

CENTRIA

Constraints and Soft Computing



Constraints and Soft Computing

- Problem Solving
 - Constraints (Hard and Soft)
 - Optimisation Goals
 - Search (Complexity)
 - Numerical Information
- Major Areas
 - Constraint Programming
 - Machine Learning and Datamining
- Despite similarities, and due to historical reasons, research has largely developed separately



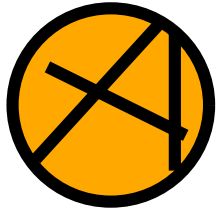
Soft Computing

- Situation in January 1999
 - 4 Ph.Ds – F. Moura Pires, R. Ribeiro, L. Correia, G. Guimarães
 - 7 Ph.D Students
 - 7 M.Sc. Students
- Variety of Interest Areas
 - Machine Learning
 - Fuzzy Decision Making
 - Autonomous Agents
- Aim at internationalization
- 3 projects under way



Fuzzy Decision Making and Autonomous Robots

- Navigation of mobile robots and Fuzzy behaviour control for autonomous vehicles
- Fuzzy optimization and Fuzzy multiple criteria decision
- Applications
 - Fuzzy theories in ergonomy;
 - Fuzzy multiple attribute decision making in military operations;
- Results:
 - 1 Ph.D. (João Moura Pires, 2000)
 - Collaboration with Henri Prade (Univ. Toulouse)
 - 4 M.Sc.s. (P. Quintas, M. Marques, C. Morgado and L. Almeida, 1999)
- Publications
 - 1 Edited Book, 1 Journal article, 2 Chapters in Books
 - 6 Papers in Conference and 5 in Workshop Proceedings (2+1 in 2000)
- Mostly “discontinued” in 1999 (Rita Ribeiro and Luís Correia left)



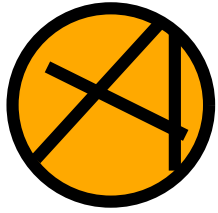
Machine Learning (1)

- Main Topics
 - Distributed genetic algorithms (discontinued in 1999 when FMP left)
 - Data mining in TV audiences (share prediction and preference enrollment)
 - Neural networks (SOMs) for temporal data mining
 - Applications
 - classification of aerial photographs and satellite images
 - interpretation of medical data (sleep apnea, protein structure)
- Results:
 - Collaboration
 - Wolfgang Urfer (Univ. of Dortmund, Germany)
 - Douglas Fisher (Vanderbilt University, TN, USA)
 - Publications
 - 3 Articles in Journal, 1 Book Chapter
 - 2 Papers in Conference and 5 in Workshop Proceedings
 - Organization of an International Conference (IDA'01)

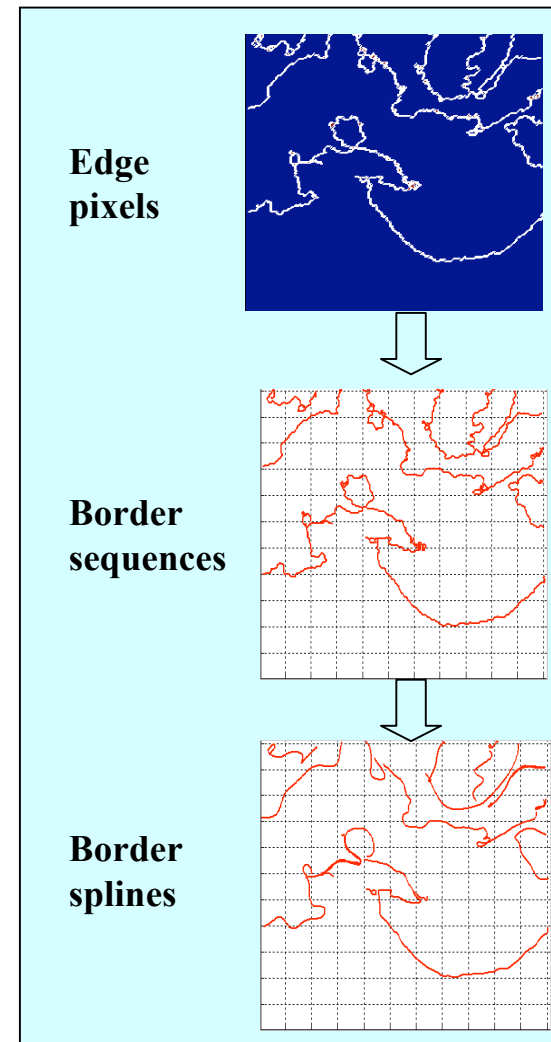
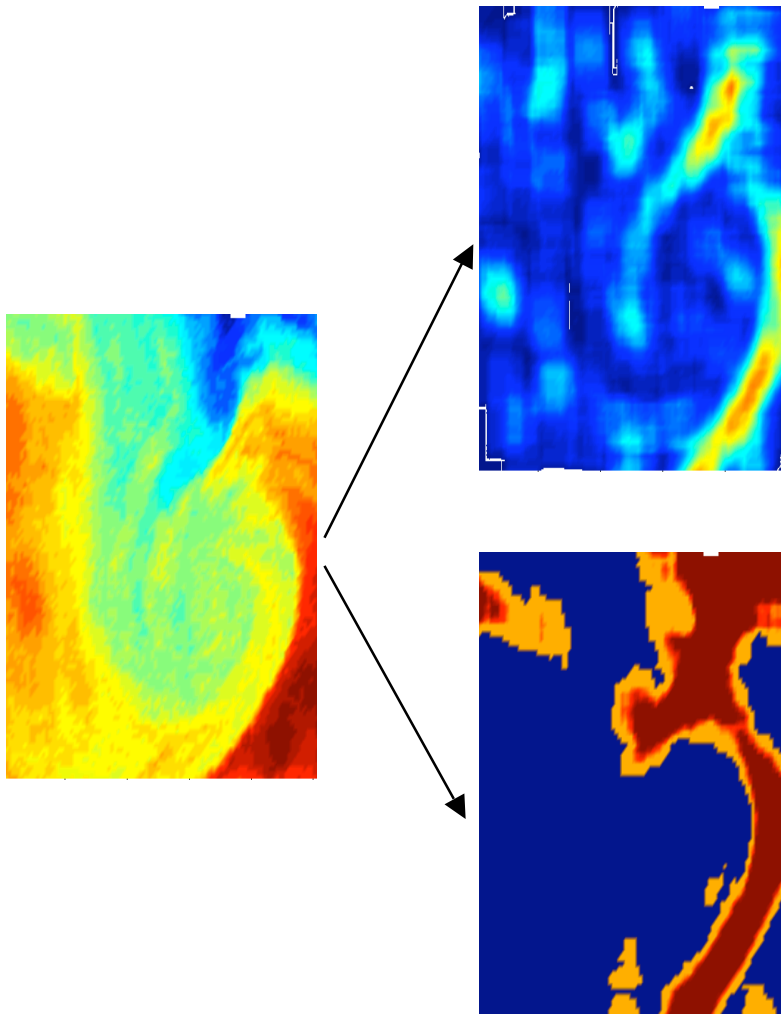


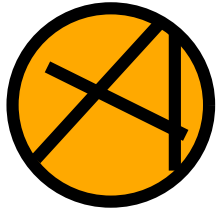
Machine Learning (2)

- Fuzzy Clustering for Data Mining and Knowledge Discovery.
- Evolutionary Programming on Neural Networks.
- Genetic and NN Optimization for Clustering and Classification.
- Real World Applications
 - Oceanographic Image Analysis
 - Structured Text Mining
- Results:
 - 2 Ph.D. (S. Nascimento, 2002 and Nuno Marques, 2000 - Nat. Lang)
 - Integration of Post-Docs (A. Braud, Marco Castellani, and Ning Chen)
 - Collaboration
 - Boris Mirkin (Birkbeck Col., Un. of London), DIMACS (Rutgers Univ. NJ, USA)
 - Instituto de Oceanografia
 - Publications
 - 1 Article in Journal, 6 Papers in Conference and 2 in Ws Proceeds
 - Set up of a Joint Project (RENA) submitted to ESA



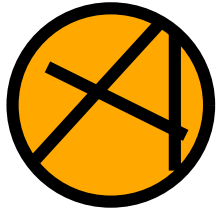
Oceanography Application (Pres)





Constraint Programming

- Situation in January 1999
 - 2 PhD – Pedro Barahona, Salvador Abreu (partly)
 - 5 Ph.D Students (Paula Amaral, Francisco Azevedo, Ludwig Krippahl, Jorge Cruz, Lgia Ferreira)
- Goals:
 - To cover a broad spectrum of Constraint Programming
 - Implementations, Techniques and Applications.
 - To aim at an international level of excellence
 - Multidisciplinary Research
 - Architectures, Mathematical Foundations, Applications
- Projects
 - 2 (in Medicine) about to finish
 - 1 in Architecture of CLP Systems about to start (OAR)



Architectures for Constraint Systems

- Prototype implementation for a parallel and distributed logic programming language (OAR)
 - based on contextual logic programming and and-or tree rewriting systems.
- Integration of a Java distributed constraint programming system
- ISTO as an appropriate formalism to specify and implement agents in a Semantic Web setting.
- Results:
 - Collaborations with
 - Univ. Paris (Daniel Diaz , Philippe Codognet)
 - Univ. Porto, Univ. Federal Rio Janeiro
 - Joint Projects with above (OAR, AJACS)
 - Publications
 - 2 Journal Research Notes,
 - 2 Papers in Conference and 4 in Workshop Proceedings



Inconsistent Linear Constraint Systems

- Close to Fuzzy Linear Constraints
 - Different Approach To Handle Uncertainty
 - Support Model Changes
 - Algebraic Approach vs. Optimization
- Results:
 - 1 Ph.D. (Paula Amaral, 2002)
- Publications
 - 1 Journal (2000) + 2 Journal (2004)
 - 2 Conference and 3 Workshop Proceedings
- International Collaboration
 - Michael Trosset (William Mary University)



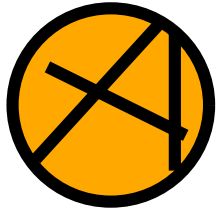
Constraints over Sets and Finite Domains

- Modeling Digital Circuits with Multi-valued Logics
- Develop and Apply new Constraint Solvers
 - Set Constraint Solvers
 - Hybrid Solvers
 - Compare Results with alternative Approaches (SAT)
- Results:
 - 1 Ph.D. (Francisco Azevedo, 2002)
 - Collaboration with Imperial College
- Publications
 - 1 Book, 1 Research Note in Journal
 - 3 Papers in Conference and 4 in Workshop Proceedings
 - Set up of a National Project with Instituto Superior Técnico



Constraints in Continuous Domains

- Modelling Differential Equations as Constraints
- Safe and Efficient Methods for dealing with such Constraints
 - New Consistency Criterion
 - Local Search
- Biomedical and Engineering Applications
- Results:
 - 1 Ph.D. (Jorge Cruz, 2003)
- Publications
 - 2 Journal (2004), 7 Conference and 3 Workshop Proceedings
- Collaboration with Frederic Benhamou (University of Nantes)
- Set up of a European FET project (under evaluation)
 - Univ. College Cork, Dassault, EPFL Lausanne and Univ. Nantes.

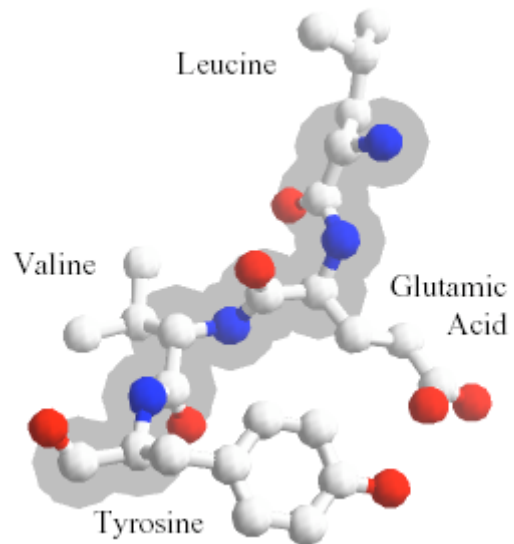


Constraints in Biochemistry

- Biochemical Application (Protein Structure Determination)
 - Difference Constraints to handle NMR data
 - Hybrid Methods to solve
 - Machine Learning (Search Heuristics)
 - Global Constraints
- Results:
 - 1 Ph.D. (Ludwig Krippahl, 2003) +
 - 2 M.Sc. (Ludwig Krippahl, 2000 and Marco Correia, 2004)
- Publications
 - 1 Journal (2002),
 - 2 Conference and 3 Workshop Proceedings
- National Project (Protein) + Task in REVERSE
 - International Collaboration (Tom Dietterich, Michael Trosset)
 - Envisaged CRAFT Project w/ Biotechnol + LORIA + ENGINEST



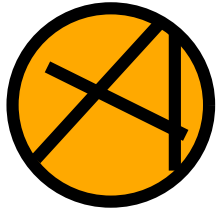
Constraints in Biochemistry (Demo)





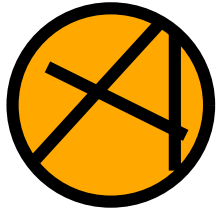
Global Results (1)

- Set Up of a research Group with Critical Mass
 - 9 Ph.Ds (3 Associates)
 - Pedro Barahona
 - Salvador Pinto Abreu
 - Gabriela Guimarães (Ass)
 - Nuno Marques
 - Francisco Azevedo
 - Susana Nascimento
 - Jorge Cruz
 - Paula Amaral (Ass)
 - Ludwig Krippahl (Ass)
 - 1 Ph.D + 1 M.Sc. (forthcoming – March 2004)
 - Lígia Ferreira
 - Marco Correia
 - 2 Post-Docs + 1 left
 - Marco Castellani
 - Ning Chen
 - Agnès Braud
- ...but unbalanced (mostly in Constraints, less in Soft Computing)



Global Results (2)

- Internationalisation becoming mature
 - Most Ph.Ds involved international collaboration
 - Organization of International Conferences
 - AIME'01, AIME'03
 - EPIA'99, EPIA'03
 - IDA'01
 - Invitation to PC of major conferences in the Area
 - ECCAI'00
 - CP'02, CP'04
 - IDA'01, IDA'02, IDA'03
 - International Projects
 - Bilateral Projects – Nantes, INRIA/Paris
 - Networks of Excellence – Rewerse
 - Setup of international projects
 - FET in evaluation, CRAFT in preparation



Global Results (3)

- International Collaboration
 - Henri Prade (Univ. Toulouse, France)
 - Wolfgang Urfer (Univ. of Dortmund, Germany)
 - Douglas Fisher (Vanderbilt University, TN, USA)
 - Boris Mirkin (Birkbeck College, Un. of London),
DIMACS (Rutgers Univ. NJ, USA)
 - Daniel Diaz, Philippe Codognet (Univ. Paris)
 - Vitor Santos Costa (Univ. Porto, Univ. Federal Rio Janeiro)
 - Michael Trosset (William Mary University)
 - Carmen Gervet, Mark Wallace (Imperial College – IC Parc)
 - Frederic Benhamou (University of Nantes)
 - Tom Dietterich (Oregon State University, USA)
 - Alexander Bockmayr (INRIA – Lorraine)



Global Results (4)

- Publications

- 1 Book
- 4 Book Editions
- 7 Articles in Journals (+ 4 forthcoming)
- 3 Research Notes in Journals
- 3 Book Chapters
- 30 Papers in Conference Proceedings
- 29 Papers in Workshop Proceedings

- Post Graduate Formation

- 5 M.Sc. (+ 1 forthcoming)
- 7 Ph.D. (+ 1 forthcoming)



Global Results (5)

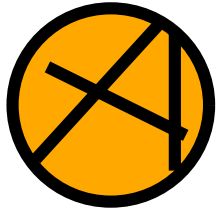
- Projects
 - About to Finish at beginning 1999
 - Neuroweb, Prestige, Emolite
 - In Course 1999-2003
 - HOC-TV
 - TSAM
 - ECO
 - PROTEIN
 - OAR
 - AJACS
 - PRACTIC (finance starting at in 2004)
 - REVERSE
 - In Evaluation / Preparation
 - RENA, FET, CRAFT



Future Goals (1)

For the period 2004-2006

- Consolidate Research Team
 - Keep and Attract PostDocs
 - Start new Post-Graduates
 - Several New Ph.Ds as supervisors
 - Participation in international MSc. (PhD in Comp. Log.)
- Increase Number and Quality of Publications
 - Duplicate average 1999-2003 results
 - 10 in Journals, 36 in Major Conferences,
- Increase Participation in International Projects
 - 4 Major International Projects
- Increase Organization of Events
 - Major Conferences, Workshops



Future Goals (2)

Research Directions

- **Improve Constraint Solving Techniques**
 - Develop a Constraint Platform extensible to different domains
- **Develop Machine Learning Techniques**
 - Extending clustering techniques (feature extraction, mixed feature spaces).
 - Evolving neural nets (feature selection, parameter tuning and structure learning.
 - Extending part-of-speech neural tagger for text mining
 - Distributed neural network architectures: parallel processing, hardware implementation.
- **Better integration Machine Learning & Constraint Solving**
 - Hybrid Solvers
 - Better Optimisation Features in Constraint Programming
- **Different Areas of Application**
 - Engineering, Decision Making, Image Processing, Oceanography, Text Mining...



Future Goals (3)

Improved Synergies with other CENTRIA areas

- **IIS - Intelligent Information Systems**
 - Machine Learning
 - Text Mining
- **KRRRLP - Knowledge Representation and Logic Programming**
 - Inductive Logic Programming
 - Constraint Logic Programming
- **Wide Ranged Projects and Applications**
 - Rewerse as an example



Future Goals (4) – A vision

To become an internationally referenced Centre in **Bioinformatics**

- Collaboration with UNL Biochemistry Centre in UNL
 - Centro de Química Fina e Biotecnologia
- UNL interest in a Biomedicine network of its Research Centres
 - Access to “Bio-Experts”
- AIME background
- International Collaboration
 - Rewerse, LORIA, Rutgers, Oregon
- Suitable Applications and Techniques in this area
 - Protein Structure, Protein Docking, Tuning Biological Models, Gene Sequencing, ...
 - Opportunities to Exploit Biochemical Data Banks
 - Both CP & ML, as well as their integration