

Objectives & Achievements

This part of the report will allow you to describe the way in which the Unit is organized and managed, to give the general objectives of the research within the Unit and finally to give a brief description of the main achievements of the research carried out in the Unit as a whole during the 2007 period. A maximum number of characters (without spaces) is allowed in each field. If the number of characters exceeds the maximum you will not be able to complete the form and an error message will appear when you try to save your work.

1. Unit Description (2000 ca.)

Here indicate form of organization and management.

CEOC is structured by a Council, formed by all the members who own a PhD, and an Executive Committee, formed by the unit Coordinator, Sub-coordinator, Secretary and the Coordinators of each of the Research Groups. The unit has a Board of Advisors, formed by internationally well known important researchers in each group area of research. The council elects the Coordinator each four years, and meets at least once a year to define the general research strategy, to approve possible structural modifications, to approve the budget and to admit or exclude unit members. The Coordinator is in charge of general management such as the allocation of financial resources and physical facilities, towards achievement of the unit goals and convenes the executive committee at least once each semester as his local advisory board. Each research group elects its Coordinator from among its doctors; this coordinator defines the group specific objectives and is responsible for their fulfilment.

2. General Objectives (3000 ca.)

This refers to the current aims of the Unit as a whole.

The primary goals of CEOC include carrying out research and providing advanced training in optimization, computer science and mathematical control theory, comprising topics such as: operations research (including linear, nonlinear and combinatorial optimization), graph theory and combinatorics and its algebraic approach (including spectral graph theory); computability and algorithms (including computational geometry, quantum computation and machine learning); optimal control and calculus of variations (including computational mathematics and nonstandard analysis); minimal resistance and mass transfer (including the classical Newton problem of the body of least resistance in various classes of bodies and related problems of optimal mass transfer). CEOC researchers supervise several PhD projects on algebraic and combinatorial approach to polytopes; graph theory and optimization, graph theory and combinatorics, minimum resistance problems, nonlinear optimal control, nonstandard analysis and topology, computational mathematics and computational geometry. Additionally, CEOC researchers offer PhD projects on spectral graph theory, operations research (including integer programming and combinatorial optimization), calculus of variations, quantum computing, machine learning and data mining, etc. The research objectives of CEOC are the development of new results on its main topics which are divided by the following three groups: 1) Optimization, Graph Theory and Combinatorics; 2) Computability and Algorithms; 3) Control Theory Group. Among the research activities of each of these groups we may emphasize the following working applied and theoretic topics: 1) Programming involving graphs; spectral graph theory techniques in combinatorial optimization; algebraic methods in graph theory and in combinatorial polyhedra; algorithms for combinatorial optimization problems (namely,

minimum arc sum spanning star forests and constrained spanning trees); semi-infinite programming. 2) Complexity theory; digital arithmetic (including design of quantum arithmetic circuits); art gallery illumination problems; random polygons; machine learning and applications (including adaptive learning algorithms and data mining techniques in bioinformatics). 3) Control affine problems with non-commutative vector fields; Lipschitzian regularity of optimal trajectories; problems of minimal and maximal aerodynamic resistance; multiobjective Monge-Kantorovich optimal mass transfer problems; non-standard techniques on critical point theory; Noether's like results with both "energy" and "momentum" terms in a general time scale; necessary optimality conditions for problems of the calculus of variations on time scales.

Other CEOC goal is to develop applied projects solving real world problems in cooperation with industry and service organizations contributing to the development, diffusion and application of mathematical knowledge.

3. Main Achievements during the year of 2007 (3000 ca.)

Highlights from past research over the period under evaluation.

Optimization, Graph Theory and Combinatorics (OGTC): Recognition of (k,t) -regular sets; local definition of adjacency eigenvectors in strongly regular graphs as a function of their parameters; extension of the Hoffman bound for the stability number of regular graphs to the size of k -regular induced subgraphs. Complexity of the maximum size k -regular subgraph problem. Characterization of the eigenvalues of the Laplacian matrix and adjacency matrix of weighted rooted trees; Polyhedral results on a mixing mixed integer set; a heuristic for the stability number of a graph combining the Lovász theta number formulation based on convex quadratic programming with a tabu search technique; tight models for the special cases of the diameter-constrained minimum spanning tree problem for $D=2, 3$; exact linear formulations for knapsack tree sets; new algorithm results for a problem related to the optimal diversity management problem.

Computability and Algorithms (CA): Development of a model for the computational evaluation of the complexity of particular problem instances, based on the concepts of Algorithmic Complexity, Information Theory and Maximum Entropy Principle; a general theoretical model for Quantum Computation with Hybrid Quantum Systems, corresponding initial work on the Computational Complexity analysis of Classes of Quantum Circuits. Existence of constant depth quantum circuits for approximating the sum of a polynomial number of numbers based on two classes of constant depth quantum circuits for the addition of two numbers. Development of a Symbolic Quantum Computer Simulator and simulations of Grover's algorithm. Introduction of the k -illumination concept with an improved approximate algorithm to solve the Minimum Vertex Guard problem by means of orthogonal floodlights. A unified adaptive on-line framework for learning Bayesian Network Classifiers particularly advantageous in environments where quick adaptation to changes in the learned concept is needed.

Control Theory Group (cotg): Analytical and numerical results for: Maximization of the mean resistance of two-dimensional shapes with applications to retroreflectors design. A sequence of rotationally symmetric non-convex bodies minimizing Newtonian aerodynamic resistance and shapes and resistance comparison to known values for symmetric bodies. Solution of problems of least aerodynamic resistance by reduction to special problems of Monge-Kantorovich, following a new notion of rough body and corresponding measures for laws of billiard scattering. Explicit representation of the Green function for the Helmholtz and Laplace exterior equations. Existence and

Lipschitzian regularity of relaxed minimisers for non necessarily convex suitably coercive optimal controls. Asymptotics of minimizing sequences for control-affine optimal control problems; full characterization of the degree of singularity and its relation to the geometry of generalized optimal synthesis in the linear-quadratic case and for the generic driftless case.

Obtention of upper bound to the commutative case with drift. Noether's theorem for: nonconservative dynamical optimal control systems, invariant functionals containing compositions, and fractional variational problems. Existence, uniqueness, regularity, and asymptotic behavior of solutions for problems of thermistor-type in oil engineering.

Activities

This part of the report will allow you to describe general activities of the Unit that are aimed at integrating the research of various groups of which multidisciplinary and/or trans-disciplinary activities are of particular relevance. The second part is aimed to describe work that the Unit does to extend beyond the scientific environment and to reach the general public, schools or other forms of engaging the public in the work of the Unit.

1. Integrative/multidisciplinary activities during the year of 2007 (3000 ca.)

Special activities that aim to carry out research across disciplines.

The list of weekly seminars held by CEOC includes the following: "Computational Approach to Essential and Nonessential Objective Functions in Linear Multicriteria Optimization", A. Malinowska, Bialystok Technical University; "Programação com múltiplas funções objetivo", C. H. Antunes, Universidade de Coimbra; "On generalized differential quotients and invariance of differential inclusions and Remarks on generalized series on time scales", E. Girejko and D. Mozyrska, Bialystok Technical University; "Partição e geração de colunas e tópicos relacionados: aplicação ao problema de corte", J. Valério de Carvalho, Universidade do Minho; "Limites de difusão hidrodinâmicos para equações cinéticas de transporte", M. Portilheiro, Universidade de Coimbra; "Inclusões diferenciais vectoriais, noções de convexidade em sentido generalizado e aplicações a problemas de minimização não quasiconvexos", A. Ribeiro, Universidade Nova de Lisboa; "Área interior em gestão florestal: um modelo de programação inteira", M. Constantino, Universidade de Lisboa; "How to determine the conjugacy of two hyperbolic operators using multidimensional continued fractions", O. German, Moscow State University; "Integração dos Problema de Rotas para Veículos com Janelas Temporais e Empacotamento de Contentores", A. Moura, Instituto Politécnico de Leiria; "Problemas de Afectação com Preferências", A. Tomás, Universidade do Porto; "Ferramentas de modelação em optimização não linear", I. Vaz, Universidade do Minho; "Ontologias e Topic-Maps: extracção, validação e navegação - aplicações, o NAVMAP", P. Henriques, Universidade do Minho; "Singularidades do proveito médio óptimo para estratégias estacionárias", C. Moreira, Universidade do Porto.

We have received visits of the following foreign researchers: Agnieszka B. Malinowska, Bialystok Technical University, Bialystok, Poland, January 4-18, May 1-10 and December 15-22; Dorota Mozyrska and Ewa Girejko, Bialystok Technical University, Bialystok, Poland, November 18-24; Dieter Rautenbach, Technische Universität Ilmenau, Germany, 19 July - 29 July, 2007.

2. Outreach activities during the year of 2007 (3000 ca.)

Science and Society/general public/schools, etc.

The members of CEOC have participated in several activities related with the university open week to the society, designated as science and technology week. We participate also in radio programs about the difficulties, challenges and importance of mathematics nowadays and also celebrating special days like the day of Pi (March, 14). We have organized or collaborate in the organization of the following international meetings: 4th Iberian Workshop on Computational Geometry, Aveiro, February 7-9; Workshop on Mathematical Control Theory and Finance, Lisbon April 10-14, 2007; 3th CEOC/CIMA-UE joint meeting on Optimization and Optimal Control, Évora, October 12-13.

The School for Complementary Education in Mathematics project (EECM) has being developed by a team which includes several CEOC members (Rosa Amelia Martins (EECM coordinator), Alena Aleksenko, Evgeny Lakshtanov, Liliana Costa and Paula Carvalho). The EECM has three components: Experimental Circle of Mathematics (CEM), alphaMat and Summer Courses (CurVe).

CEM: In 2007 there were 6 groups of children working on a weekly basis, with about 80 children in total. One had its activities in a primary school (1st cycle of basic school) and involved about 40 students and teachers from that school. Currently the team is also working with children from 6 pre-school facilities and their teachers. In total, about 200 children are involved in these activities.

There were singular activities with children from 5 more pre-school facilities, which invited EECM for these visits. Earlier in the school year, EECM was invited to participate in meetings with teachers from all 4 schools from Aveiro's Group of 1st Cycle Basic Schools, where the project was presented and support was provided in the form of ideas and materials available at EECM's website, <http://eecm.mat.ua.pt>. About 80 children from primary schools from Oporto, Feira and Coimbra, and 90 children from Aveiro's schools made visits to EECM. Other mathematical activities were organized for 30 children and youths from a local basketball team.

There were also 6 workshops in Mathematics for parents, educators and teachers, some of them with several sessions.

alphaMat: EECM was invited to visit 8 Basic and High Schools where problem solving sessions were promoted both for students and teachers. Students from 15 Basic and High Schools from the north part of the country visited EECM. Currently, there are about 300 participants enrolled in activities at EECM's website (<http://eecm.mat.ua.pt>), working on problem solving from alphaMat.

Curve: Two Summer Courses were organized as part of the 2007 Summer Academy of the University of Aveiro, with a participation of about 50 students from all the country.

EECM also took part in 2 national meetings of Basic and High School Teachers, the XII ENEC 2007 (National Meeting of Sciences Teaching) and AveiroMat'2007, a Regional Meeting of Mathematics Teachers.

General Indicators

This section is a simple summary table describing the total number of PhD researchers within the Unit along time, as well as the total number of completed Masters and PhDs during the year of 2007

	2007
N° of Researchers (FTE)*	19
Masters Completed in the Period	7
PhDs Completed in the Period	1

* Full Time equivalent researcher refer exclusively to PhDs. 1PhD with equal of more than 20% dedicated to research in the Unit is equal to 1.0 FTE.

Research Groups

In this last section of the report you have the names of each Research Group and the Principal Investigators that were proposed to the period 2007-2010 period. You have to confirm whether the Group was part of the Unit during 2007 or insert the Research Groups that made up the unit, if they are not present on this list. Once the table is completed each individual Research Group can start filling in their individual form by pressing on the group's name.

By following the link in the groups name you will be able to access the individual form of the group.

To remove a given group you need to select the checkbox and press "-REMOVE"(4).

Group:	Principal Investigator
Control Theory Group RG-MATH-Centro-Aveiro-602-1815	Delfim Fernando Marado Torres
Optimization, Graph Theory and Combinatorics RG-MATH-Centro-Aveiro-602-1810	Domingos Moreira Cardoso
Computability and Algorithms RG-MATH-Centro-Aveiro-602-1812	Maria Rosália Dinis Rodrigues

Group Description

Please confirm here the name of the group, the Host Institution in which the Principal Investigator is located, four Key words that best describe your work and finally in concise form indicate main sources of funding for the research of your group. Include all types of funding, like FCT projects, FCT Base, as well as funding from other institutions. You should indicate an approximate amount in EUROS, and the source to which the funds apply.

1. Group Name/Designation

Control Theory Group

(RG-MATH-Centro-Aveiro-602-1815)

2. Principal Investigator

Delfim Fernando Marado Torres

3. Location of Group (Host Institution)

Universidade de Aveiro

4. Keywords

calc. of variat. | mot. appli. & c. | min. resist. & r. | nonlinear cont.

5. Funding, source, dates (1000 ca.)

FCT Base

January - December 2007.

Funding: 39 942,25 Euros.

2007-2010, Optimization of Newtonian resistance for non-convex bodies, FCT PTDC/MAT/72840/2006 (60 000 Euro)

Coordinator: A. Plakhov; 60 000 Euro.

PI & Researchers

In this section indicate first the PhD researchers that make up the group by selecting them from the list of researchers integrated in the Unit. In the second section you can indicate whether other PhD researchers not integrated in the Unit collaborate with group by typing their public key. Finally in the last part you should include all the non-PhDs members of the group.

1. Researchers in the Group (**PhD. Only**) (1)

Alexandre Plakhov (Professor Convocado)

Delfim Fernando Marado Torres (Professor Associado)

João Pedro Antunes Ferreira da Cruz (Professor Auxiliar)

Lakshatanov Evgeny (Não aplicável (bolseiro))

Manuel Cidraes Castro Guerra (Professor Auxiliar)

Natália da Costa Martins (Professor Auxiliar)

Sidi Ammi Moulay Rchid (Não aplicável (bolseiro))

Vítor Manuel Carvalho das Neves (Professor Associado)

2. Other Researchers in the Group (**PhD.**) (2)

Agnieszka Barbara Malinowska (Professor Auxiliar)

Martin Bohner (Professor Associado)

Olena Mul (Professor Associado)

TRELAT Emmanuel Pierre Gilles (Professor Catedrático)

3. Other Researchers in the Group (**non PhD.**) (2)

Alena Aleksenko (Não aplicável (bolseiro))

Cristiana Joao Soares da Silva (Não aplicável (bolseiro))

Gastão Silves Ferreira Frederico (Assistente)

Paulo Duarte Ferreira Gouveia (Professor-Adjunto)

Ricardo Miguel Moreira de Almeida (Assistente)

Rui Alexandre Cardoso Ferreira (Não aplicável (bolseiro))

Objectives & Achievements

In this section please describe the main objectives and achievements of the group during the 2007 period . If the number of characters is more than the permitted maximum you will not be able to complete the form.

1. Objectives (2000 ca.)

Construct a self-consistent theory of rough bodies and generalize existing (two-dimensional) results to higher dimensions. Study problems of optimal resistance for rough bodies (in higher dimensions); to get new families of exactly solvable Monge-Kantorovich problems. Solve the inverse problem of resistance: given the distribution of pressure of a non-isotropic rarefied flow, determine its structure (flow density over directions). Further examine analytical questions related to the newly-introduced vector-valued Monge-Kantorovich problem. Expand the theory to the case of "not so rarefied" flow and to determine connections with the Boltzmann equation. Study the Magnus effect in three dimensions. Application of the notion of mu-differentiability to optimization problems and nonstandard treatment of critical points. Development of numerical tools for optimal control problems and numerical simulations of minimal and maximal resistance problems. To study the degree of singularity for generic (noncommutative) control-affine optimal control problems and its relation with the generalized optimal synthesis. Obtain existence results for singular optimal control problems in various classes of generalized controls. Study of optimal reinsurance strategies under more sophisticated stochastic models, various risk structures and optimality criteria; and investigate the geometric structure of optimality conditions. To prove generic properties of optimal reinsurance strategies under nonlinear constraints. Develop a computational approach to essential and nonessential objective functions in multicriteria optimization. To develop the theory on fractional problems of the calculus of variations and optimal control. Obtain constants of motion for non-differentiable

quantum variational problems. Establish a connection between variational symmetries of the problems of the calculus of variations on time scales and the existence of conservation laws along the respective delta-extremals. To obtain new necessary optimality conditions for problems of the calculus of variations and optimal control on time scales, via delta, nabla and diamond derivatives. To develop the theory of inequalities with explicit estimates on generic time scales.

2. Main Achievements (2000 ca.)

Maximization of the mean resistance for two-dimensional shapes, both analytically and numerically. Possible applications of these shapes

in retroreflectors design were justified. Newton's problem of minimal aerodynamic resistance in the case of rotationally symmetric, but nonconvex bodies: the infimum in this problem is not attained; there was explicitly found a sequence of bodies minimizing the resistance; the shape of these bodies and the value of minimal resistance were compared with the corresponding results for previously studied cases of symmetric bodies. New notion of a rough body. To each rough body corresponds a measure describing the law of billiard scattering on the body. Classification theorem for laws of scattering on rough bodies, allowing to solve various problems of least aerodynamic resistance by reducing them to special problems of Monge-Kantorovich. The effect of trajectory deflection of a spinning rough circle moving in a 2D rarefied medium. We studied, both analytically and numerically, the reverse Magnus effect caused by multiple elastic collisions by reducing it to a vector-valued Monge-Kantorovich problem. Explicit representation of the Green function for the Helmholtz and Laplace exterior equations. Existence and Lipschitzian regularity of relaxed minimisers for optimal control problems satisfying suitable coercivity assumptions without convexity. Asymptotics of minimizing sequences for control-affine optimal control problems; the degree of singularity and its relation to the geometry of generalized optimal synthesis was fully characterized in the linear-quadratic case and for the generic driftless case. An upper bound was obtained for the commutative case with drift. Existence and uniqueness of optimal reinsurance strategy for the adjustment coefficient and the expected utility criteria and generic premium calculation principles.

Noether's theorem for: nonconservative dynamical optimal control systems, invariant functionals containing compositions, and fractional variational problems. Existence, uniqueness, regularity, and asymptotic behavior of solutions for problems of thermistor-type resulting from the modeling of oil engineering.

Productivity

This section refers to the research output of the group during the 2007. From the list provided choose the items that you want to complete and a field will appear. Follow the instructions provided in each item. You are not required to fill in all the items only those for which your group has output. Please note that for peer reviewed publication you must include impact factor and number of citations. If these indicators are not available you must include that publication as **Other Publications**.

Publications in peer review Journals (3000 ca.)

(Up to a max of 10. Always indicate at the end of the citation, impact factor of the journal (IF=) and number of citations (n° C=). Give title and full citation in original language. DO NOT translate)

- [1] W. de Roeck, E.L. LAKSHTANOV. Total cross section exceeds transport cross section for quantum scattering from hard bodies at low and high wave numbers, *J. Math. Phys.* (IF = 1.018) 48, 013501 (2007), n° C = 0.
- [2] R.A. El-Nabulsi, D.F.M. TORRES. Necessary Optimality Conditions for Fractional Action-Like Integrals of Variational Calculus with Riemann-Liouville Derivatives of Order (α, β) , *Math. Meth. Appl. Sci.* (IF = 0.473) Vol. 30, Issue 15, pp. 1931-1939, 2007, n° C = 0.
- [3] G.S.F. FREDERICO, D. F. M. TORRES. A formulation of Noether's theorem for fractional problems of the calculus of variations, *J. Math. Anal. Appl.* (IF = 0.758) 334 (2), 2007, pp. 834-846, n° C = 1.
- [4] E.L. LAKSHTANOV. Short-wave limit of scattering amplitude in inhomogeneous medium, *Russ. Mat. Surv* (IF = 0.303), 62:4, pp. 163--164, 2007, n° C = 0.
- [5] A. PLAKHOV, P. GOUVEIA. Problems of maximal mean resistance on the plane, *Nonlinearity* (IF = 1.288), vol.20, 2271-2287 (2007), n° C = 0.
- [6] M.R. SIDI AMMI, D.F.M. TORRES. Necessary Optimality Conditions for a Dead Oil Isotherm Optimal Control Problem, *J. Optim. Theory Appl.* (IF = 0.633) Vol. 135, Nr 1, 2007, pp. 135-143, n° C = 0.
- Other publications (3000 ca.)
(Include only Books, chapters or full papers published in conference proceedings up to max of 10. Give title and full citation in original language)
- [1] R. ALMEIDA. A nonstandard characterization of regular surfaces, *Balkan J. Geom. Appl.* (12) no. 2, pp. 1--7.
- [2] P.A.F. CRUZ, D.F.M. TORRES. Evolution strategies in optimization problems, *Proc. Estonian Acad. Sci. Phys. Math.* (2007), 56(4), 299--309.
- [3] R.A.C. FERREIRA, D.F.M. TORRES. Remarks on the calculus of variations on time scales, *Int. J. Ecol. Econ. Stat.*, Vol. 9, no. F07, 2007, pp. 65--73.
- [4] G.S.F. FREDERICO, D. F. M. TORRES. Conservation laws for invariant functionals containing compositions, *Appl. Anal.* 86 (2007) no. 9, pp. 1117--1126.
- [5] M. GUERRA. Generalized solutions for singular optimal control problems. *Sovrem. Mat. Fundam. Napravl.* 27 (2007), 60--184.
- [6] N. MARTINS, V. NEVES. Nonstandard Palais-Smale conditions, *The Strength of Nonstandard Analysis*. Berg, Imme van den; Neves, Vitor (Eds.), Springer, Vienna, 2007, pp. 271--285.
- [7] M.R. SIDI AMMI, D.F.M. TORRES. Regularity of solutions for the autonomous integrals of the calculus of variations. In the book "Differential Equations, Chaos and Variational Problems", Series: Progress in Nonlinear Differential Equations and Their Applications, Vol. 75, Birkhauser, 2007, pp. 407--414.

[8] M.R. SIDI AMMI, D.F.M. TORRES. Existence and Regularity of Optimal Solution for a Dead Oil Isotherm Problem, Appl. Sci. 9 (2007), pp. 5--12. n° C = 1 (Scopus)

[9] M.R. SIDI AMMI, D.F.M. TORRES. Existence of Positive Solutions for Non Local p-Laplacian Thermistor Problems on Time Scales, J. Inequal. Pure and Appl. Math. 8(3) (2007), Art.69, 10pp.

[10] D.F.M. TORRES, E. TRÉLAT (Eds.) Special Issue on: Control Applications of Optimisation - control and aeronautics, optimal control, control of partial differential equations, Int. J. Tomogr. Stat. 5, no. W07, 2007 (179 pages).

Organization of conferences (2000 ca.)

Workshop on Mathematical Control Theory and Finance. Co-organized by CIM, CEOC and CEMAPRE. ISEG/TULisbon, April 10-14, 2007.

<http://srv-ceoc.mat.ua.pt/conf/wmctf2007/> (Manuel Guerra was Chairman of the Organizing Committee; Delfim F. M. Torres was member of the Organizing Committee).

10a edição do Concurso/Encontro Nacional de Programação em Lógica e Funcional CeNPLf'07, Universidade de Aveiro, de 4 a 6 Maio de 2007.

<http://ceoc.mat.ua.pt/cenplf2007/> (João Pedro Cruz and Delfim F. M. Torres were members of the Organizing Committee and members of the Scientific Committee).

Internationalization (2000 ca.)

(Collaborative publication, Research, Graduate Training Networks or other forms of participation of the Research Group at the international level)

In 2007, cotg members have been authors of papers in international journals with co-authors from: Belgium, France, Italy, Korea, Morocco, Poland, and Ukraine.

Three post-docs, from Ukraine, Morocco, and Russia, were coordinated by the cotg.

Members of cotg participated during 2007 in several international conferences and workshops in Europe, Canada, and Russia.

Delfim F. M. Torres gave a plenary talk at the International Conference on

"Applied Mathematics, Technology and Environment", that took place May 2007, in Tanger, Morocco.

During 2007, members of cotg served as Editors for several international journals (IJAMAS, AJMAA, IJMS and SJI); were referees for several papers submitted to different international journals; and have written several reviews for MathSciNet and Zbl databases.

Cotg members were invited to Scientific Committees of several International Conferences.

Alexander Plakhov took also part in a jury of a PhD defence in Latvia.

In 2007, 5 foreign mathematicians, from Russia, Poland and Italy, visited cotg members.

Cotg members have also done several working visits to foreign universities and research institutions in 2007, including: University of Toronto, Canada; Riga Technical University, Latvia; University of Florence, Italy; Radon Institute for Computational and Applied Mathematics, Austria; University of Cape Verde, Cape Verde; Bialystok Technical University, Poland.

Delfim F. M. Torres was Invited Professor (Professeur Invité) for one month at the Université de Pau et des Pays de l'Adour, France; Alexander Plakhov is, since October 2007, invited to the University of Wales, UK.

Talks:

A.Plakhov and T:Tchemisova “An Example of multiobjective optimization in mechanics”, “Euro XXII”, Prague, July 8-11, 2007.

Group Description

Please confirm here the name of the group, the Host Institution in which the Principal Investigator is located, four Key words that best describe your work and finally in concise form indicate main sources of funding for the research of your group. Include all types of funding, like FCT projects, FCT Base, as well as funding from other institutions. You should indicate an approximate amount in EUROS, and the source to which the funds apply.

1. Group Name/Designation

Optimization, Graph Theory and Combinatorics

(RG-MATH-Centro-Aveiro-602-1810)

2. Principal Investigator

Domingos Moreira Cardoso

3. Location of Group (Host Institution)

Universidade de Aveiro

4. Keywords

Operations Re | Combinat. Opt | Graph Theory | Spectral Grap

5. Funding, source, dates (1000 ca.)

FCT Base

January - December 2007.

Funding: 37 483,06 Euros.

PI & Researchers

In this section indicate first the PhD researchers that make up the group by selecting them from the list of researchers integrated in the Unit. In the second section you can indicate whether other PhD researchers not integrated in the Unit collaborate with group by typing their public key. Finally in the last part you should include all the non-PhDs members of the group.

1. Researchers in the Group (**PhD. Only**) (1)

Agostinho Miguel Mendes Agra (Professor Auxiliar)

Carlos Jorge da Silva Luz (Professor Coordenador)

Domingos Moreira Cardoso (Professor Catedrático)

ENiDE CASCAIS SILVA ANDRADE MARTINS (Professor Auxiliar)

Maria Cristina Saraiva Requejo Agra (Professor Auxiliar)

Paula Cristina Roque da Silva Rama (Professor Auxiliar)

Tatiana Tchemisova Cordeiro (Professor Auxiliar)

2. Other Researchers in the Group (**PhD.**) (2)

Deolinda Maria Lopes Dias Rasteiro (Professor-Adjunto)

Jorge Manuel Sá Esteves (Professor Auxiliar)

Maria Paula Lopes dos Reis Carvalho (Professor Auxiliar)

Rosa Amélia Baptista Ferreira Soares Martins (Professor Auxiliar)

3. Other Researchers in the Group (**non PhD.**) (2)

Andjelic Milica (Outra)

Maria de Fátima Moreira da Silva Pacheco (Professor-Adjunto)

Nuno Miguel dos Santos Baeta (Assistente)

Sofia Alexandra Marques Jorge Pinheiro (Assistente Convidado)

Objectives & Achievements

In this section please describe the main objectives and achievements of the group during the 2007 period . If the number of characters is more than the permitted maximum you will not be able to complete the form.

1. Objectives (2000 ca.)

Graph spectra: Minimum adjacency eigenvalue of graphs (in particular, when it is non-main). Graphs with eigenvalues determined by (k,t) -regular sets. Recognition of (k,t) -regular sets, using graph eigenvalues and graph eigenvectors. Spectral implications in graphs with induced d -regular subgraphs and its generalizations to d -degenerated graphs (that is, graphs where every induced subgraph has a vertex of degree less than d). Determination of spectral upper bounds on the size of k -regular induced subgraphs. Study of the spectra of some graphs like weighted rooted trees and study of polytopes associated to trees.

Combinatorial optimization: designing of algorithms to approximate the maximum stable set in large graphs; recognition of graphs with convex quadratic stability number. Approximation algorithms for the minimum diversity management problems and related combinatorial results. Study the polyhedra associated with basic mixed integer sets; extended formulations for knapsack tree problems; improve algorithm's efficiency for the optimal diversity management problem. Study the polyhedra associated with basic mixed integer sets; extended formulations for knapsack tree problems. Models for special cases of the diameter-constrained minimum spanning tree problem; extended formulations for knapsack tree problems.

Continuous optimization: Continuous optimization techniques applied to combinatorial problems (upper bounds on the size of k -regular induced subgraphs by convex quadratic programming; recognition of graphs for which this upper bound is tight). Study of the convex semi infinite programming (SIP) problems, mainly the new optimality conditions that do not demand constraint qualifications. Numerical simulation for the Newton problem of minimal resistance of a nonconvex body moving in a rarified medium aimed to construction of the convex hull of the set of the resistance' distribution. Study of the reverse Magnus effect appearing in the cases of movement in extremely rarefied media.

Combinatorics and related results: to finish the book "Matemática Discreta: combinatoria, teoria dos grafos e algoritmos"; efficient edge subsets in regular and strongly regular graphs.

2. Main Achievements (2000 ca.)

Graph spectra: Several alternative characterizations of graphs with (k,t) -regular sets were published. Extensions to the size of k -regular induced subgraphs of several previous results obtained for the particular case of 0-regular induced subgraphs were achieved (joint work with Marcin Kaminski and Vadim Lozin from Rutgers, USA). A generalization of the Hoffman bound on the stability number of regular graphs was obtained for graphs with non-main least eigenvalue. For a graph G like weighted rooted trees we gave a complete characterization of the eigenvalues of the Laplacian matrix and adjacency matrix of G and we derive an upper bound on the largest eigenvalue of a graph defined by a weighted tree and a weighted triangle attached, by one of its vertices, to a pendant vertex of the

tree.

Combinatorial optimization: polyhedral results on a mixing mixed integer set were obtained; derived exact linear formulations for knapsack tree sets; new algorithm results concerned with a problem related with the optimal diversity management problem. Tight models for the special cases of the diameter-constrained minimum spanning tree problem with $D=2$ and 3; derive exact linear formulations for knapsack tree sets. A heuristic for the stability number of a graph that combines the Lovász theta number formulation based on convex quadratic programming with a tabu search technique was developed.

Continuous optimization: extension of the optimality results obtained for convex SIP problems with continuum of constraints with a finite active set to the case of an infinite active set. New optimality criterion for convex SIP problems with analytical constraints functions without CQ. Comparison of the criterion with the existent optimality conditions.

Combinatorics and related results: the book "Matemática Discreta: combinatoria, teoria dos grafos e algoritmos" written by Domingos M. Cardoso, Jerzy Szymanski and Mahammad Rostami was finished (with the exception of the parts devoted to exercises). We gave an interpretation of the vertices and edges of the acyclic Birkhoff polytope, $\frac{\mathfrak{T}}{n} = \Omega_n(T)$, where T is a tree

with n vertices and we generalize a recent result on the diameter of the graph $G(\frac{\mathfrak{T}}{n})$.

Productivity

This section refers to the research output of the group during the 2007. From the list provided choose the items that you want to complete and a field will appear. Follow the instructions provided in each item. You are not required to fill in all the items only those for which your group has output. Please note that for peer reviewed publication you must include impact factor and number of citations. If these indicators are not available you must include that publication as **Other Publications**.

Publications in peer review Journals (3000 ca.)

(Up to a max of 10. Always indicate at the end of the citation, impact factor of the journal (IF=) and number of citations (n° C=). Give title and full citation in original language. DO NOT translate)

- [1] D. M. Cardoso and P. Rama. Spectral results on regular graphs with (k, τ) -regular sets. *Discrete Mathematics* (IF=0.347), 307, pp. 1306-1316, 2007, n° C=0.
- [2] D. M. Cardoso, C. Delorme, P. Rama. Laplacian eigenvectors and eigenvalues and almost equitable partitions”. “*European Journal of Combinatorics*. (IF=0.710), 28, pp.665-673, 200, n° C=0.
- [3] D. M. Cardoso and P. Rama. Spectral results on graphs with regularity constraints. *Linear Algebra and Its Applications* (IF=0.585), 423, pp.90-98, 2007, n° C=0.
- [4] D. M. Cardoso, M. Kaminski and V. Lozin. Maximum k -regular induced subgraphs. *J. Comb. Optim.* (IF=0.615), 14, pp. 455-463, 2007, n° C=0.
- [5] A. Agra and M. Constantino. Lifting two-integer knapsack inequalities, *Mathematical Programming* (IF=1.117), 109 (1), 115-154, 2007, n° C=0.
- [6] C. J. Luz. A characterization of Delsarte’s linear programming bound as a ratio bound, *Linear Algebra and its Applications* (IF=0.585), 423. pp. 99–108, 2007, n° C=0.
- [7] T. V. Tchemisova. Abnormal Extrema in Non Linear Programming Problem Optimality Conditions and Rigidity, *EJOR* (IF=0.918), 182, Issue 3, pp. 1233-1242, 2007, n° C=0.

Other publications (3000 ca.)

(Include only Books, chapters or full papers published in conference proceedings up to max of 10. Give title and full citation in original language)

- [1] O. I. Kostyukova, T. V. Tchemisova, S. A. Yermalinskaya. Explicit Optimality Conditions for the Problems of Convex Semi-Infinite Programming, *Dolkady of National Academy of Sciences of Belarus*, 2007 (in russian).
- [2] O. I. Kostyukova, T. V. Tchemisova, S. A. Yermalinskaya, An Implicit Optimality Criterion for Problems of Convex Semi-Infinite Programming, *Vestnik Grodnenskogo Gosydarstvennogo Universiteta*, Ser. 2, 2, pp. 78-84, 2007 (in russian).
- [3] L. Gouveia, T. Magnanti and C. Requejo. Tight models for special cases of the diameter-constrained minimum spanning tree problem. *Proceedings of the International Network Optimization Conference, INOC2007*. 2007.
- Master and Ph.D. thesis completed (3000 ca.)
- [1] Susana Azevedo. Conjuntos convexos e algoritmos para construir invólucros convexos, *MSc Thesis at UA*, June 2007, (co-supervisor T. Tchemisova);
- [2] Carlos Rocha. On the Applications of the algorithms and methods of Semi-Infinite Programming, *MSc Thesis at UA*, December 2007,(supervisor T. Tchemisova);
- [3] Eulália Maria Mota Santos. Problema da Árvore de Suporte de Custo Mínimo com Restrições de Diâmetro. *MSc Thesis at UA*, June 2007 (supervisor C. Requejo);
- [4] Aldina Maria Pedro Soares. Reciclagem e Políticas Públicas: O Caso da Reciclagem de Plásticos do Sector Automóvel. *MSc. Thesis at IST*, December 2007 (co-supervisor

C. Luz).

Organization of conferences (2000 ca.)

D. Cardoso, T. Tchemisova: program committee of "Optimization 2007", Porto, July 22-25, 2007

Tatiana Tchemisova: organization of session and tutorial course in "EURO XXII", Prague, July 8-11, 2007;

Tatiana Tchemisova (together with colleagues from Evora) 3th CEOC-CIMA-UE joint meeting in Optimization and Optimal Control, Evora, October 12-13, 2007.

Internationalization (2000 ca.)

(Collaborative publication, Research, Graduate Training Networks or other forms of participation of the Research Group at the international level)

The members of OGTC have been authors of papers in international journals with co-authors from Belarus, France, Russia and USA.

Invited presentations at foreign institutions:

D. M. Cardoso, Convex quadratic programming techniques on graphs and related spectral results. Seminar on Applied and Industrial Mathematics of the Mathematical Institute of Serbian Academy of Sciences and Arts, June 5, Belgrade.

D. M. Cardoso, Graphs whose stability number is easily determined, Conference on Graph Theory on the Occasion of the 80th Birthday of Professor Horst Sachs, March 27-30, Ilmenau.

Visits to foreign institutions: Domingos M. Cardoso has visited the Mathematical Institute of Serbian Academy of Sciences and Arts, 2-8 June, 2007, by invitation of Professors Slobodan Simic and Dragos Cvetkovic, to develop scientific cooperation within the project: "Graph theory and mathematical programming with applications in chemistry" and also the University of Adam Mickiewicz, 1-20 July, 2007, by invitation of Professor Jerzy Szymanski to develop scientific collaboration. Tatiana Tchemisova has visited in December the Institute of Mathematics of Belarusian National Academy of Sciences by invitation of Olga Kostyukova to work within the project "Mathematical Models 13".

Scientific collaborations with Sergey Savchenko from L. D. Landau Institute for theoretical Physics, Russia; Diet, Dieter Rautenbach, Technische Universität Ilmenau, Germany; Gerhard Wilhelm Weber from Institute of Applied Mathematics, Ankara, Turkey.

Talks:

A. Agra, "Lower bounds on the optimal diversity management problem" (joint work with D. M. Cardoso, J. Orestes Cerdeira and E. Rocha), Optimization 2007, Porto, July.

P. Carvalho, "Non Embeddability in Euclidean Three-space: an approach by Oriented Matroid Theory", 14th International Conference of Linear Algebra Society, Shanghai

University, China, July, 2007.

E. Martins, "On Jordan Product Problems" presented at 14th Conference of the International Linear Algebra Society at University of Shanghai, China, June 2007.

E. Martins, "Acyclic Birkhoff Polytope" (joint work with Liliana Costa and Carlos Fonseca), at Summer School on Algebra and Combinatorics, Lisbon, organized by Centro de Estruturas Lineares e Combinaórias, June 2007.

C. Requejo, "Special cases of the diameter-constrained minimum spanning tree problem" (joint work with L. Gouveia and T. Magnanti). Optimization 2007, Porto, July.

C. Requejo, "Tight models for special cases of the diameter-constrained minimum spanning tree problem" (joint work with L. Gouveia and T. Magnanti. INOC 2007. Spa, Belgium, 22-25 April. 2007.

J. Sá Esteves, "An Efficient Algorithm for Allocation of Servers to Erlang-C Systems", Optimization 2007, Porto, July.

J.Sá Esteves, "On a Bicriterion Allocation of Servers for a Multidimensional Erlang Delay System", EURO XXII, Prague, Check Republic, July, 2007.

T. V. Tchemisova, "On reduction approach in convex Semi-Infinite Programming", Optimization 2007, Porto, July.

Centro de Estudos em Optimização e Controlo (CEOC) (24-04-2008 12:09:33)

Group Description

Please confirm here the name of the group, the Host Institution in which the Principal Investigator is located, four Key words that best describe your work and finally in

concise form indicate main sources of funding for the research of your group. Include all types of funding, like FCT projects, FCT Base, as well as funding from other institutions. You should indicate an approximate amount in EUROS, and the source to which the funds apply.

1. Group Name/Designation

Computability and Algorithms

(RG-MATH-Centro-Aveiro-602-1812)

2. Principal Investigator

Maria Rosália Dinis Rodrigues

3. Location of Group (Host Institution)

Universidade de Aveiro

4. Keywords

Complexity Th

Quantum Com

Computational

Machine Learn

5. Funding, source, dates (1000 ca.)

Project: "Illumination, visibility and surveillance algorithmic problems,"

Accoes Integradas Luso-Espanholas, January 2006 - December 2007. Funding (Portuguese part): 2 400 Euros,

Coordinators: Manuel Abellanas (Spanish part, Univ. Politcnica de Madrid), A. Leslie Bajuelos (Portuguese part, Univ. de Aveiro, CEOC).

PI & Researchers

In this section indicate first the PhD researchers that make up the group by selecting them from the list of researchers integrated in the Unit. In the second section you can indicate whether other PhD researchers not integrated in the Unit collaborate with group by typing their public key. Finally in the last part you should include all the non-PhDs members of the group.

1. Researchers in the Group (**PhD. Only**) (1)

António Ferreira Pereira (Professor Auxiliar)

Antonio Leslie Bajuelos Dominguez (Professor Auxiliar)

Gladys Castillo Jordan (Professor Auxiliar)

Maria Rosália Dinis Rodrigues (Professor Associado)

2. Other Researchers in the Group (**PhD.**) (2)

No researchers found for the Research Group ...

3. Other Researchers in the Group (**non PhD.**) (2)

Ana Mafalda de Oliveira Martins (Não aplicável (bolseiro))

Inês Pereira de Matos (Não aplicável (bolseiro))

Objectives & Achievements

In this section please describe the main objectives and achievements of the group during the 2007 period . If the number of characters is more than the permitted maximum you will not be able to complete the form.

1. Objectives (2000 ca.)

1. Complexity Theory: We search for a theoretical framework for the classification of the Instances of NP-hard Problems, in terms of their computational cost.

2. Quantum Computation: Our work focuses on the development of a theoretical model for quantum computation with hybrid quantum systems, on the design of quantum arithmetic circuitry, as well as on the problem of quantum computation simulation.

3. Computational Geometry: The main goal of the Computational Geometry subgroup is the study of algorithms for visibility and illumination problems. In 2007 our work focused on the following tasks:

- The study on the number of canonical classes for a family of orthogonal polygons.

- Improvements on good illumination range algorithm with minimum range.

- Implementation of heuristics and meta-heuristics for the Minimum Vertex Guard, Maximum Hidden Set and Maximum Hidden Vertex Set problems in orthogonal polygons using CGAL.

- Conclusion of an MSc thesis that explores an implementation of an approximated algorithm to illuminate orthogonal polygons using orthogonal floodlight.

- The organization of the 4th Iberian Workshop on Computational Geometry to take place at the University of Aveiro (February 2007).

4. Machine Learning and Data Mining: our work focuses on the development of adaptive learning algorithms in data mining and its applicability in two major domains: e-learning and bioinformatics. For the e-learning domain, our focus is on the application of adaptive ML algorithms to discover the student preferences in e-learning. For bioinformatics, the goal is to develop a methodology that allows to adequately analyse and interpret the great amount of data generated by the microarray experiments with focus on the evaluation of several normalization methods.

2. Main Achievements (2000 ca.)

1. Complexity Theory: A model has been developed, based on the concepts of Algorithmic Complexity, Information Theory and Maximum Entropy Principle, for the computational evaluation of the complexity of particular problem instances.

2. Quantum Computation:

- A general theoretical model for Quantum Computation with Hybrid Quantum Systems was proposed. Under this model, we started work on the Computational Complexity

analysis of Classes of Quantum Circuits.

- Based on two classes of constant depth quantum circuits for the addition of two numbers, previously developed, we proved the existence of constant depth quantum circuits for approximating the sum of a polynomial number of numbers.
- We developed a Symbolic Quantum Computer Simulator and performed simulations of Grover's algorithm.

3. Computational Geometry:

- We continued the study of 1-good illumination of minimum range and introduced a new branch: the embracing contours.
- We introduced k-illumination as a new topic.
- We continued the study of the following NP-hard visibility problems: the Minimum Vertex Guard (MVG), the Maximum Hidden Set (MHS) and the Maximum Hidden Vertex Set (MHVS). Developed and implemented approximate algorithms for the MVG problem in orthogonal polygons and for the MHVS problem in arbitrary polygons using the CGAL system.
- We improve an anytime approximate algorithm to solve the MVG problem using orthogonal floodlights.
- We organized the "4th Workshop on Computational Geometry" in the University of Aveiro.

4. Machine Learning and Data Mining:

- We developed a unified adaptive on-line framework for learning Bayesian Network Classifiers and experimentally proved the advantages of its use, especially in those environments where it is needed to quickly adapt to changes in the learned concept.
- We developed an adaptive student model that implements adaptive ML algorithms aimed at reflecting more accurately the current student's preferences, thus allowing to improve personalization in e-learning.

Productivity

This section refers to the research output of the group during the 2007. From the list provided choose the items that you want to complete and a field will appear. Follow the instructions provided in each item. You are not required to fill in all the items only those for which your group has output. Please note that for peer reviewed publication you must include impact factor and number of citations. If these indicators are not available you must include that publication as **Other Publications**.

Other publications (3000 ca.)

(Include only Books, chapters or full papers published in conference proceedings up to max of 10. Give title and full citation in original language)

[1] A. Bajuelos, S. Canales, G. Hernández, A. M. Martins. Solving some Combinatorial Problems in grid n-ogons”, International Journal of Mathematics and Computers in Simulation, NAUN, Vol.1, Issue 1, (2007), pp 184-188.

[2] M. Abellanas, A. Bajuelos, I. Matos. Some Problems Related to Good Illumination, ICCSA 2007, Lecture Notes in Computer Science (LNCS) 4705, Springer Berlag Berlin Heidelberg (2007), Chapter: pp 1 - 14.

[3] M. Abellanas, A. Bajuelos, I. Matos. Good theta-illumination of Points, in Proc. of 23rd European Workshop on Computational Geometry, Graz, Austria, 61-64, (2007).

[4] A. Bajuelos, S. Canales, G. Hernández, A. M. Martins. Solving some Combinatorial Problems in grid n-ogons, Revetria R. (ed.) et al., Computer Science Challenges. 7th WSEAS International Conference on Applied Computer Science (ACS'07). Official conference of the World Scientific and Engineering Academy and Society (WSEAS), Venice, Italy, November 21-23, 2007, ISBN: 978-960-6766-15-2, ISSN: 1790-5117, 151-156 (2007).

[5] G.Castillo, J.Gama, A.M. Breda. An Adaptive Predictive Model for Student Modeling, in Online and Distance Learning: Concepts, Methodologies, Tools and Applications, Volume III, Chapter 2.43, Information Science Reference Pub, 2007.

[6] C.Carmona, G.Castillo, E.Millán: Discovering Student Preferences in E-Learning, in Proceedings of the International Workshop on Applying Data Mining in e-Learning, ADML-07, 2007, pp 33-43.

Master and Ph.D. thesis completed (3000 ca.)

[1] António Ferreira Pereira, "Algoritmos e Complexidade no Modelo de Computação Quântica", MSc Thesis at UA, May 2007, (supervisor Rosália Rodrigues);

[2] Ana Gonçalves: “Sobre Iluminação de Polígonos com Focos ou Reflectores em vértices”, MSc Thesis at UA, September 2007. (supervisors: Antonio L. Bajuelos and Ana Paula Tomás from University of Porto).

[3] Susana Azevedo, “Conjuntos Convexos e Algoritmos para construir Invólucros Convexos”, MSc Thesis at UA, June 2007. (supervisors: Antonio L. Bajuelos and Tatiana Tchemisova).

Organization of conferences (2000 ca.)

4th Workshop on Computational Geometry, Universidade de Aveiro, February 7-9, 2007.

Internationalization (2000 ca.)

(Collaborative publication, Research, Graduate Training Networks or other forms of participation of the Research Group at the international level)

The Computational Geometry group collaborates with: Universidad Politécnica de Madrid, Universidad de Valladolid, Universitat Politècnica de Catalunya, Universidad Pontificia de Comillas de Madrid and Universidad de Alcalá.

Several informal working meetings took place during 2007. In November, Ana Mafalda Martins and Inês Matos visited the Facultad de Matemática Aplicada of the Universidad

Politécnica de Madrid. Manuel Abellanas (Facultad de Matemática Aplicada, Universidad Politécnica de Madrid), Gregorio Hernández (Facultad de Matemática Aplicada, Universidad Politécnica de Madrid) and Santiago Canales (Universidad Pontificia de Comillas, Madrid) have visited us during 2007.

In February of 2007, we organized the “4th Workshop on Computational Geometry” (<http://srv-ceoc.mat.ua.pt/conf/wcg2007/>) in the University of Aveiro. The event took place outside of Spain for the first time and it could not have been more successful with everyone looking forward for a fifth edition in the year of 2008, again in Aveiro.

All members of this group have participated in the project: “Problems of Illumination and Visibility in Computational Geometry”, Acções Integradas Luso-Espanholas, 2006-2007, No. E-77/06.

Gladys Castilho collaborates with the Department of Languages and Computer Science School of Informatics at the University of Malaga in two main research lines: adaptive Bayesian student models and data mining in e-learning and sequence pattern mining. A PhD thesis in the first research line is in progress. The following researchers have visited the Department of Mathematics of the University of Aveiro during 2007: Cristina Carmona and Manuel Baena Garcia (3 month), David Bueno Vallejo and Rafael Morales (working meeting). Gladys Castillo was invited to present a seminar in this group at Malaga.

Talks:

Ana M. Martins: “Some Problems Related to grid n-ogons”, XII Spanish Workshop on Computational Geometry, Valladolid, Spain, June 2007.

Antonio L. Bajuelos, “Solving some Combinatorial Problems in grid n-ogons”, 7th WSEAS International Conference on Applied Computer Science (ACS'07). Official conference of the World Scientific and Engineering Academy and Society (WSEAS), Venice, Italy, November 2007.

Inês Matos, “Good theta-illumination of Points”, in Proc. of 23rd European Workshop on Computational Geometry, Graz, Austria, March 2007.

Inês Matos, “Some Problems Related to Good Illumination”, ICCSA 2007, Kuala Lumpur, Malaysia, August 2007.

Inês Matos: “Variations of Good Illumination”, XII Spanish Workshop on Computational Geometry, Valladolid, Spain, June 25-27, 2007.

Adaptive Learning Algorithms for Bayesian Network Classifiers, Universidad de Málaga, Escuela Técnica Superior de Ingeniería Informática, Dpto. Lenguajes y Ciencias de la Computación, (Junho 2007)