Fundação para a Ciência e a Tecnologia
Evaluation Research Unit 2013

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1. IDENTIFICATION OF THE R&D UNIT

1.6 Reference
297

1.1 Name of the R&D Unit
Center for Mathematics and Applications

1.2 Acronym
CMA/FCT/UNL

1.3 Coordinator
Maria Luisa Martins Macedo de Faria Mascarenhas

1.4 Multidisciplinary/interdisciplinary R&D Unit
No

Scientific areas
Mathematics (Main Scientific Area)

1.5 Profile of the R&D Unit
70% Basic research
30% Applied research and/or Experimental development

1.6 Keywords
Statistics and Risk Management
Modeling, Optimization and Algorithms
Mathematical Analysis and its Applications
Algebra, Logic and Computation

1.7 Link to the R&D Unit's page on the Internet
http://www.cma.fct.unl.pt

1.8 Unit registration options
Keep
2. INSTITUTIONS AND THEIR ROLES

2.1 Main Host Institution
Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa (FCT/UNL)

2.2 Other(s) Host Institution(s)

2.3 Participating Institution(s)

<table>
<thead>
<tr>
<th>Institution Name</th>
<th>Host Institution</th>
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2.4 Institutional commitment
The host institution, Faculdade de Ciências e Tecnologia da Universidade NOVA de Lisboa (FCTUNL), is the largest academic unit of Universidade NOVA de Lisboa, founded in 1977 and dedicated to research and higher education in Sciences, Technology and Engineering. It has ca. 7500 faculty and postgraduate students. Its mission focuses on the development of high quality, international level, research which is being implemented through a fundamental policy to strength FCTUNL as a Research Oriented School, where the quality of research is the essential support for high quality of teaching, especially of postgraduate teaching. As such, the Research Centers are fundamental instruments of FCTUNL’s strategy, to whose success it is fully committed.

FCTUNL actively promotes the research activities of its academic staff, giving it a primordial role in the periodic assessment of their individual work and allocating to it a significant part of the staff’s workload. The research activity of the academic staff, directly funded by FCTUNL through their salaries, is fully integrated in the hosted research centers and represents a substantial part of the human resources allocated to the centers. FCTUNL is based on a 30ha campus that provides all basic infrastructures required by its research centers. Basic services supporting research activities are also provided. These include all logistics and financial accounting services, an international relations office, an informatics systems support division (which also provides basic web infrastructures), a library (enabling open access publications) and an office for intellectual property and technology transfer. Regarding the latter, it is worth mentioning that FCTUNL is one of the founding partners of Madan Parque, an incubator of start-ups, which is co-located with the campus, and serves as a privileged means for technology transfer.

Though FCTUNL services already provide assistance to the management of research projects, a new office is being created for enhancing that assistance, in particular by providing additional support in the setting up of project proposal. CMA occupies an area of 135 m2 in the first floor of the building EVII, where the Department of Mathematics (DM) is located. The area is divided into two parts: a social one (30 m2), and a working one, consisting of 10 open-space offices (75 m2). The offices are equipped with personal computers and share a color laser jet multifunction and a workstation. The open-space offices are reserved for non-faculty members, visitors, postdoctoral fellows or PhD students. Faculty members have individual or double offices attributed by the DM. CMA also has a nearby office (30 m2) occupied by a science and technology manager through a grant contract, covered by the Unit budget. Administrative and technical support is also provided to CMA by the DM, which has 3 administrative staff. The DM also provides spaces and equipment.

3. R&D UNIT DESCRIPTION AND ACHIEVEMENTS

3.1 Description of the R&D Unit
The Unit underwent structural changes along the period under evaluation: until the end of 2009 members were organized into 6 teams or groups, according to the following scientific areas: Algebra (A) (Algebraic Geometry; Algebraic Topology; Combinatorics; Linear Algebra; Semigroups); Differential Equations and Numeยgers Analysis (DENA) (Biomathematics; Calculus of Variations; Dynamic Systems; Functional Analysis; Numerical Analysis; Ordinary and Partial Differential Equations); Operations Research (OR) (Modeling, Optimization and Algorithms); Actuarial and Financial Mathematics; Distribution Theory; Statistical Inference. In 2010, further to a project proposal. The Unit formed a young and very promising scientific cluster in the national scientific system.

Routine decisions are taken by the EC or by the EC together with the team coordinators. The SC takes fundamental decisions for the Unit. This is our present structure.

Each team develops fundamental research in the areas mentioned above. Applications emerge naturally from fundamental research and from the interaction among the different areas. As an example, we mention the contributions of the team A to Computation, Cryptography and Mathematical Physics; of team DENA to Biomathematics, Image Reconstruction, Mathematical Physics and Material Science; of team OR to Management, Optimization and Algorithms; of team SRM to Agriculture, Geosciences and Medicine. Most of the publications appear in leading journals.

We stress that, as a consequence of the diversity and importance of its research areas, together with their increasing interactions, the Unit forms a young and very promising scientific cluster in the national scientific system.

The main goals of the Unit during the period under evaluation were the following:

• To promote high-level scientific research in pure and applied Mathematics encouraging its national and international relevance. One of the main objectives of the Unit is to gather pure and applied teams, covering
1. Scientific achievements

Since 2008 there has been a significant improvement in the quantity and in the quality of the scientific production of the Unit, for all the areas represented (see Section 5.2).

We mention, as main scientific results:

- The Statistic and Risk Management group made clear progress in inference for Linear Mixed Models both in the foundational and applied perspectives, developing different areas, and connect them with applications.
- To create the best conditions for a scientific interchange, not only between the different groups of the Unit, but also between Mathematics and Engineering, inside and outside the Campus.
- To attract high-level PhD students and Postdoctoral fellows at national and international level.
- To promote the interest of young students, in particular in local institutions, in Mathematics and its applications.

The Unit took several courses of action in order to achieve the mentioned goals:

During 2010 the Unit implemented a scientific production criterion to define active member. The idea was to increase the number, the quality and the output of the scientific production, promoting publication in high-level WoS journals and conferences. The members that did not satisfy the criterion were invited to submit a 3 years work plan. If the plan was approved, they were considered internal collaborators. This designation also included PhD students. Internal collaborators were funded on equal basis.

The criterion was activated each year, what justifies the annual oscillation of the number of active members / internal collaborators. Through the period in assessment we had an average of 50 active members and 20 internal collaborators.

It has been our main concern to strengthen the mathematical impact of each team and of the center as a whole. In that sense we followed a strategy for the admission of new members, attracting fundamental research, we promoted publication in high quality journals and proceedings and collaborations with world leading universities.

The visibility of our research center is clearly increasing, as shows the Leiden ranking 2007-2010, especially in what concerns Operations Research and Management, where the MFCS (Mean Field Normalized Citation Score) is 3.34. Other areas, like Geosciences Multidisciplinary, Water Resources, Transportation Science &Technology, Industrial Engineering, were also high above the international mean (see section 3.2).

In order to promote scientific interchange, not only between the different mathematical areas of the Unit, but also between Mathematics and Engineering, inside the Campus, all the teams support regular seminars. We also promote informal workshops involving other departments or units inside our Campus where each investigator briefly exposes his research subjects. Some projects and internal collaborations were launched this way. With the aim of attracting high level international collaborations and exchanging Post docs and PhD students, we participated in the CMU|Portugal and in the UTA|Portugal programs in Applied Mathematics, forming PhD, hosting Postdoctoral fellows and coordinating, or participating, in related international projects and meetings.

Unit members coordinated 6 international projects, 2 of them with EUA, 1 with Germany, 1 with Spain and 2 with Brazil.

Finally, in order to promote the interest of young students in Mathematics and its applications, we support, organize or collaborate in the following regular outreach activities directed to

- High school honor students/university students:
  3. Tutoring of students in the program Novos Talentos em Matemática (since 2008), sponsored by Fundação Calouste Gulbenkian.
  4. In 2013, members of the Unit founded the first Iberian SIAM student Chapter. The Chapter aims communication and exchange of ideas between students from different branches of Science and Engineering, potentiating interdisciplinary scientific work. http://www.siam.org/students/chapters/current.php

- Basic/high school students:
  6. DiMat (from 2008), several activities for high schools students and their teachers, like exhibitions, series of conferences or visits to schools. https://sites.google.com/site/dimatfct/

- General public:
  8. Television broadcasting Isto é Matemática (from 2013). Directed and presented by one of our members. Sponsored by Sociedade Portuguesa de Matemática and the private television channel SIC Notícias. https://www.facebook.com/istoematematica

32. Major achievements

1. Scientific achievements

Since 2008 there has been a significant improvement in the quantity and in the quality of the scientific production of the Unit, for all the areas represented (see Section 5.2).
• The Algebra and Logic group (former Algebra, 8 integrated members): published 46 papers in highly reputed international journals, such as Duke Math. J., Compos. Math., Adv. Math., participated in 6 projects funded by FCT/MCTES, one of which led by a member of the group; (co-)organized 3 international conferences, one of which hosted by CMA; a PhD thesis, supervised by a member, was completed.

• The Analysis group (formerly Differential Equations and Numerical Analysis, around 12 members) started the period 08/12 as a younger team and gained seniority. Members of the team led several national and international projects, published an average of 4 papers per member in peer-reviewed journals, supervised 2 PhD thesis and 2 post-docs.

• The 7 members of the Operations Research group obtained their PhD between 2002 and 2007. During 08-12, they published 23 papers in peer-reviewed international journals, 10 book chap., 18 papers in conf. proceedings, 2 ed. books, 5 software codes. Supervised 1 PhD and 7 MScs. Hosted the ICCOPT 2013 conference (500 part) and a Summer School on Global Optimization (200 part). One paper was awarded the Best EJOR paper in Theory and Methodology category.

• The Leiden ranking 2007-2010 gives the following Mean Field Normalized Citation Score (MFCS) to the contributions of our Unit in the following fields (level 1 corresponds to the world average): Operations Research & Management: 3.34 Water Resources: 2.57 Geosciences Multidisciplinary: 2.57 Transportation: 2.45 Transportation Sc & T: 2.45 Industrial Engineering: 2.16 Civil Engineering: 1.69 Automatic & Control Systems: 1.62 Computational Science, Software Engineering: 1.48

2. Increment of funding

Members of the Unit were/are leaders of 11 scientific projects (5 national and 6 international) corresponding to a total funding of around 320 K€, of a contract with a bank (50 K€) and of a long-term scholarship (2,8 K€) (see Section 4.1).

Recently, 2 other national projects (Projetos Exploratórios IC&DT) were approved, corresponding to a total amount of 50 K€.

3. International collaborations

Several collaborations were consolidated or are being launched. The most important ones are:

• In the scope of the program CMUPortugal in Applied Mathematics our Unit co-supervised a successful PhD student (2011) and hosted a Postdoctoral fellow (2011-2012).

• We are successfully negotiating the collaboration with Universidade Fluminense, Brazil, and with Carnegie Mellon University, USA, for our future PhD program.


Postdocs: C. Kreisbeck (2011-12); O. Daniilkin (2012-13); P.C. Rodrigues (2012-13); X Lu (2013-14).


As his contract will start in January 14, A.J. Cain does not integrate yet the list of internal collaborators.

5. Prizes and awards

G. Tabuada: prize Programa de Estímulo à Investigação 2008 from Fundação Calouste Gulbenkian, for the project Combinatória finita de DG-categorias de Calabi-Yau e Motivos não-comutativos.

M.L. Afonso: prize from Instituto de Seguros de Portugal for the best PhD dissertation in Mathematics Applied to Economy and Management 2008, entitled Evaluation of ruin probabilities for surplus processes with credibility and surplus dependent premiums.

M.B. Carvalho: 2011 Young Researcher Award, Section of Risk Analysis, by the American Statistical Association-best paper award 2010.


J. T. Mexia, C. Nunes, D. Ferman and E. Moreira: Best Paper Award at the International Conference on Applied Mathematics, Simulation, Modelling (ASM’11), held in Corfu Island, Greece, 14-16 July, with the work entitled Orthogonal Fixed Effects ANOVA with Random Sample Sizes.

M.B. Carvalho: 2011 Young Researcher Award, Section of Risk Analysis, by the American Statistical Association.

P. C. Rodrigues: Young Scientists Awards for the Best Communication in MAT TRIAD 2011.

F. Chalub: 5-years grant from FCT, to focus on his research, the interface between mathematics and biology.


R. Martins (3 awards): • Selected as one of the 100 more influential Portuguese 2012-2013, by the periodic Expresso, for its TV broadcasting program Isto é Matemática.

• Homenagem Especial VerCiência 2013 by the 19th International Exhibition of Science in TV, 21-27 October 2013, Rio, Brazil.

• Ciência Viva Montepio Media 2013, Lisbon, 24 Nov 2013, by the TV broadcasting program Isto é Matemática.

6. Conferences and meetings

The Unit organized and sponsored 20 international conferences / meetings, 10 of which took place in our Campus.


8. First Iberian SIAM Student Chapter, founded by Unit members in 2013.
showed, answering a question of Fields medalist E. Zelmanov, that Plactic monoids of finite rank are biautomatic.

(1) Malheiro obtained results for some classes of rewriting systems and its associated monoids; in particular he

Theory (1), Finite Fields (2), Logic (3), Algebraic and Differential Geometry (4):

Debrecen, Rev Symb Log, Semigroup Forum, Theor Comput Sci. They pursued research in Semigroup/Automata


category prediction using loglinear models, Journal of Hydrology, 354 (1-4), 116-130, IF = 2.964, Times 

Cited: 29

Lima, A.T., Rodrigues, P.C. and Mexia, J.T. (2010), Heavy metal migration during electroremediation of 

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Ferreira, R. and Fonseca, I. (2012), Reiterated homogenization in BV via multiscale convergence, SIAM 


L. N. Vicente and A. L. Custódio (2012), Analysis of direct searches for discontinuous functions, 
Mathematical Programming, 133, 299-325, IF = 2.090, Times Cited: 3

Dias, J. P., Figueria, M. and Oliveira, F. (2010), Well-posedness and existence of bound states for a 
coupled Schrödinger-gKdV system, Nonlinear Analysis: Theory, Methods & Applications, 73 (8), 2686- 
2698, IF = 1.640, Times Cited: 2

F.A.C.C. Chalub and M.O.Souza (2009), A non-standard evolution problem arising in population genetics, 

During 2008-12 these new members published 6 book-chapters and 32 papers in international peer-reviewed 
publications. The scientific performance of the new members can be assessed considering the following 
publications:

Three of the 13 Integrated Members of the Algebra and Logic group (Malheiro, Fernandes, Jesus, Quinteiro; 
Nogueira, Kahle, Oitavem; Casimiro) were members of other research centers in the period 2008-12. They will 
reinforce the already existing research fields, and will extend the Center's expertise to new areas.

Eight of the 13 Integrated Members of the Algebra and Logic group (Malheiro, Fernandes, Jesus, Quinteiro; 
Nogueira, Kahle, Oitavem; Casimiro) were members of other research centers in the period 2008-12. They will 
reinforce the already existing research fields, and will extend the Center's expertise to new areas. These members have well established collaborations with mathematicians from several national and international high level Universities, as St Andrews, York, Illinois Chicago, Lisbon, Coimbra, Porto, Paris 7, Potsdam, Chiang Mai, East Anglia, Aberta, Mary Washington, Denver, Salamanca, Lorrain Nancy, Toronto, Sultan Qaboos, South-West Neodit Rilsiki, Urul Federal, Bar-Ilan, Queen Mary of London; and research centers, as Academic College of 

Mai, East Anglia, Aberta, Mary Washington, Denver, 

University of Zielona Gora, Poland

Key Publications

Tabuada, Goncalo (2008), Higher K-theory via universal invariants, DUKE MATHEMATICAL JOURNAL, 

Martins, Joao Faria and Picken, Roger (2011), Surface holonomy for non-abelian 2-bundles via double 
groupoids, ADVANCES IN MATHEMATICS, 226 (4), 3309-3366, DOI: 10.1016/j.aim.2010.10.017, IF = 1.373, Times Cited: 3

Salima, M. I. G., Pôvoa, A. P. B. and Noaais, A. Q. (2010), Simultaneous design and planning of supply 
chains with reverse flows: a generic modelling framework , European Journal of Operational Research, 
203(2), 336-349, IF = 2.159, Times Cited: 26

3.3 External Advisory Committee Reports

R&D Unit 
Center for Mathematics and Applications

Member Name 
Immanuel Bomze

Institution 
University of California, USA

R&D Unit 
Center for Mathematics and Applications

Member Name 
Barry Arnold

Institution 
University of California, USA

R&D Unit 
Center for Mathematics and Applications

Member Name 
Charles R. Johnson

Institution 
College of William & Mary, USA

R&D Unit 
Center for Mathematics and Applications

Member Name 
Lennart Ljung

Institution 
Lund University, Sweden

R&D Unit 
Center for Mathematics and Applications

Member Name 
Roman Zmyslony

Institution 
University of Zielona Gora, Poland

3.4 Composition of the External Advisory Committee

3.5 Brief description of the output indicators 2008/2012 of the research team of the new unit that support 
the vision and objectives of the strategic program

In comparison with the 2008-2012 teams of Algebra and of Differential Equations and Numerical Analysis, the 
2015-2020 groups of Algebra and Logic and of Analysis has been strengthened by the inclusion of several 
researchers previously affiliated to other R&D units. Several areas received a strong new breath, particularly 
Semigroups, Numerical Analysis and Stochastic Analysis. The area of Logic is now represented in the Unit.

In this section we describe the impact on the strategic program of the new members' research during 08-12.
showed, answering a question of Fields medalist E. Zelmanov, that Plactic monoids of finite rank are biautomatic. Most of the work of Fernandes, and his former PhD students Jesus and Quinteiro, was devoted to the study of transformation semigroups in the special case of monotone transformations; he also obtained results on aspects of special classes of semigroups, such as block-groups and quotients of numerical semigroups.

(2) Nogueira described several configurations which give rise to standard and non-standard f-subgroups for linear recurrences of order 2, and also a number of families of non-standard f-subgroups for recurrences of order greater than 2.

(3) The team consists of 2 integrated members, Oitavem, working in computational complexity and Kahle, also a computer scientist, coming from mathematical proof theory, and the collaborator Gaspar, with a recent PhD in mathematical proof theory, working now in cryptography.

(4) Casimiro proved the equivalence between the single stability notion for points of a character variety with respect to the action of an algebraic group G, and the complete reducibility irreducibility notion of subgroups of G. She also obtained a discrete geometric formulation of variational calculus in several independent variables.

During this period they supervised 4 PhD students. These new members will improve the current level of scientific research thereby increasing the number of published papers in highly reputed international peer-reviewed journals. They will give a strong contribution to promote internal collaborations among members of the Center and to have a competitive PhD program in Mathematics at FCT-UNL, therefore bringing more PhD students to the Center.

The Analysis group received 5 new members: Luis Trabucho (LT), Magda Rebelo (MR) and Nuno Martins (NM) work on numerical analysis, Oleyksi Karloich (OK) works on functional analysis and Fernanda Cipriano Marques (FCM) works on stochastic modeling.

LT collaborated with Mascarenhas on the study of the limit equation governing propagation in thin waveguides with Robin boundary conditions. The asymptotic behavior of the spectrum of the Robin-Laplace operator was studied. Different limit problems were found, depending on a symmetry criterion for the fundamental mode in the cross section (1 joint paper).

LT studied wave propagation models of Boussinesq type. This lead to a new 6th order model containing previous wave propagation models namely, Airy, Nwogu, KdV, BBM, among others. Dispersive and stability properties were studied. A new Continuous/Discontinuous Galerkin Finite Element Method was implemented. Some numerical examples were considered and the obtained were compared with the classical models (2 papers).

MR worked on the analytical and numerical analysis of the weakly singular Volterra integral equations (VIEs) with nonlinear Hammerstein-type kernels, arising in heat conduction problems. MR also worked on the development and analysis of a mathematical model, in the form of two coupled diffusion equations, for a competitive chemical reaction between an antigen and a labeled antigen that take place on a homogeneous immunoassay, the Fluorescent Capillary-Fill Device. NM and MR developed jointly a meshfree method based on fundamental solutions basis functions for a transmission problem in linear elasticity with interfaces. This method was used in the identification of acoustic sources from information obtained from the boundaries. Direct and inverse methods were considered. (5 papers by MR, 6 by NM, 1 joint paper).

OK works on operator theory, particularly in the boundedness and Fredholmness of maximal operators, singular integral operators, and pseudodifferential operators on variable Lebesgue spaces and on general Banach function spaces (7 papers, 5 book chapters).

OK joined a project involving several CMA members to study imaging recovering and denoising. In particular, OK will study the relationship between Sobolev spaces and nonlocal functionals arising in image denoising models. This project will be funded by FCT in 2014-15 (see section 9.5 for further description). OK regularly collaborates with Cláudio Fernandes, internal collaborator of CMA.

FCM worked on different aspects of stochastic processes. For the Poisson-Vlasov equation a stochastic representation for the solutions of was obtained. Such representation involves both an exponential and a branching stochastic process. In the framework of infinite dimensional white noise analysis. FCM used The Airault-Malliavin method to construct surface measures for surfaces in the dual space of the Schwarz space. FCM also worked on boundary layer turbulence, were the Navier–Stokes equations in a 2D-bounded domain with Navier slip boundary conditions prescribed on permeable boundaries were considered (7 papers).

FCM will collaborate with Paula Rodrigues on stochastic modeling of epidemics and they are co-supervising a master. FCM intends to interact with the SRM group.

### 4. FUNDING 2008/2012

#### 4.1 Description

<table>
<thead>
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<th>Description</th>
<th>2008</th>
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<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>TOTAL (€)</th>
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<td>Other national projects</td>
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<td>National industry projects</td>
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<td>International industry projects</td>
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</tbody>
</table>

### 5. GENERAL INDICATORS 2008/2012
One member of the group of Operations Research and Management, M.I. Gomes, was awarded two prizes in forecasts in Western Europe-PHDROUGHT (2012-2013).

Members of the group of Statistics and Risk Management - Statistical Inference contributed to the impact of the research done by the unit in several areas, for example Water Resources, Geosciences and Meteorology. They are participating in the European project “Predictability assessment and hybridization of seasonal drought forecasts in Western Europe-PHDROUGHT” (2012-2013).

In 2013 we also registered: Two patents: MATHDETECTIVES, IGAC nº 2874/2013 (G. Guerreiro, N.C. Martins, M.F. Rodrigues and M.C. Soares)

A computational code: TETR4MATH, IGAC nº 3893/2013 (G. Guerreiro, N.C. Martins, M.F. Rodrigues and M.C. Soares)


We begin with some comments on the indicators shown in table 5.1. The first row corresponds to the number of integrated members, displayed in the second row, plus the number of internal collaborators (for the definition of integrated members and of internal collaborators we refer to section 3.1).

From 2011 to date, the unit employs a science and technology manager.

The number of PhD students supervised by members of the unit, displayed in the fourth row, significantly decreased in the years 2010 and 2011. It however begun re-increasing in 2012, and three PhD theses were defended in 2013 (B. Ghola, D. Salvador and J. Beleza). One more PhD defense is scheduled for January 2014 (N. Lopes).

In addition, the number of full time researchers (not included in table 5.1) is increasing:

4 Postdocs: C. Kreisbeck (2011-12); O. Danilkina (2012-13); P. C. Rodrigues (2012-13); X. Lu (2012-13).

5 full time researchers: 2 Science 2008 5-year contracts (H. Liu, M. Fonseca); 1 long-term postdoc (2009-2015) (E. Moreira) and 2 FCT Researchers 5-year contracts (F. Chalub, A.J. Cain).

As far as publications are concerned, in the fifth row we display the number of published papers in peer-reviewed journals. We remark that in the annual reports of 2008, 2009 and 2010, the number of papers in peer-reviewed journals included accepted papers. In the added row “Other international publications” we present the number of papers published in proceedings of international conferences, or in journal’s surveys.

From 2008 the Unit had a clear improvement in the quantity and in the quality of its publications. In the year 2010 the number of publications in WoS journals was 30 out of a total of 41 papers in peer-reviewed journals, in 2011 the former increased to 32 out of a total of 39 publications, and in 2012 to 48 out of a total of 57 publications. Concerning “Books and chapters”, we mention two books co-authored by Unit members, one appeared in 2013 and the other is scheduled to appear in 2014:


2. V. I. Channelo, W. Johnson & M. B. Canalho, Bayesian Nonparametric Modeling of Diagnostic Data Chapman & Hall: CRC Statistics 2014 http://www.amazon.co.uk/Bayesian-Nonparametric-Modeling-Diagnostic-Data/dp/1466580399/ref=cm_sw_r_alp_FS5Uqb0HK2M2Y0_It

During the year 2013 we also registered: Two patents: MATHDETECTIVES, IGAC nº 2874/2013 (S. Batista)

A computational code: TETR4MATH, IGAC nº 3893/2013 (G. Guerreiro, N.C. Martins, M.F. Rodrigues and M.C. Soares)

A computational code:


We remark that the number of codes displayed in 13th row also includes relevant updates.

Relevant scientific achievements, partially included in the unit 10 best papers are the following: Relevant to Scientific Topology, Algebraic Geometry, K-theory, and Homological Algebra, in particular: (a) Kontsevich’s program for a theory of noncommutative motives; (b) conceptual characterization of Quillen’s higher K-theory; (c) Homotopical characterization of Drinfeld’s DG quotient; homotopy theory of Gray-categories, Categorification and Higher Gauge Theory. Results in Biomathematics, in Differential Equations and in Calculus of Variations.

The participation in the CMU|Portugal program in Applied Mathematics, as well as the participation in a joint project with CMU, produced a PhD during 2011 and launched several research projects in Calculus of Variations and its applications to image reconstruction and to Material Science problems.

Members of the group of Statistics and Risk Management - Statistical Inference contributed to the impact of the research done by the unit in several areas, for example Water Resources, Geosciences and Meteorology. They are participating in the European project “Predictability assessment and hybridization of seasonal drought forecasts in Western Europe-PHDROUGHT” (2012-2013).

Another member of the group Operations research, R. Rodrigues, was ranked 3rd in the PhysioNet/Computing in Cardiology Challenge 2013. We finally mention the following awards in 2013, concerning the outreach activity of R. Martins, from the Analysis group:
1. Selected as one of the 100 more influent Portuguese 2012-2013, by the periodic Expresso, for his TV broadcasting program Isto é Matemática.
2. Homenagem Especial VerCiência 2013 by the 19th International Exhibition of Science in TV, 21-27 October 2013, Rio, Brazil.
3. Ciência Viva Montepio Media 2013, Lisbon, 24 Nov 2013, for the TV broadcasting program Isto é Matemática.

6. SCIENTIFIC COMPONENT – STRATEGIC PROGRAMME 2015/2020

6.1 Abstract in Portuguese for publication

The "Centro de Matemática e Aplicações" (CMA) is an independent research unit of FCT/UNL, partnering in several national and international research projects and performing knowledge transfer to industry. CMA employs a science and technology manager through a bursary contract to perform the administrative tasks related with the management of the research projects and knowledge transfer. CMA integrates as active members the majority of the professors in the Department of Mathematics involved in research activities, as well as mathematicians belonging to units of other universities.

The goal of the Unit is the pursuit of mathematical knowledge in targeted areas, with an emphasis on new and relevant applications. The present research profile of the Unit aims to stimulate collaboration between its research groups and with other technical disciplines from Science and Engineering, contributing to new and fruitful applications. The main fundamental scientific areas are grouped as follows: Algebra and Logic; Analysis; Operations Research; Statistics and Risk Management.

The future internal organization of the CMA will present two dimensions: structural and thematic. The structural dimension of the Unit corresponds to the already existing four groups, which represent the main areas of research within the Unit. Each group has its own coordinator. The Group of Algebra and Logic integrates the areas of Algebraic Geometry, Geometric Topology, Algebraic Topology, Semigroup Theory, Combinatorics, Logic, as well as Applications to Mathematical Physics, to Computer Science and Cryptography. The Group of Analysis develops research in the areas of Functional Analysis, Numerical Analysis, Stochastic Analysis, Dynamical Systems, Partial Differential Equations and Biomathematics, modeling diverse problems of Mechanics of Continuous Media, of Mathematical Physics and of Epidemiology. The Group of Operations Research conjugates the fields of Modeling and Simulation, Optimization, Algorithms and Resources Management. Several addressed subjects in the areas of Optimization and of Algorithms connect with problems of Partial Differential Equations and Numerical Analysis and also of Combinatorics. Finally, the Group of Statistics and Risk Management includes Statistics, Stochastic Processes and Actuarial Mathematics, integrating projects in the area of Financial Mathematics, frequently treated using methods of Analysis, such as Partial Differential Equations, Numerical Analysis and Stochastic Analysis.

The thematic dimension of the unit’s organization will involves a coordinated approach to inter-collaboration and multidisciplinary applications between each of the four groups, called thematic lines. A thematic line is a research project lead by a coordinating researcher, nominated by the involved teams, and will have designated internal financial support. Regular meetings and mini-courses will create opportunities for cross-group discussion and exchange, series of thematic seminars will announce the progress on and the results obtained with respect to each thematic line.

The fundamental research developed at the Unit supports the corresponding knowledge transfer to industry.

6.2 Abstract in English for evaluation

The "Centro de Matemática e Aplicações" (CMA) is an independent research unit of FCT/UNL, partnering in several national and international research projects and performing knowledge transfer to industry. CMA employs a science and technology secretary through a bursary contract to perform the administrative tasks related with the management of the research projects and knowledge transfer. CMA integrates as active members the majority of the professors in the Department of Mathematics involved in research activities, as well as mathematicians belonging to units of other universities.

The goal of the Unit is the reach of mathematical knowledge in targeted areas, with an emphasis to new and relevant applications. The present research profile of the Unit aims to stimulate close links between its research groups and with other technical disciplines from Science and Engineering, contributing to new and fruitful applications. The main fundamental scientific areas are grouped as follows: Algebra and Logic; Analysis; Operations Research; Statistics and Risk Management.

The future internal organization of the CMA will present two dimensions: structural and thematic. The structural dimension of the Unit corresponds to the already existing four groups, which represent the main areas of research within the Unit. Each group has its own coordinator. The Group of Algebra and Logic integrates the areas of Algebraic Geometry, Geometric Topology, Algebraic Topology, Semigroup Theory, Combinatorics, Logic, as well as Applications to Mathematical Physics, to Computer Science and Cryptography. The Group of Analysis develops research in the areas of Functional Analysis, Numerical Analysis, Stochastic Analysis, Dynamical Systems, Partial Differential Equations and Biomathematics, modeling diverse problems of Mechanics of Continuous Media, of Mathematical Physics and of Epidemiology. The Group of Operations Research conjugates the fields of Modeling and Simulation, Optimization, Algorithms and Resources Management. Several addressed subjects in the areas of Optimization and of Algorithms connect with problems of Partial Differential Equations and Numerical Analysis and also of Combinatorics. Finally, the Group of Statistics and Risk Management includes Statistics, Stochastic Processes and Actuarial Mathematics, integrating projects in the area of Financial Mathematics, frequently treated using methods of Analysis, such as Partial Differential Equations, Numerical Analysis and Stochastic Analysis.

The thematic dimension of the unit’s organization will involves a coordinated approach to inter-collaboration and multidisciplinary applications between each of the four groups, called thematic lines. A thematic line is a research project lead by a coordinating researcher, nominated by the involved teams, and will have designated internal financial support. Regular meetings and mini-courses will create opportunities for cross-group discussion and exchange, series of thematic seminars will announce the progress on and the results obtained with respect to each thematic line.

The fundamental research developed at the Unit supports the corresponding knowledge transfer to industry.
Equations and Numerical Analysis and also of Combinatorics. Finally, the Group of Statistics and Risk Management includes Statistics, Stochastic Processes and Actuarial Mathematics, integrating projects in the area of Financial Mathematics, frequently treated using methods of Analysis, such as Partial Differential Equations, Numerical Analysis and Stochastic Analysis.

The thematic dimension of the unit's organization will involve a coordinated approach to inter-collaboration and multidisciplinary applications between each of the four groups, called thematic lines. A thematic line is a research project lead by a coordinating researcher, nominated by the involved teams, and will have dedicated internal financial support. Regular meetings and mini-courses will create opportunities for cross-group discussion and exchange, series of thematic seminars will announce the progress on and the results obtained with respect to each theme.

We emphasize the importance of the fundamental research developed by the unit, structural dimension for the good progress of the thematic dimension. The fundamental research developed in the Unit supports the corresponding knowledge transfer to industry.

### 6.3 Strategy and vision of the unit and future management

The goal of the Unit is the reach of mathematical knowledge in targeted areas, with an emphasis to new and relevant applications. The present research profile of the Unit aims to generate close links between its research groups and with other technical disciplines from Science and Engineering, contributing to new and fruitful applications. The main fundamental scientific areas (see 6.1) are grouped as follows:

**Algebra & Logic (AL):** Analysis (A); Operations Research (OR); Statistics & Risk Management (SRM)

These groups were strengthened with the inclusion, from 2015 on, of 17 researchers, previously integrated in other R&D units; most of them belong to the Department of Mathematics of FCT/UNL. With this inclusion, some areas received a strong new breath, like Semigroups, Numerical Analysis and Stochastic Analysis. Logic is now represented in the Unit.

We also host in the Unit 4 full time investigators: a Science 2008 (M.Fonseca), a long-term postdoc (E.Moreira) and 2 5-years Research grants (F.Chalub, working in the interface between Mathematics and Biology, and A.J.Cain, working in Semigroups and Languages).

This new team promises a great impact in fundamental research and, consequently, in several applications.

As mentioned in section 6.1, the internal organization of CMA has two transverse dimensions: the structural one and the thematic one. The structural dimension corresponds to the group structure, where fundamental research and more theoretical applications are developed. The thematic dimension aims inter-collaboration and multidisciplinary applications between each of the four groups or even with groups from other units. The idea of creating this double research dimension is to facilitate this inter-collaboration and multidisciplinary applications, maintaining the natural course of fundamental research, or even incrementing it, by finding emerging mathematical themes of fundamental interest, derived back from application problems.

The main targeted research topics, in the group context, are the following:

**AL:** Proof theory and implicit computational complexity; transformation semigroups and its strong connection with automata; bridge between motives and noncommutative motives; categorification of Drinfeld associates and the 4-term relations; harmonic analysis for representations of Lie categorical-groups; graph decomposition; algebraic combinatorics; inverse eigenvalue problems; classification of f-groups as standard/nonstandard; Ockham algebras; topology and singularities of character varieties of free group representations in real Lie groups; geometric formulation of variational problems involving principal bundles.

**A:** Image reconstitution; epidemiology and game theory; propagation of nonlinear iono-sonic waves in a magnetized plasma; Boussinesq-like wave models; convolution type operators; minimizers of the Dirichlet integral under volume or shape constraints; stochastic Navier-Stokes, periodic sine-Gordon equation with friction; control techniques for over-determined and under-determined boundary value problems.

**OR:** algorithm development for the eigenvalue complementarity problem and for multiplicative derivative free problems; derivative-free estimates of the Lipschitz constant; connections between semidefinite programming and the Satisfiability problem; sustainability and stochastic modeling within supply chain design problems; multiobjective metaheuristics approaches; water network design problem; new variants for the hub location problem; minimum Steiner tree and minimum Steiner forest within ecological problems; multi-compartment vehicle routing problems; resource constraint project scheduling problem.

**SRM:** F-tests with random non-centrality parameters and random degrees of freedom for the errors; univariate models with constraints on fixed and random effects; second-order parameters estimation for reduced-bias parameter estimation of extreme events; near-exact distributions for elaborate covariance structures; ruin probability under the presence of a Bonus Malus System on an automobile insurance (industry project); ruin probabilities, time to ruin and expected present dividend amounts for the dual risk model; trading complementarities and bourse formation costs explaining market fragmentation and the emergence of bourses with an incomplete security structure.

As transversal topics (thematic lines), we have the two following projects, involving members of two or more groups:

- Mathematical Modelling in Ecology, Genetic and Evolution
- Modeling for the Elderly: Mathematical modeling for the independent living of elderly, disable, and chronic patients.

Regular seminars will contribute to normal circulation of scientific knowledge within each group. Also interdisciplinary meetings, including mini-courses, will be scheduled to create opportunities for cross-group discussion and exchange, and series of thematic seminars to announce the progress on and the results obtained with respect to each theme.

The group coordinators and the principal investigator of the thematic lines will promote the dissemination of the scientific results, through the organization/participation of national international meetings.
The Unit project also includes:

- Reorganization of the present PhD program of the Department of Mathematics /CMA: international collaborations with Carnegie Mellon University (USA) and Universidade Federal Fluminense (Brazil) are being negotiated.
- Increment of the postdoctoral positions in the Unit.
- Knowledge transfer to industry: we have presently consulting activity with Banco Atlântico Europa and with Actuarial Institutions. Some MSc theses, supervised by our members, have been developed in collaboration with enterprises.
- We have been negotiating knowledge transfer between our Unit and the resource management enterprise SISCOG and the financial support for 2 MSc theses is now granted. FCT/UNL and Hospital Garcia de Horta recently signed a protocol including analysis of statistical data. We intend to develop this kind of knowledge exchange with local enterprises and institutions.
- During 2014, CMA will host the study group101 ESGI (European Study Group with Industry). This meeting is part of the series of European Study Groups and will count with the participation of several European experts with a large experience in this type of events.
- CMA also participates in the Portuguese network of the European Network “Mathematics in Industry”.
- Interdisciplinary: during 2013, members of the Unit founded in the Campus the first Iberian SIAM Student Chapter. The Chapter aims communication and exchange of ideas between students from different branches of Science and Engineering, potentiating interdisciplinary scientific work.
- Outreach activities (see section 3.1).

### 6.4 Laboratory intensity level of the unit

**Medium**

**Laboratory intensity level Justification**

The research conducted by the Unit requires a medium level of laboratorial intensity, in view of the research goals defined.

The Unit aims at developing fundamental theoretical research while it is also focused on the ensuing applications. An applied component of research would motivate the development of more theoretical results, by posing new questions and problems. Simultaneously, it would provide a collaborative dimension to the developed research, contributing to the establishment of partnerships with industry. This applied research requires a strong computational component, addressing the challenges inherent to real applications. Additionally, both theoretical and applied researches require the access to international databases, in order to keep up with the state-of-the-art of the field under analysis.

The research developed within each group contributes to the goals defined by the Unit, each of which entails a set of apparatus. That would be less evident in the Algebra and Logic group, but it is clear for all the remaining research teams.

In the Analysis group, besides the theoretical foundations, models are routinely developed and numerically implemented to solve problems. As examples of applications we refer to image restoration and models for dynamic of fluids. The laboratory needs are clear in the Operations Research group. The research is developed under two main methodologies: problem modeling and algorithmic development. In either case there is a clear computational component for solving the proposed models and of algorithmic development and testing. For the Statistical and Risk Management group, is a fundamental requirement in analysis of large volume of data. Also in the Algebra and Logic group applications of Semigroups to automata evidence computational needs. These are also a consequence of the proposed thematic lines, whose objective includes approaching the most practical problems.

Since the equipment needs amount to hardware, software and access to international databases, according to the FCT definition the laboratory intensity level required by the Unit is considered to be medium.

### 6.5 General objectives

**PLANEDE RESEARCH ACTIVITIES:**

- **Algebra and Logic:** Proof theory and implicit computational complexity; transformation semigroups and its strong connection with automata; bridge between motives and noncommutative motives; categorification of Drinfeld associators and the 4-term relations; harmonic analysis for representations of Lie categorical-groups; graph decomposition; algebraic combinatorics; inverse eigenvalue problems; classification of f-groups as standard/nonstandard; Ockham algebras; topology and singularities of character varieties of free group representations in real Lie groups; geometric formulation of variational problems involving principal bundles.

- **Analysis:** Image reconstitution and the corresponding numerical approach; epidemiology and game theory; propagation of nonlinear ionic-sonic waves in a magnetized plasma; Boussinesq-like wave models; convolution type operators; minimizers of the Dirichlet integral under volume or shape constraints; stochastic Navier-Stokes; periodic Sine-Gordon equation with friction; control techniques for over-determined and under-determined boundary value problems.

- **Operations Research:** algorithmic development for the eigenvalue complementarity problem and for multiobjective derivative free problems; derivative-free estimates of the Lipschitz constant; connections between semi definite programming and the Satisfiability problem; sustainability and stochastic modeling within supply chain design problems; multiobjective metaheuristics approaches; water network design problem; new variants for the hub location problem; minimum Steiner tree and minimum Steiner forest within ecological problems; multi-compartment vehicle routing problems; resource constraint project scheduling problem.
As transversal topics (thematic lines), we have the two following projects, involving members of several groups (see section 10):

- Mathematical Modeling in Ecology, Genetic and Evolution.
- Modeling for the Elderly: Mathematical modeling for the independent living of elderly, disable, and chronic patients.

The programmed topics will be periodically reformulated, according to the obtained results. Other research topics, or research thematic lines, may emerge from the group’s internal and external interactions. Those new projects will be added to the programmed activity.

Regular seminars will contribute to the normal circulation of scientific knowledge within each group. Also interdisciplinary meetings, including mini-courses, will be scheduled to create opportunities for cross-group discussion and exchange, and series of thematic seminars to announce the progress on and the results obtained with respect to each theme.

The group coordinators and the principal investigator of the thematic lines will promote the dissemination of the scientific results, through the organization/participation of international meetings. All these activities will have the support of a science and technology manager.

MSC, PHD, POSTDOCTORAL FELLOWS:

Many MSc and PhD theses supervised by our members have been developed in collaboration with enterprises, like banks and insurance companies. Strengthening this component may attract students and promote scientific links with industry. Recently the Unit negotiated knowledge transfer with a successful resource management enterprise and the financial support for 2 MSc theses is granted.

The Department of Mathematics, together with the Unit, intends to reorganize the PhD program in Mathematics: international collaborations with Carnegie Mellon University (USA) and the Universidade Federal Fluminense (Brazil) are being negotiated since February 2012. This is an excellent opportunity to attract high-level PhD students.

During 2013, members of the Unit funded in the Campus the first Iberian SIAM Student Chapter. The Chapter aims communication and exchange of ideas between students from different branches of Science and Engineering, evidencing a strong enthusiasm and scientific skills in Mathematics, potentiating interdisciplinary scientific work. The Unit will take advantage of this excellent opportunity to promote Mathematics and its applications to Science and Engineering and to promote an interdisciplinary PhD strategy. We are sure that the development of the thematic lines will be a valuable contribute in that direction.

Recently we have hosted 4 postdoctoral fellows, 3 supported by FCT projects and one by a foreign institution. We intend to use our new projects to get, at least, 4 postdoctoral positions during the period 2015-2020.

KNOWLEDGE DISSIMINATION AND TRANSFER TO INDUSTRY:

We have presently consulting activity with Banco Atlântico Europa and with Actuarial Institutions. Also MSc and PhD theses, supervised by some of our members, have been developed in collaboration with enterprises. In particular, we have been negotiating knowledge transfer between our Unit and the resource management enterprise SISCOG. FCT/UNL and Hospital Garcia de Horta recently signed a protocol involving analysis of statistical data. We intend to develop this kind of knowledge exchange with local enterprises and institutions.

During 2014, CMA will host the study group101 ESGI (European Study Group with Industry). This meeting is part of the series of European Study Groups and will count with the participation of several European experts with a large experience in this type of events. CMA also participates in the Portuguese network associated to the European Network “Mathematics in Industry” (EU-MATHS-IN).

The purpose is to strengthen the links between Mathematics and Industry by using Mathematics to tackle industrial problems, which are proposed by industrial partners.

Also the SIAM Student Chapter, recently founded in the Campus, will encourage the communication and exchange of ideas between students from Mathematics, Science and Engineering and professionals from Industry, potentiating interdisciplinary collaborations.

We intend to pursue and develop the already existing outreach activities mentioned at the end of section 3.1.

6.6 Implementation

The main implementation issues in order to meet our goals are the following:

1. Scientific criterion to be an integrated member

In Mathematics, publication in high-level journals is the most important scientific indicator. The criterion adopted by the Unit, and described in section 8.1, although inspired by the one suggested by FCT, gives special relevance to WoS production. Even slightly reducing the quantity of the scientific production, it distinguishes its quality. In order to motivate and keep high quality scientific production, we will apply, each year, the following version of the criterion detailed in section 8.1. When convenient, we will update it to a higher or equivalent level.

*During the year X a researcher is considered as an integrated member if he or she satisfies at least one of the following 4 items, during the period from 1st January of year X-5 until 31 December of year X-1,

A) 1 publication in one of the 10% WoS top journals in the following WoS scientific areas:
Surely increase the links between science and engineering departments. As explained in section 10, some this kind of co-advising occurred sporadically in the last few years. However, the focus in the thematic lines will an important issue of the Unit strategy. Where more than 90% of the students follow engineering courses, interdisciplinary co-advising of MSc and PhD is (see section 6.8). However, the involvement in education is not limited to the DM PhD programs. In a school An important goal of the Unit is its involvement in the PhD program offered by the Department of Mathematics (see section 6.8). However, the involvement in education is not limited to the DM PhD programs. In a school

6. Education

An important goal of the Unit is its involvement in the PhD program offered by the Department of Mathematics (see section 6.8). However, the involvement in education is not limited to the DM PhD programs. In a school where more than 90% of the students follow engineering courses, interdisciplinary co-advising of MSc and PhD is an important issue of the Unit strategy.

This kind of co-advising occurred sporadically in the last few years. However, the focus in the thematic lines will

A part from the 6-year budged, it is important to look for alternative funds. The Unit has been successful in many previous calls (see section 4.1). Recently, in the 2012 national call, one proposal won 40 K€ and in the 2013 national call, two other proposals received jointly 50 K€. It is our goal to apply for European funds, as Marie Curie Scholarships and ERC grants. We did not succeeded so far, however a long-term strategy consists in creating a national call, two other proposals received jointly 50 K€. It is our goal to apply for European funds, as Marie Curie Scholarships and ERC grants. We did not succeeded so far, however a long-term strategy consists in creating

The fact of passing from integrated member to internal collaborator must be seem not as a penalty, but as an encouragement for scientific productivity.

2. Internal collaborators and work plans

The members that do not satisfy the criterion are invited to present a 3 years work plan, in the scope of the group project. The plan should present a credible strategy to recover scientific productivity (as measured by the Unit criterion). If the plan is approved, they will be considered as “internal collaborators”. Internal collaborators are funded in the same condition as integrated members. Integrated members and internal collaborators contribute together to the progress of the scientific program of the group or of the thematic lines. The designation “internal collaborators” also applies to PhD students supervised by members of the Unit. As soon as an internal collaborator meets the criterion or completes its PhD, he will be considered an integrated member.

3. General management

The general management structure of the unit consists of a scientific council (SC), composed by all the integrated members (those that satisfy the criterion described above), and by an executive committee (EC) composed by the coordinator of the Unit and by 3 other active members selected by the coordinator as advisors. Each group elects a coordinator, responsible for the scientific strategy of the group, for the implementation of the general scientific strategy of the Unit and for the annual scientific reports. The group coordinators will promote regular seminars. Interdisciplinary meetings including mini-courses will be scheduled to create opportunities for cross-group discussion and exchange, and series of thematic seminars to announce the progress on and the results obtained with respect to each theme. The group coordinator is also responsible for the group budget, for the application of the scientific criterion, for the approval of the internal collaborator’s work plans and for enhance of their scientific productivity. Groups have their own annual budget proportionally to the number of integrated members. However along the year, corrections may be introduced in the budget, if necessary. All group coordinators act closely with the EC to guarantee the implementation of the general scientific strategy of the Unit. Thematic lines have also financial independence, concerning activities with broad impact as, for instance, the organization of workshops, short-courses, collaborator’s visits, software licenses. Thematic lines are not allowed to fund missions or individual equipment. Structural decisions for the Unit are taken by the SC. Apart from the institutional support, we have the assistance of a science and technology secretary through a grant contract.

Each year the budget is internally organized as follows:

• Overheads: due to the host Institution FCT/UNL.
• Human Resources: covers the salary/grant of administrative staff, post-docs and visitors.
• General expenses: covers administrative expenses and the organization of conferences and outreach activities.
• Thematic lines: part of the budget dedicated workshops or mini-courses.
• Groups: part of the budget assigned to the groups, proportionally to the number of integrated members. Despite the above distribution rule, and since expenses may vary along the civil year, corrections may be introduced in the budget of each group or thematic line according to needs.

4. Hiring strategy

Since the majority of the integrated members of the Unit are professors at the Department of Mathematics (DM) of the FCT/UNL, the Unit plans to develop with the DM a joint hiring plan, fostering competitive research groups. Presently we have 4 full-time researchers. We will pursue our strategy to increase the number of integrated members fully dedicated to research.

5. Funding

A part from the 6-year budged, it is important to look for alternative funds. The Unit has been successful in many previous calls (see section 4.1). Recently, in the 2012 national call, one proposal won 40 K€ and in the 2013 national call, two other proposals received jointly 50 K€. It is our goal to apply for European funds, as Marie Curie Scholarships and ERC grants. We did not succeeded so far, however a long-term strategy consists in creating very competitive projects to apply to European calls, at most by 2020. The thematic lines will have an important role concerning this task. Important funds may also come from industry or consulting activity, as presently from Banco Atlântico Europa.

6. Education

An important goal of the Unit is its involvement in the PhD program offered by the Department of Mathematics (see section 6.8). However, the involvement in education is not limited to the DM PhD programs. In a school where more than 90% of the students follow engineering courses, interdisciplinary co-advising of MSc and PhD is an important issue of the Unit strategy.

This kind of co-advising occurred sporadically in the last few years. However, the focus in the thematic lines will
surely increase the links between science and engineering departments. As explained in section 10, some thematic lines will enhance joint PhD programs. SIAM Student Chapter is also a possibility to strengthen connections between Applied Mathematics and Engineering, promoting collaborations.

8.7. Contributions for the regional strategy

There exists a long-term interaction between the City Council of Almada (CCA) and our host Institution, FCT/UNL. They collaborate in terms of environment, biodiversity and energetic policies, medical care, urban mobility, culture and education. Recently FCT/UNL signed a protocol with Hospital Garcia de Horta, located in Almada, involving the analysis of statistical data.

Our strategy has been the intensification of that interaction, not only at education level, but also by offering our mathematical ability for solving several problems related with, for instance, optimization of resources, statistical models or quality control.

The development of our thematic lines:

Mathematical Modeling in Ecology, Genetic and Evolution

Modeling for the Elderly: Mathematical modeling for the independent living of elderly, disable, and chronic patients

inspired in concrete problems, will contribute for solving real issues of the local community. Also the collaboration of local Institutions, like the Hospital Garcia de Horta or traffic enterprises, may contribute to our project by posing challenging applications problems.

We mention that the organization of conferences and of all our local outreach activities has been always welcomed and logistically supported by the CCA. In particular, a member of the CCA has participated as a speaker in the series of conferences Implica Matemática.

The current exhibition MATER, about Mathematics and Time, Space, Life, Art and Daily life, in the Caparica Campus, provides guided tours specifically dedicated to students from the local schools. As heart of the theme exhibition, a scale solar system reproduction, spread all over the region, was constructed and installed with the collaboration of those schools.

Finally we recall our outreach activities, promoting the interest of young students of the region of Almada in Mathematics and its applications. We remark that one tangible consequence of the outreach activities was the increase of both the number and the quality of the mathematical undergraduate students.

Directed to high school honor students or to university students:


Directed to basic and high school students:


4. DiMat (from 2008) gathers several activities for high schools students and their teachers. The organization includes exhibitions, series of conferences or visits to schools. https://sites.google.com/site/dimatfct/

Directed also to general public:


6.8 Opportunities for advanced training

The Department of Mathematics has two PhD Programs: PhD in Mathematics, and PhD in Statistics and Risk Management. The areas of Analysis, Algebra, Logic and Operations Research are directly involved in the former, while Statistics and Risk Management is involved in the latter.

The PhD in Mathematics is currently under revision. We intend to reformulate the program during the academic year 2014-15 and to include two international partners: Carnegie Mellon University (CMU, USA) and Universidade Federal Fluminense (UFF, Brazil). CMU is considered one of the top 20 universities in the USA (Times Higher Education ranking) and has a long-term collaboration with CMA. UFF has one of the top 10 PhD programs in mathematics in Brazil (official ranking by the Brazilian government), and has also ongoing collaborations and scientific projects. In both cases there are a number of joint projects that will foster student’s interchange. We expect an increase of the number of the PhD students as a consequence of two factors: the appealing of an international program and the possibility of students interchange; in the last case, it is expectable a larger flow from Brazil than from USA. Co-supervision was already implemented in the CMU program and is part of the deal with UFF. Our plan also includes the interchange of long-term visitors between the partners.

The PhD in Statistics and Risk Management attracts circa 10 students per year and is running since 2009. Apart from Portugal, we frequently have students from Brazil, Cape Verde and Mozambique. Links with African countries are expect to be transformed into a strategic partnership, and frequently CMA researches go to both Cape Verde and Mozambique to teach advanced courses.

In both cases, PhD programs are structured in 3 years courses (180 ECTS), including basic courses, qualifying exams and thesis defense, with internal supervision (with a possibility of external co-supervision).

Due to the inclusion of new active members and to the increase of full time researchers, our team has now a larger capacity for the supervision postdoctoral fellows, a fundamental contribution for our research, in particular for the development of the thematic lines.

6.9 Internationalization

The internationalization strategy has two main points: the internationalization of PhD program and participation of international projects.
One joint PhD program is planned to start in the academic year of 2014-5 and will involve three groups, Analysis, Operations Research and Algebra. This will enhance the interest in the program, as it promotes international mobility of students. The second PhD program involves the Statistics and Risk Management group. This program has a long tradition of receiving students from Portuguese-speaking African countries (Cape Verde and Mozambique, mainly). See the appropriate topic for further details.

The second important landmark is the participation in binational, international projects and research networks. In the last few years, members of the center led binational projects with USA (Carnegie Mellon University), Brazil (Rio de Janeiro and Porto Alegre), Spain (Granada and Salamanca), France (Toulon) and German (Saarbrücken). Previous attempts to be part of European Networks failed, but in the next years we plan to participate in a network related to mathematical hemodynamics (led by the University of Lisbon). There are several international collaborations, ongoing or planned (United Kingdom, Norway, Russia, China, France, Italy, Spain, among others) than can develop into international partnership.

The Unit is directly involved in the preparation of the Portuguese participation in the European Network "Mathematics in the Industry" (EU-MATH-IN), jointly with Porto and Coimbra. The purpose of this network is to apply for infrastructure for industrial mathematical research and training of students in the appropriate subject. The EU-MATH-IN group plans to apply in the Horizon 2020 call.

The thematic line Models in Evolution, Genetics and Ecology plans to apply for a ERC grant in the end of the period 2015-20.

Finally, we stress that the scientific impact of our unit in the following specific areas is above the world mean (see section 3.2): Operations Research and Management; Water Resources; Geosciences Multidisciplinary; Transportation of Science and Technology; Industrial Engineering; Civil Engineering; Automatic and Control Systems; Computational Science, Software Engineering.

6.10 Knowledge transfer

The Leiden ranking 2007-2010 classifies above the world mean the scientific impact of the Unit in some specific areas: (by score order) Operations Research and Management; Water Resources; Geosciences Multidisciplinary; Transportation; Transportation Sc & T; Industrial Engineering; Civil Engineering; Automatic & Control Systems; Computational Science, Software Engineering (see section 3.2). We intend to develop an aggressive strategy of collaboration with industry, exploring those skills.

We have presently consulting activity with Banco Atlântico Europa and with Actuarial Institutions. We have been negotiating knowledge transfer with a successful resource management enterprise and the financial support for 2 MSc theses is now granted.

Also MSc theses, supervised by some of our members, have been developed in collaboration with enterprises. The Unit is committed in retrieving former connections between industry and the Department of Mathematics, partially lost as a direct consequence of the syllabus reformulations after the Bologna process. The establishment of partnerships with industry will promote applied research, with social impact. Students could also perceive it as a distinguishing factor of FCT-UNL for percussing their graduate studies.

During 2014, CMA will host the important study group101 ESGI (European Science Group with Industry). This meeting is part of the series of European Study Groups and will count with the participation of several European experts with a large experience in this type of events. The purpose is to strengthen the links between Mathematics and Industry by using Mathematics to tackle industrial problems, which are proposed by industrial partners.

Recently, members of the Unit founded in the Campus the first Iberian SIAM Student Chapter. The Chapter aims communication and exchange of ideas between students from Science and Engineering; evidencing a strong enthusiasm and scientific skills in Mathematics, potentiating interdisciplinary scientific work. The Unit will take advantage of this excellent opportunity to promote Mathematics and its applications to Science and Engineering and connections with industry.

On the other way, there exists a long-term interaction between the City Council of Almada and FCT/UNL. They collaborate in terms of environment, biodiversity and energetic policies, medical care, urban mobility, culture and education. We will intensify that interaction, by offering our mathematical ability for solving several problems related with, e.g., optimization of resources, statistical models or quality control. The development of our thematic lines, inspired in concrete problems, will surely contribute to solving real issues of the local community. On the other hand, the collaboration with local Institutions, like the Hospital Garcia de Horta, with which FCT/UNL recently signed a protocol involving the analysis of statistical data, will raise interesting problems to our projects.

6.11 Ethical issues

N/A

7. EXPECTED INDICATORS OF THE STRATEGIC PROGRAMME 2015/2020

<table>
<thead>
<tr>
<th>Description</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>TOTAL (Σ)</th>
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<tbody>
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<td>Publications in peer-review international journals</td>
<td>61</td>
<td>59</td>
<td>62</td>
<td>62</td>
<td>64</td>
<td>66</td>
<td>374</td>
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<td>Patents and performing patents</td>
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<td>Books and chapters of international distribution</td>
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<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>11</td>
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</tbody>
</table>
8. PROPOSED RESEARCH TEAM

8.1 Criteria adopted by the R&D unit for the definition of integrated member, if different from FCT reference table

In the area of Mathematics, publication in high-level journals is the most important scientific indicator. The criteria adopted by the Unit, although following the one suggested by FCT, give special relevance to WoS production (see C). Even slightly reducing the quantity, it stresses the quality (see D). The criteria used for the definition of integrated member is the following:

A researcher is considered as an integrated member if he satisfies at least one of the following 4 items, during one of the two periods: 1 January 2008 - 31 December 2012 or 1 January 2009 – 30 October 2013.

A) 1 publication in one of the 10% WoS top journals of the following WoS scientific areas:

- Computer Science, Theory and Methods
- Logic
- Mathematical and Computational Biology
- Mathematics
- Mathematics, Applied
- Mathematics, Interdisciplinary Applications
- Operations Research & Management Science
- Statistics & Probability
- Physics, Mathematical

B) PhD thesis supported after 1 January 2010 and one publication in a peer reviewed journal

C) 4 scientific indicators, according to the FCT definition (see Registration Guide p. 25), 2 of them classified in WoS

D) 3 scientific indicators, according to the FCT definition (see Registration Guide p. 25), all of them classified in WoS

8.2 List of Integrated Members / 10 nuclear CVs

<table>
<thead>
<tr>
<th>Name</th>
<th>Nuclear CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maria Luísa Martins Macedo de Faria Mascarenhas (Coordinator)</td>
<td>Yes</td>
</tr>
<tr>
<td>Ana Cristina Malheiro Casimiro</td>
<td>No</td>
</tr>
<tr>
<td>Ana Luísa da Graça Batista Custódio</td>
<td>No</td>
</tr>
</tbody>
</table>
9. PROPOSED RESEARCH GROUPS

<table>
<thead>
<tr>
<th>Reference</th>
<th>Name</th>
<th>Principal Investigator</th>
</tr>
</thead>
<tbody>
<tr>
<td>RG-297-113</td>
<td>Operations Research</td>
<td>Maria Isabel Azevedo Rodrigues Gomes</td>
</tr>
<tr>
<td>RG-297-117</td>
<td>Algebra and Logic</td>
<td>Carlos Manuel Saiago</td>
</tr>
<tr>
<td>RG-297-118</td>
<td>Analysis</td>
<td>Fabio Augusto da Costa Canaio Chalub</td>
</tr>
<tr>
<td>RG-297-1133</td>
<td>Statistics and Risk Management</td>
<td>Manuel Leote Tavares Ingles Esquivel</td>
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(RG-297-113) Operations Research

9.1. IDENTIFICATION OF THE RESEARCH GROUP

9.1.1 Reference of the research group
RG-297-113

9.1.2 Name of the Research Group in portuguese
Investigação Operacional

9.1.3 Name of the Research Group in English
Operations Research

9.1.4 Keyword(s)
Application driven problems
Optimization
Modeling
Algorithms

9.1.6 Existed in 2008/2012
Yes
9.2. RESEARCHERS IN THE GROUP

9.2.1. List of Integrated Members / 3 nuclear CVs

<table>
<thead>
<tr>
<th>Name</th>
<th>Principal Investigator</th>
<th>Nuclear CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maria Isabel Azevedo Rodrigues Gomes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Ana Luisa da Graça Batista Custódio</td>
<td>No</td>
<td>Yes</td>
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<tr>
<td>Jorge Orestes Lasbarres Cerdeira</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Graça Maria Marques da Silva Gonçalves</td>
<td>No</td>
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</tr>
<tr>
<td>Isabel Cristina Silva Correia</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Lídia Ludovina Lampreia Célio Pica Lourenço</td>
<td>No</td>
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<tr>
<td>Manuel Valdemar Cabral Vieira</td>
<td>No</td>
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<tr>
<td>Maria do Carmo Proença Caseiro Brás</td>
<td>No</td>
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<tr>
<td>Nelson Fernando Chibeles Pereira Martins</td>
<td>No</td>
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<tr>
<td>Paula Alexandra da Costa Amaral Jorge</td>
<td>No</td>
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<tr>
<td>Susana Maria Marques Henriques Botelho Baptista</td>
<td>No</td>
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</table>

9.2.2. List of current PhD students

NAME
Bernardo Pedro Esteves Ferreira de Almeida
Bruna Alexandra Elias Mota

9.2.3. List of other researchers of the Research Group

NAME
Maria Paula da Costa Couto
rui alberto pimenta rodrigues

9.3. RESEARCH GROUP DESCRIPTION AND ACHIEVEMENTS FOR 2008/2012

9.3.1. Description of the Research Group

Seven active members and one internal collaborator, on average, whose PhD degrees date from 2002 to 2007, composed the Operations Research (OR) group. All researchers are assistant professors at the Department of Mathematics of FCT/UNL and teach undergraduate courses with a teaching load of at least 9 hours a week, often more than one course per semester.

Being such a young group, all researchers have been working in close collaboration with other national and international renowned colleagues (collaborations have been established with University of Coimbra, University of Lisbon, University of Vienna, Saarland University of Applied Sciences, École Polytechnique de Montréal, Karlsruhe Institute of Technology, University of Florida, University of Kyoto, Rice University, Virginia Tech). Recently a few collaborations among group members have emerged, which denote the increasing maturity of the group members.

The main research topics are within nonlinear and combinatorial optimization.

In combinatorial optimization, research has been focusing on problem such as (i) facility and hubs location through different approaches: exact formulations (deterministic or stochastic, with the development of valid inequalities), metaheuristic approaches (mostly simulated annealing) and multi-objective formulations; (ii) project scheduling with flexible resources; (iii) multi-purpose manufacturing batch plants (iv) vehicle routing and dial-a-ride problems; (v) stochastic generalization assignment problem. In nonlinear optimization, research has addressed (i) semidefinite programming; (ii) derivative free optimization in single and multiobjective problems; (iii) complementary problems; (iv) copositive programming; (v) algorithm development.

Many of the abovementioned works have been applied to real world problems in other scientific fields such as engineering, medicine and management. In engineering the problems addressed concern structural mechanics, project-level structures, and design of electronic components. In medicine, work has been done in recognizing patterns of human vital signs. In management problems, the network design and operations planning within supply chain management have been tackled through different perspectives (algorithm development, deterministic and stochastic mathematical formulation, and multiobjective optimization). Many of these works have been developed in close collaboration not only with researchers of other scientific areas but also with practitioners.

Since 2008 the group has a regular seminar, encouraging knowledge exchange among group members, researchers from other campus units and invited national and international visitors.

Group members are engaged in activities to promote the interest of young students towards Mathematics. In particular, ClubeMath develops activities for 1st graders to high school students in 7 weekend afternoon sessions.
during the year. MatNova is a summer school for merit high-school students. These students are invited for a week in campus where, in small groups, they develop a project in one of 5 available themes. Group members were invited to participate in Tardes da Matemática (Afternoons of Mathematics) which are organized by the Portuguese Mathematics Society to promote mathematics to the general public. Lastly, two scientific posters are in display at the MATER exhibition, which is integrated in the celebration of Mathematics for Planet Earth 2013 and promoted by the FCT-UNL Department of Mathematics.

Formally, the group has one coordinator that is elected among the active members. The coordinator is responsible for the adequate distribution of the available funding and to support the adequate scientific development of members and collaborators (as short research visits to and from group members, conference participation, software and bibliography).

9.3.2 Main achievements

Within this five-year period the group has published 23 papers in peer-reviewed international journals, 10 book chapters, 18 papers in conference proceedings, and two national edited book. Five software codes were developed and made available for public use. The group members supervised 7 MSc students and one PhD student.

In the Leiden ranking 2007-2010, the unit has a MNCS (Mean Normalized Citation Score) score of 3.34 in the subject category Operations Research and Management being in the 2nd place among national institutions. In the same subject category, EU27 and National Science Foundation scores are 1.07 and 1.19, respectively.

Some researchers participated in seven scientific projects (funded by the National Science Foundation). Four of these projects were/are coordinated locally by group members.

The group was the local organizer of two international conferences: ICCOPT 2013, a flagship conference of the Mathematical Optimization Society, organized every three years, brought together about 500 participants; Optimization 2011 conference gathering about 200 participants. Taking the opportunity offered by ICCOPT, a weekend summer school on continuous optimization was organized which attracted about 200 students. The group also organized the National Operations Research Conference IO2009. The group integrated other national and international scientific events as members of the organizing or/and scientific committees.

Three works received recently special international recognition: (1) the paper [SPN10] co-authored by Maria Isabel Gomes was awarded 2013 Best Paper of European Journal of Operational Research in the category of “Theory and Methodology”, (2) the paper entitled “Addressing the uncertain quality and quantity of returns in closed-loop supply chains” co-authored by Maria Isabel Gomes was awarded as one of the “Most Downloaded” papers of Computers & Chemical Engineering, from September 2012 to August 2013, (3) Rui Rodrigues was ranked 3rd in the PhysioNet/Computing in Cardiology Challenge 2013.

9.4. RESEARCH GROUP OUTPUT 2008/2012

9.4.1 Publications in peer reviewed journals and/or other publications


9.4.2 Completed PhD theses


9.4.3 Patents and Prototypes or other research outputs

Mathdetetives – patent developed under ClubeMath activities

9.4.4 Books and book chapters of international circulation


9.4.5 Proceedings and papers of international conferences

Three works received recently special international recognition: (1) the paper [SPN10] co-authored by Maria Isabel Gomes was awarded 2013 Best Paper of European Journal of Operational Research in the category of “Theory and Methodology”, (2) the paper entitled “Addressing the uncertain quality and quantity of returns in closed-loop supply chains” co-authored by Maria Isabel Gomes was awarded as one of the “Most Downloaded” papers of Computers & Chemical Engineering, from September 2012 to August 2013, (3) Rui Rodrigues was ranked 3rd in the PhysioNet/Computing in Cardiology Challenge 2013.

9.4.6 Other research outputs

Three works received recently special international recognition: (1) the paper [SPN10] co-authored by Maria Isabel Gomes was awarded 2013 Best Paper of European Journal of Operational Research in the category of “Theory and Methodology”, (2) the paper entitled “Addressing the uncertain quality and quantity of returns in closed-loop supply chains” co-authored by Maria Isabel Gomes was awarded as one of the “Most Downloaded” papers of Computers & Chemical Engineering, from September 2012 to August 2013, (3) Rui Rodrigues was ranked 3rd in the PhysioNet/Computing in Cardiology Challenge 2013.
9.4.5 Conference proceedings


9.4.6 New materials, devices, products and processes

A. L. Custódio and J. F. A. Madeira, A test set for global optimization (MATLAB)
(http://ferrari.dmat.fct.unl.pt/personal/acustodio/glots)

A. L. Custódio, J. F. A. Madeira, A. I. F. Vaz and L. N. Vicente, A test set for derivative-free multiobjective optimization (AMPL)
(http://www.mat.uc.pt/dms)

9.4.7 Software, computer code and algorithms

A. L. Custódio and L. N. Vicente, SID-PSM: A pattern search method guided by simplex derivatives for use in derivative-free optimization (MATLAB), version 1.2
(http://www.mat.uc.pt/sid-psm/) No of requests = 138

A. L. Custódio, J. F. A. Madeira, A. I. F. Vaz and L. N. Vicente, Direct MultiSearch (DMS): a solver for derivative-free multiobjective optimization (MATLAB), version 0.2
(http://www.mat.uc.pt/dms) No of requests = 68

A. L. Custódio and J. F. A. Madeira, GLODS: Global and Local Optimization using Direct Search (MATLAB), version 0.1
(http://ferrari.dmat.fct.unl.pt/personal/acustodio/glots) No of requests = 1

R. Rodrigues, Detection of T-wave alternans
(http://physionet.org/challenge/2008/sources/Rodrigues/)

R. Rodrigues, Filling in Gaps in Physiologic Data
(http://physionet.org/challenge/2010/sources/Rui-Rodrigues/)

9.4.8 Books, including single-authored works (including scholarly editions of oral or written texts and translations with introduction and commentary)

Proceedings of the National Meeting of the Portuguese Mathematical Society, July 2012, Guest-editor Ana Luisa Custódio.


9.4.9 Edited special issues of journals, with substantial research input on the part of the researcher

9.4.10 Chapters in books, including contributions to conference proceedings, essays in collections


9.4.11 Creative writing (to the extent that it embodies research)

9.4.12 Encyclopedia entries (to the extent that they embody research)

9.4.13 Audio/visual and electronic/digital materials

9.4.14 Other categories, including web-based resources; video and audio recordings (to the extent that they embody research)

9.4.15 Performances and exhibitions to the extent that they embody research

A. L. Custódio, Calculando a idade das estrelas… um problema de OPTIMIZAÇÃO, scientific poster in MATER exhibition (in Portuguese)

M.I. Gomes, Projecto e planeamento de cadeias de abastecimento com fluxos inversos: um modelo genérico, scientific poster in MATER exhibition (in Portuguese)

9.4.16 Other research outputs

9.4.17 Organisation of scientific dissemination activities


Summer School on Continuous Optimization, FCT/UNL, July 2013 (http://eventos.fct.unl.pt/iccopt2013/summer-school)

Mini-Conference Calculus of Variations: from Engineering to Economy, FCT/UNL, September 2008 (http://ferrari.dmat.fct.unl.pt/caa2008/)


Thematic sessions in Optimization and Operational Research, Portuguese Mathematical Society, Algave University, July 2012

Short Courses on Stochastic Mixed Integer Optimization, lectured by Prof. Laureano Escudero (Universidad Rey Juan Carlos, Madrid) and Prof. Francisco Saldanha-da-Gama (Universidade de Lisboa), 2013 and 2011

Short Courses on Global Optimization, lectured by Prof. Immanuel Bomze (University of Vienna) and Prof. Eligius Hendrix (University of Malaga), 2010 and 2009 (http://www.fct.unl.pt/noticias/2010/11/global-optimization-course)

Operations Research Seminars, FCT/UNL, since 2008

9.4.18 Research contracts with national or international entities

9.4.19 Projects funded in national and international competitive calls

Luso-German Integrated Actions 2011, New quantitative approaches for logistics network design problems, Principal Investigator: Isabel Correia, Funding: 2.500 € (2011)

PTDC/MAT/116736/2010, Sparse and smoothing methods for nonlinear optimization of complex models,
9.5 ORGANISATIONAL STRUCTURE AND OBJECTIVES OF THE RESEARCH GROUP 2015/2020

9.5.1 Structure of the Research Group

The OR research group has 11 integrated members and 2 collaborators. The coordinator is elected among the group members and will be responsible to assure an adequate distribution of available funding, to promote group internal and external visibility and to support members’ activities when requested.

Scientifically, four members are experts in nonlinear optimization, being the remaining seven mostly involved in research topics within combinatorial optimization. Some collaborative works within the group and the unit are to be continued and new ones to be promoted.

The group will pursue with the scientific seminars in order to share the developed work among the group members and within nearby researcher groups. National and international researchers will be invited to participate at the seminars so that scientific collaborations can be strengthened or new ones emerge.

The short courses will also continue. These may be of the initiative of any group member and are to be supported by the group’s coordinator.

9.5.2 Objectives of the Research Group

The group develops research in two main areas: Non-Linear Optimization (NLO) and Combinatorial Optimization (CO). The topics addressed in NLO include: Derivative-free Optimization (DFO), Complementarity Problems (CP), Semi-definite Programming (SDP); in CO include: Networks Design Models (NDM), Hub Location Problems (HL), Vehicle Routing Problems (VRP), Resource Constraint Project Scheduling Problem (RPS).

Besides theoretical results, part of the work has been directed to real applications (as retail distribution [SBN10], electric and electronic equipment [FGB11]), reports in the scope of European Study Groups in Industry (http://www.maths-in-industry.org), and to the development of free available software, e.g DMS (http://www.mat.uc.pt/dms), SID-PSM (http://www.mat.uc.pt/sid-psm/), GLODS (http://ferrari.dmat.fct.unl.pt/personal/alcustodio) MuTyLink (http://pascal.iseg.utl.pt/~rbras/MuTyLink/), subselect (http://cran.r-project.org/web/packages/subselect/index.html).

Brief description of specific work to be carried out on the topics above follows.

DFO will address (i) the development of algorithms for global multiobjective problems, with applications in engineering. Software will be developed integrating ideas from previous codes (DMS and GLODS) (ii) noisy DFO problems, motivated by questions arising in Chemical Engineering, and for which a study on derivative-free estimates of the Lipschitz constant will be developed.

CP will, in particular, address the Second Order Cones for the Eigenvalue Complementarity Problem (EiCP), and Inverse and Quadratic EiCP, both for symmetric and non-symmetric cases by designing algorithms to solve the problem and explore the solution of the problems that occur in different classes of applications, as control theory and structural analysis.

SDP will investigate connections between SDP and the Satisfiability problem (SAT), namely between the feasibility of the SDP relaxation and unsatisfiability of the SAT.

The group addresses a number of different problems in the scope of NDM: (1) previous work has focused on supply chain design with cost minimization [SBN10]: the work will now continue into a multiobjective approach to model sustainability by considering economic, environmental and social objectives; (2) the development of single and multiobjective metaheuristics to tackle computational complexity when the modeling of supply chain following previous work [CPBN12], (3) the modeling of sources of supply chain uncertainty by stochastic formulation with the development of decomposition based solution strategies as previous work follow up [BBG12]; (4) work will continue on water network design problem considering piecewise-linear relaxations and applying principles of bilinear relaxation, (5) development of new quantitative models for variants of the classical hub location problems; (6) Past work on a generalization of the (node version of the) minimum Steiner tree and the minimum Steiner forest focused on the development of heuristics to handle very large instances (ENV/RON MODELL SOFTW, 40:336-339). The work will now be directed to the study of the polyhedra associated to a cut-covering formulation. The problem has applications in the design of ecological corridors linking habitats for multiple species.

VRP will continue its study on the modeling of multi-compartment vehicles and periodic issues intrinsic to collection problems, and on the dial-a-ride problem arising within the context of medical services. RPS will, in particular, focus on (1) the formulation of new variants for the resource constrained project scheduling problem with flexible resources following the previous work, (2) the tailoring of solution procedures to improve the quality of obtained feasible solutions.

The group will develop a PhD course on Operations Research to integrate Operations Research on a decision
9.1. IDENTIFICATION OF THE RESEARCH GROUP

9.1.1 Reference of the research group
RG-297-117

9.1.2 Name of the Research Group in portuguese
Álgebra e Lógica

9.1.3 Name of the Research Group in English
Algebra and Logic

9.1.4 Keyword(s)
Algebra
Logic
Graphs
Computation

9.1.5 Existed in 2008/2012
Yes

9.1.6 Participating Institution(s) to which the Research Group belongs
Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa (FCT/UNL)

9.2. RESEARCHERS IN THE GROUP

9.2.1 List of Integrated Members / 3 nuclear CVs

<table>
<thead>
<tr>
<th>Name</th>
<th>Principal Investigator</th>
<th>Nuclear CV</th>
</tr>
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<tbody>
<tr>
<td>João Nuno Gonçalves Faria Martins</td>
<td>No</td>
<td>Yes</td>
</tr>
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<td>Vitor Hugo Bento Dias Fernandes</td>
<td>No</td>
<td>Yes</td>
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<td>Carlos Manuel Saiago</td>
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<td>Ana Cristina Malheiro Casimiro</td>
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<td>António José Mesquita da Cunha Machado Malheiro</td>
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<td>Goncalo Jorge Trigo Nery Tabuada</td>
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<td>Isabel Maria Oitavem Fonseca da Rocha Kahle</td>
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<tr>
<td>Joaquim Eurico Anes Duarte Nogueira</td>
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<td>Manuel Messias Rocha de Jesus</td>
<td>No</td>
<td>No</td>
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<tr>
<td>Maria Helena Coutinho Gomes de Almeida Santos</td>
<td>No</td>
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<td>Reinhard Josef Klaus Kahle</td>
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<tr>
<td>Teresa Maria Jerónimo Sousa</td>
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<tr>
<td>Teresa Maria de Araújo Melo Quinteiro</td>
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</tr>
</tbody>
</table>

9.2.2 List of current PhD students

NAME
João Leitão Guerreiro

9.2.3 List of other researchers of the Research Group

NAME
Herberto Jesus Silva
Björn Gohla
9.3. RESEARCH GROUP DESCRIPTION AND ACHIEVEMENTS FOR 2008/2012

9.3.1 Description of the Research Group

In the period 2008-12 the group had a total of 8 members, each of which was a full member of the group for at least two consecutive years (during this period there was already a criterion adopted by the Center for the definition of an active member, namely the publication of a WOS indexed paper in the three antecedent years): H Liu (fired researcher), CM Saiago, G Tabuada, HJ Silva, JF Martins, MH Almeida Santos, T Sousa, and M Silva; and an Internal Collaborator C Perdigão. All the latter are currently professors at the Mathematics Department of FCT-UNL, teaching at least 9 hours per week. G Tabuada was on leave during 2011 and 2012, lecturing at the Mathematics Department of MIT. There were also two external Collaborators: B Gohla (PhD student of JF Martins) and J Guerreiro (Honour undergraduate student, financed by CMA, and advised by M Silva).

During the period 2008-12, the research was carried out in: Combinatorial Number Theory and Graph theory, where M Silva studied Numerical Semigroups, two problems related to the subset structure in the integers, as well as internal edge colorings for graphs; Extremal Graph Theory and Combinatorics, where T Sousa and H Liu, developed research on graph decomposition and its Ramsey version; Linear Algebra and Matrix Theory, where CM Saiago and C Perdigão worked on Inverse Eigenvalue Problems and eigenvalue multiplicities of Hermitian matrices with a given graph; Algebraic Topology, Algebraic Geometry, K-theory, and Homological Algebra, where G Tabuada successfully addressed (a) Kontsevich’s program for a theory of noncommutative motives, (b) conceptual characterization of Quillen’s higher K-theory, (c) Homotopical characterization of Drinfeld’s DG quotient; Higher Categories and Algebraic / Differentl Geometrical Methods for Topological Quantum Field Theories (TQFTs) where in the last few years JF Martins has focused on specific (categorical, topological and differential geometric) instances of a long-term project for extending Witten’s Chern-Simons invariants to the 4-dimensional world, via Higher Gauge Theory and categorification techniques; Ockham Algebras and Universal Algebra where HJ Silva studied the strong endomorphism kernel property for various kinds of algebras, namely for some particular varieties of Ockham algebras, yielding a description of minimal Ockham algebras; Semigroup Theory where MH Almeida Santos studied the structure of regular semigroups.

9.3.2 Main achievements

1) A considerable number of published papers in highly reputed international peer-reviewed journals (46 papers in 2008-12), such as Duke Math J, Adv Math, Adv Theor Math Phys, Linear Algebra Appl, Algebra Univers, Semigroup Forum, J Graph Theory.
2) Great increase in the number of international seminars and invited talks in international conferences (e.g.: QOO-Tallinn 2012, Conf. Motives-Tokyo 2012, Midwest Topology Conf.-Chicago 2011, ILAS-Pisa 2010, International Conf. on Homotopy Theory and Derived Algebraic Geometry-Toronto 2010), as well as contributed talks.
3) Organization of International conferences.
4) Six projects funded by the FCT/MCTES in course: one led by a member (T Sousa), and scientifically hosted by CMA, and the remaining 5 with participation of members of the group.
6) Interaction through projects or direct collaboration with researchers from national and international high level research centers and universities: e.g.: MIT, Unv St Andrews, Coll William and Mary, Univ Illinois Chicago, Univ Lisbon, Univ Coimbra, Univ Park, Nat Autonomous Univ Mexico, Univ Porto, Univ Warsaw, Univ Sci Tech Lille, California Inst Tech, Univ California LA, Univ Texas Austin, Univ Paul Sabatier Toulouse III, Univ Luxembourg, Univ Munster.
7) Promotion of the interest of young students by Mathematics and its applications (1) MatNova: a Summer School, specifically directed to high school students, is a regular event since 2010; (2) DI Math: with several activities directed to high school students and their teachers. (3) Aleph: a program for students from 7th-12th grade consisting of regular sessions every two weeks, exposing students to challenging mathematical concepts not covered by the school curriculum.
8) Some of the main Scientific Achievements. G. Tabuada: (1) First conceptual characterization of Quillen’s higher K-theory. This enabled streamlined construction of the higher Chern characters and of the cyclotomic trace map. (2) Homotopical characterization of Drinfeld’s DG quotient, making use of the cofiber construction in the realm of the theory of noncommutative motives. (3) Proof of a conjecture of Paranjape-Srinivas for the intersection of two quadrics and three odd-dimensional quadrics. (4) Semi-simplicity of noncommutative numerical motives. JF Martins: (1) Beginning of the theory of tri-bundles and their gauge transformations. (2) Categorification of the Kontsevich Lie algebra of chord-diagrams. MH Almeida Santos: Obtained necessary and sufficient conditions for the theory of noncommutative motives. (3) Beginning of the theory of numerical motives for the intersection of two K-theory. This enabled streamlined construction of the higher Chern characters and of the cyclotomic trace map. (4) Some of the main Scientific Achievements. G Tabuada: (1) First conceptual characterization of Quillen’s higher K-theory. This enabled streamlined construction of the higher Chern characters and of the cyclotomic trace map. (2) Homotopical characterization of Drinfeld’s DG quotient, making use of the cofiber construction in the realm of the theory of noncommutative motives. (3) Proof of a conjecture of Paranjape-Srinivas for the intersection of two quadrics and three odd-dimensional quadrics. (4) Semi-simplicity of noncommutative numerical motives. JF Martins: (1) Beginning of the theory of tri-bundles and their gauge transformations. (2) Categorification of the Kontsevich Lie algebra of chord-diagrams. MH Almeida Santos: Obtained necessary and sufficient conditions for the theory of noncommutative motives. (3) Beginning of the theory of numerical motives for the intersection of two K-theory. This enabled streamlined construction of the higher Chern characters and of the cyclotomic trace map. (4)
9.4. RESEARCH GROUP OUTPUT 2008/2012

9.4.1 Publications in peer reviewed journals and/or other publications

Blyth, T. S.; Santos, M. H. Almeida (2009), E-inversive Dubreil-Jacotin semigroups, Semigroup Forum, 78 (3), 511-527, DOI: 10.1007/s00233-008-9127-8, IF = 0.597, Times Cited: 1

Henry Liu, Sousa, Teresa (2013), Monochromatic K_r-Decompositions of Graphs, Journal of Graph Theory, DOI 10.1002/jgt.21750, IF = 0.626


Tabuada, Goncalo (2009), Homotopy theory of spectral categories, Advances in Mathematics, 221 (4), 1122-1143, DOI: 10.1016/j.aim.2009.01.014, IF = 1.403, Times Cited: 4


Martins, Joao Faria; Picken, Roger (2010), On two-dimensional holonomy, Transactions of the American Mathematical Society, 362 (11), 5657-5695, IF = 1.019, Times Cited: 5

Martins, Joao Faria; Mikovic, Aleksandar (2008), Invariants of spin networks embedded in three-manifolds, Communications in Mathematical Physics, 279 (2), 381-399, DOI: 10.1007/s00220-008-0422-8, IF = 1.971, Times Cited: 5

Kao, Jui-Yi; Rampersad, Narad; Shallit, Jeffrey; Silva, Manuel (2008), Words avoiding repetitions in arithmetic progressions, (English), Zbl 1133.68066, Theoretical Computer Science, 391 (1-2), 126-137, IF = 0.806

Liu, Henry; Mestre, Angela; Sousa, Teresa (2013), Rainbow vertex k-connection in graphs, Discrete Applied Mathematics, 161 (16-17), 2549-2555, DOI: 10.1016/j.dam.2013.04.025, IF = 0.718, Times Cited: 0

Silva, H. J. (2012), Minimal Ockham algebras, Algebra Universalis, 67 (4), 393-395, DOI: 10.1007/s00012-012-0193-0, IF = 0.446, Times Cited: 0

9.4.2 Completed PhD theses


9.4.3 Patents and Prototypes or other research outputs

9.4.4 Books and book chapters of international circulation

9.4.5 Conference proceedings


9.4.6 New materials, devices, products and processes

9.4.7 Software, computer code and algorithms

9.4.8 Books, including single-authored works (including scholarly editions of oral or written texts and translations with introduction and commentary)


9.4.9 Edited special issues of journals, with substantial research input on the part of the researcher

9.4.10 Chapters in books, including contributions to conference proceedings, essays in collections


9.4.11 Creative writing (to the extent that it embodies research)

9.4.12 Encyclopedia entries (to the extent that they embody research)

9.4.13 Audio/visual and electronic/digital materials

9.4.14 Other categories, including web-based resources; video and audio recordings (to the extent that they embody research)

9.4.15 Performances and exhibitions to the extent that they embody research
The overall aim is to improve the current (already advanced) level of scientific research thereby increasing the
An expansion of the Group is expected: new students and new collaborators.
Commun Algebra, Algebra Univers, Discrete Appl Math, Discrete Math, Linear Algebra Appl, J Graph Theory,
Cryptography); B. Gohla (Higher categories). During 2008-12 they published 19 papers in peer-reviewed journals:
(Universal Algebra); J Cabral (Algebraic Geometry); J André (Semigroup Theory); J Gaspar (Proof Theory and
(Linear/Multilinear Algebra); M Silva, H Liu (Combinatorics, Number and Graph Theory); JV Carvalho, H Silva
The research carried out by the remaining Integrated Members focus in the areas of: Linear Algebra, where CM
G. She also obtained a discrete geometric formulation of variational calculus in several independent variables.
respect to the action of an algebraic group G, and the (complete reducibility) irreducibility notion of subgroups of
(4)AC Casimiro proved the equivalence between the (poly)stability notion for points of a character variety with
MH Fernandes, and his former PhD student TM Quinteiro, was devoted to the study of transformation semigroups in the special case of monotone transformations; he also obtained results on aspects of special classes of semigroups, such as block-groups and quotient numerical semigroups.
(2)J Nogueira described several configurations which give rise to standard and non-standard f-subgroups for linear recurrences of order 2, and also a number of families of non-standard f-subgroups for recurrences of order greater than 2.
(3)The team consists of 2 Integrated Members, I Oitavem, working in computational complexity and R Kahé, a computer scientist, coming from mathematical proof theory, and a Collaborator J Gaspar, with a recent PhD in mathematical proof theory, working now in cryptography.
(4)AC Casimiro proved the equivalence between the (poly)stability notion for points of a character variety with respect to the action of an algebraic group G, and the (complete reducibility) irreducibility notion of subgroups of G. She also obtained a discrete geometric formulation of variational calculus in several independent variables. The research carried out by the remaining Integrated Members focus in the areas of: Linear Algebra, where CM Saiago works in eigenvalue problems for Hermitian matrices with a given graph; Semigroup Theory, where MH Fernandes (2009-2013) and R Kahé, a computer scientist, coming from mathematical proof theory, and a Collaborator J Gaspar, with a recent PhD in mathematical proof theory, working now in cryptography.
9.5 organisations STRUCTure AND OBJECTIVES of the RESEARCH GROUP 2015/2020
9.5.1 structure of the research group
The group of Algebra and Logic consists of 13 Integrated Members and 9 Collaborators. All of them are
mathematicians and, except TM Quinteiro (professor of ISEL), professors at the Mathematics Department of
FCT-UNL.
Eight of the 13 Integrated Members (A Malheiro, VH Fernandes, MM Jesus, TM Quinteiro; J Nogueira; R Kahé, I
(1A) Malheiro obtained results for some classes of rewriting systems and its associated monoids; in particular he showed, answering a question of Fields medalist E Zelmanov, that Plactic monoids of finite rank are biautomatic. Most of the work of VH Fernandes, and his former PhD student TM Quinteiro, was devoted to the study of transformation semigroups in the special case of monotone transformations; he also obtained results on aspects of special classes of semigroups, such as block-groups and quotient numerical semigroups.
(2J) Nogueira described several configurations which give rise to standard and non-standard f-subgroups for linear recurrences of order 2, and also a number of families of non-standard f-subgroups for recurrences of order greater than 2.
(3)The team consists of 2 Integrated Members, I Oitavem, working in computational complexity and R Kahé, a computer scientist, coming from mathematical proof theory, and a Collaborator J Gaspar, with a recent PhD in mathematical proof theory, working now in cryptography.
(4)AC Casimiro proved the equivalence between the (poly)stability notion for points of a character variety with respect to the action of an algebraic group G, and the (complete reducibility) irreducibility notion of subgroups of G. She also obtained a discrete geometric formulation of variational calculus in several independent variables.
The research carried out by the remaining Integrated Members focus in the areas of: Linear Algebra, where CM Saiago works in eigenvalue problems for Hermitian matrices with a given graph; Semigroup Theory, where MH Fernandes (2009-2013) and R Kahé, a computer scientist, coming from mathematical proof theory, and a Collaborator J Gaspar, with a recent PhD in mathematical proof theory, working now in cryptography.
9.5.2 Objectives of the Research Group
An expansion of the Group is expected: new students and new collaborators.
The overall aim is to improve the current (already advanced) level of scientific research thereby increasing the number of published papers in highly reputed international peer-reviewed journals.

Adding to the research objectives, the Group intends to increase internal collaborations among members of the Center and to contribute to have a competitive PhD program in Mathematics at FCT-UNL, therefore bringing PhD students to the Center.

The Group will address the important issues:
1) Oitavem and R Kahle will focus on Foundational research in Proof Theory (PT) and Implicit Computational Complexity (ICC). PT: formal theories accessible to a proof-theoretic analysis and with wide syntactical expressive power. ICC: design and analysis of restricted recursion schemata suitable to characterize classes of computational complexity. Interdisciplinarity Philosophy: the notion of proof and intentionality; History: the legacy of the rise of modern logic; Linguistics: sense and denotation as proof and truth; Computer science: interactive theorem provers, functional programming, and computational complexity.
2) G Tabuada plans to bridge the gap between motives and noncommutative motives by constructing an explicit functor from Voevodsky’s triangulated category of mixed motives to Kontsevich’s triangulated category of noncommutative mixed motives.
3) JF Martins will address: a) Categorification of Drinfeld associators and the 4-term relations, via a Lie-2-algebra of chord diagrams, in order to extend the Kontsevich integral. b) Harmonic analysis for representations of Lie categorical-groups, in order to address path integrals for 2-BF theories.
4) In Graph Theory T Sousa will pursue research in graph decomposition, the main problem being finding the smallest number \( f(n,H) \) such that, any graph on \( n \) vertices admits a decomposition into edge disjoint copies of a fixed graph \( H \) and single edges with at most \( fn(H) \) parts. T Sousa also intends to study the Ramsey/colored version of this problem, when the ground graph is colored, the goal being to find an optimal monochromatic \( H \)-decomposition. M Silva will address the Ramsey problems for infinite words and Interval Coloring.
5) In Algebraic Combinatorics we intend to obtain: a) Grobner-Shirshov basis for free associative algebras, arising from crystal graphs as in Kashiwara’s theory. b) Characterization of linear independence in orbital subspaces by the RSK correspondence and pairs of Young semistandard tableaux.
6) The research topic in Linear Algebra is Inverse Eigenvalue Problems and eigenvalue multiplicities of Hermitian matrices with a given graph.
7) In Finite Fields the research topic concerns the classification of f-groups as standard/nonstandard, their link with the restricted period and with cyclic linear codes.
8) In Semigroup Theory and Universal Algebra, the group plans to: a) Study transformation semigroups under several different aspects: combinatorial properties, congruences, presentations, maximal subsemigroups, automorphisms, endomorphisms, semidirect products, and other constructions, pseudovarieties generated by, etc. We note that transformation semigroups are strongly connected with automata, this being one of the deep links between Theoret Comp Sci and Abstract Algebra. b) Study special classes of semigroups, for instance block-groups or ordered semigroups. In particular, investigate elements of a semigroup that are structurally important (e.g. idempotents or the biggest idempotent with respect to a particular property). c) Study known algebras with an additional unary operation, such as semigroups, distributive lattices and Ockham algebras.
9) In Algebraic and Differential Geometry: a) The topology and singularities of character varieties of free group representations in a real Lie group and the Schottky uniformization problem for principal bundles over algebraic curves. b) The geometric formulation of variational problems involving principal bundles. c) Local fundamental groups of plane curves.

(RG-297-118) Analysis

9.1. IDENTIFICATION OF THE RESEARCH GROUP

9.1.1 Reference of the research group

RG-297-118

9.1.2 Name of the Research Group in portuguese

Análise

9.1.3 Name of the Research Group in English

Analysis

9.1.4 Keyword(s)

Partial & Ordinary Differential Equations
Numerical Analysis
Functional Analysis
Real-world applications

9.1.5 Existed in 2008/2012

Yes

9.1.6 Participating Institution(s) to which the Research Group belongs

Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa (FCT/UNL)

9.2. RESEARCHERS IN THE GROUP

9.2.1 List of Integrated Members / 3 nuclear CVs

<table>
<thead>
<tr>
<th>Name</th>
<th>Principal Investigator</th>
<th>Nuclear CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fabio Augusto da Costa Carvalho Chalub</td>
<td>Yes</td>
<td>Nuclear CV</td>
</tr>
</tbody>
</table>

9.2.2 List of current PhD students

NAME

Gonçalo Nuno Rosado Morais
Telma Margarida Cotovio Guerra Santos
Nuno David de Jesus Lopes
André Filipe Anaclério de Almeida
Ana Paula Barreiro Pimenta

9.2.3 List of other researchers of the Research Group

NAME

Ana Maria de Sousa Alves de Sá
João de Deus Mota da Silva Marques
Maria Fernanda Alves da Veiga de Oliveira
Cláudio António Rainha Aires Fernandes
ANTÓNIO MANUEL MORAIS FERNANDES DE OLIVEIRA
Ana Maria Manteigas Pedro

9.3. RESEARCH GROUP DESCRIPTION AND ACHIEVEMENTS FOR 2008/2012

9.3.1 Description of the Research Group

The group Analysis, formerly Differential Equations and Numerical Analysis, was consolidated during the years 2008-12. The team started the period under evaluation as an extremely young team. In 2010, 3 out of 11 members had less than 12 years after the PhD, and 6 less than 7 years after the PhD (data from 2008 and 2009 cannot be used, since 2010 was the first year when the scientific productivity criteria was applied to define membership).

Therefore, one of the strengths of the group was the diversity of scientific areas. Without the intention of being exhaustive, group members worked in Biomathematics; Calculus of Variations; Dynamic Systems; Functional Analysis; Numerical Analysis; Ordinary and Partial Differential Equations. All these fields were object of publications in peer-reviewed journals during the 5 years under evaluation.

A second strong point was the level of internationalization. Group members had scientific collaborations with researchers from Brazil, Spain, USA, France, Italy, Russia and Norway, including bilateral projects with the three first countries. Projects with Brazil and Spain only covered travel expenses, while those with USA also supported high level training and equipment.

During these five years, scientific productivity per capita remained stable, while group size had a small tendency for increasing (basically due to new hires from the Department of Mathematics, new PhD from non-PhD
However, the most important feature during these five years is that many members started to publish autonomously, alone or finding new collaborations.

Many national and binational projects were led by group members and funding proved to be adequate. In particular, we would like to stress the involvement of the group in the Carnegie Mellon University | Portugal collaboration, particularly Mascarenhas, Ferreira and Ribeiro. Ferreira finished her PhD in 2011 coadvised by Mascarenhas and Fonseca (CMU). During 2011/12 the team received the post-doc Kreisbeck in the scope of that program. A second post-doc was Danilkina, funded by the Multic project (Russia-EU) coadvised by Chalub (2012/13).

Two PhD theses were completed in 2011 and 2012 (Ferreira and Orey, respectively). At the end of 2012, Chalub received the “Investigador FCT”, a 5 years grant to pursue full time research.

Partly due to the youth of the group, there are few internal collaborations, a part from those supervisor-student. However, this is clearly about to change (see 9.5).

The involvement of the group in advanced training was limited and should be one of the first priorities for the next 5 years.

Specific achievements from team members during the period 2008-12 will be briefly explained below. We remark that This is not exhaustive, since some members moved away from the team (Kreisbeck moved to Germany, Caetano to France etc).

Outreach activities are one of the main goals of our Unit. Martins was the director of “Gazeta de Matemática”, a non profit-publication of the Portuguese Mathematical Society (SPM), Chalub writes regularly in the same magazine. Martins started a TV broadcasting about explaining Mathematics. Oliveira was treasury and vice-president of SPM. Mascarenhas, during 2008-2009, was member of the Committee of Applied Mathematics of the EMS, and president of the audit board of SPM, Soares participates in several activities for high-school students and is now part of a European network for outreach activities.

9.3.2 Main achievements

We now describe more specific achievements from individual group members during years 2008-12. After the work description, we refer to the number of publication in peer reviewed journals in the last five years.

Mascarenhas and Ferreira studied the asymptotic behavior of the spectrum of the Dirichlet-Laplace operator in thin periodically heterogeneous domains. Mascarenhas studied the eigenvalues of the Robin-Laplace operator in wave guides, using dimension reduction 3D-1D with respect to torsion, curvature and cross section. Localization effects due to asymmetries in the cross section were found. Ferreira characterized the multiscale limit of bounded sequences in BV and applied it to homogenization. (4 papers by Mascarenhas and 4 by Ferreira including 2 joint paper).

Ribeiro studied the relaxation and homogenization of certain integral functionals depending on two vector fields with different behaviors. The general relaxation problem was treated for cross-quasiconvex integrands. In the lack of this hypothesis the relaxed functional was obtained for decoupled models. The existence of solutions to vectorial differential inclusions, including problems involving isotropic deformations was also addressed. (4 papers).

Oliveira studied the local-well posedness of several dispersive systems (e.g. the quasilinear Benjamin system or the Schrodinger-Debye system). Regarding this last problem, a result of global existence, in both focusing and defocusing, for initial large data was obtained. In a different work, related to the Zakharov-Rubenchik equation, pointwise convergence of the magnetic field to a solution of the cubic nonlinear Schr"odinger equation, in the adiabatic limit is established. With respect to Boltzmann-like equations, a shock-wave profile for a discrete velocity model of the Boltzmann equation with multiple collisions is derived. H-theorem and the trend to equilibrium for a model describing a chemically active mixture of gases is established. (7 papers).

Chalub developed rigorous theory on how to simplify detailed stochastic models, providing, firstly diffusive approximations and finally, ODE-type models (e.g., the replicator dynamics or the SIR model in epidemics). Chalub also worked on the application of evolutionary game theory to models of cancer development (6 papers, one with impact factor above 5).

Rodrigues developed an alternative explanation for the increased reinfection cases among recurrent cases of tuberculosis. By using a simple model, experimental data was interpreted as a result from heterogeneity effects and not necessarily from an enhanced susceptibility after recovery. The model was fitted to data resulting from a systematic literature review. (2 papers, one with impact factor above 5).

Martins developed a theory of synchronization for coupled non-identical non-autonomous oscillators, coupled through an environment. Existence of orbits that attracts all the other orbits in the future was proved for a model in liquid crystals in the presence of an alternating shear and magnetic fields. (3 papers).

Arada studied optimal control problems governed by Navier-Stokes equations with shear-dependent viscosity (3 papers).

Louro and Soares showed the well posedness of the Riccati equation arriving from the invariant embedding method applied to a Poisson problem in a quasi-cylindrical domain. (3 joint papers).

Gomes has studied a classical variational framework known as the Nehari manifold related to the equation $-\Delta u=f(u)$ where $f$ is non-linear and $u$ satisfies Dirichlet boundary conditions on a regular domain $\Omega$. The results may be summarized as a local description of an infinite-dimensional hyper-surface in a Sobolev space $W^{1,\infty}(\Omega)\setminus\{0\}$ using a generalized notion of principal curvature. (4 papers).

Doutor studied the generalization of the classical thermodynamic formalism for nonadditive sequences, and characterization of the dimension spectra of Hölder continuous functions. (3 papers).
9.4. RESEARCH GROUP OUTPUT 2008/2012

9.4.1 Publications in peer reviewed journals and/or other publications


D. Dingli, F.A.C.C. Chalub, F.C. Santos, S. Van Segbroeck and J.M Pacheco (2009), Disease phenotype as the outcome of an evolutionary game between cells, British Journal of Cancer, 101, 1124-1129, IF = 5.082, Times Cited: 10


9.4.2 Completed PhD theses


9.4.3 Patents and Prototypes or other research outputs

Tetr4Math: no 20101000060575 (INPI); no 5638/2010 (IGAC)

9.4.4 Books and book chapters of international circulation


9.4.5 Conference proceedings


9.4.6 New materials, devices, products and processes

9.4.7 Software, computer code and algorithms

9.4.8 Books, including single-authored works (including scholarly editions of oral or written texts and translations with introduction and commentary)

9.4.9 Edited special issues of journals, with substantial research input on the part of the researcher

9.4.10 Chapters in books, including contributions to conference proceedings, essays in collections


9.4.11 Creative writing (to the extent that it embodies research)

9.4.12 Encyclopedia entries (to the extent that they embody research)

9.4.13 Audio/visual and electronic/digital materials

9.4.14 Other categories, including web-based resources; video and audio recordings (to the extent that they embody research)

R. Martins, Deputy director (2008-2010) and Director (since 2011), Gazeta de Matemática, a non profit publication from the Portuguese Mathematical Society (one publication every three months, Jan. 2008 - Dec. 2010)

R. Martins, Presenter of a program about mathematics for general audiences in a commercial (cable) television (weekly, since 2012).


M. C. Soares - Organizer of MatNova (a summer school for secondary students, 2010-12), ClubeMath (Club of Mathematics, with periodic meetings and activities, for basic and high school students, 2008-12, a series of lectures for the general public (since 2010).

F. Chalub, Several articles at Gazeta de Matemática, a non profit publication from the Portuguese Mathematical Society (one paper, every three months since 2009)

9.4.15 Performances and exhibitions to the extent that they embody research

9.4.16 Other research outputs

9.4.17 Organisation of scientific dissemination activities


First workshop of the CMU-Portugal ICTI program in Mathematics New Developments in PDE & Calculus of Variations, 11 September, 2008 CMA Member: M. Luísa Mascarenhas (Organizer and Scientific Committee) http://www.math.cmu.edu/CNA/CNAevents/icti08/index.html


Encontro Nacional da Sociedade Portuguesa de Matemática, 8-10 July 2010 CMA Member: F. Oliveira (Scientific Committee)

10th Colloque Franco-Roumain de Mathématiques Appliquées, Poitiers, France 26-31 August 2010 CMA Member: L. Mascarenhas (Scientific Committee)


First Workshop in Game Theory and Evolutionary Dynamics, Niterói, Brazil, 31 January-4 February 2011. CMA Member: Fabio Chalub (Organizer and Scientific Committee)

Summer School "Dynamical Models in Life Sciences" (Centro Internacional de Matemática, European
9.4.18 Research contracts with national or international entities

9.4.19 Projects funded in national and international competitive calls

PTDC/MAT/109973/2009 Optimization methods in continuum mechanics, Principal Investigator: M. Luísa Mascarenhas, CMA Participants: Rita Ferreira, Bento Louro, Maria do Céu Soares, Nadir Arada, Ana Margarida Ribeiro, Maria de Serpa Orey and Telma Santos, Total funding: 70.000 euros (2010-2013)

PTDC/MAT/66426/2006 Mathematical models of evolutionary processes funded by FCT/Portugal, Principal Investigator: Fabio Chalub, Funding: 49.000 euros. (2008-2010)


UTA_CMU/MAT/0005/2009 Thin structures, homogenization and multi phase problems, Coordinator: M. Luísa Mascarenhas, CMA Participants: Carolin Kreisbeck, Ana Margarida Ribeiro and Rita Ferreira, Total funding: 168.200 euros (2011-2013), Funding: FCT/Portugal, University of Texas at Austin and Carnegie Mellon University

Project CMU-PT/0019/2007 FCT/ UNL Activities Plan under the Mathematics focus area of the CMU-Portugal Program, Coordinator: Fabio Chalub, CMA Participants: Carolin Kreisbeck, Rita Ferreira, Ana Margarida Ribeiro and Maria Luisa Mascarenhas, Total funding: 41.248 euros (2007-2012), Funding: Carnegie Mellon University and FCT/ Portugal

Bilateral Agreement Portugal-Brazil, Mathematical and Computational Aspects of Game Theory, Portuguese Coordinator: F.A.C.C. Chalub, Total funding: 10.000 euros (2009-2010), Funding: FCT/Portugal and CAPES/Brazil

Bilateral Agreement Portugal-Brazil, "Dispersive equations", Portuguese coordinator: Filipe Oliveira, Total funding: 10.000 euros (2010-2011), Funding: FCT/Portugal and CAPES/Brazil

Luso-Spanish integrated actions 2010. Action number E98/10, Portuguese Coordinator: Rogério Ferreira Martins, Total funding 4.000 euros (2010-2011), Funding: FCT/Portugal and MCI/IN/Spain

9.5. ORGANISATIONAL STRUCTURE AND OBJECTIVES OF THE RESEARCH GROUP 2015/2020

9.5.1 Structure of the Research Group

The group is composed of all elements of the CMA that works primarily with mathematical analysis, either as a tool for better understanding of problems originated in other fields of knowledge (applied mathematics) or looking for the development of the area by itself (pure mathematics).

The group works in a wide range of problems:
- Calculus of variations and optimization (AMR, RF, LM, JMG, NA)
- Numerical analysis (MR, LT, NM, NA)
- Mathematical modeling in biology (FC, PCR, PD, MCS, AO*)
- Fluid mechanics (NA, FCM)
- Inverse problems (NM)
- Conservation laws in hyperbolic differential equations (FO)
- Dynamical systems (RM, AMST*),
- Geometrical view of partial differential equations (JMG)
- Boundary value problems (BL, MO),
- Functional analysis and operator theory (OK, CF*, JDM*, AP*)
- Stochastic modeling (FCM)
- Optimal control (NA)

(* collaborators in the present proposal)

Comparing with the evaluation of 2008-12, it is clear that the group experimented an increase in number of members, fields of work, scientific quality and internal coherence. In particular, there is a large number of ongoing scientific collaboration that are expected to fructify in the next five years, with funding for two projects guaranteed for 2014-15 (50 keuros). Some of these collaborations will be explained in further detail in 9.5.2.

The level of internationalization of the group is high: USA (LM, RF, LT, OK), Italy (AMR), France (BL, MO, MCS), Spain (RM), UK (MR), Brazil (FC, PCR, FO), Tunisia (FCM). Collaboration with researchers in Portuguese universities is also high (Technical, Lisbon, Minho, Évora, Vila Real). The interdisciplinarity is good, with ongoing collaborations with physicists (FC, RM), biologists (PCR), engineers (LT), chemists (FC, LT).

For the next five years, we plan a larger involvement in the doctoral program. It is important to note that the two international partner of the FCT/UNL doctoral program in mathematics, Carnegie Mellon University (CMU), USA, and Universidade Federal Fluminense (UFF), Brazil, are important partners of group members. In particular, Mascarenhas and Ferreira have ongoing collaboration with Fonseca (CMA) and Chalub has collaborations with Souza (UFF). In both cases, as part of the joint PhD program (expected to be running in the academic year 2014-15), there are a number of joint projects that will foster students interchange. Therefore we expect an increasing in number of the PhD students as a consequence of two factors: the larger attractiveness of an international program and the possibility to have students interchange; in the last case, it is likely to expect a larger flow from Brazil than from USA. Cosupervison was already implemented in the CMU program and is part of the deal with UFF. It is part of our plan to have long terms visitors of these partners at CMA and that group members spent time at both partners.

We plan weekly/biweekly seminars for the full group, plus eventual seminars in the thematic lines involving analysis. Short courses are also planned as a mean to foster internal collaborations.
Thematic lines involve members of the group as a natural consequence of the importance of the analytical tools in all fields of math. This will be described in further details at the appropriated topic.

Due to the high level of internationalizations, having appropriate funds both for incoming visitors and for missions abroad is important. Of vital importance is to have long term visitors (3 months - 1 year). Working conditions (office and computers) for visitors shall be provided by the department of mathematics or by the center. It is also important, mainly to junior members in the current proposal or to be hired, to have the possibility to spend at least one year abroad.

As part of the group is involved in computer simulations, it is important during the time span of 5 years to renew the computer cluster. Also, all desktops and laptops should be renewed in the next five years.

9.5.2 Objectives of the Research Group

Here we describe our main objectives for the next five years. We give focus to projects with guaranteed funding (calculus of variation/imaging restoration and math-biology/epidemics/vaccinations). Afterwards, we describe other projects, with highlights in partial differential equations, numerical and functional analysis. Due to the lack of space, collaborators are not discriminated.

The work of AMR, LM, NA, OK and RF will focus on some variational methods used in image restoration. The restored image, obtained as a minimizer of a suitable energy functional, is generally a solution of a highly nonlinear and severely ill posed partial differential equation. The aim is to set these problems in appropriate functional frameworks and to carry out the corresponding mathematical analysis and numerical implementation. Part of this research will be funded in 2014-15 by FCT (24 keuros).

AMR also works on minimization of functionals to ensure existence of minima when there is a lack of lower semicontinuity.

PCR, FC, MCS, PD work in the intersection between epidemiology and game theory. The main objective is to address the impact of voluntary vaccination in the spread of diseases, particularly in seasonal epidemics. The SIR epidemic model with periodic coefficients and voluntary vaccination will be considered and the aim is to look for optimal vaccination strategies. It is expected that a rational choice with respect to pulse vaccination, in the beginning or in the end of the season, will have different impact on the epidemics. These conditions will be analyzed for different vaccination types. This research will be funded in 2014-15 by FCT (25 keuros).

PCR, FC, MCS, PD work in the intersection between epidemiology and game theory. The main objective is to address the impact of voluntary vaccination in the spread of diseases, particularly in seasonal epidemics. The SIR epidemic model with periodic coefficients and voluntary vaccination will be considered and the aim is to look for optimal vaccination strategies. It is expected that a rational choice with respect to pulse vaccination, in the beginning or in the end of the season, will have different impact on the epidemics. These conditions will be analyzed for different vaccination types. This research will be funded in 2014-15 by FCT (25 keuros).

FO studies local well-posedness issues and the existence and stability of solitary waves for the Zakharov-Kuznetsov equation, which models the propagation of nonlinear ion-sonic waves in a magnetized plasma. FO also plans to research on singularity formation of solutions and is interested in adapting these methods to Schrodinger-Debye and Dawey-Stewartson systems.

OK, CF will study convolution type operators in more general spaces than Banach spaces. Typical examples are Lebesgue spaces $L_p$ and $l_p$ for $p$ less than one as well as more general Orlicz spaces generated by non-convex Orlicz functions. CF intend to investigate the Fredholm property in C$^*$ algebras of nonlocal type operators generated by partial isometries. OK will prove boundedness conditions and Fredholm criteria for pseudodifferential operators with certain symbols of limited smoothness on variable exponent Lebesgue spaces over $R^n$.

LT will study Boussinesq-like wave models and, in collaboration with chemists, diffusion of chemical substances through membranes. Both studies will include the analytical and the numerical points of view. MR intends to develop a robust, efficient and stable method with a reasonable order of convergence for the numerical solution of the time-fractional diffusion equations. NM will use mesh-free inverse numerical methods to identify thermal and acoustic sources and obstacles.

JMG will study properties of level sets of ground-states, i.e. minimizers of the Dirichlet integral under volume constraints (or shape constraints such as quasi-concavity). The approach consists in using small perturbations of Lipschitz functions that preserve the imposed constraints such as ‘local’ translations or rotations of superlevel sets. FCM will proceed the study of the inviscid limit and boundary layer problem to deterministic and stochastic Navier-Stokes equation, using the entropy and the large deviations techniques. RM will study the periodic sine-Gordon equation with friction, to find a topological characterization of the attractor. MO and BL will use control techniques to study over-determined and under-determined boundary value problems in PDE.

(RG-297-1133) Statistics and Risk Management

9.1. IDENTIFICATION OF THE RESEARCH GROUP

9.1.1 Reference of the research group
RG-297-1133

9.1.2 Name of the Research Group in portuguese
Estatística e Gestão do Risco

9.1.3 Name of the Research Group in English
Statistics and Risk Management

9.1.4 Keyword(s)
Statistics
Actuarial and Financial Mathematics
Modelling
9.1.5 Existed in 2008/2012
Yes

9.1.6 Participating Institution(s) to which the Research Group belongs
Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa (FCT/UNL)

9.2. RESEARCHERS IN THE GROUP

9.2.1 List of Integrated Members / 3 nuclear CVs

<table>
<thead>
<tr>
<th>Name</th>
<th>Principal Investigator</th>
<th>Nuclear CV</th>
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<tbody>
<tr>
<td>João Tiago Praça Nunes Mexia</td>
<td>No</td>
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<td>Carlos Manuel Agra Coelho</td>
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<td>Manuel Leote Tavares Inglês Esquivel</td>
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<td>Ayana Maria Xavier Furtado Mateus</td>
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<td>Célia Maria da Silva Fernandes</td>
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<td>Filipe José Gonçalves Pereira Marques</td>
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<td>Francisco Paulo Vilhena Antunes Bernardino Canhalho</td>
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<td>Frederico Almeida Giao Gonçalves Caeiro</td>
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<td>Isabel Cristina Maciel Natário</td>
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<td>João Filipe Lita da Silva</td>
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<td>Luís Pedro Carneiro Ramos</td>
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<td>Maria de Lourdes Belchior Afonso</td>
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<td>Marta Cristina Vieira Faisal Mateus</td>
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<td>Miguel dos Santos Fonseca</td>
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<td>Paulo Jorge Canas Rodrigues</td>
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<td>Pedro José dos Santos Palhinhas Mota</td>
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<td>Vanda Marisa da Rosa Milheiro Lourenço</td>
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</tbody>
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9.2.2 List of current PhD students

NAME
RUTE ALEXANDRA BAIÃO CARRUJO
Sandra Inês da Cunha Monteiro
Dina Maria Morgado Salvador
João Beleza Teixeira Seixas e Sousa
Ricardo Pinto Moura

9.2.3 List of other researchers of the Research Group

NAME
Gracinda Rita Diogo Guerreiro
RUI MANUEL PESADO ALBERTO
Luís Miguel Lindinho da Cunha Mendes Grilo
Inês Jorge da Silva Sequeira
9.3. RESEARCH GROUP DESCRIPTION AND ACHIEVEMENTS FOR 2008/2012

9.3.1 Description of the Research Group

Following a recommendation of the evaluation panel, the present group is the fusion of the three previous lines: “Statistical Inference” coordinated by JTMexia gathering the researchers EMMoreira and MFonseca, and the university professors CNunes, DFMFeira, SSFerreira, CNunes, AMAteus, LRamos, PPRamos, RCovas, ISeleuca, PCRodrigues from the Federal University of Bahia, Salvador, Brazil; “Distribution Theory” coordinated by CACoelho integrated FMarques, FCAeiro, DGomes, MFMcguens all from FCT/UNL and LRuico; “Actuarial and Financial Mathematics” coordinated by MLAfiaia also with GQuerreiro, MFaias, RRCardoso, MLAfiaia, PPOMota, from FCT, MBdCanhalho from Pontificia Universidade Católica de Chile, GDReis, from Technische Universitat Berlin and CAVeiga from Barclays Capital in London. Several members of the group collaborate lecturing courses and directing thesis work in the PhD program of FCT/UNL Statistics and Risk Management that has now 25 active students.

During the period 2008-2012 the main subjects treated by the research lines were as follows.

The research line “Statistical Inference” studied various extensions of linear models, in particular a new very exciting subject introduced in 2009, the analysis of variance for models with a random number of observations. Other themes treated by researchers were: a mechanical instrument to evaluate posture of the tridimensional spine position, crossing balanced nested, stair nesting and step nesting designs, an application of statistical methods to the study of chromosomal fragile sites as regions of human genome susceptible to chromosomal rearrangements and viral integrations, forest fires and droughts, structuring genotype and environment interaction and, spectral modeling of time series with missing data. The works of the researchers in this line received several awards, detailed in the section 9.3.2; other awards deserving to be mentioned received by the works of PCRodrigues are: the Mat Triad Young Scientists Awards 2011; the LinStat Young Scientists Awards 2010 and Prêmio SPE 2009, Portuguese Statistical Society, September 30, 2009 prize attributed to the best paper by young statisticians submitted to the XVII Conference of the Portuguese Statistical Society. The researchers have strong international connections for instance with the universities of Zielona Gora in Poland and Greensboro in USA.

In the research line “Distribution Theory” there were two main research subjects: near-exact distributions for likelihood ratio test statistics and extreme value theory. The strong points of this sub-group are its quite good productivity, and its wide international relations, among which we may refer the following. Studies on the exact distributions of several likelihood ratio test statistics with Professor Barry C. Arnold from the Statistics Department of the University of California at Riverside; development of near-exact distributions for the Behrens-Fisher statistic, carried out in collaboration with Professor Junyong Park from the Department of Mathematics and Statistics of the University of Maryland Baltimore County; near-exact distributions for very elaborate structures of covariance matrices, with Professor Anuradha Roy from the Department of Management Sciences and Statistics at the University of Texas at San Antonio; near-exact distributions for covariance structures defined by Kronecker products with Martin Singull from the Mathematics Department at Linköping University in Sweden; several distributional problems and issues in collaboration with Professor Benjamin Kedem from the Department of Mathematics of the University of Maryland at College Park, Washington DC.

In the research line “Actuarial and Financial Mathematics” the themes spread over the classical actuarial problems in risk theory, to new models for pricing and hedging derivative products, passing through Markov chain models applications to credit scoring and insurance bonus-malus models.

9.3.2 Main achievements

JTMexia, CNunes, EMMoreira, DFMFeira, SSFerreira: obtained impressive results on F-tests with random non-centrality parameters and random degrees of freedom for the errors, appearing in 12 published papers starting in 2009. The case of random non-centrality parameters was fully studied. The paper “Orthogonal fixed effects ANOVA with random sample sizes” received the WSEAS Award the prize of the Best Paper of the 5th International Conference on Applied Mathematics, Simulation, Modelling.

CACoelho, FMarques, LRuico, in near-exact distributions, got the development of near-exact distributions for likelihood ratio test statistics, namely the sphericity test, the test of equality of covariance matrices, and a new approach to the test of independence of blocks of variables which, were in turn used in the study of some tests such as the multi-sample block-diagonal sphericity test and the multi-sample block-matrix sphericity test. These results appeared in one book, 11 papers in peer-reviewed journals and 5 short papers indexed in the ISI Web-of-Science.

Frederico CAeiro, in 7 papers and 2 conference proceedings, made several comparative studies of reduced bias
extreme value index estimators and studied several classic semi-parametric estimators of parameters of rare events, including the recently introduced “Probability Weighted Moments” estimators of parameters of extreme events.

DGomes: resampling techniques together with the adaptive choice of a ‘tuning’ parameter were applied in the estimation in statistics of extremes. A new “Probability Weighted Moment” estimator for extreme quantiles was proposed based on the estimators of the tail's shape and scale parameters. A real case of extreme spatial precipitation in Portugal was discussed. A software in R environment is available for the statistical analysis of spatial extremes. The results were published in 2 papers, 2 book chapters and 4 conference proceedings.

GGuerreiro: got confidence intervals and asymptotic distributions for a Markov chain model for open populations subject to periodical reclassifications, published in 4 papers dealing also with applications to “automobile insurance”, “pension fund populations” and “default probability on a corporate credit portfolio”.

MFonsoeca, CUNunes, EMoreira, DFerreira, SSFerreira, MBdeCanalho, JTMexia: Advances were made in the inference for models with orthogonal block structure and for estimation and hypothesis testing with constraints on fixed effects parameters. A method for inference in multi-levelled data with equicorrelated data was also developed. Results were published in 7 journal papers and 3 conference proceedings.

MBdeCanalho received two important awards: Young Researcher Award, Section on Risk Analysis (2011) from the American Statistical Association and ERS IASC Young Researcher Award (2008) from the International Association for Statistical Computing. His work focused in the development of methods of stochastic optimization and application of methods of statistics of extremes, resulting in 4 papers and a book to appear December 2014. MFaias obtained results in Mathematical Economics. In an incomplete financial market economy, endogenization of the asset structure to prove the existence of equilibrium in which agents are unable to infer any additional information from prices. By means of a Shapley-Shubik game provided strategic foundations for the Walrasian equilibrium of an economy that have incomplete and asymmetric information on the states of nature in an economy with public goods. These results were published in 4 papers and 2 book chapters.

MLEsquivel, LLamors, JFLSilva, JTMexia, MFonsoeca, PPMota published 5 papers on the asymptotic analysis of distribution functions and 2 papers on diffusions with regime switching and delays. GdSoReis, studied proof mathematical economics and financial mathematics and stability path regularity of backward and forward backward stochastic differential equations (6 published papers).

9.4. RESEARCH GROUP OUTPUT 2008/2012

9.4.1. Publications in peer reviewed journals and/or other publications


Caeiro, F., Gomes, M.I. and Rodrigues, L.H. (2009), Reduced-bias tail index estimators under a third-order distribution functions and 2 papers on diffusions with regime switching and delays.

GdSoReis, studied proof mathematical economics and financial mathematics and stability path regularity of backward and forward backward stochastic differential equations (6 published papers).

Francisco Canelha (2010), Inferência para Modelos com Commutative Orthogonal Block Structure, Departamento de Matemática, Universidade de Évora. Supervisor: João Tiago Mexia.


Paulo Ramos (2009), Interacção entre factores aninhados, Departamento de Matemática, Universidade da Beira Interior. Supervisor: João Tiago Mexia.


9.4.3 Patents and Prototypes or other research outputs

9.4.4 Books and book chapters of international circulation


9.4.5 Conference proceedings


9.4.7 Software, computer code and algorithms

9.4.8 Books, including single-authored works (including scholarly editions of oral or written texts and translations with introduction and commentary)

9.4.9 Edited special issues of journals, with substantial research input on the part of the researcher

9.4.10 Chapters in books, including contributions to conference proceedings, essays in collections

9.4.11 Creative writing (to the extent that it embodies research)

9.4.12 Encyclopedia entries (to the extent that they embody research)

9.4.13 Audio/visual and electronic/digital materials

9.4.14 Other categories, including web-based resources; video and audio recordings (to the extent that they embody research)

9.4.15 Performances and exhibitions to the extent that they embody research

9.4.16 Other research outputs

9.4.17 Organisation of scientific dissemination activities


Paulo Canas Rodrigues: Chair of the International Organizing Committee/Scientific Program Committee of the 17th European Young Statisticians Meeting, Caparica, Portugal, 5-8 September 2011.

Paulo Canas Rodrigues: Member of the International Program Committee of the 11th annual conference of ENBIS (European Network for Business and Industrial Statistics), Coimbra, Portugal, 4-8 September 2011.

Paulo Canas Rodrigues: Member of the International Scientific Program Committee of the YSI 2011 – ISI Young Statisticians Meeting, Dublin, Ireland, 19-21 August 2011.

Francisco Canalho: Member of the Organizing Committee of the International Conference on Trends and Perspectives in Linear Statistical Inference (LINSTAT 2012) and 21st International Workshop on Matrices and Statistics (WMS 2012), Bedlewo, Poland, 16-20 July 2012.

Rui Cardoso: Member of the Scientific Committee of the ASTIN COLLOQUIUM 2011, Madrid, 19-22 June 2011.

Marta Faias: Member of the Local Organizing of the UT-Austin Portugal Summer School and Workshop in Mathematics-Mathematical Finance and Stochastic Control, Department of Mathematics of the Faculdade de Ciências e Tecnologia of Universidade Nova de Lisboa, 2-13 July 2012.


9.4.18 Research contracts with national or international entities

Software Platform for V@R portfolio computations, Principal Investigator: Manuel L. Esquivel, CMA Participants: Pedro Corde Real and João Beleza Sousa, Total funding: 50,000 € (2010-2011).

9.4.19 Projects funded in national and international competitive calls

Constrained inference problems in extreme value modeling, Principal Investigator: Miguel de Carvalho, Total funding: 79,858 Euros (50638000 Chilean Pesos), Grant by: FONDECYT-Chilean NSF, Duration: 3 years (Start: October 2012).

PTDC/MAT/101736/2008, Extrema: statistical extremes in today’s world, Principal Investigator: María hette Leal de Canhalho Gomes, CMA Participants: Dora Gomes and Frederico Caeiro, Total funding: 89,520€ (UL) (2010-2013).

Project number 226544-Models for adaptive forest management, Principal Investigator: José G. Borges, CMA Participants: Ayana Furtado, Total funding: 9,071€ (European Commission) (2009-2013).


SA0870A08: Junta de Castilla y León, Spain, Mercados, Coaliciones e Información. Principal Investigator: Emma Moreno, CMA Participants: Marta Faias, Total funding: 2,000€ (2008-2010).

CCES project spatial extremes and environmental sustainability: Statistical methods and applications in


9.5. ORGANISATIONAL STRUCTURE AND OBJECTIVES OF THE RESEARCH GROUP 2015/2020

9.5.1 Structure of the Research Group

The group’s composition for 2015-20 remains essentially the same, except for the integration of Natalio that will bring her expertise in hierarchical Bayesian models for epidemiological studies, modeling of population dynamics, Bayesian networks, syndromic surveillance, and spatial and temporal point processes. Also MBCanhalo, GdosReis and CVEiga are no longer integrated members, since they do not have a contract with a Portuguese academic institution.

Despite the existence of the three research lines “Statistical Inference”, “Distribution Theory” and “Actuarial and Financial Mathematics”, collaborations between them is driven by common research interests and productivity improvement. We are also deepening collaborations with other research groups.

There will be reinforcement on both national and international connections of the group. Firstly, we will continue our links with the previous integrated members MBCanhalo, GdosReis and CVEiga; secondly, the already existing collaborations will be reinforced; thirdly, new collaborating countries will take place, mainly due to the influx of students from Mozambique, Cape Verde and Brazil to our PhD program in “Statistics and Risk Management”. An attractive feature of this PhD program is the associated European Doctorate Degree.

There is a strong drive for establishing partnerships with industry. Besides the perspective of being able to properly fund the research activities, this is seen as an opportunity to collaborate in the study of scientifically interesting and socially relevant problems. The university-industry cooperation will consist of two future projects: “Modeling in Actuarial and Financial Mathematics and Risk Assessment” (MAFM&RA) and “Statistical Modeling in Health, Environment and Genetics” (SMHE&G). Both projects will take advantage of previous cooperation with industry that will be deepened and extended. Concerning the project MAFM&RA, there has been two contracts with banks for providing software to deal with pricing of derivative interest rate products, in one case, and with risk measures computations for derivative products in the other. In both projects master and PhD students were involved and played decisive roles.

Concerning new collaborations we stress the following: ISequeira and EMoreira, collaborate with the Department of Genetics, Faculdade de Ciências Médicas, Universidade Nova de Lisboa (FCM/UNL) they apply statistical methods to the study of chromosomal fragile sites as regions of human genome susceptible to chromosomal rearrangements and viral integrations, using the database of Chromosomal Imbalance and Phenotype in Humans using Ensembl Resources (DECIPHER) and the International Standardization of Chromosomal Imbalances and Arrays (ISCA) Consortium database. The same two researchers, in collaboration with the Department of Pharmacy, University of Brasilia (UnB), will estimate the prevalence of endothelial dysfunction and the presence of inflammatory markers suggesting early vascular abnormalities in preadolescent children with type I diabetes mellitus and will do an analysis of seroprevalence of toxoplasmosis and rubella in pregnant women attending at Laboratório de Patologia Clínica do Hospital Universitário de Brasilia.

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9.5.2 Objectives of the Research Group

The group will pursue the same research themes that have received peer recognition and appreciation in the recent past: only some of these are detailed below. The group will look for establishing a solid net of industry relationships aiming at diversifying the financing sources for research.

JTMexia, CNunes, EMoreira, DFemeira, SSFerreira: F-tests with random non-centrality parameters and random degrees of freedom for the errors. Determination of the statistics and their distributions, and the development of techniques for calculating critical values for models with random sample sizes. Applications on real and simulated data.

CACoelho, FMarques, LGrilo, will pursue the development of near-exact distributions for elaborate covariance structures used in multivariate Growth Curve, Time Series and Mixed Models (Khati, 1973; Lee, 1991; Yokoyama and Fujikoshi, 1992; Pollock, 2002; McCullagh, 2006, 2008, Srivastava et al., 2009). The covariance structures used in those models assume a block structure, related with some Kronecker product so, we aim at developing near-exact distributions for the distributions of likelihood ratio test statistics for such structures.

GGuerreiro: The study of Ruin Probability under the presence of a Bonus Malus System on an automobile insurance portfolio is a project with industry. Using data from two Portuguese insurance companies and using the model on Aonso et al. (2009) we intend to develop a model for estimation of ruin probability under a BMS following classical and open approach for BMS.

MFonseca, JTMexia: The main research activities will be in univariate models with constraints on fixed and random effects, regarding estimation, hypothesis testing and confidence regions. For multivariate models, inference will be developed for structured data in complex model, also incorporating time dependency. These
10. PROPOSED THEMATIC LINES

<table>
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<tr>
<th>Reference</th>
<th>Name</th>
<th>Principal Investigator</th>
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<tr>
<td>TL-297-61</td>
<td>Mathematical modeling for the independent living of elderly, disable, and chronic patients</td>
<td>Maria Isabel Azevedo Rodrigues Gomes</td>
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(TL-297-61) Mathematical modeling for the independent living of elderly, disable, and chronic patients

10.1. IDENTIFICATION OF THE THEMATIC LINE

10.1.1 Reference of Thematic Line
TL-297-61

10.1.2 Name of the Thematic Line in Portuguese
Modelos matemáticos de apoio à vida independente

10.1.3 Name of the Thematic Line in English
Mathematical modeling for the independent living of elderly, disable, and chronic patients

10.1.4 Principal Investigator
Maria Isabel Azevedo Rodrigues Gomes

10.1.5 Scientific areas
Mathematics
Neurosciences, Ageing and Degenerative Diseases
Diagnostic, Therapies and Public Health

10.2. DESCRIPTION OF THE THEMATIC LINE

10.2.1 Description of the Thematic Line
In the last decade the Europe Union (EU) has faced some demographic changes. The increase of life expectancy as well as the decrease of birth rate has changed Europe’s demography. In one hand, our society has now a larger number of elder people who will need in a near future some kind of assistance in order to live in the most independent way. Other social groups have similar needs. People with disabilities need assistance, some of them all their lives, in order to be able to live a productive and independent life. Chronic-ill patient may reach a dependency state of living that will need assistant to improve their quality of life. On the other hand, a smaller number of active people are available to support independent living (nurses, home workers, drivers, among others). A recent report from the Instituto Nacional de Estatística (Statistic Portugal) on Portuguese fertility as methods will be applied in analysis and forecasting in long-term care services. Comfort Keepers, a personal assistance service provider, is involved in this research.

RRCardoso: In one published and 1 accepter paper, the classical risk model was considered modified in two different ways by the inclusion of a dividend barrier: numerical algorithms were presented to approximate or bound the expected discounted value of dividends up to a finite time horizon. Also it was established a closed connection between the dual and the classical risk. In the following, we will extend the results for ruin probabilities, time to ruin and expected present dividend amounts for the dual risk model considering inter-claim distributions Erlang(n), generalized Erlang(n) and Phase-Type(n). Calculate the ruin probability for an auto insurance policy portfolio with a bonus malus system.

FCardoso will work on Second-order Parameters Estimation for reduced-bias parameter estimation of extreme events and in "adaptive selection of thresholds". We now intend to apply an idea of Gomes & Oliveira (2001) - bootstrap threshold selection - to adaptive selection of thresholds in reduced bias estimation procedures.

DGomes: will work on the estimation of relevant parameters in statistics of extremes using an adaptive algorithm on "Probability Weighted Moment Estimator of Extreme Quantiles" and modeling spatial extremes in real cases studies.

MBdeCarvalho: will work on Bayesian nonparametrics, multivariate extreme value modeling and Inference methods for diagnostic data.

MFaias: We used club theory for the first time to provide an equilibrium setting where traders sort into bourses to trade their securities. Our aim now is to show that trading complementarities and bourse formation costs explain market fragmentation and the emergence of bourses with an incomplete security structure. We will study a game with incomplete information and stable residual demand functions where firms compete in prices. The stability in the demand is provided by a new variable, the type of the firm, reflecting its ability to attract customers.
concluded that, on average, the Portuguese have 1.77 children. This value is far below the 2.1 children which is the threshold on population's renewal. This sets Portugal among the EU27 countries with low fertility rate. The 2008 EU report on Healthcare clearly stated that “multidisciplinary advanced and applied research (…) is needed for cost effective user-friendly solutions for active, independent and assisted daily living (…) for the ageing population and people with disabilities” (“Home care in Europe”, WHO report 2008, p.37). In this research line we aim to contribute to this appeal.

The academic community has already woken up for this problem, mostly from the social, medical or technologic points of view. In Beswick et al. (The Lancet, 371:725-35) an extensive meta-analysis allowed authors to conclude that quality of life improves if people with needs are helped at their homes. Moreover, they suggest that care should be tailored to the needs of each individual. From the technologic side, extensive research has been done in the development of technologic instruments (as robots, online software, direct connections between homes and medical center). Some EU supported projects have investigated and tested equipment and software to assist older people on their everyday lives. As examples we can mention SILVER (Supporting Independent LIving for the Elderly through Robotics - www.silver ccp.eu) or OLDES (Older People's E-SErvices at home - coords.europa.eu/projects/rcn/80510_en.html). However, the mathematical modeling of elderly, disabled and chronic-ill patients related issues are still at an embryonic stage. One of the first works was proposed by Evebom et al. (in INTERFACES 39: 18-34) where a decision support system based on optimization models is proposed. Under Swedish context, the developed system plans on a daily basis and as efficiently as possible staff scheduling and transportation routes. Nickel et al. (in EJOR, 219:574-87) mathematically formulated the problem of home health care assistance integrating decisions such as nurse rostering, nurse allocation and vehicle routing. Due to computational difficulties, a metaheuristic approach was applied and the problem was solved through a decomposition approach. Recently, Cardoso et al. (Health Care Management Science, 15:385-412) developed a simulation model based on a Markov tree structure to forecast future demand for long time care services in Portugal. Authors point out the need of mathematical models to help the planning of service supply so that increasing demand is met. A socio-economic study of disability in Portugal can be found in (Portugal, Martins, Ramos, and Hespanha, 2010) but it does not go deep in the analysis of cost factors and resource needs.

Within thematic strand, we will look into “active, independent and assisted daily living” in two main perspectives. A first one is to study these social groups (elderly and disable people) through statistical models so that influences of location, economical and medical factors, among others, are analyzed and statistically modeled. Optimization is the second perspective. These groups have special needs that translate into new problems. As example, the home care assistance integrates a set of services (e.g. medical care, home cleaning, help with eating, meal delivery, door-to-door transportation) and service providers (such as nurses and home workers) which, as the volume of provided service becomes larger, renders the efficient decision making harder. Tools will be developed to support the decision-making process. The statistical studies will provide the characterization of the individual, the needs and the services that are being provided at the present, the identification of significant covariates associated with individuals, and the prediction of resource needs across individual, geographic area and time. To achieve this, multivariate linear and non-linear models will be used to identify observable and latent influential variables. Time dependency will be incorporated in these prediction models, including Markov processes for discrete variables, like medical condition or economical status. Deterministic and dynamic optimization models will allow managing in a more effective and efficient way all the complex systems that emerge when providing different kinds of care at different places, fulfilling different needs. The connection between these two modeling perspectives will be integrated through the modeling of systems’ uncertainties and risks within optimization models. When speaking about efficiency and effectiveness, one should not forget that all activities have a direct effect on peoples’ lives. Decision must therefore be taken in a compromise between cost efficiency and service quality. This calls for multiobjective approaches where both objectives can be put into a trade-off perspective. Collaboration with agents in the field is of the outmost importance, and the research team will collaborate with IPCVI (Portuguese Institute for Citizenship and Independent Life) and a non-profit organization promoting the Independent Living philosophy, and Comfort Keepers, a company that provides personal assistance services (www.comfortkeepers.pt). Computational difficulties are expected since real world modeling can easily be computational intractable. Therefore, a deep study of models’ nature in terms of their algebraic structure will be performed in order to develop decomposition approaches improving model solvability. Other relocation directions such as efficient strengthening (Math. Program., Ser. A 122: 121-54) and preprocessing procedures (Math. Program, 71:221-45) are to be investigated.

10.3. RESEARCH GROUPS INVOLVED IN THE THEMATIC LINE

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10.4. ORGANISATIONAL STRUCTURE AND OBJECTIVES OF THE THEMATIC LINE

10.4.1. Structure of the Thematic Line

Researchers from three research groups of the unit will compose this strand research group. The work will be divided among the three groups according to each scientific skill. The coordination will be in charge of the one investigator from the Operations Research group. The Statistics and Risk Management group will be in charge of all tasks related with the data collection, characterization of the population and prediction of parameters of interest. The investigators with expertise on statistical inference and prediction namely, on linear multivariate mixed models, time series and Markov chain models. Spatial statistics is also an area of expertise for this team. The Operations Research group will support all the work related with the optimization modeling. The OR investigators have been developing their research mostly on logistics problems related with distribution networks and supply chain management (see the OR research group report). Among technical issues, topics such as mixed-integer linear programming modeling, stochastic modeling and meta-heuristic algorithms are among the OR group expertise.

Since we aim at developing integrated approaches that fit reality the best way possible, knowledge created by the statistical studies will be embed in the models developed by the OR group. Researchers of the Algebra and Logic research group will be in charge of the theoretical studies to improve the computational performance of the developed models. These researchers have been investigating on linear and
multilinear algebra, and matrix theory. In particular, they have been focusing on matrix associated with graphs. It is our intention to propose MSc and PhD research themes and therefore create a student research group within the PhDs of Mathematics and Statistics and Risk Management programs available at the Department of Mathematics of FCT/UNL.

10.4.2 Objectives of the Thematic Line

Our main objective is to support planning and increase the knowledge concerning independent living for the elderly, disabled and patients with chronic diseases. The models will contribute to a better decision making process towards life quality for these societal groups. Our work will develop in three main tasks:

Task one will study and characterize the population with different needs related to their well being. This characterization will allow the analysis of significantly influential factors like geographical location, financial status, medical situation and socio-economical variables on the needs of the elderly and the disabled. Another purpose of this study is to compare the costs of a patient living at home in an institutionalized environment (like a nursing home, for example) and living with the aid of personal assistance. Techniques used will range from multivariate linear models and GIS models to stochastic time series and Markov processes. The aim is to create a predictive model on the logistic needs of each person and the necessary resources on each locale.

Task two will develop models supporting decision-making process related with homecare assistance, personal transportation, among others in order to increase both efficiency and service quality. The modeling approaches will be mixed-integer linear programming, stochastic programming and meta-heuristic algorithms. Nonetheless, being this research topic a recent one among academia, new problems may arise where other modeling techniques may be more adequate. The research performed within the previous task will be integrated into the developed models so that the operations research formulations will better fit the studied problems. This will bring new challenges since we aim at integrating, for instance, Markov processes and mixed-integer linear formulations.

In order to face computation difficulties we intend to develop solution strategies based on integrating exact modeling with heuristics or meta-heuristics approaches (matheuristics), strategies that will take advantages of models underlying matrix structure which will permit the development of decomposition solutions techniques. This will be the third major task.

Some of the models will be tested under real problem context in close collaboration with companies and associations. These tests will allow the fitting of the models to real worlds problems, which eventually will bring new insights and new modeling challenges. Moreover, we believe that knowledge has to be accessible to practitioners. Therefore we aim at making a difference with the development of tools that will be useful to users with no background on optimization. At present we have been in close contact with the Portuguese Institute for Citizenship and Independent Living and Comfort Keepers.

For the 5-year period we aim at producing 6 international peer-review journals. The work will be presented in national and international scientific meetings (as the EURO Working Group on Operational Research Applied to Health Services, CompStat, Conference of the Portuguese Operations Research Society). We also aim at attracting students to research topics related with the theme. Therefore we expect to have at least 2 PhDs and some MSc students developing their studies around this topic.


10.1. IDENTIFICATION OF THE THEMATIC LINE

10.1.1 Reference of Thematic Line

TL-297-62

10.1.2 Name of the Thematic Line in Portuguese

Modelação Matemática em Ecologia, Evolução e Genética

10.1.3 Name of the Thematic Line in English

Mathematical Modeling in Ecology, Evolution and Genetics

10.1.4 Principal Investigator

Jorge Orestes Lasbarreres Cerdeira

10.1.5

Scientific areas

Mathematics
Diagnostic, Therapies and Public Health
Biological Sciences or Environmental Biology

10.2. DESCRIPTION OF THE THEMATIC LINE

10.2.1 Description of the Thematic Line

Biology is nowadays a focal discipline for many sciences, and its attachment to mathematics, in particular, significantly grew during the last years [MAY04]. Complex mathematical models are increasingly used in studies from various fields of biology, and sophisticated computer applications produce results that support actions by decision-makers. The enormous variety of mathematical questions addressed (e.g., modeling suitable conditions for species, estimating impacts of climate change, study of emerging diseases, cancer modeling, statistical analysis of medical data, medical imaging etc.), and the speed at which studies are developed to respond to pressing questions, are factors that incur serious risks regarding the appropriateness of models and, consequently, on conclusions and eventual decisions [DJLSW98, CR11]. Thus, there is an urgent need for a
greater interaction between mathematicians and biologists. A number of researchers of CMA have been working in different mathematical subjects (differential equations, statistics and stochastic processes) with applications to different areas in biology (evolution, epidemiology and genetics). This group of researchers includes Fabio Chalub (FC), Paula Rodrigues (PR), Vanda Lourenço (VL) and Paulo Canas Rodrigues (PCR). Since he has joined CMA, FC has published several papers combining game theory and partial differential equations to model population dynamics [FC09a, FC09b, FC14] and disease transmissions [FC11]. He is co-editor, together with JF Rodrigues, of the book “The Mathematics of Darwin's Legacy” (Springer, 2011). PR is working since her PhD, which she has finished in 2009, in epidemic models, and in particular in the spread of tuberculosis [PR09, PR12]. She is PI of the FCT project EXPL/MAT-CAL/6794/2013 which will study the effect of voluntary vaccination in seasonal epidemics, combining game theory and epidemiology. Vanda Lourenço (VL) and Paulo Canas Rodrigues (PCR), both having their PhDs completed in 2012, are actively working in statistics applied to genetics [VL11, PCR13, PCR12, PCR11a, PCR11b, PCR11c]. VL is PI of project PTDC/AGR-FRO/2335/2012, which aims at developing new statistical methods to improve the understanding of genotype-by-environment interaction and QTL (quantitative trait loci)-by-environment interaction as well as improve QTL detection, in the context of plant genetics.

Work on mathematical models for biology will now be strengthen with the inclusion in CMA of two new members: Isabel Natário (IN), previously at the Statistical Research Center of the University of Lisbon (CEAUL) and Jorge Céspedes Cerdeira (JOC) that was at the Forestry Research Center (CEF) of the Technology University of Lisbon. IN has been working for more than 10 years in spatial statistics, in a Bayesian statistical framework, especially in the context of applications to epidemiological studies of contagious diseases [IN13a, IN11, IN05, IN03] (in collaboration with the Health National Institute Dr. Ricardo Jorge), forest fires [IN13b], and in modeling deep fish populations' dynamics [IN13c] (collaborations with Portuguese Institute of the Sea and Atmosphere). JOC has skills in graphs and combinatorial optimization, which he has applied to conservation biology and ecology. In conservation, he has mainly focused in connectivity issues [BCAA13, JOC12, JOC10, JOC07, JOC05a, JOC05b]. In ecology he has worked in issues related to the characterization the ecological niche of species [JOC14a, JOC13b, JOC12b], and started recently working on ecological networks [JOC14b].

Besides these researchers, several other members of CMA from every research group (Analysis, Operations Research, Statistics and Risk Management, and Algebra) are willing to work with core members for carrying their expertise on mathematics to address biological issues. A thematic line on mathematical models on ecology, evolution and genetics would create an appropriate environment for scientific collaboration and interchange for all the researchers at CMA with interest in mathematical biology, even if this is not their primary field of research. It would increase the impact of their work within biological sciences, and would be a strategic endeavor for CMA. In particular, it would be a fundamental step to:

a) Establish collaborations with other departments (departments of Life Sciences, Earth Sciences, and Environmental Engineer) of the Faculty for co-supervising students;
b) Create a PhD program on mathematical modeling on ecology, evolution and genetics;
c) Compete for national projects;
d) Establish a solid and competitive research team in mathematical applications to biology to be a strong opponent to ERC grants by 2020

If a single goal were to be picked this would be setting a strong group in math applied to biology, and a competent partner for addressing the mathematical issues in projects on environment, ecology or genetics.

References (authors not from CMA)

References (one author within the thematic line)
[PCR13] Australian J. of Crop Science, accepted
[PCR11c] Crop Science 51: 96-980, 2011
[IN13c] Aquatic Living Resources, in press.
[IN05] Statistical Methods in Medical Research 14: 61-82, 2005
[JOC14b] Biology Letters, accepted
[JOC14a] Environmental and Ecological Statistics, in press
[JOC10] Biological Conservation 143: 408-415, 2010

10.3. RESEARCH GROUPS INVOLVED IN THE THEMATIC LINE

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10.4. ORGANISATIONAL STRUCTURE AND OBJECTIVES OF THE THEMATIC LINE

10.4.1 Structure of the Thematic Line

The present proposal aims at putting together several people working in different however related topics, all of them connected to the applications of mathematics in problems in biology, namely in evolution, ecology and genetics. The goal is to create a team recognized by its expertise on mathematics to biology, and capable to be a valuable partner in projects on different areas of biology, tackling the underlying mathematical issues.

The team on the thematic line consists of core members (those that are already well familiarized to work in math-biology), other members who have already expressed intention to direct their work to the interface of mathematics and biology in collaboration with core members, and expectately other CMA members that may wish to participate in initiatives in the scope of the thematic line, and that may become interested in joining the team.

To make the team grow, scientifically strong and coherent, the PI of the thematic line, together with core members, will promote a series of initiatives, such as:

* Organization of regular seminars, where different techniques are discussed. In particular, presentations of standard techniques in one subject to specialists from other areas.

* Organization of short courses given by experts to introduce compelling unresolved issues in different biological areas.

* Establishment of protocols with institutions (a protocol with Hospital Garcia da Horta in Almada, a big hospital located near the Faculty campus, was recently signed) needing advice on problems that fit in the scope of the thematic line. This can be a source of interesting problems, and a valid contribution of CMA at regional or national level.

* Establishment of contacts with other departments of the Faculty for co-supervision of students.

As short range goal, we intend to:

* Publishing both in biological and mathematical journals, not only in journals in the interface of these subjects. Note that core members have expertise to publish in a wide variety of areas. The work will be performed in close collaboration between core members, non-core members and external collaborators.

* To apply in the FCT periodic calls. It is worth mention that four core members of the thematic line are PI of four FCT projects (three ongoing, and the other due to start by 2014), with a total budget of approximately 140 Keuros.

* To actively participate in the PhD program, teaching math-biology disciplines and supervising students.

* To increase international collaboration with leading international groups. Current collaborations include Global Change and Conservation, Univ. Helsinki ; Grand Challenges in Ecosystems and the Environment, Imperial College London ; School of Environmental Sciences, Univ. of East Anglia, UK; Centro de Estudos Florestais, Univ. Lisboa ; Universidade Federal Fluminense, Universidade Federal de Pernambuco, Brazil; International Council for the Exploration of the Sea; Institut Français de Recherche pour l'Exploitation de la Mer. Planned collaborations for the next years include Fudan University (China).

As middle and long range goals, we establish:

* To be competitive, by year 2020, in European calls, alone or in network, therefore being able to get funds outside FCT.

* To participate actively in the PhD program in mathematics, aiming to become the kernel of a future PhD program in mathematical biology, to be offered jointly or in collaboration with appropriate departments at UNL (Life Sciences, Environment, Physics (Biomedicine)).

10.4.2 Objectives of the Thematic Line

Here we describe specific scientific tasks to be addressed.

1 – Characterization of the ecological niche of species. a) Members of this task are currently developing software to produce maps of environmental suitability for species. Preliminary results indicate that the approach is capable to adequately relate environment with biota, but practicability requires the development of efficient algorithms to compute depth. Combinatorial optimization models and techniques will be developed. b) A related important issue is niche overlap. This is a notion which is difficult to quantify as the intersection of niches should account for distinct fitness species’ gradients. We plan to address this issue exploring a combinatorial general proposal to assess the separability of sets of entities accounting for distinct levels of depth [JOC12b]. c) A conservationist pressing question is to estimate and decide on the viability of species under climate change. Response relies on the knowledge of ecological species niche, species dispersal pattern, and prediction on climate change over time. Putting this information together, the persistence of species along temporal corridors (sequence of sites on each of different time periods) may be estimated. We deem at identifying corridors for different species, assessing the given level of persistence for each species, and minimizing the costs of using selected sites for conservation purposes. We intend to address this problem in the context of network flow, and to develop solution methods that permit to handle large instances. We are planning to apply this methodology for Europe (excluding Eastern countries), assessing four time periods (current baseline, 2020, 2050 and 2080), and a wide array of species (approx. 1500 vertebrate and plant species) in approximately 25,000 (100km2) planning units.

2- Work will continue on the intersection between epidemiology and game theory to address the impact of voluntary vaccination in the spread of diseases [PNAS 101: 13391-13394], in particular in seasonal epidemics [J Math. Biol. 33(4): 421-438]. See the description in the Analysis group (section 9.5) to details.

3 - Evolutionary models of populations with constant size and in discrete time are described as Markov processes. There are some natural requirements that are shared by most models used in the literature. In this task, we aim to filter the essentials of all these processes (e.g., homogeneous states are stationary; non homogeneous states always diffuse – in a process called genetic drift; fixation probabilities are increasing etc), in order to obtain a general description. Matrices within this class should form an Algebra, as the composition of different evolutionary processes should be admitted. It is natural to expect that stochastic ordering will play a central role [Stochastic Proc. Appl. 5, 231–241].

4- Research on case-control secondary phenotype analysis will assess and develop: a) strategies for dealing with non-random sampling; b) robust statistical methods to account for data-misspecifications.

5- Development and application of new algorithms for low-rank approximations, robust statistical methods and linear mixed models for statistical modeling of GEI and QEI.

6- Research on genetic algebras and microarray experiments will also be of interest.

7- Optimizing the sampling of sparse (small number of trees per hectare), aggregate (no random nor regular spatial structures) and irregular (include trees of several ages and sizes) forest stands. Theoretical approaches
based on spatial stochastic models exhibiting spatial clustering will be explored for comparing the ratios (precision/costs) of alternative sampling designs considering: different sampling units (fixed-area plot vs k-tree distance sampling), different size of the sampling units (radius in fixed-area and number of trees in k-tree distance sampling) and different number of sampling units, using real and simulated data.

11. BUDGET FOR THE STRATEGIC PROGRAMME 2015/2020

11.1 The unit is a candidate for evaluation and intend to apply for funding?
Yes

11.2 Host institution’s budget

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Overall budget:

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12. STRATEGIC PROGRAMME AND BUDGET RATIONALE 2015/2020

12.1 Overall budget rationale

Overheads due to FCT/UNL represent 20% of the expenses of the project in missions, consultants, services and acquisitions, human resources and equipment.

The annual costs of missions and consultants are based in the previous budgets, taking into account the increment of the number of active members. Regarding consultants we added about 10% of the budget to support the thematic lines.

Missions, per year: 130 000€
Total of Missions: 780 000€
Consultants, per year: 36 000€
Total of consultants: 216 000€

In service procurement and acquisitions, we considered current expenses with consumables, bibliography, open access expenses, electronic access to important databases as MathSciNet and a contract for computer assistance.

Consumables / bibliography / open access, per year: 5 000€
MathSciNet access (single subscriber rate outside of a consortium), per year: 9 000€
12.2 Human Resources rationale

The needs of the Unit, concerning human resources, are the following:

1. A science and technology secretary grant, presently supported by our budget, is fundamental to the regular scientific management of the Unit (65 active members).
2. 4 initiation research grants.
3. 4 postdoctoral fellows positions.
4. A visitor position.

The salaries considered in the budget correspond to the values established by the FCT for the corresponding grants (2013). Additionally to each grant, we considered the social insurance (SI), with an annual update, based on the increments from 2011 to 2012 and from 2012 to 2013.

A science and technology manager grant, per year: \((12\text{months}) \times 1000€ = 12\ 000€\)

4 initiation research grants, per year: \((4\text{persons}) \times 12\text{(months)} \times 745€ = 35\ 780€\)

4 postdoctoral fellows grants, per year: \((4\text{persons}) \times 12\text{(months)} \times 1495€ = 71\ 760€\)

A visitor grant, per year: \((12\text{months}) \times 2650€ = 31\ 800€\)

Total of 6 yearly updated SI:

\[\text{SI, per month, during 2015: 127,87€} \times (1+2+3+4+5) \times 6,29€ \times 12\text{(months)} \times 10\text{(persons)} = 103\ 388€\]

Total of human resources: \(1\ 011\ 308€\)

12.3 Equipment rationale

The scientific justification for our equipment necessities may be found in section 6.4.

Personal computers (PC) have an efficient lifetime of approximately 5 years, so we considered the renovation of all the existent PC, along the 6 years of the project duration. This corresponds to a total of 71 units (65 active members, 5 post doctoral fellows / visitors, and a science and technology secretary). The equipment must consist of updated models, corresponding to the effective scientific needs of the research. The previewed costs also include small equipment, such as individual multifunction printer / scanner or external disks. We also considered the renovation of a Color Laser Jet - multifunction, of the workstation Leibniz, a Linux machine used for massive computations, and the annual acquisition and maintenance of software. The annual costs with the acquisition and maintenance of software were based in the previous budgets, taking into account the increment of the number of active members.

PC (desktop / laptop) update (spread along the 6 years): \(71\text{(persons)} \times 1300 € = 91\ 300€\)

Color LaserJet Multifunction (2015): \(1\ 000 €\)

Workstation (2016): \(2 \times 5\ 000 €\)

Software, per year: \(5\ 000 €\)

Total of equipment: \(133\ 300€\)

13. REVIEWERS PROPOSED BY THE R&D UNIT(S)

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<td>University of Pisa, Italy</td>
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<tr>
<td>Jorge Zubelli</td>
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