositional Logic

We plan to expand the existing theorem provers, which are kept public at the moment (KEMS). Also, new implementations of theorem provers, exploring other strategies and techniques are planned here.

- Subtask 2.2: First-Order Approximate Inference

This sub-task was cancelled.

- Subtask 2.3: Resource Sensitive Inference

Future steps in this task continues to aim at studying application of logics and AI techniques to the design of automated agents in computer games.

- Subtask 2.4: Automatizing Paraconsistent Inference
The future developments in this line aims at expanding the KEMS theorem prover that already to deal with a larger class o paraconsistent logics.
- **Task 3: Quantum Logics and Algorithms**, coordinated by Walter Carnielli.
 - The celebrated Cook’s theorem of 1971 states that any NP-problem can be converted to the satisfiability problem in propositional classical logic in polynomial time. The proof shows, in a constructive way, how to translate a Turing machine into a set of propositional formulas in such a way that the machine outputs ‘1’ if, and only if, the collection of formulas is consistent. We conjecture that a result similar to Cook’s theorem can be proven to paraconsistent Turing machines. This would confirm our running conjecture that paraconsistent circuits could be shown to efficiently solve Deutsch-Jozsa problem. As a second, conceptually more involved investigation, it would be possible to define ‘non-standard’ complexity classes relative to unconventional models of computation founded over non-classical logics. The overall consequences of a move like this cannot be yet anticipated

References

- [A06] J.C. Agudelo. *Da Computação Paraconsistente à Computação Quântica (From Paraconsistent Computation to Quantum Computation*, in Portuguese). Master’s Thesis. IFCH-UNICAMP, 2006.
- [AC06] J.C. Agudelo and W.A. Carnielli. Quantum Computation via Paraconsistent Computation. Preprint available at:
<http://arxiv.org/abs/quant-ph/0607100>
<http://wslc.math.ist.utl.pt/ftp/pub/CarnielliWA/06-AC-qcvpc.pdf>
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