Report 2004 and Plan 2005

NIAD&R, Faculdade de Engenharia da Universidade do Porto

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2005

Contents

Introductory Note

This report describes the results of the research done at the Laboratory of Artificial Intelligence and Computer Science (LIACC) of the University of Porto during 2004 and the planned research for the next years. It follows the strutucture of the previous reports. More information on LIACC activities can be retrieved from the LIACC Home Page (`http://www.liacc.up.pt`) or on demand.

A. Short Description of LIACC

The Laboratory of Artificial Intelligence and Computer Science (LIACC) of the University of Porto is a research centre that has already attained a good degree of visibility at both the national and the international levels. Its main aim is to pursue research, both at the theoretical and practical levels, in order to increase the quality of software in what concerns, for instance, declarativity, distributiveness, adaptativeness and flexibility. The main areas of research are (in alphabetic order):

- Coordination of Teams of Agents: agent-based robot control, hybrid architectures, simulated robosoccer;
- Declarative Programming and Parallelism: design and implementation (sequential or parallel) of declarative programming languages;
- Distributed Artificial Intelligence: multi-agent systems techniques and applications, agents negotiation and adaptation, Electronic Commerce;
- Information and Communication Networks: theoretical foundations, system architectures, and security mechanisms for mobile, ad-hoc and sensor networks, scalable solutions for reliable Quality of Service, service-oriented integration of heterogenous network infrastructures;
- Innovative Applications: development of practical applications based on recent languages and tools;
- Logic, Language and Computation: algorithmic complexity, formal systems, cryptography and language theory;
- Machine Learning: design and implementation of automatic inductive learning methods useful in classification and regression;
- Modelling of Cognitive-Behavioural Systems: ontologies for human-machine interaction and intelligent distributed systems with only partially consistent knowledge bases, agent-based models for cognitive and behavioural systems;
- Optimization, Constraints and Heuristics: constraint programming, heuristics and meta-heuristics for optimization and problem-solving;
- Parallel and Distributed Systems: design and implementation of programming environments with support for mobility and distribution of computations.

Results of this research have been extensively used by other institutions, both in the academic milieu and in the industry, and both in Portugal and abroad. Three examples of this are: the YAP Prolog compiler, the Data Mining Advisor (DMA), and the ARCA Expert System.

LIACC provides a research environment for the activities of several PhD students, and gives support to MSc courses organized by the Faculties of Science, Economics and Engineering.

LIACC participates in the activities of several international research networks, and has projects in colaboration with several institutions abroad and in Portugal.

Since its creation, back in 1988, LIACC has been able to maintain a good level of scientific production, as confirmed by previous independent evaluations, while giving an important contribution to the formation of a new generation of young researchers (as demonstrated by the conclusion of 25 doctoral degrees in the period 1999/2004). This in turn enhances the potential of LIACC to achieve not only higher production both in terms of quality and quantity, but also extend the research to new potentialy useful areas.

A(p). Descrição Sumária do LIACC

O Laboratório de Inteligência Artificial e Ciência de Computadores (LIACC) da Universidade do Porto é um centro de investigação que atingiu já um bom nível de visibilidade a nível quer nacional, quer internacional. O seu objectivo principal é a realização de investigação, tanto teórica como aplicada, que permita melhorar a qualidade do software no que se refere, por exemplo, a declaritividade, utilização distribuída, adaptabilidade e flexibilidade. As áreas de investigação mais importantes são (por ordem alfabética):

- Aplicações Inovadoras: desenvolvimento de aplicações práticas baseadas em novas linguagens e ferramentas;
- Aprendizagem: desenho e implementação de métodos automáticos de aprendizagem indutiva úteis para classificação e regressão;
- Coordenação de Equipas de Agentes: controle de robots baseado em agentes, arquitecturas híbridas, robôs simulados para competição em "futebol robótico";
- Descoberta de Conhecimentos e Prospecção de Dados: desenho e implementação de métodos para extracção, a partir de dados, de informação não trivial, potencialmente útil e fácil de interpretar;
- Inteligência Artificial Distribuída: técnicas e aplicações de sistemas multi-agente, negociação e adaptabilidade, Comércio Electrónico;
- Lógica, Linguagem e Computação: complexidade de algoritmos, sistemas formais, criptografia e teoria de linguagens;
- Modelos de Sistemas Cognitivos e Comportamentais: ontologias para interacção homem-máquina e sistemas inteligentes distribuídos com bases de conhecimento parcialmente consistentes, modelos baseados em agentes para sistemas cognitivos e comportamentais;
- Optimização, Restrições e Heurísticas: programação por restrições, heurísticas e meta-heurísticas para optimização e resolução de problemas;
- Programação Declarativa e Paralelismo: definição e implementação (sequencial ou paralela) de linguagens de programação declarativas;
- Redes de Comunicação e Informação: fundamentos teóricos, arquitecturas de sistema, e mecanismos de segurança para redes de telecomunicações móveis, redes ad-hoc e redes distribuídas de sensores; soluções escaláveis com qualidade de serviço garantido, integração orientada para serviços em redes heterógeneas;
- Sistemas Paralelos e Distribuídos: desenho e implementação de ambientes de programação que suportem a mobilidade e a distribuição de computações.

Alguns resultados desta investigação têm sido aplicados intensivamente por outras instituições, tanto no meio académico como na indústria, e em Portugal e no estrangeiro. Três exemplos são: o compilador de Prolog YAP, o sistema "Data Mining Advisor (DMA)", e o Sistema Pericial ARCA.

O LIACC tem acolhido as actividades de investigação de um número significativo de estudantes de doutoramento, e dá apoio a Mestrados organizados pelas Faculdades de Ciências, de Economia e de Engenharia. Participa também nas actividades de redes de investigação internacionais, e tem projectos de colaboração com várias instituições estrangeiras e portuguesas.

Desde a sua criação em 1988, o LIACC tem conseguido manter um bom nível de produção científica, como confirmado pelos resultados de avaliações independentes já realizadas, ao mesmo tempo que tem dado um contributo importante na formação de uma nova geração de jovens investigadores (como o demonstra a conclusão de 25 doutoramentos no período 1999/2004). O que por outro lado reforça o potencial do LIACC para obter não só um elevado nível de produção científica em termos de qualidade e quantidade, mas também extender a investigação a novas áreas potencialmente úteis.

B. LIACC Organization

LIACC is organized as a set of three groups all of them under coordination of professors of the University of Porto:

- NCC — Computer Science Group coordinated by Prof. Luís Damas and Prof. Miguel Filgueiras;

- NIA&AD — Artificial Intelligence and Data Analysis Group coordinated by Prof. Pavel Brazdil;

- NIAD&R — Distributed Artificial Intelligence & Robotics Group coordinated by Prof. Eugénio Oliveira.

LIACC has a Coordinating Board, whose present members are the 4 coordinators of the 3 groups, with a composition aproximately reflecting the proportionality of the number of members in each group. Each year one of the members of the Coordinating Board is appointed, in turn, as the coordinator of LIACC.

LIACC being a research centre dependent of the Rectorate of the University of Porto, the accounting services are provided by the Rectorate.

LIACC activities are periodically reviewed by an Advisory Committee. LIACC invites as members to this committee 3 researchers internationally recognized as outstanding experts. The current members of this committee are Prof. Claude Kirchner (LORIA, Nancy), Prof. Peter Flach (University of Bristol) and Prof. Nick Jennings (University of Southampton). The committee usually visits LIACC once a year and prepares a written commentary on the activities report and plan.

LIACC has a Scientific Council composed by all its researchers holding a PhD. The annual activities reports and plans are submitted to it for approval.

B.3 NIAD&R: the Distributed AI & Robotics Group

NIAD&R the Distributed Artificial Intelligence Group is LIACC smallest group aiming at promoting focused research in the academic environment. We simultaneously aim at i) helping researchers to develop their own thesis, ii) collaborating in contributing for innovative international trends in the autonomous agents research area and iii) trying to influence non-academics through meaningful transference of concepts, models and case studies exemplifying our main ideas in the Software Autonomous Agents field. Although having always in mind the application oriented work, we have been pursuing three main research lines in the Autonomous Agents field that we believe can be of great importance also in the near future:

- Flexible Tools and trustful Frameworks for agents interaction. We believe that sophistication of autonomous and pro-active agents can only be relevant when people understand and trust the environment in which their procurers (intelligent software agents) perform their activities on their behalf. This is why our research aims at the progressive establishment of largely accepted Electronic Institutions providing, on one hand, all the needed capabilities for fair, however personalized automatica negotiation protocols as well as agents' coordination policies and, on the other hand, the capability of guiding, monitoring and providing help for all that is happening during the agents' electronic encounters. We are pursuing this research line mainly in the domain of Virtual Enterprises life cycle supervision.

- Advanced features for Autonomous Agents. A set of new, essential and intrinsic features are needed for computational agents to show intelligent (sometimes human-inspired) behaviour. The quest for real learning and flexible adaptation is a difficult one. Due to our current interests, we have elected as our research objective in what this topic is concerned, enhancing agents' on-line (therefore not using traditional off-line examples-based) learning policies. Also in the same line, we are now exploring how "emotion-based" architectures can lead agents to display decision-making capabilities that are not completely under the utility-based function paradigm.

- Multi-Agent simulation, coordination and cooperation in dynamic environments. Our aim here is deriving methods and protocols for coordination and cooperation of agent teams that perform complex tasks in dynamic, inaccessible, non-deterministic multi-agent scenarios. Our research is aimed at assembling teams of physical (robotic) or virtual (software) agents that perform complex tasks in real world or simulated environments. Research is focused on cooperation protocols and models for cooperation, teamwork and coalition formation methods, coordination languages and systems and implementation of multi-agent systems paying specific attention to cooperation and coordination methods. Moreover we are now interested in developing simulators for agent-based systems applied to distributed, complex domains.

Another important issue we are involved with is Agents and Multi-agent systems applications. We are currently trying to apply agent-based techniques to automatic Virtual Enterprises formation as well as to Electronic Markets frameworks. Electronic Markets for Electrical Energy is one of our applications in progress. Automatic agent-mediated e-Brokering for the Insurance domain, is another problem we have modeled, developed and proposed an interesting (feasible) solution to, which has been demonstrated to potentially interested Software houses. Multi-Agent learning for improving road traffic control is another field of application we are dealing with. Learning to model data communication networks' messages congestion and applying "emotion-based" agent architectures to fire combat simulation are two recent applications we have been developing. We may summarize the scope of our research efforts by explicitly emphasising the following topics: Adaptive, multi-attribute agents negotiation leading to electronic contracts; emotion-like agents architectures for group behaviour simulation; learning capabilities and decision-making in the Multi-Agent Systems context; Agent-based teams coordination and simulation. We also have been, for the last years, present in some of the major international agent related conferences Program Committees (AA-MAS - Autonomous Agents and Multiagent Systems, ECAI - European Conference on Artificial

Intelligence, Autonomous Agents - AA, CIA - Coopertive Information Agents Workshop, IEEE International Conference on Web Intelligence, EUMAS - European Conference on Multi-Agent Systems) as well as ICMAS, MAAMAW, IEEE International Conference on Concurrent Engineering, EPIA - Portuguese AI Meeting, SBIA - Brasilian AI Symposium. We have been co-founders of the European Network of Excellence AgentLink, now AgentLink III. We have been active, since the beginning, in both the AMEC (Agent-mediated Electronic Commerce) and ALAD (Adaptive and Learning Agents) Special Interest Groups, organising special sessions and presenting our current research. We also have contributed to the book already published by AMEC SIG. We have also successfully participated in the major robotic soccer (RoboCup) competitions. We are currently supervising students both coming from foreign Universities (Brasil, Germany) and staying at foreign Universities and Laboratories (Centre for Biomedical Engineering-University Colege London, University of Essex). We have agreements under the Sokrates European Funding Programme enabling both students as well as professors exchanges with University of Trier (Germany), École des Mines de Saint Étienne (France) and Haute École de Liége (Belgium). We belong to the Editorial Board of the Autonomous Agents and Multiagent Systems International Journal (Kluwer), the Internationl Journal of Agent-Oriented Software Engineering (Inderscience) and to the European Board for the IOS and Ohmsha Ltd. "Frontiers in AI and its Applications" books sub-series.

International cooperation

- AgentLink III: (IIIA- Barcelona, U.York-UK).
- Imperial College - University of London, Prof. Abe Mamdani, prof. Igor Aleksander.
- Université de Technologie de Compiègne, France, Prof. Jean Paul Barthès.
- University of York, United Kingdom, Dr. Dimitar Kazakov, Dr. Daniel Kudenko.
- DFKI – German Artificial Intelligence Research Center, Saarbrücken, Dr. Klaus Fischer, Dr. Mathias Klush.
- École National des Mines de Saint-Étienne, France, Dr. Olivier Boissier.
- University of Trier, Germany, Dr. Norbert Kuhn.
- Universidade Federal do Rio Grande do Sul, Prof. Ana Bazzan.
- The Centre for Biomedical Engineering, University College of London, Dr. Stephen Taylor.
- City College, University of London, Dr. Eduardo Alonso.
- International Institute for Artificial Intelligence, Spain, Dr. Carles Sierra.
- Universidade Católica de Curitiba, Brasil, Dr. Flávio Bortolosi, Dr. Marcus Shmeil.

Team

Name	Position
Eugénio Oliveira	Senior Researcher
Maria Benedita Malheiro	PhD Researcher
Ana Paula Rocha	PhD Researcher
Luís Paulo Gonçalves dos Reis	PhD Researcher
Rui Camacho Ferreira da Silva	PhD Researcher
Henrique Daniel Lopes Cardoso	Researcher
Andreia Malucelli	Researcher
Luís Miguel Martins Nunes	Researcher
Maria Dulce Fernandes Mota	Researcher
Luís Miguel Pinho Nogueira	Researcher
António Manuel Correia Pereira	Researcher
Célia Talma Pinho Valente	Researcher
Nuno José da Silva Trindade Duarte	Researcher
Luís António Diniz Morais Sarmento	Research Assistant
Alexessander da Silva Couto Alves	Researcher
Francisco António Fernandes Reinaldo	Researcher
Sergio Fernando Grilate Louro	Research
Daniel Cardoso Moura	Research Assistant
Hugo Pedro Martins Carriço Proença	Research Assistant
Carlos Alberto de Sousa Leão	Researcher
Hugo Gravato Marques	Research Assistant
Nuno Miguel Tavares de Sousa	Research Assistant
Sónia Alexandra Sousa Rocha	Research Assistant
David Palzer	Research Assistant
External Collaborators	
Fernando Mouta	PhD Researcher
José Luís Pinto	Research Assistant
Ricardo Filipe Silva Afonso	Student
Tiago Azevedo Gonçalves Carvalho	Student
Rui André Ferreira	Student
Rui Couto Soares Sampaio	Student

C.3 NIAD&R: Results of Research

Publications

Theses

1. Sarmento, Luis Morais, An Emotion-based Agent Architecture. Master Thesis in Artificial Intelligence and Computing, Universidade do Porto, 2004.

2. Alves, Alexessander Couto, Internet Traffic Enginnering: An Artificial Intelligence Approach. Master Thesis in Informatics, Faculdade de Ciências da Universidade do Porto, 2004.

3. Louro, Sérgio Grilate, MAICC: Multi-Agent System for Controlling Intelligent Cameras (MAICC: Sistema Multi-Agente para Controlo de Câmaras Inteligentes). Master Thesis in Artificial Intelligence and Computing, Universidade do Porto, 2004.

4. Proença, Hugo, MARCS - Multi-Agent System for Train Traffic Control (MARCS - Sistema Multi-Agente para controlo de tráfego Ferroviário), Master Thesis in Artificial Intelligence and Computing, University of Porto, 2004.

Book edited

5. Reis, Luis P., Moreira, A. P., Costa, P., Silva, E., Almeida, J.M., Actas do Encontro Nacional de Robótica, (Proceedings of the Scientific Meeting of the Portuguese Robotics Open), FEUP Edições, Colecção Colectâneas, Vol. 14, ISBN 972-752-066-9, 2004.

6. Sen, Sandip; Oliveira, E.; Plaza, E.; Stone P. (Editors), "Learning and Evolution in Agent Based Systems", Proceedings of the W17 of AAMAS'04, New York, 2004.

7. Camacho,Rui, King, Ross D., Srinivasan, Ashwin, Proceedings of Inductive Logic Programming, 14th International Conference, ILP 2004, Porto, Portugal, September, 2004,Springer.

Chapter in book

8. Oliveira, Eugénio and Nunes, Luis, Learning by Exchanging Advice, in Design of Intelligent Multi-Agent Systems, Ed. R. Khosla, N. Ichalkaranje, L. Jain, Studies in Fuzziness and Soft Computing Series, Chapter 9, pp. 279-314, Springer, 2004.

9. Rocha, Ana Paula; Cardoso, Henrique Lopes and Oliveira, Eugénio, Contributions to an Electronic Institution supporting Virtual Enterprises' life cycle, in Virtual Enterprise Integration: Technological and Organizational Perspectives , Idea Group Inc, Chapter XI, ISBN 1-59140-405-3, 2004.

Publications in series   reviewed by the Science Citation Index or published by major international houses.

10. Alves, Alexessander; Camacho, Rui and Oliveira, Eugénio, Discovery of Functional Relationships in Multi- Relational Data using Inductive Logic Programming, in Proceedings of the International Conference on Data Mining , IEEE Computer Society Press, pp.319-322, 2004.

11. Alves, Alexessander; Camacho, Rui and Oliveira, Eugénio, Improving Numerical Reasoning Capabilities of Inductive Logic Programming Systems in Advances in Artificial Intelligence: Iberamia 2004, Ed. C.Lemaitre, C.Reyes, J.González, Lecture Notes in Artificial Intelligence V.3315, pp. 195-204, Springer, 2004.

12. Camacho, Rui, IndLog – Induction in Logic, in JELIA 2004 - Ninth European Conference on Logics in Artificial Intelligence, eds. J. Alferes and J.Leite, pp.718-721, Springer-Verlag, LNAI 3229, 2004.

13. Malucelli, Andreia and Oliveira, Eugénio, Ontology-Services Agent to Help in the Structural and Semantic Heterogeneity, in Virtual Enterprises and Collaborative Networks , Eds. Luis M. Camarinha-Matos, Kluwer Academic Publishers, pp. 175-182, August 2004.

14. Malucelli, Andreia and Oliveira, Eugénio Towards to Similarity Identification to help in the Agents' Negotiation, in Advances on Artificial Intelligence , LNAI, Vol. 3171, pp. 536-545, Springer-Verlag, 2004.

15. Nunes, Luís; Oliveira, Eugénio, Learning from Multiple Sources, Proc. of the 3rd International Joint Conference on Autonomous Agents and Multiagent Systems, NY USA, ACM Press, pp. 1106-1114, July 2004.

16. Proença, Hugo; Oliveira, Eugénio, MARCS: Multi-Agent Railway Control System, Advances in Artificial Intelligence: Iberamia 2004, Ed. C.Lemaitre, C. Reyes, J.González, Lecture Notes in Artificial Intelligence V.3315, pp.12-21, Springer, 2004.

Communications in proceedings of scientific meetings   (with referees).

17. Mota, D., Oliveira, E., Mouta, F.: MyClass - A Web-based system to support interactive learning in virtual environments. Workshop on Modelling Human Teaching Tactics and Strategies. Alagoas, Brasil, 2004.

18. Sarmento, Luis; Moura, Daniel; Oliveira, Eugénio, Fighting Fire with Fear, in Proceedings of EUMAS-04, 2nd European Workshop on Multi-Agent Systems, Ed. C.Ghidini,P.Georgini, Wiebe van der Hoek, pp. 627-634, Barcelona, 2004.

19. Cardoso, Henrique Lopes and Oliveira, Eugénio, Virtual Enterprise Normative Framework within Electronic Institutions, in M.-P. Gleizes, A. Omicini and F. Zambonelli (eds.), Proceedings of the Fifth International Workshop Engineering Societies in the Agents World (ESAW04), pp.85-90, Toulouse, 2004.

20. Alves, Alexessander; Camacho, Rui and Oliveira, Eugénio, Inductive Logic Programming for Data Mining in Economics, in Proceedings of the 2nd International Workshop on Data Mining and Adaptive Modelling Methods for Economics and Management , Pisa, September 2004.

21. Alves, Alexessander; Camacho, Rui and Oliveira, Eugénio, Model Validation: A statistical-based criterium of hypotheses acceptance in numerical reasoning, in 14th International Conference on Inductive Logic Programming, Porto, 2004.

22. Marques, Hugo G.; Oliveira, Eugénio, Stereoscopic Depth - A Biological Inspired Judgement, in Proceedings of BICS-2004: Brain Inspired Cognitive Systems, U. of Stirling, Scotland, 2004.

23. Pereira, António; Duarte, Pedro and Reis, Luis Paulo, Agent-Based Simulation of Ecological Models. In: H. Coelho & B.Espinasse (eds.) Proceeedings of 5th Workshop on Agent-Based Simulation, pp. 135-140, Lisbon, 2004.

24. Malucelli, Andreia; Rocha, Ana Paula and Oliveira, Eugénio, B2B Transactions enhanced with ontology-based services, in ICETE'04 - 1st International Conference on E-business and Telecommunication Networks, pp. 10-17, Portugal, 2004.

25. Marques, Hugo; Lau, Nuno and Reis, Luís Paulo, FC Portugal 3D Simulation Team: Architecture, Low-Level Skills and Team Behaviour Optimized for the New RoboCup 3D Simulator, Reis, L.P. et al. editores, Proceedings of the Scientific Meeting of the Portuguese Robotics Open 2004, FEUP Edições, Colecção Colectâneas, Vol. 14, pp.31-37, 2004.

26. Ferreira, Rui André; Reis, Luís Paulo and Lau, Nuno, Situation Based Communication for Coordination of Agents, Reis, L.P. et al. editores, Proceedings of the Scientific Meeting of the Portuguese Robotics Open 2004, FEUP Edições, Colecção Colectâneas, Vol. 14, pp.39-44, 2004.

27. Louro, Sérgio; Reis, Luís Paulo and Oliveira, Eugénio, Virtual 3D: Sistema Multi-Agente de Visualização com Controlo Inteligente de Câmara, Reis, L.P. et al. editores, Proceedings of the Scientific Meeting of the Portuguese Robotics Open 2004, FEUP Edições, Colecção Colectâneas, Vol. 14, pp.45-51, 2004.

28. Oliveira, Filipe; Rosendo, Pedro; Rebelo, Daniel; Moreira, António Paulo; Costa, Paulo and Reis, Luís Paulo, FPD2K4: Robot para a Classe de Condução Autónoma do Robótica 2004, Reis, L.P. et al. editores, Proceedings of the Scientific Meeting of the Portuguese Robotics Open 2004, FEUP Edições, Colecção Colectâneas, Vol. 14, pp.119-122, 2004.

29. Augusto, Bruno; Coutinho, José; Machado, Pedro; Silva, Vitor; Moreira, António Paulo; Costa Paulo and Reis, Luís Paulo, BotRacer - Um Robô para a Classe de Condução Autónoma do Robótica 2004, Reis, L.P. et al. editores, Proceedings of the Scientific Meeting of the Portuguese Robotics Open 2004, FEUP Edições, Colecção Colectâneas, Vol. 14, pp.123-126, 2004.

30. Sampaio, Rui; Reis, Luís Paulo and Lau, Nuno, O Agente Treinador e o Cálculo de Estatísticas do Jogo no Futebol Robótico Simulado, Reis, L.P. et al. editores, Proceedings of the Scientific Meeting of the Portuguese Robotics Open 2004, FEUP Edições, Colecção Colectâneas, Vol. 14, pp.143-148, 2004.

31. Teixeira, Cláudio; Lau, Nuno and Reis, Luís Paulo, FC Portugal 2003 Shoot Evaluation Based on Goalie Movement Prediction, Reis, L.P. et al. editores, Proceedings of the Scientific Meeting of the Portuguese Robotics Open 2004, FEUP Edições, Colecção Colectâneas, Vol. 14, pp.149-155, 2004.

32. Afonso, Ricardo; Carvalho, Tiago; Reis, Luís Paulo and Oliveira, Eugénio, Trignometric World State Fusion, Reis, L.P. et al. editores, Proceedings of the Scientific Meeting of the Portuguese Robotics Open 2004, FEUP Edições, Colecção Colectâneas, Vol. 14, pp.157-162, 2004.

33. Pereira, António; Duarte, Pedro and Reis, Luis Paulo. Agent-Based Simulation of Ecological Models, in Proceedings of the 1st International Conference on Knowledge Engineering and Decision Support, pp. 107-113, Porto,2004.

Other publications   accepted for publication in international journals

34. Srinivasan, Ashwin; Page, David; Camacho, Rui and Ross King, "Quantitative Pharmacophore Models with Inductive Logic Programming", in Machine Learning Journal, 2005.

Other publications

35. Duarte, Pedro; Pereira, António; Martins, C. & Guerreiro, M.J., Gestão de Zonas Lagunares Costeiras: Projecto DITTY, Revista da Faculdade de Ciência e Tecnologia da Universidade Fernando Pessoa, pp. 131-138, Ed. Fundação Fernando Pessoa, ISSN: 1646-0499, 2004.

36. Marques, Hugo Gravato (supervised by I. Aleksander and E. Oliveira), 3D Vision using Neural Networks at Imperial College, Report FEUP-LEIC, 2004.

37. Moura, Daniel, Creating and Monitoring Contracts in Virtual Enterprises, Technical Report, DEEC/FEUP, 2004.

Prototypes

In all cases LIACC is the entity responsible for the certification.

- BIAS - Brokerage in Insurance: An Agent-based System. BIAS is a tool including a Broker Agent suitable for the Insurance products domain. V1.2, 2004. Nogueira, Luís.
- FCPortugal 2004: A multi-agent based simulated Robosoccer Team. 2004. Reis, Luís Paulo; Lau, Nuno; Teixeira, Cláudio and Santos, Johnny.
- FCPortugal Coach 2004: A Coach for Multi-Agent based simulated Robosoccer Team. 2003. Reis, Luís Paulo; Lau, Nuno.
- Virtual 3D: a Multi-Agent System for Visualizing RoboCup simulation League Games with Intelligent Camera Control. 2004. Louro, Sérgio.
- MARCS - Multi-Agent System for Train Traffic Control. 2004. Proença, Hugo.
- ForEV V.1.4: Virtual Enterprise Formation Platform. ForEV is an Agent-based tool and platform enabling multi-attribute, adaptive negotiation between enterprises aiming at forming a temporary consortium, 2001-2004.
- PyroSim V.1.3. A simple Graphical Simulator for "Emotion-like" based Agents evolving in Fire Combat scenaria. Sarmento, Luís. 2004.

Theses supervised

Doctoral theses in preparation

1. Nunes, Luís Miguel "Learning from Multiple Sources in Heterogeneous Groups of Agents". (Supervisor Eugénio Oliveira).

2. Malucelli, Andreia "Agent-mediated Electronic Institutions". (Supervisor Eugénio Oliveira).

3. Cardoso, Henrique Lopes,"Agent-based Electronic Institutions enabling Automatic Electronic Contracts for Virtuasl Organisations (Supervisor Eugénio Oliveira).

4. Duarte, Nuno, "Emotional Learning Agents for Multi-Agent environments". (Supervisor Eugénio Oliveira).

5. Pereira, António Manuel, "Simulação Inteligente de Ecossistemas Costeiros", (Supervisor Luís Paulo Reis).

6. Reinaldo, Francisco Antonio Fernandes, "Métodos de Aprendizagem para Agentes Autónomos", (Co-Supervision: Rui Camacho and Luís Paulo Reis).

7. Valente, Célia Talma, "Methodologies for Business Processes and Distributed Workflows in Inter-Organisational Environments" (Co-supervision: Ana Paula Rocha and A. Lucas Soares).

Master theses completed

1. Sarmento, Luis Morais, "An Emotion-Based Agent Architecture", MSc on Artificial Intelligence and Computer Science, University of Porto, 2004.

2. Alves, Alexessander Couto, "Internet Traffic Engineering: An Artificial Intelligence Approach", MSc in Informatics, Faculty of Sciences UP, Porto, 2004.

3. Louro, Sérgio, "MAICC: Sistema Multi-Agente para Controlo de Câmaras Inteligentes" (MAICC: Multi- Agent System for Intelligent camera control), MSc on Artificial Intelligence and Computer Science, University of Porto, 2004.

Master theses in preparation

1. Pinto, João Luís "An Electronic Market for trading Electrical Energy". (supervision: E.Oliveira)

2. Moura, Daniel Cardoso, "Learning Capabilities of Emotion-based Agents". (supervision: E.Oliveira)

3. Rocha, Sónia Alexandra "Agent-based Text-Mining on the Web".

4. Pereira, Guilherme "Agent-mediated Travel Agency". (supervision: E.Oliveira)

5. Restivo, André, "Formalizing the Concept of Strategy for a Competition". (supervision: E.Oliveira; co-supervision: L.P.Reis)

6. Almeida, Rui, " Adversarial Behavior Modeling in simulated Robosoccer". (supervision:L.P.Reis)

7. Sousa, Nuno, "Emotion-based Facilitator Agents". (supervision: E.Oliveira)

8. Pereira, David, "Formalização Lógica de emoções em arquitecturas de Agentes". (supervision E. Oliveira; co-supervision N. Moreira)

Organization of scientific meetings

Participation in Organization Committees:

- Encontro Nacional de Robótica, Porto, 2004 (Luis Paulo Reis).
- AAMAS04 Workshop "Learning and Evolution in Agent Based Systems", Columbia University, New York, 2004 (Eugénio Oliveira).
- BESAI2004 - Binding Environmental Sciences and Artificial Intelligence. ECAI Workshop, Valencia, Spain, 2004. (Eugénio Oliveira).

Participation in Programme Committees:

- AAMAS'04 - Third Int. Joint Conference on Autonomous Agents and Multi-Agent Systems,Columbia University, New York, July, 2004. (Senior Pprogram Committee- Eugénio Oliveira)
- ECAI2004 - European Conference on Artificial Intelligence, August, Valencia,Spain. (Eugénio Oliveira).
- EUMAS - Second European Workshop on Multi-Agent Systems, Barcelona, 2004. (Advisory Board. Eugénio Oliveira)
- IEEE/WIC/ACM International Joint Conference on Web Intelligence (WI) & Intelligent Agent Technology (IAT) September, 2004, Beijing, China. (Eugénio Oliveira).

- AT2AI - Forth Int. Symposium From Agents theory to Agents Implementation, April, 2004, Vienna, Austria (Ana Paula Rocha and Eugénio Oliveira).
- Forth Symposium on Adaptive Agents and Multi-Agent Systems, March, 2004, Leeds, UK. (Eugénio Oliveira).
- SBIA2004 - Seventh Brasilian Symposium on Artificial Intelligence, Maranhão, Setember 2004. (Eugénio Oliveira).
- BASYS04 - 6th IFIP Int. Conference on Information Technology for Balanced Automation Systems in Manufacturing and Services, September, 2004, Vienna, Austria. (Eugénio Oliveira).
- ATT2004 - AAMAS Workshop in Traffic Transportation, July, 2004, New York. (Eugénio Oliveira).
- CIA2004 - Eith International Workshop on Cooperative Information Agents, September, 2004, Erfurt, Germany. (Eugénio Oliveira).
- ABS - Fifth International Workshop on Agent-Based Simulation, May, 2004, Lisboa. (Eugénio Oliveira).
- ESAW04 - 5th International Workshop on Engineering Societies in the Agent World, October, 2004,Toulouse,France. (Eugénio Oliveira).
- IBERAMIA2004 - Nineth Ibero-American Conference on Artificial Intelligence, November, 2004, Puebla, Mexico. (Eugénio Oliveira).
- Robocup 2004 Symposium, July, 2004, Lisboa. (Luis Paulo Reis and Eugénio Oliveira)
- SELMAS'2004 - 3rd Int. Workshop on Software Engineering for Large-Scale Multi-Agent Systems, May, 2004, Edinburgh, Scotland. (Eugénio Oliveira).
- Encontro Científico do Robótica 2004, April, 2004, Porto. (Eugénio Oliveira)
- IV Congresso Brasileiro de Computação, October, 2004, Itajaí, SC, Brasil. (Eugénio Oliveira).

Editorial Boards

- Member of the European Board for the IOS and Ohmsha Ltd. "Frontiers in AI and its Applications" sub-series for promoting world wide outstanding dissertations in Artificial Intelligence (E. Oliveira).
- Member of the Editorial Board of the International Journal "Autonomous Agents and Multiagent Systems" Kluwer Academic Publishers (E. Oliveira).

Advanced and post-graduate courses

- Artificial Intelligence and Intelligent Systems Masters Course, Faculty of Engineering and Faculty of Economics, University of Porto 2004-5. (E. Oliveira, R. Camacho, Ana P. Rocha, Luís P.Reis).
- Informatics Engineering Master Course, Faculty of Engineering, University of Porto, 2003-4. (E. Oliveira, R. Camacho, A.P.Rocha).

Awards

- second place at Coach contest during Robocup 2004. (L.P.Reis).

D. Research Activities

Note: numeric references below are to the list of publications under section C.

D.1.3 NIAD&R: Plan for 2005

Scientific Objectives

NIAD&R (Distributed Artificial Intelligence & Robotics Group) is LIACC's group belonging to the Faculty of Engineering at the University of Porto. Our team includes 4 PhD (one Senior), 13 Researchers including PhD students(9 working in part-time), 7 other MSc's students and 2 external collaborators. NIAD&R is the smallest LIACC's group and is mostly devoted to the Research in Distributed Artificial Intelligence and Agent-based Systems. More precisely, both the theoretical and practical aspects of Autonomous Agents as well as Multi-Agent Systems have been the broad areas of interest for our research. Our main research motivation relies on improving models for agent-based systems interoperability and applications. We can further identify specific topics inside these areas as shown below: (i) Electronic Institution for agent-based B2B trading, (ii) Agents' Adaptation, Learning and Emotions; (iii) Multi-Agent teams's coordination and simulation; (iv) Multi-agent Systems applications. In the following sub-sections a more detailed description of the work we intend to pursue is presented.

D.1.3.1 Electronic Institution for agent-based B2B trading

People involved: Eugénio Oliveira, Ana Paula Rocha, Henrique L. Cardoso, Andreia Malucelli, Célia Valente

Coordinator: Eugénio Oliveira

Research direction: Research in the context of this issue aims at developing an ElectronicInstitution for safe and trustable agent-based business operations. This objective includes the development of appropriate models for B2B Negotiation processes as well as to provide platforms, tools and frameworks enabling Agents' interaction in the context of Virtual Enterprises Life Cycle.

Electronic Contracts   *Research goals:* The Electronic Institution concept has been designed to encompass all the stages of a Virtual Organization (Enterprise) Life Cycle: Announcement of needs, Formation, Operation and Dissolution. Our main concern is now to specify what a suitable and effective "contract" can be as a result of all the negotiation process. The "E-Contract" will include a set of procedures all the agents have agreed upon. This established "contract" has to be at the disposal of the Electronic Institution in order to permit this entity to verify, at the right time, all the important steps that should be checked and, if this is the case, to enforce previously agreed corrective actions or punishements.

RECENT WORK (2004):

- Following work on the ForEV platform, we have studied the state-of-the-art literature on e-contracting, specifically in what B2B contracts are concerned. We consider e-contracts as the formalization of a business agreement, which parties agree to sign because of lack of trust for the fulfillment of that agreement. The contract will be enforced by an Electronic Institution (considered as a trusted third-party) with appropriate services. In particular, the institution incorporates a set of norms and rules to be inherited by all contracts signed within that institution; it also includes facilities that assist contract construction (through templates), monitoring and enforcement.

- We have also been studying deontic logic as a formal approach to model norms in contracts. We are enriching our model of an Electronic Institution, by considering an enhanced framework with reputation mechanisms, ontologies, transaction repositories, templates, and contract monitoring and enforcement services. As we aim at automating virtual enterprise

contracts, we are defining requirements for a representation language that considers this complex setting. We consider including a flexible level of specification of e-contracts within an electronic institution, depending on trust and reputation mechanisms.

CURRENT AND FUTURE WORK:

- We intend to study how agents and the institution itself can learn to adapt contract requirements to the reputation of the involved participants (adopting ideas from contract law and relational contract theory). Also, in order to make it more realistic for agents representing organisations (enterprises) to know how their internal processes (production and management processes) will interfere with the overall organisation operation, we are now looking at designing sound and correct inter-organisation network Workflows. Petri-Nets are good candidates for such representation, test and verification.

Electronic Institution Platform *Research goals:* To deliver an web-based Electronic Institution Service encompassing facilities to help agents as delegates of Organisations to form and o operate as Virtual Organizations/Enterprises.

RECENT WORK (2004):

- In 2004 we have finalized the implementation of a specific tool for B2B interaction - ForEV (Virtual Enterprises Formation framework). Besides including our adaptive Q-Negotiation algorithm (A. P. Rocha, H. L. Cardoso, E. Oliveira), the ForEV framework has now migrated from an elementary agents platform (Jatlite) to a more standard one (JADE) (D.Palzer).
- A major advance in a prallel work was, during this year, the initial work on Electronic Contracts to be included in ForEV. This lead us to modifications in the negotiation procedure in order to include automatic contract establishment. After contracts are established, the idea is to have their execution monitored by the EI guaranteeing that parties either stick to their promises or suffer institutionally imposed sanctions (H. L. Cardoso, E. Oliveira).
- Another important EI component, an Ontology Services Agent, has also been under development (A. Malucelli, E. Oliveira) (A. Malucelli, A. P. Rocha, E. Oliveira). These kind of services are crucial for agent-based enterprises delegates meaningful interoperability. Our Ontology Services Agent uses special algorithms for assessing lexical and semantic similarity among concepts represented in different ontologies without the need to build an a priori shared ontology. We have proposed three methods to be used: (i) calculating an n-grams value for attributes and concepts relations; (ii) calculating n-grams value for the concepts description and (iii) applying the Leacock-Chodorow (LCH) method based on WordNet to detect semantic similarity between concepts (A. Malucelli, E.Oliveira). Ontology Services also integrate a specific ontology editor (Protégé instead of previous Ontoedit) to facilitate agents Ontolgy creation.

CURRENT AND FUTURE WORK:

- To formally specify all the needed fields and concepts to represent an operational Electronic Contract, as well as norms and rules to be applied to different agents' roles according to the specific VO to be constituted.
- To integrate an Ontolgy-Services Agent (OSA) with the Electronic Institution and to find out a suitable scenario for experimentation.
- We are now starting the work on how to specify a distributed inter-organizations workflow to be used during the Virtual Entreprise operation stage.

D.1.3.2 Agents' Adaptation, Learning and Emotions

People involved: Luís Nunes, Luís Sarmento, Daniel Moura, Eugénio Oliveira, Rui Camacho, Alexessander Alves

Coordinator:Eugénio Oliveira

Research direction: Our research, following this line, deals with agents advanced capabilties due to new learning processes as well as Emotion-like features.

(i) Multi-agent learning. The main goal of this research issue is to find an answer to the following question: "(How) can several different, heterogeneous, Learning Agents improve their performance by exchanging information during their own learning process?".

(ii) Emotion-based agents' architecture. Through this research issue we would like to answer another important question: "Will it be possible to escape from usual utility-based decision functions in which decision-making for autonomous agents is concerned?"

Multi-Agent Learning *Research goal:* (How) can several different Learning Agents improve their performance by exchanging information during their own learning process?" that is the question.

RECENT WORK (2004):

- In order to answer that first question, we have been studying the effects of exchanging information during the learning process in the context of an heterogeneous group of agents with the objective of detecting possible improvements of agents' individual and global performances through learning.

- We already have specified the adaptive agents for advice-exchange. We also selected the learning algorithms, the communication protocols and an initial scenario for testing. The ultimate goal is to make experiments with a real and more sophisticated scenario (urban traffic control). Agents are learning either through Reinforcement or supervised learning as it is the case with backpropagation. Agents may be at different learning stages: Exploration, Novice, Intermediate, Expert (Nunes and Oliveira). We already have an initial software prototype including different adaptive agents that are collectively solving a simple problem (predator-prey problem). Our simulator was implemented following Gerhard-Mercator-U. Duisburg model.

- A complementar work on Agents learning is being done in our group, trying to enhance ILP (Inductive Logic Programming) algorithms for learning strategic knowledge. Numerical reasoning capabilities are being incorporated in ILP.

CURRENT AND FUTURE WORK:

- Lessons have to be learnt in order to scale up the method for learning agents in the traffic environment where agents try to control traffic lights in different crossings. Experiments with disconnected crossings have proved that advice-exchange, even in its simplest form, is effective. However, now we want to make experiments in a more complex, multi-connected crossing-roads scenario. We also want to sophisticate the situation, giving each individual vehicle some kind of autonomy according to observed drivers' behaviours.

- A PhD Thesis reporting on this subject will be submitted during 2005.

- We also want to use statistical tests to accept generated numerical models. The development of a library and special procedures to handle time-series and an interface allowing the use of any numerical function of the R-project will be used as Background Knowledge in the ILP context. We will identify the set of interesting applications where our developments will be evaluated. We want to use the above mentioned developments to induce models for domains that include large scale economy applications and data network workload prediction.

- A new direction for learning through Agents may start in a complete different context. We would like to integrate several different Information Retrieval methods and algorithms and enhance them for the sake of semantic text analysis. Could the multi-agent system paradigm be useful in this context? That is what we would like to investigate in the future.

Emotion-based Agents   *Research goal:* The second question to be answered is: Will it be possible to escape from usual utility-based decision functions in which decision-making for autonomous agents is concerned? Although the study of emotions in the realm of Artificial Intelligence is not totally new and has been addressed by Simon, Minsky, Sloman and Croucher among others, recently much more attention has been devoted to this subject by several researchers like R. Picard. This renewed effort is being motivated by trends in neuroscience (see A. Damásio's recent work), that are helping to clarify and to establish new connections between high level cognitive processes, such as memory and reasoning, and emotional processes. These recent studies point out the fundamental role of emotion in intelligent behaviour and decision-making. From our perspective, as engineers and computer scientists, we are mostly interested in studying the functional aspects of emotional processes. Particularly, we aim at understanding how emotional mechanisms can improve cognitive abilities, such as planning, learning and decision-making, for hardware and software Agents.

RECENT WORK (2004):

- We are currently developing an agents architecture in which Emotion is used as: i) Information (for deliberation); ii) Process Control Mechanism (changing the scope of local processing); iii) Resource Allocation Mechanisms (scheduling concurrent processes); iv) Selection mechanism for Information Processing Strategies (global processing policies);

  In particular, we have shown how specific Emotion-like mechanisms such as Fear, Anxiety and Self-Confidence can be used to dynamically adapt the global computational effort of the Agent to the current situation (L. Sarmento, D. Moura, E. Oliveira).

- PyroSim fire combat simulator has been further developed and experimented.

CURRENT AND FUTURE WORK:

- Besides the implementation of a software package for simulation in a specific domain (agent-based firefighting simulator), both a model, in accordance with neuro-sciences recent proposals, and a Logic-based formalism to describe emotion-based agents are being proposed (work at a preliminary stage).An Emotional-BDI architecture (BDI standing for "Believes, Desires, Intentions") will be specified. We want to continue with the development of Pyrosim simulation platform, with the aim of creating a suitable simulation environment for the development of Emotional Agents. The Pyrosim platform simulates a forest environment where a team of Agents is placed to fight an ongoing fire. Emotional Accumulators (EA) couple with Emotional Evaluation Functions (EEF) to build another element of our agent's architecture, the Basic Emotional Structure similar to well known emotions ("Fear", "Anxiety", "Self-confidence",...).

D.1.3.3 Multi-Agent Coordination and Cooperative Robotics

People involved: Luis Paulo Reis, Anónio Pereira, Francisco Reinaldo, Carlos Leão, E. Oliveira, Scholarship holders. (external collaboration: IEETA/U.Aveiro, ISR-Porto CEMAS-UFP)

Coordinator: L.P.Reis

Research direction: Coordinating teams of autonomous (or semi-autonomous) agents that perform in rich, dynamic, both competitive and adversarial environments is a major aim of this work line.

For this objective, we are exploring several research directions that can be seen as complementary: new coordination protocols; methodologies for analyzing team behavior; implementation of agent-based common framework suitable for controlling teams of cooperative robots (either physical or simulated) for robosoccer; design of realistic multi-agent simulators (Coastal Ecosystems Simulator); generalization to other domains.

Research goal: Recent work (2004):

- Agent-Based Simulation: We have being pursuing the development of realistic agent-based simulators. A new realistic multi-agent simulator for coastal ecosystems - EcoDynamo - was developed. This simulator enables us to study autonomous calibration techniques for simulation models based on machine learning. Our costal ecological simulator is now also being used for studying how correct management of environmental resources can make progress in the direction of sustainability.

- Team Coordination: We have developed several new coordination methodologies for teams of autonomous agents with application in realistic simulations like robotic soccer simulations, search and rescue simulations and ecological simulations. These methodologies included a new communication strategy - Situation Based Communication - based on our previous work about Situation Based Strategic Positioning and advanced communication methodologies. Our coordination methodologies were applied in our robotic teams and tested in real competitions and controlled experiments.

- Robotics: We have developed six real/simulated robotic teams (simulation 2D, simulation 3D, Coach, small-size, middle-size, 4legged) and we have participated in RoboCup 2004 World Robotic Soccer Championship, held in Lisbon. All teams achieved very good results (simulation 2D - 6th place, simulation 3D - 8th place, coach - 2nd place, small-size - 5th place, middle-size - 2nd elimination round and 4legged - 9th place). In RoboCup, and for the fifth consecutive time, we were the only Portuguese team to achieve an award in the senior leagues. We have also organized the Portuguese Robotics Open. This four days event had more than 500 participants and included 10 different robotic competitions, a scientific meeting and 10 different robotic demonstrations. In this event our teams won three of the senior leagues (simulation, small-size and 4 legged).

- Individual and Team Performance Analysis: Creating methodologies for analysing individual and team performance. Two prototypes are under development:
i) A distributed surveillance system based on surveillance agents capable of following a surveillance policy communicated by a central agent in a specific language. ii) A soccer intelligent analysis system based on surveillance agents (with 3D player and ball detection capabilities) placed on a soccer stadium and a central agent capable of creating match reports including player individual performance (passes, shoots, runs, dribbles, etc.) and team performance information (ball possession and circulation, playing style, space of effective play, etc.).

Current and future work:

- We are developing 4-legged robots (AIBO) applications through the use of perception including Vision.

- We are still developing further our FCPortugal robotic teams for robosoccer competitions.

- We want to specify, design and implement more generic agent-based simulators for complex, dynamic environments. Within this research line we are also currently developing new features for known simulators like SoccerServer robotic soccer simulator and RoboCup Search and Rescue simulator. This new simulated Search and Rescue team will enable us to participate in RoboCup 2005 - Osaka, Japan.

D.1.3.4 Other Agent-based systems applications

People involved: J.L.Pinto, N. Sousa, G.Pereira, H. Marques, E. Oliveira, A.Alves, S.Rocha
Coordinator: E. Oliveira

Research direction: To apply agent and multi-agent architectures, negotiation protocols and learning algorithms to specific application domains.

4-legged robotic surveillance Team- "Smart Guardian" *Research & Development goals:* The main goal of the Smart Guardian project is to create a Multi-Agent System that makes use of Team Learning techniques when patrolling and detecting intruders in a dynamic environment.

CURRENT WORK:

- The First Stage of this project concerns the development of a software system that is capable of controlling a single robot to be reused as a basis for a single agent in the next stages of the project. The goals of this stage are to map the AIBO robot's surroundings using its sensors; to define the basic architecture that enables the robot to be suficiently curious to investigate parts of the world that are unknown to it and to move to locations pointed out by the user. Local Learning capabilities have to be tested. We are using Tekkotsu framework (developed at CMU) a C++ layer on top of OPEN-R that provides a greater abstraction over the low level details of the robot.

- Next stage is to design a multi-agent system organization enabling different robots joint work. Learning capabilities have to scale-up to team learning.

Research goal: Communications network management

RECENT WORK (2004):

- A software package applying learning algorithms to improve resource allocation in multi-class packet switched networks have been developed (A. Alves thesis). The system proved to be applicable to multi class settings where decision-making problems are exceptionally complex. Improving Inductive Logic Programming (ILP) systems with numerical reasoning capabilities as well as to provide those ILP systems with appropriate background knowledge for Time Series Analysis was the cornerstone of the work done (A.Alves, R. Camacho, E. Oliveira).

- This work has been concluded by now. A Master Thesis has been produced.

Agent-based Electrical Energy e-Market *Research goals:* To design a secure platform to enable trusted encounters between agents representing energy costumers and suppliers in an Electronic Market. Current European efforts for the establishment of both de-regulated Electrical Energy Markets and Electronic Commerce platforms can be brought together through appropriate multi-agent platforms enabling autonomous agents interaction for automatic trading.

RECENT WORK:

- In the specification of the multi-agent system encompassing the needed functionalities for the Electrical Energy e-market, we have until now emphasising security procedures, accountability of the communications, good performance and software portability. Also, integration with legacy systems has been privileged. In our Electricity E-Market, agents authenticate through digital certificates, while messages between the market operator and the market agents are digitally signed. We have selected the TLS/SSl protocol and, as for the message digital signatures is concerned, the open standards are being used. They rely on classical MAC and cryptography algorithms used in SSL. Market operator is seen as a trusted third partner, responsible for registration, auctions and matching bids and offers.

- To apply and integrate all those developed algorithms in a single platform for an Energy market auction-based simulation.

Controlling a Metropolitan Railway System through Agents *Research goals:* To specify and implement a generic multi-agent system suitable for automatic control of a subset of a railway system.

Recent work:

- During 2004 this work, specifying and implementing MARCS (Railway control Multi-Agent System) came to an end. MARCS proved, in a simulated environment that, by using communication, it becomes possible to automatically take correct control decisions about trains traffic and potential conflicts may be avoided (H.Proença, E. Oliveira). Agents (trains, train stations, sub-network supervisors) exchange either plans or other specific information to help in their own reasoning process to coordinate their speed and avoid potential conflicts. Each potential conflict that has been solved by the system is recorded. Moreover, the set of all previous recorded avoided conflicts is explored by means of an unsupervised learning algorithm - APRIORI to induce rules of behaviour for future application in similar situations.
- a Master Thesis has been produced.

Biological inspired Robotic Vision *Research goals:* This work aimed at contributing to the research on depth perception mechanisms by using a biologically inspired model of stereoscopic vision.

Recent work:

- Stereogram images show that human beings are able to perceive depth just from the differences between the images coming from the retinas of both eyes. The work done (H.Marques, E. Oliveira), supports the idea that the way stereogram images are perceived by human beings is just a consequence of the way they see on real world environments; that is, it has shown that the information received by the brain for generations is perfectly enough to make us interpret stereogram images as having differences on depth. Usually, to implement a stereoscopic depth mechanism on robots two parallel cameras are used. The images supplied by these cameras are very difficult to match by means of a biologically inspired algorithm since these ones require the use of local information, and the extension of information needed to mach the images from two parallel cameras is too large. Human beings have the ability to move their eyes and when they look at a real world object both eyes converge to that object. The disparity method built expected to make use of this behaviour (eye convergence) in order to reduce the disparity computation to local and much simpler algorithms (H. Marques report under the supervision of Igor Aleksander, Imperial College, and E. Oliveira, University of Porto).

Multi-Agent System for Web searching *Research & Development goals:* We are now specifying a multi-agent system which tries to capitalize from different agents parallel searching tasks to enhance the overall system performance on finding relevant web pages for specific users.

Current work:

- How to distribute the work among the dynamically created agents as well as what information (contexts) to exchange is our primary concern. Different text analysis algorithms (like TFIDF) are being tried out. This is a preliminary work of S. Rocha.

D.2.3 NIAD&R: Ongoing projects

1. AgentLink III

This project is funded by the European Union IST Programme and supports an international network of excellence for Agent Based Computing. It follows AgentLink I and II existing for the last 6 years.

Project title: AgentLink III
Effort at LIACC: 1 man year
Funding entity: EU (IST)

Funding for LIACC: covers travelling and short stays expenses
Total award period covered: from September/2003
Coordinator at LIACC: Eugénio Oliveira
Prime contractor: University of Southampton

Other partners include, Queen Mary Westfield College/University of London, Technical University of Munich, University of York, OFAI (Vienna), University of Paris VI, University of Neuchatel, IIIA/Barcelona, Imag/Grenoble and many others.

Partners were grouped in different Special Interest Groups and NIAD&R - LIACC belongs to two different SIGs: Agent-Mediated Electronic Commerce (AMEC) and Adaptive and Learning Agents (ALAD). Our activity in AgentLink is directly related with our research on:

Agents Negotiation protocol models

- We have presented and discussed, an agent-mediated platform for Virtual Enterprise formation (ForEV)(Ana Paula Rocha).

- We also have begun to contribute for designing specific policies for representing enterprise/products knowledge, through appropriate ontologies useful for both the VE formation and the monitoring process. This work is the subject of a PhD thesis (A.Malucelli).

- As a result of the challenge presented by an industrial representative at one of the AMEC SIG's sessions, we have specified, developed, and already presented for discussion, both through papers (L.Nogueira, E.Oliveira) and through oral presentation during SIG meetings, our approach to the E-brokering services for the Insurance domain.

Our main objectives in this project are:

- To formalize the concept of Electronic Institutions, including several different kinds of services and incorporating laws and rules to be enforced on any agent-mediated electronic market. We are also interesed in specify the requirements for, formalise the concept of and explore the knowlege included in an Electronic Contract. An Electronic Contract has to be automatically built to substantiate the VE partners agreement reched during previous negotiaion stage.

- To generalize the concept of Electronic Institution for controlling and monitoring Distributed workflows,through all the available secure, robust and transparent procedures for interaction.

- Two PhD theses are being pursued in this context (A. Maluceli, H.Cardoso).

- One Master thesis on the E-Brokering for the Insurance Domain subject has been successfuly presented (L. Nogueira).

- We are also involved in another SIG (ALAD) by exchanging our research results on Multi-Agent learning.

2. PORTUS – A Common Framework for Cooperation in Mobile Robotics

Project title: PORTUS (POSI/SRI/41315/2001)
Effort at LIACC: 71 man months
Duration period: 36 months
Total award period covered:2004-2006
Funding entity: FCT, POSI
Funding for LIACC: 20,000€
Coordinator at LIACC: Eugénio Oliveira
LIACC team: Luís Paulo Reis, Eugénio Oliveira
Partners: ISR-Porto (leader) and LIACC

Motivation: This project aims at developing a new approach to cooperative robotics in general and to building RoboSoccer teams in particular. The project main goal is to design a software common framework suitable for the implementation of an agent-based software that can control robots to be used for several cooperative robotic tasks and in particular, can control robots that are able to play in any Robotic Soccer leagues (simulation, small-size, middle-size and legged). The same agent-based software will control each one of the robots of Portus team, regarding its action and perception capabilities and the cooperative task to perform. The common framework will include a knowledge representation structure capable of representing structured knowledge supplied by a domain expert to a team of cooperative robots. This structure is instantiated by special supervisor agents developed for each RoboCup league or cooperative task to perform.

Each agent in Portus includes a dynamic world state model that willbe updated though visual perception, robot communication and action prediction. In Portus project, both inter-agent cooperation and team coordination policies have to be investigated. This will include cooperation methods like dynamic positioning and role exchange, strategic positioning and intelligent communication.

In order to control different robots, the common framework software agent needs specific parts to deal with special constraints related with the agent's perception and action capabilities.

The very idea of Portus project is then to design an agent-based common framework applicable in partially cooperative, partially adversarial domains, to different cooperative robotic tasks, including all major RoboCup soccer leagues.

Main objectives of the project:

The main objective of Portus is to develop a common agent-based framework for controlling cooperative teams of mobile robots. According to the general architecture we are envisaging for the proposed framework, this objective may be subdivided into the following sub-objectives:

- To develop a general knowledge representation structures for representing adequate knowledge for cooperative robotics tasks in adversarial environments;
- To develop languages suitable for the communication between the common framework and specific modules that deal with action, perception, communication and domain knowledge;
- To formalize and implement cooperative decision-making both at individual and team level;
- To improve and refine methods for sensing and communication in the referred environments;
- To develop agents capable of supervising different teams able to fulfill different cooperative tasks.

  Portus main contribution will be a configurable common framework flexible enough to deal with perception, decision-making and action for different (both real and virtual) cooperative teams of robots.

3. LEMAS- Learning in the Multi-Agent System for the RoboCup Sonny Legged League

Project title: FCT - POSI/ROBO/43910/2002)
Effort at LIACC: 18 man months
Duration period: 12 months
Total award period covered: December 2003-December 2004
Funding entity: FCT, POSI
Funding for LIACC: 32908€
Coordinator at LIACC: Eugénio Oliveira
LIACC team: Luís Paulo Reis, Eugénio Oliveira, Ricardo Afonso, Tiago Carvalho
Partners: ISR-Porto, Faculty of Engineering and LIACC

RoboCup is an international research initiative that promotes research in the fields of artificial intelligence and intelligent robotics with focus on coordination between autonomous agents in complex dynamic environments. It includes a Legged League that uses teams of 3 quadruped robotic Sony AIBO platforms. AIBO robot has 20 degrees and freedom and 7 types of sensors: image, audio, temperature, infrared distance, acceleration, pressure and vibration. In this league, since no modification is allowed in the robots hardware, the team with the most appropriate software usually wins. Sony robots must be totally autonomous in the games. With LEMAS project we aim at developing a fully- functional soccer playing team to participate in RoboCup. Two teams of 3 robots each will be purchased to Sony together with an appropriate soccer field. Based on previous experience from the small-size league, a global vision system will be developed and installed on the field to help evaluating different parts of LEMAS project. An agent architecture appropriate to control the legged robots software will be developed providing all the needed agents features. Research in LEMAS will be focused on three main aspects: Perception, autonomous decision-making and team coordination. The first aspect mentioned above implies developing a robust vision system for the robots including capabilities for color image segmentation and object recognition. This vision system will generate high-level descriptions of the image contents to be used for self-localization, action execution and cooperative playing. To enable the team to be competitive, LEMAS project will research the application of reinforcement learning to develop efficient low-level skills for legged robots, including fast walking, fast turning, dribbling, kicking and defending. We intend to benefit from the global vision system output to enable precise measurements of low-level skills efficiency enabling the use of reinforcement learning to fine-tune the skills parameters of the robots. An audio communication system will also be developed, enabling the robots to exchange meaningful audio messages, inducing a more cooperative behavior. Behavior selection will be based on extended behavior networks. We will also use different tactics, including different roles and develop methods for dynamic role exchange using audio communication. With LEMAS project we also expect to give continuity to our successful participations in RoboCup competition with a new team in the Sony legged league

Main objectives of the project:

The main objective of this project is to create a fully functional robotic team capable of participating in RoboCup Sony legged league once no Portuguese team has ever attempted to participate in the fourth major RoboCup soccer league: Sony legged league.

We believe that the development of our Sony legged team will significantly increase Portuguese scientific competences to participate in RoboCup 2004.

Participating in the Sony legged league is also an opportunity for testing research developments we intend to pursue in three important fields: Mobile vision, adaptive decision-making and team coordination policies.

4. FC Portugal: New Coordination Methodologies Applied to the Simulation League

Project title: FCT/POSI/ROBO/43910/2002)
Effort at LIACC: 18 man months
Duration period: 12 months
Total award period covered: December 2003-December 2004
Funding entity: FCT, POSI
Funding for LIACC: 27800€
Coordinator at LIACC: Luis Paulo Reis
LIACC team: Luís Paulo Reis, Eugénio Oliveira, Ricardo Afonso, Tiago Carvalho
Partners: ISR-Porto, Faculty of Engineering and LIACC

Motivation: FC Portugal - New Coordination Methodologies project intends to continue the research performed during the development of FC Portugal RoboCup simulation league team, winner at RoboCup2000, Melbourne, and European Championships, (Amsterdam2000 and Paderborn2001). In these competitions, FC Portugal scored 386 goals, conceding only 9, when competing with teams developed by some of the best universities and companies in the world. The main goal of this project research is the development of a formal model for the concept of team strategy for a competition with an opponent team having opposite goals, general enough to be instantiated to various dynamic competitive domains. The formal model will enable the design of an agent architecture suitable for RoboCup simulation league agents and a world state model capable of storing the information needed for an intelligent agent, to play soccer. The project research focus will be concerned with developing general decision-making and cooperation models for soccer playing. Cooperation mechanisms will include developments of the previously proposed Situation Based Strategic Positioning and Dynamic Positioning and Role Exchange Mechanisms. Communication languages and protocols, to convey the most relevant information at the right times to players will also be developed. Also, research will be focused on intelligent control of players sensors to achieve maximum coordination and world state accuracy. Online optimization and reinforcement learning will be used in order to develop a complete set of efficient low-level skills for soccer playing agents. Coaching is an important research topic in RoboCup. We have proposed Coach Unilang - a general language to coach a (robo)soccer team. In this project, this language will be extended and fully implemented. Also, an agent architecture suitable for a simulation league coach and a complete soccer coaching ontology will be developed. This will allow the development of high-level reasoning methods enabling the coach to decide the best tactic at each moment in the game. FC Portugal will also be concerned with the development of agent evaluation tools like our offline client methodology; WstateMetrics that evaluates the accuracy of world states and Visual debugger used analyze the reasoning of agents. Evaluation by domain experts using graphical tools is another methodology that will be used.

Main objectives of the project: FC Portugal project main objective is the continuation of the development of FC Portugal simulation league team so that it successfully participates in the next competitions. The main objective is subdivided in several research objectives that enhance team competitiveness, namely:

- Formalization of the concept of Strategy for a Team Competition
- Definition of an agent architecture and knowledge structures suitable for RoboCup simulated soccer playing and coaching agents
- Development of New Cooperation Mechanisms for Multi-Agent competitive domains
- Definition of a General Coaching Language for RoboCup
- Development of Intelligent Communication and Perception methodologies for domains with low-bandwidth and configurable sensors

5. Electronic Contracts in Virtual Enterprises

Project title: Specification and monitoring of electronic contracts in Virtual Enterprises
Effort at LIACC: 18 man months
Duration period: 12 months
Total award period covered:December 2003-december 2004
Funding entity: DEEC-FEUP
Funding for LIACC: 9940€
Coordinator at LIACC: Ana Paula Rocha
LIACC team: Ana Paula Rocha, Daniel Moura, Henrique Cardoso
Partners: DEEC-Faculty of Engineering

Motivation: The electronic commerce originates a new economic and organizational structure, named Virtual Enterprise (VE), which is an enterprises coalition, with a limited time of life and a huge number of potential business partners that are selected in accordance with its abilities and/or availabilities. The VE is, by definition, a temporary aggregation of independent and autonomous enterprises connected through a network communication that appears to deliver a product or service in reply to a necessity of the market. The VE life cycle is decomposed in four phases: search of information, partners selection, operation, and dissolution. In electronic markets, which are for definition open environments, there is the problem of establishing confidence between potential business partners (agents) and that are, generally, not known in advance. The traditional way to attribute security to a commercial transaction is through the establishment of a contract. The contract enumerates the dependencies between the partners that participate in the commercial activity. This project focus essentially in the phase of operation of the VE, and consists in the specification and monitoring of electronic contracts. The contracts are derived from templates that contain fixed and non-fixed parameters. These parameters that are not fixed will be the object of the negotiation process that occurs in the phase of formation of the VE (subject already explored in previous projects). Thus, the result of the VE formation phase will be the instantiation of an electronic contract to be used in the monitoring process that occurs during the VE operation phase. This contract is signed by all the VE partners, and possibly supervised for an independent agent. This project includes also a study about the language and the ontology of the contract.

D.3 Cooperation

Bi-lateral Actions

1. Universidade Federal do Rio Grande do Sul (Prof. Ana Bazzan) under the GRICES-CAPES Program.

Links with foreign institutions

- City College of London, Dr. Eduardo Alonso.
- Czech Tecnical University, Prague, Professor Vladimir Marik.
- École National des Mines de Saint-Ètenne, France, Dr. Olivier Boissier.
- International Institut for Artificial Intelligence, Barcelona, Dr. Carles Sierra.
- Universidade Católica de Curitiba, Brasil, Professor Marcos Shmeil.
- Universidade Federal do Rio Grande do Sul, Professora Ana Bazzan.
- Université de Technologie de Compiègne, Professor Jean-Paul Barthés.
- University of Texas, Doctor Peter Stone.
- University of Trier, Germany, Dr. Norbert Kuhn.
- University of Utrecht, Professor Frank Dignum.
- University of York, UK, Dr. Daniel Kudenko.

Links with national institutions

There have been joint actions with:

- Universidade Fernando Pessoa, Dr. Pedro Duarte
- Universidade de Aveiro, Dr. Nuno Lau
- Universidade Atlantica, Dr. Rosaldo Rossetti

There has been collaboration in post-graduation actions with:

- Universidade Católica de Curitiba, Brasil, Professor Marcos Shmeil.
- University of Essex, Professor Owen Holland.