# CENTRIA Centro de Inteligência Artificial — UNL

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# 2010 Report of Activities

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## 1 Introduction

The Centre for Artificial Intelligence (CENTRIA) is a research centre from the Faculty of Science and Technology of the New University of Lisbon (FCT/UNL), hosted in its Department of Computer Science and also in the Department of Computer Science at the University of vora. In addition to its members, CENTRIA naturally includes, as associate members, a significant number of post-doctoral researchers and post-graduate students supervised by its members, as well as collaborators that have common research activity with its members.

The Centre has a Director, that represents the Centre externally, and an Executive Board composed of 3 members that, together with the Director, take the main executive decisions. The Scientific Council, composed of all the member of the Centre, not only elects the Director and the members of the Scientific Board but also vote and approve the admission and exclusion of members, and the general policies undertaken by the Centre, namely the yearly activity reports, future plans, and budgets. The Centre has its own Advisory Board, composed of leading international researchers (Robert Kowalski, David S. Warren, Fernando Pereira, Ivan Bratko, and Joerg Siekmann), which is regularly informed of the Centre's activities and plans, and produces comments and suggestions towards their improvement. The activities of the Centre are scientifically organised in two main subarreas:

- Knowledge Representation and Reasoning (KRR).
- Soft Computing and Constraints (SCC).

Both sub-areas include basic as well as applied research on the relevant topics within their scope. Nevertheless, these sub-areas are not exclusive, in the sense that members of the Centre are encouraged to collaborate in both sub-areas in order to exploit synergies and increase inter-disciplinary research. This division represents an evolution from our previous division, where an additional sub-area (Intelligent Information Systems) was devoted to applications, most of which utilizing results obtained in KRR and SCC. From a management perspective, CENTRIA adopts a more flexible structure, where it is encouraged that groups of members are organised, non- exclusively, to promote research in more specific topics (through seminars given by members and invited researchers, students presentations, reviewing and discussion of relevant publications) in order to strengthen mutual knowledge, and facilitate internal collaboration between the CentreÔs members and collaborators. The activities of these groups, and their contribution to the main scientific sub-areas, is coordinated by the Executive Board.

# 2 General Objectives

CENTRIA research objectives focus in two main sub-areas: Knowledge Representation and Reasoning (KRR) and Soft Computing and Constraints (SCC).

Representing knowledge in forms suitable for automatic processing and developing inference algorithms to manipulate the knowledge have long been central topics within Artificial Intelligence, and together are a cornerstone of intelligent applications.

Research in KRR at CENTRIA ranges from foundational aspects to applications, including the development of implementations of knowledge-based systems.

Our foundational research has a strong basis on Computational Logics approaches to the representation of knowledge and to reasoning methods, but also includes aspects of representation of imprecise knowledge with probabilities, as well as foundations of mathematical and philosophical logic.

Our applications of knowledge-based systems focus on the Semantic Web and Multi-Agent Systems, including formal models in cognitive science, and mostly adopt Logic Programming as implementation vehicle.

Specifically, CENTRIA's contributions to Knowledge Representation and Reasoning include foundational work of non-monotonic reasoning and evolution of knowledge bases, knowledge updates and belief revision, reasoning about actions and causality, answer-set programming, combination of ontology and rule based knowledge, Bayesian epistemology, imprecise probabilities, implementations for the web and semantic web, and of multi-agent systems.

Soft computing (SC) is inspired in the functioning of the human mind, being tolerant to imprecision, uncertainty, partial truth, and approximation and adopts a diversity of techniques to this effect, namely machine learning, neural networks, fuzzy systems evolutionary computation, Bayesian networks and swarm intelligence.

Constraint programming (CP) is closer to hard computing in that problems are modeled into sets of constraints and reasoning exploits hard relations among these constraints. However, complex problems often require an approach closer to soft computing relying in heuristics and the handling of soft and probabilistic constraints.

In CENTRIA we exploit the complementarity of these two different approaches and applying them to areas such as biology, medicine, the humanities, management sciences, and similar fields.

The main contributions of CENTRIA to the SC field are fuzzy techniques and machine learning and applications to oceanography; evolutionary models to understand the emergence of phenomena such as cooperation or ethic norms in complex agent societies; and foundations of probability theory and causality, as well as the subsequent behavior in Bayesian networks.

In CP our main contributions are novel domains and constraint propagation techniques, and their application to Bioinformatics problems; extending constraints on continuous domains to dynamic phenomena and probabilistic reasoning; and generic constraint solvers, with efficient software architectures and exploiting hardware parallelism.

A major concern in CENTRIA is exploiting the complementarity of SC and CP, namely in the adoption of a probabilistic constraint framework in oceanography; CP testing of probabilistic models of causality; and CP to assess hypotheses arising in machine learning approaches (e.g. ILP).

CENTRIA members publish their results regularly in the main journals and conferences in the area, and participate in the organization and program committees of those conferences. CENTRIA is also the editorial home of the Springer journal *Minds and Machines*.

## 3 Main Achievements

In addition to scientific research achievements that are described later, important results were obtained by CENTRIA and its members.

A new edition of the European Master in Computational Logic was approved by the European Commission in the Erasmus Mundus II programme. In addition to us, (repre-

senting UNL) the other partners are Technical University of Dresden (Germany), Technical University of Vienna (Austria), Free University of Bolzano (Italy) and NICTA (Australia). The same partners agreed to start a similar study programme at Ph:D. level, that will start in October 2011 with funding from the German DAAD agency. G. Wheeler was appointed Editor-in-Chief of *Minds and Machines*, starting January 2011. Four new projects involving CENTRIA were accepted for funding (by the FCT) in 2010, one of which within the CMU-Portugal programme.

The main scientific achievements, referring to the objectives of the Research Group, are now presented in the two sub-areas: KRR and SCC.

## 3.1 KRR Research – Semantic Web

- Development of specialised efficient methods for combining logic programming rules with EL++ ontologies [62], and implementation of a Query Answering system for Hybrid MKNF Knowledge Bases with ALC ontologies, within XSB-Prolog [58]. An article on Hybrid MKNF Knowledge Bases was accepted for publication in the journal "Artificial Intelligence".
- Development of the first ever update operator for Hybrid MKNF Knowledge Bases. An article describing the operator appeared in the journal "Theory and Practice of Logic Programming" [26].
- Development of the implementation of Modular Web leading to the release of the first prototype [54, 53]. An article describing Modular Web was accepted for publication in the journal "ACM Transactions on Computational Logic".
- Specification of the first declarative and executable semantics of the W3C Standard Rule Interchange Format Production Rule Dialect (RIF-PRD), for specification of active production rules [52].
- Development of an API for ontology mapping [56], and the conclusion of a PhD Thesis on query answering with ontologies [87].
- Development of an application for the classification and dispatch of communications in organization, which employs ontologies and rules, within the industrial QREN project XEO-ECC.

#### 3.2 KRR research – Logic Programming

- Demonstration of the impossibility of defining updates for Answer-Set Program that that simultaneously follow the KM Postulates for updates and exhibit basic desirable properties of Logic Programming such as "support" [81];
- Development of Parametrized Logic Programs which extend Answer-Set Programming with the possibility to use of complex formulas of some given logic (called the parameter logic) in both the premises and conclusions of rules [59]:
- Application of Abductive Logic Programming in the verification of properties of declarative business process specifications [20]. - Approval of an FCT project, in collaboration with INESC-Id on the use of Boolean Satisfiability to efficiently compute Answer Sets.

• Other achievements in the context of Logic Programming include the theoretical results reported in [32, 74, 73] and the applications reported in [65, 49, 43, 31].

## 3.3 KRR research – Dynamic Systems

- An article on the formalization of non-Markovian Control in the Situation Calculus was accepted for publication in the journal "Artificial Intelligence".
- Development of an approach to specifying Advanced Database Transaction Models in a formal logic, which appeared in the "Journal of Intelligent Information Systems".
- A new collaboration with Carnegie Mellon University on the verification of probabilistic hybrid dynamic systems was initiated, including the joint supervision of a PhD Student within the CMU-Portugal Joint PhD Program.

# 3.4 KRR research – Interdisciplinary

- Development of a new extended predicative approach to (recursive) Mahloness [7], and the investigation of applicative theories to capture classes of computational complexity [61], developed within the interdisciplinary EUROCORES/LogICCC DiFoS project which combines mathematical, philosophical, and linguistic aspects with computer science.
- Development of mechanisms for Decision Making and Intention Recognition via a combination of Bayesian Networks and Probabilistic Logic Programming [22, 11, 39, 37, 38].

#### 3.5 SCC research – Soft Computing

- Neural network algorithms and pattern recognition schemes have been implemented for retrieving optically active sea-water compounds from remote sensing data in different European Coastal basins [15, 8].
- a methodology for the analysis of research activities was developed within FCT project COPSRO (led by Susana Nascimento), in collaboration with Boris Mirkin from Birkbeck Colledge [19, 71, 70], using a novel Fuzzy ADDitive Spectral clustering method.
- Study of models of causation with a view to learning model parameters were carried out [16, 82], and an approach for learning novel cyber from observational network traffic data was developed [46];
- Research on modeling of social and biological phenomena and complex adaptive systems was carried out in many topics, namely focussed in the more specific topics of decision making and collective action in complex networks [25] and epidemiology [24].

## 3.6 SCC research – Constraint Programming

• In the area of continuous constraints, we continue the development of a new constraint technology that combines safe and probabilistic reasoning over mathematical

models involving nonlinear constraints. Two papers were published on its application to reliability problems [44] and addressing decision problems, namely inverse and reliability problems, in the presence of uncertainty and non-linearity [45].

- CENTRIA work on the application of Constraints to Bioinformatics was recognised by an invited chapter on the 10th anniversary of the CP-AI-OR conferences [5]. In addition to a lesser collaboration with CREM [43], project (CREMA) was submitted to FCT/MCTES and approved in 2010. The work proposed follows previous leading to 2 M.Sc. thesis supervised by the project PI, Ludwig Krippahl, and will attract students from a course on Bioinformatics that he is currently lecturing in the Chemistry Department.
- A PhD was completed involving the implementation of a constraint solver with innovative techniques generic incremental propagation and propagation of arbitrary decomposable constraints, that allowed some successful studies on look-ahead heuristics [86].
- A new project (ATTEST) in collaboration with Carnegie Mellon University and IST was approved by the FCT that will apply CP (among other techniques) for program certification.
- Work was continued on an Extended Andorra Model (EAM) back-end for GNU Prolog was built [35] and started implementation of probabilistic Logic Programming languages, in the context of a joint FCT funded project (HORUS). An hybrid concurrent and distributed constraint programming system is also reaching maturity [72]. Collaboration with Philippe Codognet (JFLI/U.Tokyo) and Daniel Diaz has continued on parallel implementations of constraint-based local search algorithms [55] and the development of the GNU Prolog programming system.

# 4 Productivity

At the end of 2009 we introduced a new policy which placed a greater emphasis on the quality of our research output, and we sought to bring about this objective by putting into place several changes which, taken together, were designed to better reward publishing in top venues. Details of this change are set out in the 2009 CENTRIA report.

With these changes in place, we anticipated that 2010 would be a transition year and that the indicators would be below 2009. However, on the whole 2010 was similar to 2009 (see table 1). The important statistic to focus on in the tables below are the A\* and A categories. Our production in this category has consistently accounted for 20-21% of our research output during the last three years, which is roughly double the 11% logged in 2007, which was indicative of the center's performance prior to 2008.

However, if you look at  $A^*$  versus A, there are signs of an important improvement in 2010 over 2009 as there were 6  $A^*$  publications in 2010 versus 3 in 2009. This is precisely the category we wish to improve. We should stress that these are small numbers and there is but this one year of complete data marking this improvement. Even so, preliminary results from 2011, which includes papers that are accepted at top journals and in a long queue to appear in print, strongly suggests that there will be sustained improvement in the proportion of  $A^*$  publications. More still, this early data suggests that the 20% proportion

Table 1: Publication Indicators

Year	Category	Count	$\mathbf{A}^*$	$\mathbf{A}$	В	$\mathbf{C}$	Total
	Monographs		-				0
	Edited Books		-			3	3
	Book Chapters		-	2	4	3	9
	Journals	major   minor	$\begin{array}{c} 2\mid 0 \\ 2 \end{array}$	$\begin{array}{c c} 3 & 1 \\ 4 & \end{array}$	$\begin{array}{c c} 2 & 0 \\ 2 & \end{array}$	6   0 6	13   1 14
	Conferences	$egin{array}{c}  ext{full} \mid  ext{short} \  ext{total} \end{array}$	$1 \mid 3$ $4$	$1 \mid 5$	9   0 9	$\begin{array}{c} 39 \mid 0 \\ 39 \end{array}$	50   8 58
2010			6	12	15	51	84
	Monographs		-				0
	Edited Books		-		1	2	3
	Book Chapters		-	1	2	2	5
	Journals	major   minor	$1 \mid 0$ $1$	5   2 7	$\begin{array}{c} 2 \mid 0 \\ 2 \end{array}$	$\begin{array}{c} 12 \mid 0 \\ 12 \end{array}$	20   2 22
	Conferences	full   short total	$\begin{array}{c c} 2 & 0 \\ 2 & \end{array}$	7   0 7	12   0 12	$\begin{array}{c} 35 \mid 0 \\ 35 \end{array}$	56   0 56
2009			3	15	17	51	86
	Monographs		-				0
	Edited Books		-	1	2	2	5
	Book Chapters		-		2	2	4
	Journals	major   minor		$\begin{array}{c} 4 \mid 0 \\ 4 \end{array}$	$\begin{array}{c c} 2 & 0 \\ 2 & \end{array}$	9   0 9	$15 \mid 0$ $15$
	Conferences	full   short total	4   1 5	3   2 5	6   0 6	30   0 30	43   3 46
2008			5	10	12	43	70
	Monographs		-			1	1
	Edited Books		-		3	2	5
	Book Chapters		-		1	1	2
	Journals	major   minor		$2 \mid 2$ $4$	$\begin{array}{c c} 3 & 1 \\ 4 & \end{array}$	8   0	13   3 16
	Conferences	$rac{ m full \mid short}{ m total}$	-	5   1 6	18   0 18	38   0 38	61   1 62

of 'high profile' publications (A\* and A) may settle closer to 1 in 4 for the next couple of years, and that growth in A\* publications will drive this increase.

# 5 Activity

#### 5.1 KRR Activities

Important foundational results in updating of non-monotonic knowledge bases were obtained during 2010, giving rise to publications in a top conference in the area (ECAI) and journal (TPLP). Namely, it was shown the impossibility of defining updates for Answer-Set Program that that simultaneously follow the KM Postulates for updates and exhibit basic desirable properties of Logic Programming such as "support" [81]; and an operator to deal with updates of hybrid theories composed of ontologies and rules [26].

Other foundational results on the combination of rules and ontologies were obtained during 2010, with the development of specialised efficient methods for combining logic programming rules with EL++ ontologies [62]. Moreover, a paper on Hybrid MKNF Knowledge Bases was accepted in 2010 for publication in Artificial Intelligence.

The work in 2010 on combining rules and ontologies was not only at the foundational level, and implementations have been also developed. Namely, an implementation (CDF-Rules) was developed that enables, within XSB-Prolog, for the usage of Hybrid MKNF with ALC ontologies. The description of the implementation can be found at [58].

The implementational work in the area of Semantic Web was not confined to Hybrid MKNF. In fact, during 2010 the development of the Modular Web implementation continued, and a first stable prototype has been concluded and made available. Some aspects of the implementation have been detailed in [54] and [53].

Moreover, we developed an API for the ontology mapping task, needed to map and merge ontologies in a distributed environment, such as the Semantic Web [56]. The work on ontologies, was also applied in the context of a QREN project with industry, XEO-ECC, which uses ontologies and rules for the classification and dispatch of communications in organisations. The development of question-answering system for ontologies was continued and José Saias concluded his PhD in May 2010 [87].

Finally in the context of the Semantic Web, we have produced the first declarative and executable version of the recently standardised Rule Interchange Format Production Rule Dialect (RIF-PRD), for specification of active production rules, via a program transformation into Answer Set Programming presented at the International Semantic Web Conference [52], whose implementation has been started in late 2010.

Also regarding active rules and reasoning about actions, the work developed by CEN-TRIA members on logical formalizations of non-Markovian Control in dynamical systems was accepted for publication and appeared online in the journal Artificial Intelligence, in 2010. Related to this work we developed, in collaboration with the University of Ottawa, an approach to specifying Advanced Database Transaction Models in a formal logic [18].

More foundational work was done related to Answer-Set Programming, namely on the definition of a class of expressive logic programs, dubbed parametrized logic programs, that allow the use of complex formulas of a given logic (called the parameter logic) on the body and head of a rule [59]. Regarding our work in Answer-Set Programming, it is worth noting that an FCT project, in collaboration with INESC-Id, has been approved in 2010, to start in 2011.

Also in regarding foundations of logic programming, in-depth investigation of logic

program based semantics, namely with a view to assigning 2-valued semantics to every program plus abduction, paraconsistency and belief revision, was done in 2010 leading to the following publication: [12, 74, 73, 65].

There was further work during 2010 on abductive logic programming, and its application to multi-agent system. Namely, it was established how to add integrity constraints in an abductive proof procedure during the computation, to support applications where domain knowledge is acquired dynamically [32], and abductive logic programming was applied for the verification of properties of declarative business process specifications [20]. Further work was developed in Program verification and its application in societies of agents and in event detection, as described in [49, 31, 48].

In the area of mathematical proof theory we have worked on a new "extended predicative" approach to (recursive) Mahloness [7] and, in computational complexity, applicative theories were studied to capture classes of computational complexity [61]. This work was made in the context of the truly interdisciplinary DiFoS/LogICCC project, which combines mathematical, philosophical, and linguistic aspects with computer science.

Interdisciplinary work has also started, crossing this area as well as that of Soft Computing, in the study of Decision Making and Intention Recognition through AI cognitive models of Intention Recognition, via Bayesian Networks and Probabilistic Logic Programming, providing results surpassing other techniques, and namely with application to Elder Care and Ambient Intelligence. This led to the 2010 publications: [38, 37, 39, 22, 11].

## 5.2 Soft Computing and Constraints

The activity of CENTRIA in Soft Computing and Constraints is presented in two separate parts, the latter further subdivided into systems and applications.

# 5.2.1 Constraints – Architectures and Systems

The design and implementation of the generic constraint solver CASPER (Constraint Solving Platform for Engineering and Research) has led to the the PhD Thesis of Marco Correia [86], supervised by Pedro Barahona, addressing two major problems: generic incremental propagation and propagation of arbitrary decomposable constraints, for which a set of novel and correct techniques are presented, envisaging extensibility and efficiency. The solver compares well with existing standards (e.g. GECODE) and is being used in a number of applications and experiments, namely regarding constraints over graphs and the effectiveness of restarts in CSP solving, carried out by Luis Baptista, a PhD student supervised by Francisco Azevedo, who successfully defended his PhD thesis plan.

Work on an Extended Andorra Model (EAM) back-end for GNU Prolog was pursued in the scope of projects STAMPA and JEDI, in which Salvador Abreu participated [35], [88]. He started work implementations of probabilistic Logic Programming languages, within the HORUS project, but initial results are expected in 2011. His collaboration with Philippe Codognet (JFLI/U.Tokyo) and Daniel Diaz has continued along parallel implementations of constraint-based local search algorithms [55] and the development of the GNU Prolog programming system. The hybrid concurrent and distributed constraint programming system, developed within Vasco Pedro's PhD. is reaching maturity [72] and is being used in Pedro Salgueiro's and Rui Machado's PhD. thesis work. The former, regarding Network Intrusion Detection has made good progress [76], and the latter, concerning computational models for massively parallel architectures is being done in collaboration with Fraunhofer ITWM, is expected to lead to publications in 2011.

In continuous constraints, we continued development of a new constraint framework that combines safe and probabilistic reasoning over nonlinear constraint models (appearing in several science and engineering problems) complementing traditional interval bounded representation of uncertainty with probabilistic distributions in order to characterize the most likely consistent scenarios. These problem arise in a number of applications and we applied them to reliability-based optimization problems [44], as well as to inverse and reliability problems citeCCBb. This work has been the focus of Elsa Carvalho, jointly supervised by Jorge Cruz and Pedro Barahona, who was recommended to write her thesis. Complementarily, joint work on interval methods has been done in close collaboration with members of the group OPTI from the Laboratoire d'Informatique de Nantes Atlantique (LINA a French research centre with world leading research groups in optimization and constraint programming for continuous domains. In June, LINA organized the 3rd Small Workshop on Interval Methods (SWIM 2010), where Jorge Cruz give a talk presenting his work on constraint composition for continuous domains [50] and a joint paper on interval quadrature methods will be submitted in early 2011.

#### 5.2.2 Constraints—Applications

Bioinformatics: Within bilateral project CHRBio, Pedro Barahona and Ludwig Krippahl, together with the linguistic partners led by Veronica Dahl, explored potential similarities between the evolution of organisms and languages, namely the possibility of constraining weights on known features of languages and organisms within acceptable intervals to obtain appropriate phylogenetic trees (a publication was accepted for 2011). Two EMCL students applied constraint techniques in bioinformatics applications, namely for simulating coevolution in multiple organisms [94] and to identify yeasts with an optimal use of restriction proteins [43, 90], the former in the context of a project (CREMA) that was accepted in 2010 by the FCT/MCTES. A major survey on the challenges posed by Bioinformatics on constraint programming was eventually published [5].

Electric Power Grid: Based on overhead line inspections via LIDAR, a complete geo-(and time-) referenced database has been built to model the Portuguese Very High Voltage grid, with its assets, electric characteristics, and inspections [14], within the collaboration of Francisco Azevedo with Albatroz Engineering. Among other possibilities, a vegetation growth model can be developed and risk assessed from that and from other environmental variables. So far, the work has shown the usefulness of Constrained Optimisation tools, e.g. regarding maintenance policies [40], although such applications have not been developed yet.

Oceanography: The application of the probabilistic continuous constraints approach to ocean color remote sensing (aiming at obtaining uncertainty budgets associated to semi-analytical ocean color models relating optically active in-water compounds with sea-surface reflectance data) was identified, in interaction with Davide d'Alimonte. The framework is able to associate error bars to products derived in different sea-water types, which is a nowadays topic problem in ocean color remote sensing. Preliminary work on this subject was already presented to researchers from the Institute for Environment and Sustainability (IES), of the Joint Research Centre (JRC), one of the largest interdisciplinary environmental research institutes in Europe, that showed interest in future collaboration.

#### 5.2.3 Soft Computing

Work on Soft Computing has mostly been driven by the following application areas:

Oceanography: Within project Meris, neural network algorithms and pattern recognition schemes have been implemented for retrieving optically active sea-water compounds from remote sensing data in different European Coastal basins. Frequent and fruitful information on optical radiometry have been exchanged with Giuseppe Zibordi of the Joint Research Center of EU. Midway results have been presented during the "MERIS validation team" MVT meeting (March), and work progress discussed during two meetings at the JRC at CENTRIA and at the Oceanographic institute (October), and accepted by the funding agency.

Monte Carlo Numerical models have been developed to assess uncertainty budgets associated to field measurements for the validation of ocean color satellite. Results were published in Applied Optics [15], reported to instrument manufacturers (e.g., Satlantic Inc., Halifax, Nova Scotia, Canada) and discussed in international meeting addressing the refinement of in-situ measurement protocols. Additional studies leaded by Tamito Kajiyama of CITI have been conducted to develop neural network algorithms for forecasting the execution time of parallel Monte Carlo simulations on computer cluster [8].

In the framework of the LSTOP project, the computational tool FuzzyUPWELL for the automatic recognition of upwelling regions from Sea Surface Temperature (SST) images, was developed by Susana Nascimento, and successfully evaluated by four oceanographers, independently. The tool is already being used by the colleagues of IO-UL.

Reasoning about Social Networks: A number of topics were addressed in this area by Francisco Santos and colleagues, namely in the following topics: a) Decision making and collective action in complex networks [25]; b) Signaling dynamics and biosemiotics [24]; c) Co-evolution of cognitive skills and pro-social behavior [23]; d) Principles of self-organization in urban growth and e) Epidemiology [10].

Moreover, "Co-evolution and Self-organization of Cooperation", FCT project PTDC-FIS-101248-2008) has started in 2010 and will run through 2013.

This research is intrinsically interdisciplinary, traversing areas as diverse as Artificial Intelligence, Computational and Theoretical Biology, Applied Mathematics, Anthropology, Geography, Philosophy, Political Science or Psychology. Hence, this research benefits from well-established interdisciplinary collaborations with several national and international research centers from areas ranging from Mathematics (ATPgroup, CMAF, Universidade de Lisboa, Portugal), Geography (Departamento de Geografia, FCSH, UNL, Portugal), Anthropology (CRIA, FCSH, UNL, Portugal), Computer Science (MLG, Université Libre de Bruxelles and AI Lab, Vrije Universiteit Brussel, Belgium) and v) Philosophy (Univ. California, Irvine, USA).

Fuzzy Classification: Work proceeded in COPSRO project, with several interchange research visits taking place between Susana NAscimento at CENTRIA and Boris Mirkin from Birkbeck College, London. The Fuzzy ADDitive Spectral clustering method (FADDIS) was developed for relational and affinity data, that involves a number of model-based stopping conditions, and allows to fine tuning the "right" number of clusters, in contrast to other relational clustering methods [?]. The found clusters are not necessarily consistent with the taxonomy, but adopting them as "query sets" and applying a recursive "Parsimonious Cluster Lifting" algorithm on them, we obtained a parsimonious representation of the research activities, positioning them in the taxonomy [9, 71, 70]. This technique was successfully applied to the analysis of research activities conducted in a University department, and their mapping to the ACM Classification of Computer Subjects. The effectiveness of the FADDIS algorithm in recovering good cluster structures in the presence of noise has been extensively tested in several simulations, during Rui Felizardo MSc thesis

(examined in 2011), showing FADDIS to be effective in recovering good cluster structures with level of noise tolerance of up to 10%.

Neuro-symbolic integration: Joint work of Nuno Marques with FCSH has continued regarding the introduction of neuro-symbolic rules in linguistic studies [67]. A proposal to fund this work has been submitted by FCT/MCTES and a private company. Another line of application of Neuro-symbolic studies concerns data mining to financial market analysis [68, 66], funded by GoBusiness Finance, a private financial consulting company. This last application has been studied by Bruno Silva, in his PhD studies supervised by Nuno Marques [69, 79].

Choh Man Teng works in machine learning and uncertain reasoning. With Gregory Wheeler at CENTRIA she developed belief change operators in the evidential probability framework [82]. With colleagues at the Institute for Human and Machine Cognition she developed an approach for learning novel cyber attack vectors from observational network traffic data [46]. She spent the summer at Carnegie Mellon University to further collaboration with researchers on causal inference. She was also invited to speak at a roundtable at the Opening Celebration Conference of CMU's Center for Formal Epistemology. She joined the editorial board of Minds and Machines in 2010.

# 6 Integrative/multidisciplinary activities

The following activities were undertaken by CENTRIA members to promote multidisciplinary research, regarding the following scientific domains:

# 6.1 Oceanography

- The definition of a large scale strategy for applying pattern recognition solutions to support ocean color remote sensing in Portugal was led by Davide d'Alimonte, envolving the organization of a network of Marine Environment Observatories of Portugal (MEOPORT), in close collaboration with the European Space Agency (ESA) and contributions from the Oceanographic Center (OC, FC/UL), CENTRIA and CITI from FCT/UNL, and Centro of Marine and Environmental Investigation (CIMA/UA).
- A computational tool FuzzyUPWELL was developed in the LSTOP project(led by Susana Nascimento) that offers to the oceanographers a systematic method for constructing working definitions of upwelling, and is already being used by colleagues of OC.

#### 6.2 Bioinformatics

- Project CREMA, led by Ludwig Krippahl, was successfully submitted to the FCT/MCTES to start in 2011. It will capitalize in previous work of this researcher in the study of co-evolution through alignment of multiple protein or DNA fragments.
- Collaboration with Joao Almeida (CREM/FCT/UNL) led to the development of a tool, implementing the ARDRA method with constraint programming, and identifies the best set of enzymes to identify some yeast.

- A joint project (Barahona, Krippahl) with Veronica Dahl, visitor of Un. Tarragona led to the application of Constraint Logic Programming to classification trees, appearing both in bioinformatics and linguistics. Engineering
- Continuous constraints have been applied to reverse engineering and reliability problems. Preliminary results were on calibration of oceanography sensors are quite promising and a project has been submitted to further develop the method in process engineering design and robotics localization, in collaboration with the REQUIMTE associate laboratory and a private company, HOLOS.

# 6.3 Mathematics and Linguistics

- Project DiFoS/LogICCC project, coordinated by Reinhard Kahle, is carrying on interdisciplinary work that combines mathematical, philosophical, and linguistic aspects with computer science. In collaboration with Sara Uckelman (Amsterdam), Jesse Alama investigated some (surprising) aspects of dialogical logic that provide a better understanding of (the problems of) this specific logical account. Kahle, in collaboration with Isabel Oitavem, provided new accounts for theories of computational complexity. Various
- Francisco Santos research, supported by project Co-evoluo, is intrinsically interdisciplinary and benefits from well-established interdisciplinary collaborations with several national and international research centers from areas ranging from i) Mathematics (ATPgroup, CMAF, UL, Portugal), ii) Geography (FCSH/UNL, Portugal), iii) Anthropology (CRIA, FCSH, UNL), iv) Computer Science (MLG, Université Libre de Bruxelles & AI Lab, Belgium) and v) Philosophy (Univ. California, Irvine, USA) among others.

# 7 Organization of conferences

The following CENTRIA members chaired (or co-chaired):

- José Júlio Alferes General Chair of The Fourth International Conference on Web Reasoning and Rule Systems, Bressanone/Brixen, Italy, September 2010.
- João Leite was Workshop Co-Chair of Third International Workshop on Languages Methodologies And Development Tools for Multi-Agent System (LADS'010). Lyon, France, August 2010.
- João Leite was Workshop Co-Chair of Eleventh International Workshop on Computational Logic in Multi-Agent Systems (CLIMA XI). Lisbon, Portugal, August 2010.
- Alfredo Gabaldon was Co-Chair of the International Workshop on Non-Monotonic Reasoning. Actions and Belief Change Track. Toronto, Canada, May 2010.
- Members of CENTRIA participated in Programme Committees of the following International conferences and workshops: AAAI'10, ECAI'10, JELIA-2010, ESWC-2010, NMR-10, SBIA'2010, IBERAMIA 2010, ALIFE 2010, AI2010, AOSE'10, AT2AI-7,

CLIMA XI, DALT'10, EUMAS'10, FALA 2010, ISIPTA 2010, JURIX'2010, KES-IDT-10, LADS'010, LAM'10, LAMAS'10, LANMR'10, LOAIT'2010, PROMAS'10, PROPOR'2010, RW'2010, SPLeT 2010, SWAT4LS 2010, UNILOG 2010, WCB10.

# 8 Industry contract research

The 2-year QREN supported project, XEO-ECC, of the company iTds, Internet, Tecnologias e Desenvolvimento de Software, continued in 2010. The main goal has been to provide an effective solution for a company to centralize and manage all the communications that enter or leave the organization. Our main contribution includes intelligent classification of communications and search and navigation in the communications repository. To support these processes, we rely on the use of ontologies and a set of tools and methodologies were proposed to extend a basic set of ontologies to specific organization domain. Interesting results have already been produced, namely leading to 3 M.Sc. theses supervised by João Moura Pires and José Julio Alferes.

CENTRIA collaboration with Albatroz Engineering, in the scope of the cooperation protocol started the previous year a complete geo- and time- referenced database has been built to model the Portuguese Very High Voltage grid. Among other possibilities, a vegetation growth model can be developed and risk assessed from that and from other environmental variables and Optimisation tools are then possible, e.g. regarding maintenance policies.

We started research work for applying data mining and neural networks to financial market analysis, under a cooperation protocol between FCT/UNL and GoBusiness, a private financial consulting company. Upon finishing his PhD, Marco Correia has restarted the use of Constraint Programming to model and control a robotic arm used in VISTEON (an electronics, car-supplying, company) to assemble electronic components in a printed circuit board. A formal commitment is expected in 2011. 8. Internationalization

CENTRIA participates, and coordinates at UNL the Erasmus Mundus sponsored European Master on Computational Logic (EMCL). The MSc programme, running from 2006, has been approved by Erasmus Mundus 2 in 2010 for funding for the following three years. The consortium for the new edition of EMCL includes, besides us, the Technical University of Dresden, Germany; Technical University of Vienna Austria, Free University of Bolzano, Italy; and National ICT Australia.

During 2010, members of CENTRIA participated in the Editorial Boards of several international journals, notably ACM Computing Surveys, Journal of Applied Logic, Journal of Universal Computer Science and Theory and Practice of Logic Programming. G. Wheeler was appointed Editor-in-chief of Minds and Machines, starting January 2011. Worth mentioning is the participation in the Program Committees of many international events (incl. AAAI, ECAI, ESWC and JELIA), the organisation of several international events (incl. RR, CLIMA, LADS and NMR) and the ongoing collaborations with many international partners.

CENTRIA members have co-authored, in 2010, scientific papers with researchers from the following foreign universities:

- Vrije University Brussels, Belgium
- Pontifcia Universidade Catlica do Rio Grande do Sul, Brasil
- University of Ottawa, Canada

- Lingnan University, China
- Technical University of Denmark, Denmark
- European Commission Joint Research Centre.
- University of Paris 1, Pantheon Sorbonne, France
- University Pierre et Marie Curie (Paris 6), France
- INRIA Rhone-Alpes, France
- University of Creete, Greece
- Foundation for Research and Technology Hellas, Greece
- Università degli Studi di L'Aquila, Italy
- University of Ferrara, Italy
- Università di Bologna, Italy
- Universidade de Tarragona, Spain.
- Linköping University, Sweden
- Birkbeck College, University of London, UK.
- Imperial College, UK
- Swansea University, UK
- Wright State University, USA
- Carnegie Mellon University, USA
- Kansas State University, USA
- Washington University in St Louis, USA

# 9 List of Ph.D. students and topics in 2010

Name	Iara Almeida
Supervisor	José Alferes
Topic	Distributed Knowledge Bases: A Proposal for Argumentation-
	based Semantics with Cooperation
Start date	October 2005
Name	Han The Anh
Supervisor	Luís Moniz Pereira
Topic	Evolution of Cognitive Agent Systems
Start date	October 2009

Name	Elsa Carvalho
Supervisor	Pedro Barahona and Jorge Cruz
Topic	Integration of Guaranteed and Preferred intervals in Constraint
	Programming over Continuous Domains
Start date	October 2006
Name	Marco Vargas Correia
Supervisor	Pedro Barahona
Topic	Modern Techniques for Constraint Solving: The CaSPER Experi-
	ence
Start date	October 2004
Finished	December 2010
Name	Nuno Miguel Soares Datia
Supervisor	João Moura Pires
Topic	Toward an intelligent personal digital photo's retrieval by au-
	tomating annotations using semantics and propagation
Start date	September 2009
Name	Sofia Gomes
Supervisor	José Alferes
Topic	Reactivity in the Semantic Web
Start date	September 2009
Name	Matthias Knorr
Supervisor	José Alferes
Topic	Combining open and closed world knowledge representation for
	reasoning on the semantic web
Start date	March 2007
Name	Rui Machado
Supervisor	Salvador Abreu
Topic	Declarative Computational Models for Massively Parallel Systems
Start date	January 2009
Name	João Martins
Supervisor	João Leite
Topic	To be defined (in the joint programme with CMU)
Start date	October 2010
Name	Pedro Patinho
Supervisor	Salvador Abreu
Topic	Parallel and Distributed Execution Models for Declarative Pro-
	gramming Languages
Start date	October 2009
Name	Vasco Pedro
Supervisor	Salvador Abreu
Topic	Constraint Programming toolkit for Hierarchical Multiprocessors
Start date	January 2009

Name	Alexandre Miguel Pinto
Supervisor	Luís Moniz Pereira
Topic	Every normal logic program has a 2-valued semantics: theory,
	extensions, applications, implementations
Start date	September 2005
Name	José Saias
Supervisor	Paulo Quaresma
Topic	Semantics and Context for Result Selection in Query Systems (in
	Portuguese)
Start date	October 2004
Finished	May 2010
Name	Pedro Salgueiro
Supervisor	Salvador Abreu
Topic	Constraint-based DSL for Intrusion Detection
Start date	January 2008
Name	Martin Slota
Supervisor	João Leite
Topic	Updates of ontologies with Rules
Start date	September 2007

# 10 Projects

Name	International M.Sc. Program in Computational Logic			
Status	Ongoing (re-start September 2010, for 5 academic years)			
Funding Institution	EU Erasmus Mundus			
Funding for 2010	15000 euros			
Principal researcher	Pedro Barahona			
CENTRIA Partici-	José Alferes, João Leite			
pants				
Participant Institu-	TU Dresden, U. Bolzano, TU Wien			
tions				
Description	The major activity was the successful submission to the European			
	Union of a continuation of the joint distributed european MSc de-			
	gree in Computational Logic with 3 other European partners (TU Dres-			
	den, TU Vienna and FU Bolzano) and the NICTA (Australia) (cf			
	http://ssdi.di.fct.unl.pt/masters/mcl/.)			
Results	Several coordinating meetings. Yearly report.			
Name	CONTEMP - CONTraintes Exécutées en MultiProcesseurs			
Status	Ongoing (start January 2008, end December 2010)			
Funding Institution	GRICES-FCT/MCTES and EGIDE			
Funding for 2010	3000 euros			
Principal researcher	Salvador Abreu			
CENTRIA Partici-	Lígia Ferreia, Pedro Barahona, Ludwig Kripphal			
pants				
Participant Institu-	Univ. of Bordeaux-I			
tions				
Description	This project involves the RUNTIME team at Univ. of Bordeaux-I/INRIA and			
	will promote cooperation in parallel execution of constraints on hierarchical multiprocessors.			

Name	DiFoS - Dialogical Foundations of Semantics
Status	Ongoing (start March 1st 2009, end February 29 2012)
Funding Institution	Fundação Ciência e Tecnologia (MCTES) LogICCC/0001/2007
Funding for 2010	19980 euros
Principal researcher	Reinhard Kahle
CENTRIA Partici-	Francisco Azevedo, Gregory Wheeler, João Leite, Luís Moniz Pereira, Jesse
pants	Alama Alama
Description	Collaborative Research Project within the EUROCORES programme âLog-
Description	iCCCâ of the European Science Foundation (ESF) Principal Investigators of the
	DiFoS project: Peter Schroeder-Heister (Tübingen) Reinhard Kahle (Lisbon)
	Benedikt Löwe (Amsterdam)
Results	Our project aims to (1) describe the foundational value of Lorenzenâs dialogical
10050105	logic, and (2) embed it into a modern scientific context taking into account its
	historical roots.
Name	
Status	CHRBio - Constraint- and Hypothetical-based Reasoning for Bioinformatics Ongoing (start April 1st 2009, end March 1st 2011)
Funding Institution	Council of Rectors (CRUP)
Funding for 2010	1500 euros
Principal researcher	Pedro Barahona
CENTRIA Partici-	Ludwig Kripphal
pants	Eddwig Krippiiai
Description	The goal of this project is to enrich the quality of the research UNL and Univ
Description	Virgil & Rovira (Tarragona, Spain) through collaboration, exploiting common
	features between linguistics (URV) and bioinformatics (UNL), and their mod-
	eling with logic programming and constraints.
Name	PSE - The Philosophy of Science in a European perspective - ESF networking
TVame	Programme
Status	Ongoing (start 2008, end 2013)
Funding Institution	European Science Foundation
Funding for 2010	1000 euros
Principal researcher	Gregory Wheeler
Description	In the beginning of the last century an important European tradition of in-
	vestigations into the nature of scientific knowledge took definitive shape. This
	devel- opment comprised a wide range of different disciplines and a number of
	different European countries.It produced an extensive and stimulating litera-
	ture and prepared the ground for a wide array of reflections on the structure
	of science, its aims and limits.
Name	ATTEST: AlgoriThms and Tools for reasoning about dEpendable SysTems
Status	Ongoing (start October 2010, end December 2012)
Funding Institution	FCT/MCTES under the CMU Portugal initiative
Funding for 2010	5000 euros
Principal researcher	Pedro Barahona
Participants	Marco Correia
Description	The ATTEST project addresses the development of certified tools for software
_	verification, extending existing decision procedures for software verification to
	produce certificates to validate the correctness of the computed result, and
	developing software model checker that uses such certified decision procedures,
	formally proving the correctness of the outputs.

Name	MERIS
Status	Ongoing (start October 2009)
Funding Institution	European Space Agency
Funding for 2010	50000 euros
Principal researcher	Davide d'Alimonte
Participants	Tamito Kajuyama (CITI)
Description	Validation of MERIS Marine Products at Several European Coastal Basins.
Name	STAMPA - Sophisticated TAbling Mechanisms for Prolog and their Applica-
1 (dille	tions
Status	Ongoing (start January 2008, end December 2010)
Funding Institution	Fundação Ciência e Tecnologia (MCTES): EUR 150,000
Principal researcher	Salvador Abreu (CENTRIA participation)
Description	Develop novel techniques and models to improve the execution of tabling logic
1	programming in order to solve complex real-world problems, mainly, in four
	well-known and established Logic Programming paradigms: Inductive Logic
	Programming, Deductive Databases, Answer Set Programming and the Ex-
	tended Andorra Model.
Name	JEDI - A Joint Environment for Deduction and Induction
Status	Ongoing (start January 2008, end March 2011)
Funding Institution	Fundação Ciência e Tecnologia (MCTES): EUR 199,725
Principal researcher	Salvador Abreu (CENTRIA participation)
Description	The main objective of this project is to obtain a novel logic programming envi-
	ronment that combines deduction with induction, offering a novel and state-of-
	the-art solution for spatial data handling in all of its aspects, namely: spatial
	data modeling, spatial query languages and spatial data-mining. The project
	will also develop and implement real-world applications, such as the study of
	biodiversity and wildfires, supported by JEDI.
Name	HORUS
Status	Ongoing (start 2010, end 2012)
Funding Institution	Fundação Ciência e Tecnologia (MCTES): EUR 199,725
Principal researcher	Salvador Abreu (CENTRIA participation)
Description	The project aims to develop algorithms and techniques that can be useful to
	learn statistical relational representations from large databases. The output
	of this work will a set of freely available datasets: preferred domains are in
	Biology and in Social Networks; a methodology for ILP-based learning in these
	algorithms; a set of learning modules for SRL systems; and the systematic
	evaluation of all these techniques in the chosen datasets plus other well-known
NT.	datasets.
Name	MEDON - Using Ontologies to model data and medical procedures
Status	Ongoing (start January 1st 2009, end December 31 2011)
Funding Institution	Fundação Ciência e Tecnologia (MCTES) PTDC/EIA/80772/2006 (50000)
Principal researcher	Paulo Miguel Quaresma
Description	This project aims to create a medical ontology allowing the representation of
	a) medical procedures and algorithms; b) clinical data; c) time events. The
	ontology will be defined in OWL (ontology web language) and computational
	applications able to manage the ontology and its instances will be created: a)
	manually via a web application; b) automatically via a XML input format; c)
	automatically via documents written in natural language. Medical procedures
	represented in the ontology can be implemented via a general application able to model algorithms and to register medical data. The medical knowledge base
	can be queried via questions posed by users in natural language.

Name	PNL - Pedro Nunes Lectures
Status	Ongoing (start July 1st 2009, end July 31 2010)
Funding Institution	Fundação Gulbenkian (7500)
Principal researcher	Reinhard Kahle
Description	Pedro Nunes Lectures is an initiative of Centro Internacional de Matemática
Description	(CIM) in cooperation with Sociedade Portuguesa de Matemática (SPM), with
	the support of the Fundação Calouste Gulbenkian, to promote visits of notable
	mathematicians to Portugal. Each visitor is invited to give two or three lectures
	in Portuguese Universities on the recent developments in mathematics, their
	applications and cultural impact. Pedro Nunes Lectures are aimed to a vast
	audience, with wide mathematical interests, especially PhD students and youth
	researchers.
Name	LSTOP - Learning Spatio-Temporal Oceanographic Patterns
Status	Ongoing (start February 2008, end January 2011)
Funding Institution	Fundação Ciência e Tecnologia (MCTES) PTDC/EIA/68183/2006
_	Susana Nascimento
Principal researcher CENTRIA Partici-	Nuno C. Marques, Davide D'Alimonte
pants	Nullo C. Marques, Davide D Allillolite
Description	The main objective of this project is the development of Machine Learning
Description	methods for the automatic identification, analysis and prediction of oceano-
	graphic mesoscale phenomena in the Iberian Coastal Ocean (eddies, upwelling
	and coastal counter-current), including their spatio-temporal evolution, from
	remote sensing images. Dynamic versions of fuzzy clutstering will be investi-
	gated in the identification and tracking of these phenomena, and knowledge-
	aware neural networks will be studied for their classification and prediction
	incorporating domain knowledge.
Name	COPSRO - Computational Approach to Ontology Profiling of Scientific Re-
	search Organisations
Status	Ongoing (start January 2008, end December 2010)
Funding Institution	Fundação Ciência e Tecnologia (MCTES) PTDC/EIA/69988/2006 (146.837,00
	$\hat{\mathbf{a}}\neg)$
Principal researcher	Susana Nascimento
CENTRIA Partici-	Luís Moniz Pereira
pants	
Description	The main objective of this research work is to develop a methodology for ontol-
	ogy profiling scientific research organisations, including a) a reliable and valid
	research subject extraction method developing text mining techniques, b) An
	effective method for establishing within-organisation similarities between the
	ontology items, c) Adequate clustering methods for representing a research
	organisation by a set of possibly overlapping or fuzzy subject clusters, d) Opti-
	mally mapping the subject clusters to the subject area ontology e) Interpreta-
	tion and evaluation of individual organisation profiles, f) Combining individual
	organisation profiles into an aggregate profile, g) Characterization of aggregate
	profiles by rule extraction, and h) Experimental verification of the method.
	The proposed methodology will be applied to scientific research organisations
	of computer science, specifically, Computer Science (CS) departments of Uni-
	versities in Portugal and UK, having as ontology of reference the ACM Classi-
	fication System (http://www.acm.org/class/1998/ccs98.html).

Name	TOURSPLAN - TOURS PLANning Support system
Status	Ongoing (start December 1st 2007, end November 30 2010)
Funding Institution	GECAD (ISEP) PTDC/EIA/74310/2006 (95000)
Principal researcher	Nuno C. Marques
Description	Nowadays personalization is becoming one of the main requisites of tourism
	sector. A step toward this personalization is achieved through this project. It
	focuses on personalised tour planning, based on route planning algorithms and
	recommendation techniques integration.

## 11 Publications

#### 11.1 Edited Books

- [1] Mehdi Dastani, Amal El Fallah-Seghrouchni, João Alexandre Leite, and Paolo Torroni, editors. Languages, Methodologies, and Development Tools for Multi-Agent Systems, Second International Workshop, LADS 2009, Torino, Italy, September 7-9, 2009, Revised Selected Papers, volume 6039 of Lecture Notes in Computer Science. Springer, 2010.
- [2] Juergen Dix, João Alexandre Leite, Guido Governatori, and Wojtek Jamroga, editors. Computational Logic in Multi-Agent Systems, 11th International Workshop, CLIMA XI, Lisbon, Portugal, August 16-17, 2010. Proceedings, volume 6245 of Lecture Notes in Computer Science. Springer, 2010.
- [3] Luís Moniz Pereira, J. Maia Neves, J. M. Machado, and Manuel Filipe Santos. Special issue: Progress in artificial intelligence, select extended papers from 13th portuguese intl. conf. on artificial intelligence part ii. *International Journal of Reasoning-based Intelligent Systems (IJRIS)*, 2(1):92, January 2010. The authors are the editors.

#### 11.2 Book Chapters

- [4] Choh Man Teng and. Data, data, everywhere: Statistical issues in data mining. In *Philosophy of Statistics*, Handbook of the Philosophy of Science. Elsevier, 2010.
- [5] Pedro Barahona, Ludwig Krippahl, and Olivier Perriquet. Bioinformatics: A challenge to constraint programming. In Michela Milano and Pascal Van Hentenryck, editors, *Hybrid Optimization*, Springer Optimization and its Applications, pages 463–85. Springer, November 2010.
- [6] Teresa Gonçalves and Paulo Quaresma. Using linguistic information and machine learning techniques to identify entities from juridical documents. In E. Francesconi, E. Montemagni, W. Peters, and D. Tiscornia, editors, Semantic Processing of Legal Texts, Lecture Notes in Artificial Intelligence LNAI 6036, pages 44–59. Springer, 2010.
- [7] Reinhard Kahle and Anton Setzer. An extended predicative definition of the mahlo universe. In Ralf Schindler, editor, Ways of Proof Theory, Mathematical Logic, pages 315–340. Ontos Verlag, 2010.
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- [9] Boris Mirkin, Susana Nascimento, and Luís Moniz Pereira. Cluster-lift method for mapping research activities over a concept tree. In J. Koronacki, S. Weirzchon, Z. Ras, and J. Kacprzyk, editors, Advances in Machine Learning II Dedicated to the memory of Ryszard S. Michalski, volume 263 of Computational Intelligence Series, pages 245–257. Springer, January 2010.
- [10] Jorge M. Pacheco, Francisco C. Santos, Max O. Souza, and Brian Skyrms. Evolutionary dynamics of collective action. In Wolfgang Alt, editor, *Book Chapter in series on Mathematics and Biosciences in Interaction*. Birkhauser Basel (in press), 2010.
- [11] Luís Moniz Pereira and Han The Anh. Intention recognition with evolution prospection and causal bayesian networks. In Ana Madureira, Judite Ferreira, and Zita Vale, editors, Computational Intelligence for Engineering Systems 3: Emergent Applications, volume 46 of Intelligent Systems, Control and Automation: Science and Engineering Book Series, pages 1–33. Springer, December 2010. Select updated papers from Intl. Symp. on Computational Intelligence for Engineering Systems. http://www.amazon.ca/Computational-Intelligence-Engineering-Systems-Applications/dp/940070092X.
- [12] Luís Moniz Pereira and Alexandre Miguel Pinto. Inspecting side-effects of abduction in logic programs. In M. Balduccini and S. Tran, editors, Logic Programming, Knowledge Representation, and Nonmonotonic Reasoning: Essays in honour of Michael Gelfond, Festschrift. Springer, October 2010. Symposium on Constructive Mathematics in Computer Science.
- [13] Choh Man Teng. Data, data, everywhere: Statistical issues in data mining. In *Handbook of the Philosophy of Science*, volume 7 of *Philosophy of Statistics*. Elsevier, 2010.

# 11.3 In Journals

- [14] Francisco Azevedo and João Gomes-Mota. A time and space framework for overhead grid maintenance optimisation. *Modern Energy Review*, 2(1):95–99, 2010.
- [15] D. D'Alimonte, G. Zibordi, Tamito Kajiyama, and José C. Cunha. Monte carlo code for high spatial resolution ocean color simulations. Appl. Opt., 49(26):4936–4950, 2010.
- [16] Clark Glymour, David Danks, Bruce Glymour, Frederick Eberhardt, Joseph Ramsey, Richard Scheines, Peter Spirtes, Choh Man Teng, and Jiji Zhang. Actual causation: A stone soup essay. Synthese, 175(2):169–192, 2010.
- [17] R. Gonçalves and C. Caleiro. An algebraic perspective on valuation semantics (abstract). *Bulletin of Symbolic Logic*, 16(1):151, 2010.
- [18] Iluju Kiringa and Alfredo Gabaldon. Synthesizing advanced transaction models using the situation calculus. *Journal of Intelligent Information Systems*, 35:157–212, 2010.

- [19] Boris Mirkin, Susana Nascimento, Trevor Fenner, and Luís Moniz Pereira. Building fuzzy thematic clusters and mapping them to higher ranks in a taxonomy. *International Journal of Software and Informatics*, 4(3):257–275, September 2010.
- [20] Marco Montali, Paolo Torroni, Marco Alberti, Federico Chesani, Evelina Lamma, and Paola Mello. Abductive logic programming as an effective technology for the static verification of declarative business processes. Fundamenta Informaticae, 102(3-4):325–361, 2010.
- [21] Luís Moniz Pereira. Tolerância evolucionária. Revista Portuguesa de Psicanálise, 30(2):117–147, December 2010.
- [22] Luís Moniz Pereira and Carroline D. P. Kencana Ramli. Modelling decision making with probabilistic causation. *Intelligent Decision Technologies*, 4(2):133–148, February 2010.
- [23] Sven Van Segbroeck, Steven de Jong, Ann Nowé, Francisco C Santos, and Tom Lenaerts. Learning to coordinate in complex networks. *Adaptive Behavior*, 18(5):416–427, 2010.
- [24] Sven Van Segbroeck, Francisco C. Santos, and Jorge M. Pacheco. Adaptive contact networks change effective disease infectiousness and dynamics. *PLoS Computational Biology*, 6(8), 2010.
- [25] Sven Van Segbroeck, Francisco C. Santos, Jorge M. Pacheco, and T. Lenaerts. Co-evolution of cooperation, response to adverse social ties and network structure. *Games*, 13(3):317–337, 2010.
- [26] Martin Slota and João Alexandre Leite. Towards closed world reasoning in dynamic open worlds. Theory and Practice of Logic Programming, 10(4-6):547–563, 2010.
- [27] Ruben Duarte Viegas and Francisco Azevedo. Grasper: constraint reasoning with graphs. *International Journal of Reasoning-based Intelligent Systems (IJRIS)*, 2(1):73–92, 2010.

#### 11.4 In Conferences

- [28] Jesse Alama. Euler's polyhedron formula in mizar. In K. Fukada, editor, *Mathematical Software ICMS 2010*, volume 6327 of *Lecture Notes in Computer Science*, pages 144–147. Springer, 2010.
- [29] Jesse Alama. Exploring steinitz-rademacher polyhedra: A challenge for automated reasoning tools. In *Proceedings of the 8th International Workshop on the Implementation of Logics*, 2010.
- [30] Jesse Alama, Josef Urban, Piotr Rudnicki, and Herman Geuvers. A wiki for mizar: Motivation, considerations, and initial prototype. In Serge Autexier, editor, *Intelligent Computer Mathematics*, volume 6167 of *Lecture Note in Computer Science*, pages 455–469. Springer, 2010.
- [31] Marco Alberti, Pierangelo Dell'Aqua, and Luís Moniz Pereira. Observation strategies for event detection with incidence on runtime verificationl. In Marco Gavanelli and

- Toni Mancini, editors, RCRA-2010 Experimental evaluation of algorithms for solving problems with combinatorial explosion, volume 616. CEUR Workshop Proceedings, June 2010.
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- [39] Han The Anh and Luís Moniz Pereira. Proactive intention recognition for home ambient intelligence. In R. López-Cózar et al., editor, Ambient Intelligence and Smart Environments, volume 8 of 6th Intl. Conf. Intelligent Environments (IE10), pages 91–100. IOS Press, July 2010.
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- [42] Helena Barbas. Avatar c?est moi ? virtual geographies of the self. In Geographies of the Self. Sociedade de Geografia de Lisboa, April 2010.
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- on Constraint Based Methods for Bioinformatics, http://wcb10.dimi.uniud.it/, July 2010.
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- [45] Elsa Carvalho, Jorge Cruz, and Pedro Barahona. Reasoning with uncertainty in continuous domains. In *Integrated Uncertainty Management and Applications*, volume 68 of *Advances in Intelligent and Soft Computing*, pages 357–369. Springer, April 2010.
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- [87] José Saias. Contextualização e Activação Semântica na Selecção de Resultados em Sistemas de Pergunta-Resposta. PhD thesis, Universidade de Évora, May 2010. Paulo Quaresma (superv.);.

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- [89] Luís Borrego. Criação de uma ontologia e respectiva povoação a partir do processamento de relatórios médicos. Master's thesis, Universidade de Évora, December 2010. Paulo Quaresma (superv.);.
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