



Center for Mathematics and Applications

CMA/FCT/UNL

2015 Report

FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

Funded by Project UID/MAT/00297/2013



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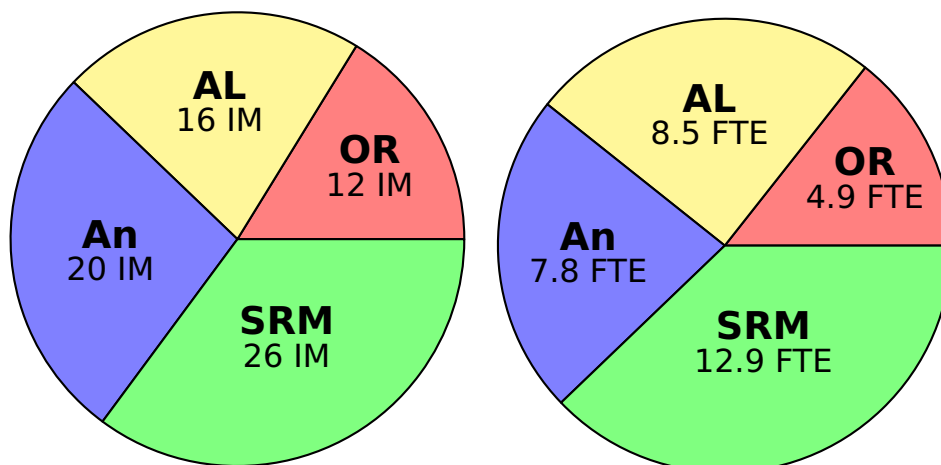
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Part I

Pictorial Report

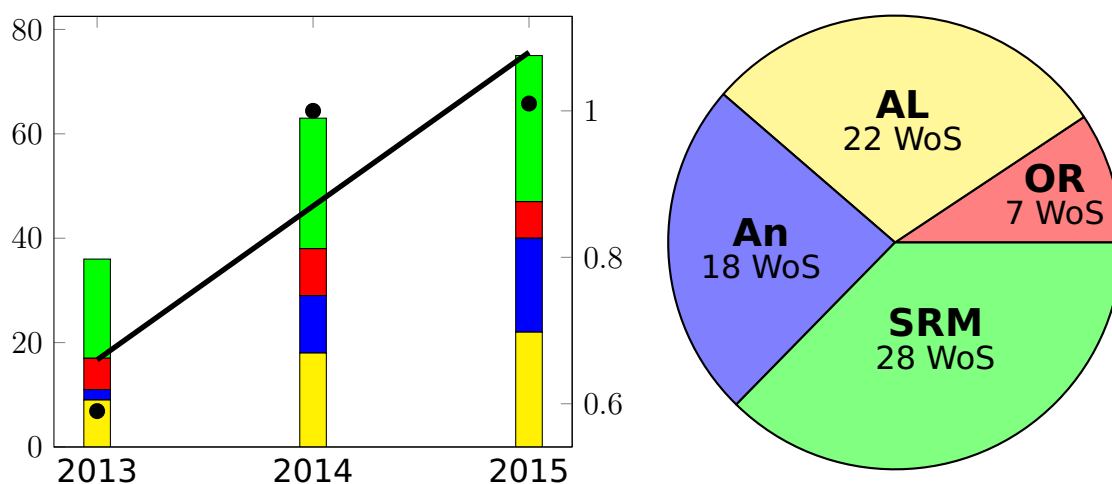
■ — Algebra and Logic; ■ — Analysis;
■ — Operations Research; ■ — Statistics and Risk Management.

Composition — 2015



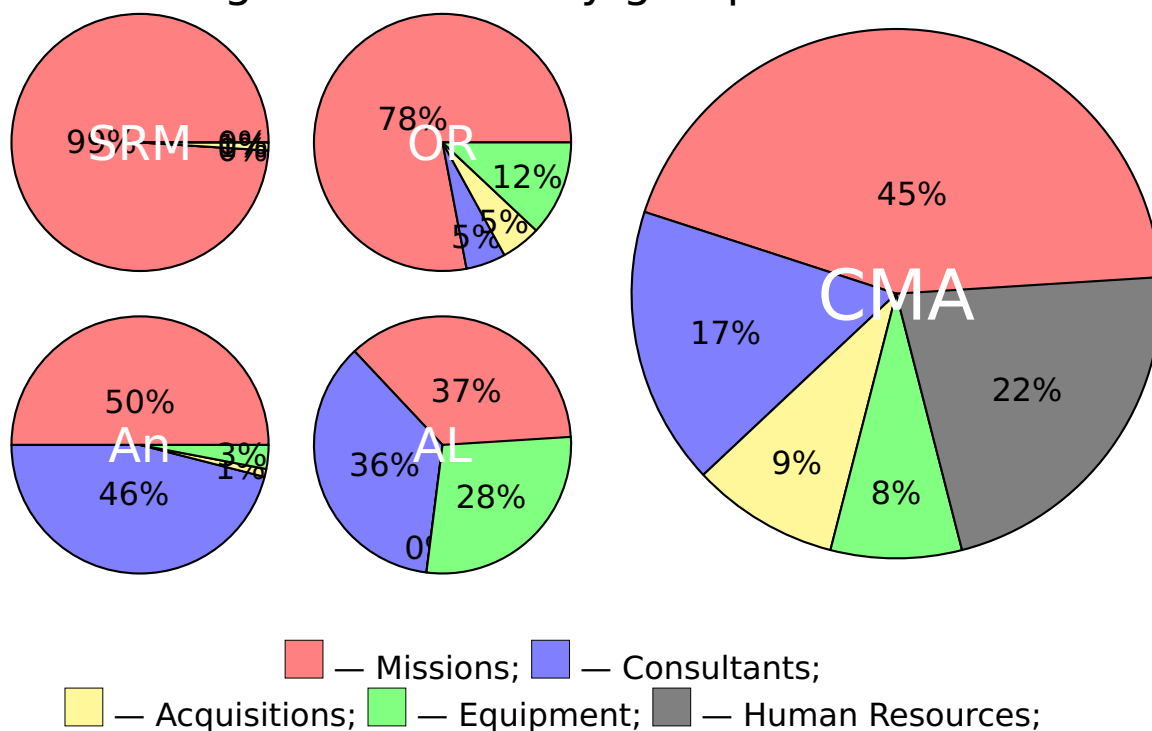
Number of Integrated Members (IM) per group (i.e., members that satisfy a productivity criterion). Left: Absolute values; Right: Full-time equivalent. Group budget is proportional to the number of IM.

Productivity

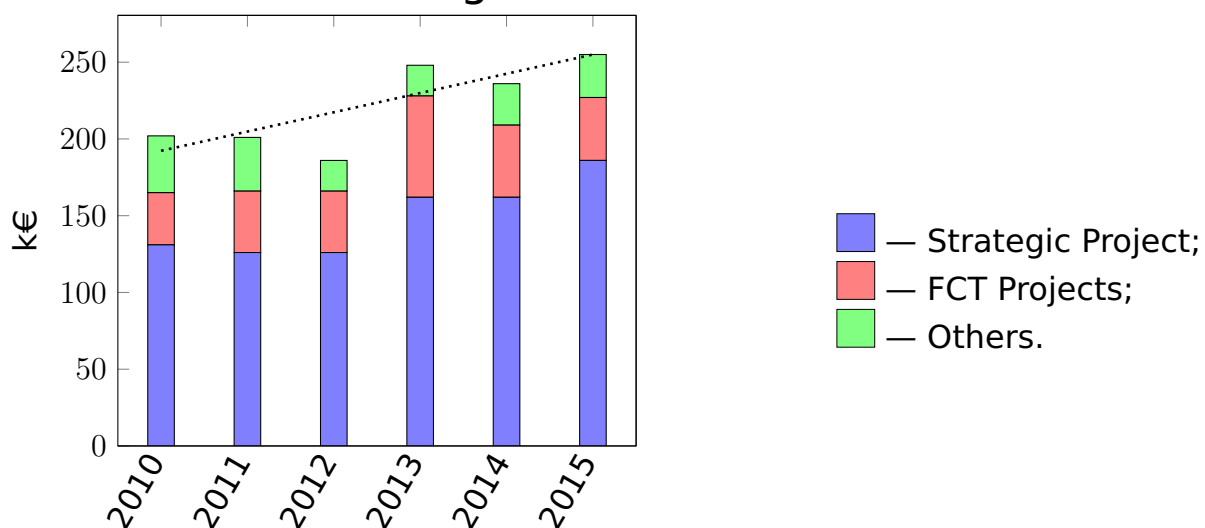


Web of Science (WoS) Publications: Left: Evolution 2013-2015. The solid line and dots indicate the evolution in the WoS publications per capita (right scale). Right: WoS publications in the year 2015. Prior data is not available for WoS publications.

Budget execution by groups — 2015



Budget Evolution



Funding from different sources from 2010 to 2015. The dotted line indicates the trend.

Highlights

One conference with almost 100 participants was organized in campus.

INTERNATIONAL WORKSHOP ON

CALCULUS OF VARIATIONS AND ITS APPLICATIONS

ON THE OCCASION OF LUÍSA MASCARENHAS' 65TH BIRTHDAY

17-19 December, 2015 | Universidade Nova de Lisboa, Caparica, Portugal



<http://eventos.fct.unl.pt/cvamascar/home>

52 research seminars and 4 mini-courses in the year 2015.

<http://www.cma.fct.unl.pt/seminarios>

6 special sessions in the joint meeting of the American, European and Portuguese Mathematical societies were organized by CMA members.



2015

10 - 13 June, Porto - Portugal

INTERNATIONAL MEETING



AMS / american mathematical society



/ european mathematical society



spm / sociedade portuguesa de matemática

<http://aep-math2015.spm.pt/>



For the first time, two post-docs are fully funded by CMA: Benjamín Heredia and Miguel Fonseca.

A large project dedicated to study the *Hilbert's 24th problem* will be funded by FCT — starting in 2016.

The 24th Problem:

In 2000, it was discovered that Hilbert had originally planned for a 24th problem.

- This problem was not in his lecture notes or any published texts.
- His close friends and proofreaders were also not aware of this problem.



We started in 2015 a “Invited Researcher’s program” to foster longer (ca 1 month) stays of distinguished visitors.

11 relevant outcomes

Goncalo Tabuada. *Noncommutative Motives*, volume 63 of *University Lecture Series*. AMS, 2015.

Alan J. Cain, Robert D. Gray, and **Antonio Malheiro.** Finite Grobner-Shirshov bases for Plactic algebras and biautomatic structures for Plactic monoids. *JOURNAL OF ALGEBRA*, 423:37-53, FEB 1 2015.

Lucio Simone Cirio and **Joao Faria Martins.** Infinitesimal 2-braidings and differential, crossed modules. *ADVANCES IN MATHEMATICS*, 277:426-491, JUN 4 2015.

Rita Ferreira, Carolin Kreisbeck, and **Ana Margarida Ribeiro.** Characterization of polynomials and higher-order Sobolev spaces in terms of functionals involving difference quotients. *NONLINEAR ANALYSIS-THEORY METHODS & APPLICATIONS*, 112:199-214, JAN 2015.

Luis L. Ferras, Neville J. Ford, Maria L. Morgado, João M. Nobrega, and **Magda S. Rebelo.** Fractional Pennes' bioheat equation: theoretical and numerical studies. *FRACTIONAL CALCULUS AND APPLIED ANALYSIS*, 18(4):1080-1106, AUG 2015.

Fernanda Cipriano and Ivan Torrecilla. Inviscid limit for 2D stochastic Navier-Stokes equations. *STOCHASTIC PROCESSES AND THEIR APPLICATIONS*, 125(6):2405-2426, JUN 2015.

A. L. Custodio and J. F. A. Madeira. GLODS: Global and Local Optimization using Direct Search. *JOURNAL OF GLOBAL OPTIMIZATION*, 62(1):1-28, MAY 2015.

Carmo P. Bras, Masao Fukushima, Alfredo N. Iusem, and Joaquim J. Judice. On the Quadratic Eigenvalue Complementarity Problem over a general convex cone. *APPLIED MATHEMATICS AND COMPUTATION*, 271:594-608, NOV 15 2015.

Paulo C. Rodrigues, Andreia Monteiro, and **Vanda M. Lourenco.** A robust AMMI model for the analysis of genotype-by-environment data. *BIOINFORMATICS*, 32(1):58-66, 16 DEZ 2015.

Filipe J. Marques, **Carlos A. Coelho**, and Miguel de Carvalho. On the distribution of linear combinations of independent Gumbel random variables. *STATISTICS AND COMPUTING*, 25(3):683-701, MAY 2015.

Gill Adams, **Susana Baptista**, Albrecht Beutelspacher, **Gracinda Rita Guerreiro**, Ferenc Holló-Szabó, Colin Jackson, Carola Kahlen, **Nelson Chibeles-Martins**, Katalin Munkácsy, Hilary Povey, **Fátima Rodrigues**, **Maria do Céu Soares**, Emanuela Ughi, Éva Vásárhelyi, Rosina Weber, and Gergely Wintsche. *MiMa - Mathematics in the Making - The Project*. Sheffield Hallam University, City Campus, Sheffield, England, 2015. Translated to Portuguese, Hungarian, Italian and German.

Part II

Activities at CMA

General Information

Highlights

- For the first time, two post-docs directly funded by CMA joined the team!
- 20 new members joined CMA in 2015.
- Funding increased in 10%, the number of Integrated Members increased in 16% and papers indexed at Web of Science increased in 22% when compared to 2014.
- One conference with almost 100 participants was organized in campus.
- 6 special sessions in the joint meeting of the American, European and Portuguese Mathematical societies were organized by CMA members.
- One national project of 200 k€ was awarded to a group led by a CMA member.

Objectives and Achievements

Unit Description

The Center for Mathematics and Applications (*Centro de Matemática e Aplicações*, CMA/FCT/UNL, or, simply, CMA) is located at Faculdade de Ciências e Tecnologia of Universidade Nova de Lisboa (FCT/UNL) at Caparica Campus and occupies two large rooms on the first floor of building VII. The Department of Mathematics (DM) is also located in this building.

CMA/FCT/UNL has 74 active Ph.D. researchers and 22 internal collaborators.

The center is organized into four research groups: **Algebra and Logic** (AL), **Analysis** (An), **Operations Research** (OR), and **Statistics and Risk Management** (SRM) and two thematic lines: **Mathematical modelling for the independent living of elderly, disable, and chronic patients** and **Mathematical modelling in ecology, evolution and genetics**.

Each group has one elected group coordinator, primarily responsible for guaranteeing that the team budget is used according to the Center's strategic project (approved by FCT). The center is led by one General Coordinator who guarantees the implementation of the Strategic Project as approved by FCT. To achieve this goal, he/she is assisted by an Executive Committee composed by the General Coordinator and three appointed members.

During the year 2015, new group coordinators were elected.

An External Permanent Advising Scientific Committee including five internationally recognized high-level researchers assesses the scientific activities of the center. General administrative support is provided by a BGCT (*Bolsa de Gestão em Ciência e Tecnologia*, or, Science and Technology Management Fellowship), with the help of the secretariat of the Department of Mathematics. CMA bylaws and membership requirement regulations are available in a written document, reviewed every year in order to contemplate the classification of the researchers according to productivity indicators. Funding is allocated to each team, proportionally to the corresponding number of active Ph.D. researchers. For more information please visit the CMA/FCT/UNL web site:

<http://www.cma.fct.unl.pt>

Productivity Criterion

Starting from January 1, 2015, a new criterion is used to define integrated members (from now on, IM). Namely,

During the year X a researcher is considered to be 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 WoS¹ 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) Ph.D. thesis defended after 1st January of year X-3 and one publication in a peer reviewed journal.

C) 4 scientific indicators, according to the FCT definition² (see Registration Guide³ 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.

Members that do not satisfy the criterion are invited to present a 3-year 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 productivity criterion). If the plan is approved, they will be considered as “internal collaborators”. Internal collaborators are funded in the same way as integrated members. Integrated members and internal collaborators contribute together to the progress of the scientific program of the centre. The designation “internal collaborators” also applies to Ph.D. students supervised by

¹Web of Science

²International publication with referees, books, book chapters, patents.

³The Registration Guide, used by *Fundação para a Ciência e Tecnologia* - Science and Technology Foundation (FCT) is available in Portuguese at http://www.fct.pt/apoios/unidades/avaliacoes/2013/docs/GuiaoRegisto_AvaliacaoUnidades2013.pdf.

members of the Unit. As soon as an internal collaborator meets the criterion or completes his/her Ph.D., he or she will be considered an integrated member.

In all internal decisions, only integrated members have the right to vote.

It is important to note that the CMA team for the year 2015 was composed by all members in the FCT proposal, drafted in 2013 (i.e., all members that satisfied the criterion in 2012 or 2013) plus all members that satisfied the criterion in 2014. No one was excluded as Integrated Member before the start of the project. This explains the increase in the number of IM in 2015. This will not be repeated in 2016, and therefore we expect a slight decrease in the number of IM in the year 2016.

Indicators

Scientific productivity

CMA has experienced a steady increase in the ratio of publications (total number of publications in peer reviewed journals per integrated member). Since 2014 we also count the total and the per capita number of publications indexed at Web of Science (WoS). Note that only WoS publications are considered in the definition of Integrated Members (IM).

	2009	10	11	12	13	14	15
Publications in international peer reviewed journals	46	41	39	57	38	76	105
Publications in international peer reviewed journals per IM	0.96	0.84	0.80	1.03	0.62	1.25	1.42
WoS publications					36	63	75
WoS per IM					0.59	1.00	1.01

Group	WoS	WoS per capita	Peer reviewed	Per capita
AL	22	1.4	24	1.5
An	18	0.9	20	1.0
OR	7	0.6	22	1.8
SRM	28	1.1	40	1.5

A detailed list of publications (including proceedings, book chapters, didactic, and popular science publications) is available in Part III of this report.

Funding

In 2015, CMA successfully finished its first European project: MiMa — Mathematics in the Making —, with a total funding of €369.851,00 (UNL funding of €54.537,00). UNL is the only Portuguese university associated to this project, led by Emmanuela Ughi, Università degli Studi di Perugia (Italy) and involving partners of five different EU member states.

In 2015, and due to start in 2016, a project named “Hilbert’s 24th problem”, led by Reinhard Kahle and involving several CMA members (Algebra and Logic group) was selected by FCT to be funded with 200 k€. The project includes post-doc and student grants.

In 2015, total funding for CMA (including strategic project, national and international funds) increased in 22%. We expect a further increase for 2016, as a consequence of the above mentioned project, plus other projects described in part III of this report.

See table 1 for the 2010-15 evolution and see part III for details of projects.

Team

In the table below, we present the evolution, from 2007 to 2015 of the number of Integrated Members. Note that a productivity criterion was implemented starting from 2010. In the second line, we present the number of full-time researchers in the CMA team with salary directly paid by the Ministry of Science, Technology and Higher Education (up to 2011 and after 2015) and the Ministry of Education and Science (from 2011 to 2015) — programs “Ciência”, “Investigador FCT,” and post-docs directly paid from CMA’s budget. Post-docs paid by projects are not included in this table.

	2010	2011	2012	2013	2014	2015
LA FCT	0	0	0	0	0	0
Units FCT	131381	126348	126348	162438	162504	185787
Projects FCT	34125	39743	39743	65858	46625	41187
Other (National)	0	2850	0	0	0	5740
Other (International)	12000	9500	19965	19965	27268	27993
National Industry	25000	25000	0	0	0	0
International Industry	0	0	0	0	0	0
Total	202506	203441	186056	248327	236397	260707

Table 1: Funding evolution 2010-15. Values in euros.

	2007	08	09	10	11	12	13	14	15
Integrated Members	42	49	48	49	49	55	61	63	74
Full time researchers	0	2	2	0	0	0	1	2	4
Ph.D. theses completed	12	9	7	1	1	5	4	3	2

Other relevant information

Technical Personnel: **Vanda Sofia dos Santos Martins**, since 1 April 2011.

Visitors

In 2015, CMA launched a program to attract researchers for stays of circa 1 month. Every 6 months, approximately, CMA asks all their members to invite a researcher for stays between 20 and 40 days, and pays all expenses, including air ticket and an allowance of 2650 euros per month before taxes. Visitors are expected to interact with the CMA members and present a short-course. In 2015, we had three visitors within this program:

1. Anton Setzer, Department of Computer Science, University of Swansea, U.K. (from 2 September to 22 September 2015) — in this case, the visit was only partially funded by CMA;
2. Maria-Magdalena Boureanu, University of Craiova, Romania (from 8 September to 14 October 2015);
3. Miguel de Carvalho, Pontificia Universidad Católica de Chile, Chile (from 27 November to 21 December 2015).

Post-doctoral program

For the first time, CMA opened a call for post-docs. Out of 20 candidates, **Benjamin Alarcón Heredia** and **Miguel Fonseca** were selected and started working in September 2015, in the groups of Algebra and Logic, and Statistics and Risk Management, respectively.

Activities

Organization of events

Calculus of Variations and Its Applications

17-19 December 2015, Campus of Caparica, FCT/UNL.

The aim of the workshop was both to bring together experts on Calculus of Variations and its applications, promoting the exchange of ideas and attracting young scientists to the field, and also to honor Professor Luísa Mascarenhas, retired in 2014, for her contribution to Science. During the workshop 24 invited lectures, 16 contributed talks, and 14 posters were presented. 89 participants from 14 different countries attended the workshop.

<http://eventos.fct.unl.pt/cvamascar/home>

6 special sessions at “American Mathematical Society—European Mathematical Society—Portuguese Mathematical Society Joint Meeting”

The American Mathematical Society joins a host society from another country once a year to organize meetings for members of the mathematical com-

munity both in the U.S. and abroad. In 2015, the annual meeting was co-hosted by the European Mathematical Society and the Portuguese Mathematical Society at Porto, from June 10 to 13. CMA was not one of the main organizers of the meeting, but decided to provide specific funding for CMA members that intended to organize special sessions, whenever the CMA member was the main organizer of the session. Out of 53 sessions, CMA provided funds for:

1. Algebraic Theory of Semigroups and Applications;
2. Convolution Type Operators;
3. Homogenization and Its Contemporary Stochastic Aspects;
4. Mathematical Models in Epidemiology;
5. The Notion of Proof;
6. Stochastic Numerical Methods for Non-linear Equations.

Further information: <http://aep-math2015.spm.pt/ListOfSessions>

Like every year, we also funded the following activities for students:

1. ClubeMath (<http://eventos.fct.unl.pt/clubemath>);
2. DivMAT (<https://sites.google.com/site/divmatfct/home/o-grupo-divmat>);
3. ExpoFCT (<http://eventos.fct.unl.pt/expofct>);
4. Summer School MatNova 2015 (<http://eventos.fct.unl.pt/matnova2015>);
5. Scientific diffusion in high schools;
6. Summer School MathInGenius 2015 (<http://eventos.fct.unl.pt/mathingenious2015>);
7. Several lectures for students or general public.

Seminars

During the year 2015, 52 seminars and 4 mini-courses were organized by CMA. We do not count student seminars, or seminars that were part of larger events (e.g., conferences, Jornadas da Matemática, MatNova etc).

32 seminars were given by specialists outside CMA, including 15 from visitors from abroad. In the second part of this report, we present a full list of seminars.

Part III

Activities in the research groups

Research line

Algebra and Logic

Highlights

- Project “Hilbert’s 24th problem”, funded with €199.902 and led by R. Kahle is due to start in 2016.
- The group more than doubled in size with 13 new members.
- G. Tabuada has published a book in the University Lecture Series published by the AMS.
- The first post-doc directly funded by CMA’s budget, B. Heredia, joined the centre.
- R. Kahle was elected as a full member of the Académie Internationale de Philosophie des Sciences.
- Gulbenkian Foundation approved the project “A correspondência de Hugo Baptista Ribeiro”

Team

Integrated Members

1. **Alan James Cain** — a.cain@fct.unl.pt
2. **Ana Cristina Malheiro Casimiro** — amc@fct.unl.pt
3. **António José Mesquita da Cunha Machado Malheiro** — ajm@fct.unl.pt
4. **Benjamín Alarcón Heredia** — baheredia@ugr.es
5. **Carlos Manuel Saiago** — cls@fct.unl.pt
6. **Gonçalo Jorge Trigo Nery Tabuada** — tabuada@fct.unl.pt
7. **Isabel Maria Oitavem Fonseca da Rocha Kahle** — ifr@fct.unl.pt
8. **João Nuno Gonçalves Faria Martins** — jn.martins@fct.unl.pt
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10. **Manuel Almeida Silva** — mnas@fct.unl.pt
11. **Manuel Messias Rocha de Jesus** — mrj@fct.unl.pt
12. **Maria Helena Coutinho Gomes de Almeida Santos** — mhas@fct.unl.pt
13. **Reinhard Josef Klaus Kahle** — kahle@fct.unl.pt
14. **Teresa Maria de Araújo Melo Quinteiro** — tmeloquinteiro@gmail.com
15. **Teresa Maria Jerónimo Sousa** — tmjs@fct.unl.pt
16. **Vítor Hugo Bento Dias Fernandes** — vhf@fct.unl.pt

Collaborators

1. **Herberto de Jesus da Silva** — hdjs@fct.unl.pt
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3. **João Pedro Bizarro Cabral** — jpbc@fct.unl.pt
4. **Jorge Manuel Leocádio André** — jmla@fct.unl.pt
5. **Júlia Maria Nunes Loureiro Vaz de Carvalho** — jvc@fct.unl.pt
6. **Maria Cecília Perdigão Dias da Silva** — mcds@fct.unl.pt
7. **Maria de Fátima Vale de Gato Santos Rodrigues** — mfsr@fct.unl.pt

Projects

Projects led by team members

1. **IF/01622/2013/CP1161/CT0001**, *Investigador FCT Exploratory Project*, led by **Alan Cain** (2014-2019): Total funding (CMA only) €50 000.00.
2. **Jaime Gaspar** continues to be funded by a Research Postgraduate Scholarship from the UK Engineering and Physical Sciences Research Council (EPSRC)/ School of Computing, University of Kent.
3. **The notion of mathematical proof** (2013-2015)
PTDC/MHC-FIL/5363/2012
PI: **Reinhard Kahle**
Total funding: €71.690,00 (FCT)
4. **A correspondência de Hugo Baptista Ribeiro** (2015-2016) IP: **Reinhard Kahle**
Members of CMA: **R. Kahle, I. Oitavem**
Funded by Gulbenkian Foundation. Total funding: €11.480

Projects with the participation of team members

1. **Geometry and Mathematical-Physics**
EXCL/MAT- GEO/0222/2012
PI: Miguel Tribolet Abreu (CGASMD/IST-U. Lisboa), Total funding €326 000.00 (FCT)
Group members: **João Nuno Gonçalves Faria Martins** and **A. Casimiro** (2013-2016).
2. **Geometria Algébrica em Portugal** (2012-2015)
PTDC/MAT-GEO/0675/2012
PI: Margarida Mendes Lopes
Members of CMA: **A. Casimiro**
Total funding €83.000,00
3. **Mathematics in the Making-Mima**
539872-LLP-1-2013-1-IT-COMENIUS-CMP (2013 – 2015)

PI: Emanuela Ughi (Università degli Studi di Perugia, Italy)

Total funding: 369.851,00 €(FCT) — UNL funding: 54.537,00 €

Group member: Fatima Rodrigues (PI of the Portuguese participation).

UNL team consists of 5 members of CMA

Achievements

The team has continued to improve its level of scientific research. It has published 22 papers in highly-reputed international peer-reviewed journals. In pursuing its stated research objectives, the group has made the following achievements:

In 2015 **I. Oitavem** initiated studies concerning probabilistic classes of complexity. Together with **R. Kahle** and U. Dal Lago, they achieved recursion-theoretic characterizations of $\#P$ and the hierarchy of counting functions (FCH). For FCH a proof-theoretic characterization was developed by **I. Oitavem** and **R. Kahle** in collaboration with T. Strahm.

R. Kahle finished as Principal Investigator the FCT funded project “The notion of Mathematical Proof” with a major workshop held as a special session of the AMS-EMS-SPM annual meeting which took place in Porto in June 2015. The initial results of the project have already been published and a volume with contributions by leading researchers in the field is in preparation. (This will link the finished project with the new one on Hilbert’s 24th problem which should start in 2016.)

During 2015 **G. Tabuada** continued the development of the foundations and applications of the theory of noncommutative motives. Among other achievements, he extended the classical theory of Weil restriction to the non-commutative setting and established a precise relation between the existence of exceptional collections and the existence of motivic decompositions.

J.F. Martins has addressed two-dimensional holonomy operators with values in crossed modules of Hopf algebras and in crossed modules of associative algebras. He has also obtained results on the Moore complex of a simplicial Hopf algebra.

T. Sousa has extended results on the decomposition of graphs to the case where its monochromatic decompositions are cliques.

M. Silva (with G. Fici, A. Restivo, L. Zamboni) introduced the notion of anti-power in the context of combinatorics of words, that is, a concatenation of all-distinct blocks of the same length. This notion is dual with respect to the classical definition of power. They showed that every infinite word must contain powers or anti-powers of arbitrary exponent. In particular, every uniformly recurrent word must contain anti-powers of arbitrary exponent.

A.J. Cain and **A. Malheiro** developed a “quasi-crystal” theory for quasi-ribbon tableau and the hypoplactic monoid that has many of the beautiful combinatorial properties that the representation-theoretic notion of crystal theory supplies for the plactic monoid. They have also studied conjugacy in important monoids connected to algebraic combinatorics, such as the plactic, sylvestre, and Baxter monoids. For most of these monoids, they combinatorially characterized notions of conjugacy, and determined how many iterations of p -conjugacy are required to obtain o -conjugacy. They also determined which of these monoids satisfy semigroup identities.

M. Fátima Rodrigues continued her work on the RSK-correspondence and symmetry classes of tensors, with M.M. Torres (FC-UL), P.C. Silva (ISA) e J.P. Dias da Silva (FC-UL), in order to characterize the linear independence in the orbital subspaces using the RSK-correspondence and semistandard Young tableaux.

C. Saiago investigated, for a Hermitian matrix A whose graph is a tree T , the number of eigenvalues of A whose multiplicity decreases when a particular vertex is deleted from T .

C. Perdigão continued her work on problems concerning Hermitian matrices whose graphs have at most one or two vertices with degree greater than two.

As non-standard g -groups may be created lifting non-standard f -groups, when f is primitive of degree 2, J.E. Nogueira (with O. Brison) using ratio-equivalence characterized the polynomials g and the related g -sequences.

A.J. Cain (with T. Brough) proved that free products of finite semigroups always arise as automaton semigroups, proving also various closure results for the class of automaton semigroups, including finding new examples of residually finite semigroups that are not automaton semigroups.

A.J. Cain (with M. Pfeiffer) proved that the isomorphism problem is unde-

cidable for word-hyperbolic semigroups, in contrast to the situation for hyperbolic groups.

V.H. Fernandes and **T.M. Quinteiro** determined presentations for monoids of partial isometries and for monoids of order-preserving partial isometries. They obtained decompositions of certain monoids of partial permutations using both semidirect products and bilateral semidirect products (Zappa products). These decompositions yielded immediate results at the pseudovariety level.

A. Malheiro (with J. Araújo, M. Kinyon and J. Konieczny) have established the relationship between several notions of conjugacy within particular classes of semigroups.

M. H. Santos (with T. S. Blyth) generalised the notion of inverse transversal and associate subgroup.

A. Casimiro studied Schottky principal G -bundles over a compact Riemann surface X , where G is a connected reductive algebraic group. She showed that all Schottky G -bundles have trivial topological type. This also proved the local surjectivity of the Schottky moduli map.

Publications

Publications in Web of Science journals

- [1] Henry Liu, Oleg Pikhurko, and **Teresa Sousa**. Monochromatic Clique Decompositions of Graphs. *JOURNAL OF GRAPH THEORY*, 80(4):287–298, DEC 2015.
- [2] Marcello Bernardara and **Goncalo Tabuada**. Relations between the Chow motive and the noncommutative motive of a smooth projective variety. *JOURNAL OF PURE AND APPLIED ALGEBRA*, 219(11):5068–5077, NOV 2015.
- [3] **Alan J. Cain** and **Antonio Malheiro**. Deciding conjugacy in sylvester monoids and other homogeneous monoids. *INTERNATIONAL JOURNAL OF ALGEBRA AND COMPUTATION*, 25(5):899–915, AUG 2015.
- [4] **Goncalo Tabuada**. $A(1)$ -homotopy invariants of dg orbit categories. *JOURNAL OF ALGEBRA*, 434:169–192, JUL 15 2015.

- [5] Lucio Simone Cirio and **Joao Faria Martins**. Infinitesimal 2-braidings and differential, crossed modules. *ADVANCES IN MATHEMATICS*, 277:426–491, JUN 4 2015.
- [6] **Goncalo Tabuada**. Weil restriction of noncommutative motives. *JOURNAL OF ALGEBRA*, 430:119–152, MAY 15 2015.
- [7] **Goncalo Tabuada** and Michel van den Bergh. NONCOMMUTATIVE MOTIVES OF AZUMAYA ALGEBRAS. *JOURNAL OF THE INSTITUTE OF MATHEMATICS OF JUSSIEU*, 14(2):379–403, APR 2015.
- [8] Serena Cicalo, **Vitor H. Fernandes**, and Csaba Schneider. Partial transformation monoids preserving a uniform partition. *SEMIGROUP FORUM*, 90(2):532–544, APR 2015.
- [9] Matilde Marcolli and **Goncalo Tabuada**. From exceptional collections to motivic decompositions via noncommutative motives. *JOURNAL FUR DIE REINE UND ANGEWANDTE MATHEMATIK*, 701:153–167, APR 2015.
- [10] **Reinhard Kahle**. What is a Proof? *AXIOMATHES*, 25(1, SI):79–91, MAR 2015.
- [11] **Alan J. Cain**, Robert D. Gray, and **Antonio Malheiro**. Finite Grobner-Shirshov bases for Plactic algebras and biautomatic structures for Plactic monoids. *JOURNAL OF ALGEBRA*, 423:37–53, FEB 1 2015.
- [12] **Alan J. Cain**, Robert D. Gray, and **Antonio Malheiro**. Rewriting systems and biautomatic structures for Chinese, hypoplactic, and sylvester monoids. *INTERNATIONAL JOURNAL OF ALGEBRA AND COMPUTATION*, 25(1-2):51–80, FEB-MAR 2015.
- [13] **Goncalo Tabuada**. A(1)-homotopy theory of noncommutative motives. *JOURNAL OF NONCOMMUTATIVE GEOMETRY*, 9(3):851–875, 2015.
- [14] **Joao Faria Martins** and Roger Picken. LINK INVARIANTS FROM FINITE CATEGORICAL GROUPS. *HOMOLOGY HOMOTOPY AND APPLICATIONS*, 17(2):205–233, 2015.

- [15] Matilde Marcolli and **Goncalo Tabuada**. Unconditional noncommutative motivic Galois groups. In Kennedy, G and Caibar, M and Castravet, AM and Macri, E, editor, *HODGE THEORY AND CLASSICAL ALGEBRAIC GEOMETRY*, volume 647 of *Contemporary Mathematics*, pages 109–115, 2015. Conference on Hodge Theory and Classical Algebraic Geometry, Ohio State Univ, Columbus, OH, MAY 13-15, 2013.
- [16] **Goncalo Tabuada**. Bivariant cyclic cohomology and Connes’ bilinear pairings in noncommutative motives. *JOURNAL OF NONCOMMUTATIVE GEOMETRY*, 9(2):265–285, 2015.
- [17] T. S. Blyth and **M. H. Almeida Santos**. E-SPECIAL ORDERED REGULAR SEMIGROUPS. *COMMUNICATIONS IN ALGEBRA*, 43(8):3294–3312, 2015.
- [18] **Teresa Sousa**. Decomposition of graphs into cycles of length seven and single edges. *ARS COMBINATORIA*, 119:321–329, JAN 2015.
- [19] Ping Zhao and **Vitor H. Fernandes**. THE RANKS OF IDEALS IN VARIOUS TRANSFORMATION MONOIDS. *COMMUNICATIONS IN ALGEBRA*, 43(2):674–692, 2015.
- [20] Tara Brough and **Alan J. Cain**. Automaton semigroup constructions. *SEMIGROUP FORUM*, 90(3):763–774, JUN 2015.
- [21] Fernando Ferreira and **Jaime Gaspar**. Nonstandardness and the bounded functional interpretation. *ANNALS OF PURE AND APPLIED LOGIC*, 166(6):701–712, JUN 2015.
- [22] **Alan J. Cain** and Victor Maltcev. A simple non-bisimple congruence-free finitely presented monoid. *SEMIGROUP FORUM*, 90(1):184–188, FEB 2015.

Other publications in peer-reviewed journals

- [1] Fatma Al-Kharousi, **Alan James Cain**, Victor Maltcev, and Abdullahi Umar. A countable family of congruence-free finitely presented monoids. *Acta Sci. Math. (Szeged)*, 81(3–4):437–445, 2015.
- [2] **Jaime Gaspar** and Orlando Neto. All triangles at once. *The American Mathematical Monthly*, 122:982, 2015.

Other (international) publications

- [1] **Reinhard Kahle**. After hilbert and brouwer: Bourbaki and bishop. In Evandro Agazzi and Gerhard Heinzmann, editors, *Pragmatism and the Practical Turn in Philosophy of Science*, pages 190–200. FrancoAngeli, 2015.
- [2] **Reinhard Kahle**. Gentzen’s theorem in context. In **Reinhard Kahle** and Michael Rathjen, editors, *Gentzen’s Centenary: The quest for consistency*, pages 3–24. Springer, 2015.
- [3] **Reinhard Kahle**. Sets, truth, and recursion. In Dora Achourioti, Kentaro Fujimoto, Henri Galinon, and Jose Martinez, editors, *Unifying the Philosophy of Truth*, volume 36 of *Logic, Epistemology and the Unity of Science*, pages 143–152. Springer, 2015.
- [4] **Reinhard Kahle**. Dialoge als semantik. In Jürgen Mittelstraß and Christopher von Bülow, editors, *Dialogische Logik*, pages 43–54. Mentis, 2015.

Accepted papers

- [1] **Jorge Andre**, Joao Araujo, and Peter Cameron. The classification of partition homogeneous groups with applications to semigroup theory. To appear.
- [2] Guillaume Bonfante, **Reinhard Kahle**, Jean-Yves Marion, and **Isabel Oitavem**. Two functions algebras defining functions in nck boolean circuits. *Information and Computation*. To appear.
- [3] **João Cabral** and Orlando Neto. Limits of tangents of surfaces. *The Journal of the London Mathematical Society*, To appear.
- [4] **Alan James Cain** and Victor Maltcev. Growths of endomorphisms of finitely generated semigroups. *J. Aust. Math. Soc.*, To appear.
- [5] **Vítor Fernandes** and **Teresa Quinteiro**. Presentations for monoids of finite partial isometries. *Semigroup Forum*. To appear.

- [6] **Vítor Fernandes** and **Teresa Quinteiro**. A note on bilateral semidirect product decompositions of monoids of order-preserving partial permutations. *Bull. Korean Math Soc.* To appear.
- [7] Charles R. Johnson and **Carlos M. Saiago**. Diameter minimal trees. *Linear Multilinear Algebra*, 64(3):557–571, 2016.
- [8] **João Faria Martins**. Crossed modules of Hopf algebras and of associative algebras and two-dimensional holonomy. *J. Geom. Phys.*, 99:68–110, 2016.
- [9] İ. İlker Akça, **K. Emir**, and **J. Faria Martins**. Pointed Homotopy of Maps Between 2-Crossed Modules of Commutative Algebras. *Homology, Homotopy and Applications*, 2016. To appear.
- [10] **Reinhard Kahle**. Towards a proof-theoretic semantics of equalities. In Thomas Piecha and Peter Schroeder-Heister, editors, *Advances in Proof-Theoretic Semantics*, Trends in Logic. Springer. To appear.
- [11] **Reinhard Kahle**, Thomas Strahm, and Thomas Studer, editors. *Advances in Proof Theory*, volume 28 of *Progress in Computer Science and Applied Logic*. Birkhäuser. To appear.
- [12] Susana Baptista, Nelson Chibeles-Martins, Gracinda Rita Guerreiro, **Maria de Fátima Rodrigues**, Maria do Céu Soares, and Emanuela Ughi. Mathematics in the making - a view over the portuguese activities. In Associação Ludus, editor, *Proceedings of the Recreational Mathematics Colloquium IV (2015) · G4G Europe, Pavilhão do Conhecimento, Portugal, January 24-27, 2015*.

Other National publication

- [1] **Reinhard Kahle**, **Isabel Oitavem**, and Helena Rocha. A correspondência de Hugo Ribeiro. In Jaime Silva, editor, *CiEMeLP 2015, Conferência Internacional do Espaço Matemático em Língua Portuguesa, Conferência Regional da ICMI; Grupos de Discussão*. 2015.

Submitted papers

- [1] **Jaime Gaspar**. Todas as afirmações [logicamente] verdadeiras são demonstráveis. Submitted, 2015.
- [2] **Jaime Gaspar**. Primeiro teorema da incompletude de gödel. Submitted, 2015.
- [3] **Jaime Gaspar** and Iti Sharma. Mathematical analysis of the feasibility of iti sharma's "fully homomorphic encryption scheme with symmetric keys". Submitted, 2015.
- [4] António; **Saiaço Carlos M.** Johnson, Charles R.; Leal Duarte. The number of distinct eigenvalues for which an index decreases multiplicity. Submitted, 2015.
- [5] J. Araújo, M. Kinyon, J. Konieczny, and **A. Malheiro**. Four notions of conjugacy for abstract semigroups. Submitted, 2015.
- [6] **Reinhard Kahle**. From Hilbert to Bourbaki. In Luís Saraiva, editor, *Actas/Anais do 7. Encontro Luso-Brasileiro de História da Matemática*.
- [7] **J. Nogueira**. Knight's tours and their history. In Associação Ludus, editor, *Actas do congresso "Recreational Mathematics colloquium IV"*. Submitted.

Editing and authorship of books and journals

- [1] Gill Adams, Susana Baptista, Albrecht Beutelspacher, Gracinda Rita Guerreiro, Ferenc Holló-Szabó, Colin Jackson, Carola Kahlen, Nelson Chibeles-Martins, Katalin Munkácsy, Hilary Povey, **Fátima Rodrigues**, Maria do Céu Soares, Emanuela Ughi, Éva Vásárhelyi, Rosina Weber, and Gergely Wintsche. *MiMa - Mathematics in the Making - The Project*. Sheffield Hallam University, City Campus, Sheffield, England, 2015. Translated to Portuguese, Hungarian, Italian and German.
- [2] **Reinhard Kahle** and Michael Rathjen, editors. *Gentzen's Centenary: The quest for consistency*. Springer, 2015.

- [3] **Goncalo Tabuada**. *Noncommutative Motives*, volume 63 of *University Lecture Series*. AMS, 2015.

Report

- [1] Eerke Boiten and **Jaime Gaspar**. Composition theorems of one-way functions – proofs and presentations. 2015.
- [2] **Jaime Gaspar**. A proof without words of $1 + 2 + 3 + \dots + n = n(n + 1)/2$. 2015.
- [3] **Jaime Gaspar**. Variants into minimal logic of the Kuroda negative translation. 2015.
- [4] **Jaime Gaspar**. One-way functions. Mini-thesis, University of Kent, 2015.

Seminars

Jan 07: *The word problem for semigroups generated by idempotents*, Robert Gray, East Anglia University, UK.

Feb 18: *Logical Reasoning in the Auto Industry*, Wolfgang Küchlin, Symbolic Computation Group Informatik, Universität Tübingen & Steinbeis Technology Transfer Center STZ OIT, Germany.

Feb 25: *On some semigroups of partial order-preserving transformations*, Ilinka Dimitrova, Faculty of Mathematics and Natural Science, South-West University Neot Rilski, Bulgaria.

Mar 11: *Gröbner bases and nonassociative algebras. Some applications*, Manuel Ladra, Departamento de Algebra, Faculdade de Matematica, Universidade de Santiago de Compostela, Spain.

Mar 25: *Combinatorics in the Auto Industry*, Jorge Orestes, Departamento de Matemática, CMA/FCT/UNL, Portugal.

Apr 29: *Algebraic approach to complexity*, Isabel Oitavem, Departamento de Matemática, CMA/FCT/UNL, Portugal.

May 13: *Actions of 2-groups, moduli spaces in higher gauge theory, and TQFT's*, Roger Picken, Departamento de Matemática, CAMGSD, IST-UL, Portugal.

May 20: *Matróides na Criptografia*, Rosário Fernandes, Departamento de Matemática, FCT/UNL, Portugal.

Jun 08: *Algorithmic Problems in Polycyclic Groups and Applications*, Delaram Kahrobaei, CUNY Graduate Center, Associate Professor of Mathematics, NYCCT, City University of New York, US.

Jun 22: *Detecting solubility for finitely generated groups of piecewise-linear homeomorphisms*, Tara Brough, Research Fellow in Algebra, School of Mathematics and Statistics, Mathematical Institute St Andrews, UK.

Oct 07: *Sobre autómatos sincronizantes*, António Malheiro & Jorge Orestes Cerdeira, Departamento de Matemática, CMA/FCT/UNL, Portugal.

Oct 28: *Homotopy theory and categories*, Benjamín Heredia, CMA/FCT/UNL, Portugal.

Nov 11: *Crystals, Young tableau, and the (hypo)plactic monoid*, Alan Cain, CMA/FCT/UNL, Portugal.

Nov 25: *Quantum computing: why knot (sic)?*, João Martins, Departamento de Matemática, CMA/FCT/UNL, Portugal.

Dec 09: *Categorification of quantum algebras, their representations and knot invariants*, Marco Mackaay, Centro de Física Matemática e Física Teórica, Universidade do Algarve, Portugal.

Short-courses

Feb 26—Mar 03: *Syntactic Semigroups*, Jörg Koppitz, Institute of Mathematics, Potsdam University, Germany.

Internationalization

Conferences participation

Invited talks at international conferences

1. **G. Tabuada**, at the Colloquium, University of California at Los Angeles, USA. February 2015.
2. **R. Kahle**. Theories for classes of computational complexity, Computer Science Seminar, Bologna, 8 April 2015.
3. **A.J. Cain**, 'Computation and conjugacy in hypoplactic and sylvester monoids and other homogenous monoids'. Invited conference talk: North Britain Semigroups and Applications Network, University of St Andrews, 25th April 2015.
4. **V. H. Fernandes**, "Semigroups of order preserving transformations on a finite chain", Workshop on Groups and Semigroups, on the occasion of the 60th birthday of Mikhail Volkov, 9 June 2015.
5. **A.J.Cain**, 'Crystal bases, finite convergent presentations, and automaticity for plactic monoids'. International meeting of the American Mathematical Society, European Mathematical Society, and Sociedade Portuguesa de Matemática: Special Session on Algebraic Theory of Semigroups and Applications, University of Porto, 11th June 2015.
6. **R. Kahle**. Schwichtenberg's Paradox in Dialogical Logic, Logic Seminar, Bern, 17 June 2015.
7. **G. Tabuada**, at the Algebraic geometry seminar, Università degli Studi di Milano, Italy. July 2015.
8. **I. Oitavem**. Recursion and Complexity, Hilbert Bernays Summer School on Logic and Computation, University of Goettingen, Germany. 27-31 July 2015.

9. **R. Kahle.** Round Table on "Formal Sciences, Objectivity, and Truth" (with Gerhard Heinzmann, Nancy; Jean Guy Meunier, Montreal; Marco Buzzoni, Macerata), Scientific Realism: Objectivity and Truth in Science, A Coruña, 22 September 2015.
10. **I. Oitavem.** The class #P, PCC2015, University of Oslo, Norway, 24 May, 2015.
11. **I. Oitavem.** Classes of computational complexity: P and Pspace, 9th Workshop on Statistics, Mathematics and Computation, 15 December Universidade Aberta, Portugal.
12. **A. Malheiro.** Computing conjugacy in homogeneous monoids, 9th Workshop on Statistics, Mathematics and Computation, 15 December Universidade Aberta, Portugal.
13. **V. H. Fernandes.** Transformation Semigroups: order and generalizations, 9th Workshop on Statistics, Mathematics and Computation, 15 December Universidade Aberta, Portugal.

Special session organization

1. *Algebraic Theory of Semigroups and Applications*, American Mathematical Society-European Mathematical Society-Portuguese Mathematical Society joint meeting, Porto, June 10-13, coorganized by Alfredo Costa, Universidade de Coimbra, **António Malheiro**, Universidade Nova de Lisboa, John C. Meakin, University of Nebraska-Lincoln, Ana Moura, Instituto Politécnico do Porto, and Jean-Éric Pin, Université Paris-Diderot, and CNRS.
2. *Higher Dimensional Algebra in Geometry and Quantum Field Theory*, American Mathematical Society-European Mathematical Society-Portuguese Mathematical Society joint meeting, Porto, June 10-13, coorganized by André Henriques, Universiteit Utrecht, **João Faria Martins**, Universidade Nova de Lisboa, Roger Picken, Universidade de Lisboa, and James D. Stasheff, University of North Carolina at Chapel Hill.

3. *The Notion of Proof*, American Mathematical Society-European Mathematical Society-Portuguese Mathematical Society joint meeting, Porto, June 10-13, coorganized by Alexei Angelides, Stanford University, Jesse Alama, Technical University of Vienna, **Reinhard Kahle**, Universidade Nova de Lisboa, and Gregory Wheeler, University of Munich

Contributed talk (international)

1. **J. Gaspar**. "One-way function compositions. CryptoForma meeting", Canterbury, United Kingdom, January 15.
2. **J. Nogueira**. "Knight's tours and their history", Recreational Mathematics Colloquium IV, Lisbon, 24/27-January.
3. **I. Oitavem**. "P, NP and Pspace from a recursion-theoretic perspective", Focus meeting, University of Bologna, Italy, March 18.
4. **I. Oitavem**. "The probabilistic class PP", DICE 2015, Queen Mary University, London, UK, April 12.
5. **R. Kahle**. "The notion of proof revisited (with Jesse Alama)", AMS-EMS-SPM International Meeting 2015, Porto, June 10.
6. **T. Quinteiro**. "On monoids of finite partial isometries." AMS-EMS-SPM International Meeting 2015, Porto, June 11.
7. **R. Kahle**. "Syntax versus Semantics (together with and delivered by Wilfried Keller)", 4th International Conference on Tools for Teaching Logic (TTL 2015), Rennes. 10.6.15
8. **I. Oitavem**. "A recursion-theoretic approach to $\#P$ ", University of Berne, Switzerland, June 17.
9. **R. Kahle**. "Coloured syntax and semantics (together with and delivered by Wilfried Keller)", History and Philosophy of Logic Notations, Tallinn, August 2.
10. **B. Heredia**. "(Co)límites homotópicos de 2-funtores", Jornadas sobre "Métodos Homotópicos y Categóricos", Universidad de Murcia, October 2.

11. **R. Kahle, I. Oitavem**, and H. Rocha. “Da correspondência de Hugo Ribeiro, CiEMeLP 2015, Universidade de Coimbra, October 29.
12. **R. Kahle**. Is there a "Hilbert thesis"?, General Proof Theory, Tübingen, November 29.
13. **I. Oitavem**. “A correspondência de Hilbert”, CIEMeLP 2015, Coimbra, Portugal. October.
14. **A. Casimiro**. "Moduli spaces of free group representations in reductive groups". Young Women in Algebraic Geometry, Bonn, Germany, 5–7 October.

Invited talk (national)

R. Kahle. “The Notion of Proof”, GEOMETRIX, Aveiro, May 13.

Contributed talk (national)

1. **A. Malheiro**, “An overview over conjugacy in semigroups”, Seminar on Semigroups, Automata and Languages, Centro de Matemática da Universidade do Porto, 4 December, 2015.

Poster

F. Rodrigues. “Mathematics in the Making – a view over the Portuguese activities”, (Baptista, S., Capela, A., Chibeles-Martins, N., Guerreiro G.R., Neves, C., Rodrigues, F., Soares), M.C., at CiEMeLP 2015 - Conferência Internacional do Espaço Matemático em Língua Portuguesa, Coimbra, October.

Other Important Information

Peer-reviewing activities

A. Cain: Information and Computation; International Journal of Algebra and Computation; Journal de l'École Polytechnique — Mathématiques; Rewrit-

ing Techniques and Applications 2015; Semigroup Forum; Theoretical Computer Science; Theory of Computer Systems.

A. Malheiro: Rewriting Techniques and Applications 2015; Semigroup Forum; Theoretical Computer Science.

C. Saiago: Linear Algebra and Its Applications.

E. Nogueira: Mathematica Slovaca.

I. Oitavem: Information and Computation.

J. Martins: Collectanea Mathematica; Journal of Knot Theory and its Ramifications; Topology and its Applications.

R. Kahle: Studia Logica.

T. Quinteiro: Communications in Algebra; Journal of Algebra and its applications.

V. H. Fernandes: Communications in Algebra.

Supervision of Ph.D. (2015)

1. **J Martins:** co-supervised K Emir (erasmus PhD advisor), who concluded his PhD in September 2015. (Eskişehir Osmangazi University, Turkey);
2. **R. Kahle:** supervises René Gazarri, University of Tübingen, co-supervision with Peter Schroeder-Heister. Topic: The Calculus of Natural Calculations. Ongoing.
3. **A. Malheiro,** supervises F. Silva, Universidade de Lisboa, co-supervision with G. Gomes. Topic: Computations and combinatorics on Hopf algebras and monoids. Ongoing.

Editorial board

V. H. Fernandes is editor of: Asian-European Journal of Mathematics; Journal of Semigroup Theory and Application; The Scientific World Journal (Algebra).

2016 research of IM

I. Oitavem devoted 2015 to studies concerning implicit approaches to probabilistic classes of complexity. This is a very sensitive issue and we are facing fundamental problems. **R. Kahle**, U. Dal Lago and T. Strahm make up part of the group of researchers working together on this subject. These studies will continue in 2016.

R. Kahle will, in addition, as Principal Investigator of the new project on “Hilbert’s 24th problem” pursue his research on the notion of proof, with special emphasis on the preparation of a volume with contributions of leading researchers of the field on this topic.

J. Gaspar will continue his work in cryptography and in mathematical logic.

G. Tabuada will continue the development of the theory of noncommutative motives. In particular, to compute the Picard groups of several subcategories of noncommutative motives.

J. F. Martins aims to understand Drinfel’d 2-associators and Kontsevich’s algebra of Feynman Diagrams, and to understand the quantisation of higher gauge theories. He plans to find applications to topological quantum field theory, low dimensional topology, Condensed Matter Physics (topological matter phases) and quantum computing.

J. F. Martins, B. Heredia and Josep Elgueta (Universitat Politècnica de Catalunya), will attempt to obtain generalization of the well-known Peter-Weyl theorem for classical representations of groups.

B. Heredia in collaboration with A. M. Cegarra will study the homotopy properties of the Grothendieck construction on lax bidiagrams of bicategories. He also plans, in collaboration with N. Gurski, to obtain several coherence results for higher categorical structures which will simplify computations for dealing with them; in particular, a coherence result for lax homomorphisms of tricategories.

T. Sousa will pursue ongoing research in decompositions of graphs.

M. Silva will continue the study of connections between classical Ramsey Theory and Combinatorics on infinite words.

A.J.Cain and **A. Malheiro** aim to develop theories of quasi-crystals for

other monoids connected with algebraic combinatorics, such as the sylvester monoid. They also plan to investigate whether identities hold in such monoids. In collaboration with **M. F. Rodrigues** they plan to investigate new classes of combinatorial monoids arising from the theory of quasi-crystals.

C. Saiago will investigate some of the open problems concerning Hermitian matrices whose graph is a tree and **C. Perdigão** plans to study problems concerning the previous matrices whose graphs have at most two vertices with degree greater than two.

M. F. Rodrigues [with M.L. Esquivel, G.R. Guerreiro and M. F. Miguens] will develop a stochastic vortice model for the case of non diagonalizable matrices.

J. E. Nogueira intends to continue the study of standard and non-standard f-groups on finite and complex fields, and study general superprimitive polynomials.

A. J. Cain [with M. Pfeiffer] will investigate the class of semigroups with word problem in 2-MCFG, and seek a non-technical proof that the rank-2 free abelian group is in this class.

V. H. Fernandes and **T. Quinteiro** aim to obtain structural results such as Green's classes, ideals, congruences as well as generators, ranks and presentations for several classes of monoids of finite partial transformations (for instance for the monoid of all partial automorphisms of a finite tournament).

V. H. Fernandes and **M. Jesus** aim to describe various notions of conjugacy for some classes of semigroups of transformations on a finite chain.

V. H. Fernandes [with J. Matos] plans to describe pseudovarieties of inverse semigroups generated by some classes of semigroups of partial permutations.

H. Silva will pursue ongoing research on congruences and ideals in Ockham algebras.

J. Andre will carry on the investigation on some properties of subsemigroups of the Madhavan semigroups and other classes of transformation semigroups that preserve equivalence relations and images.

M. H. Santos will pursue ongoing research in regular and ordered semigroups.

B. Heredia with P. García Sánchez (Universidad de Granada) will explore

new approaches to a known conjecture about the Feng-Rao distance of telescopic numerical semigroups. They will also study the simplicial complexes given by the shadow sets of the elements of a numerical semigroup to illuminate some open questions about the Hilbert series of a numerical semigroup.

A. Casimiro plans to study Schottky principal G -bundles over compact Riemann surfaces, when G is a connected reductive algebraic group. She will study the extension of the Segal-Bargmann-Hall transformation to distributions on a maximal compact subgroup of G ; analyze the relation between this transformation and the non abelian theta functions and obtain a relation between these and the geometric quantization of the moduli space of G -bundles.

J. Cabral will pursue the study of limits of tangents of hypersurfaces. He aims to obtain a generalization of the Kodaira-Spencer map in the context of equisingular microlocal versal deformations of plane curves. He will also continue the study of the decomposition of the dual graph of the resolution of a plane curve.

Strategic Plan: 2015-2020

This text was written during the second semester of 2013, as part of the CMA's strategic plan for 2015-2020 and includes all members.

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 Kahle, I Oitavem; AC Casimiro) were members of other research centers during 2008-12. They will reinforce the already existing research fields, and will extend the Center's expertise to new areas. During 2008-12 these new members published 6 book-chapters and 32 papers in international peer-reviewed journals: J Algebra, Algebr Colloq, Ann Pure Appl Logic, Commun Algebra, Finite Fields Appl, Glasg Math J, Inf Comput, Int J Math, J Geom Phys, J Log Comput, Math Log Q, Publ Math-Debrecen, Rev Symb Log, Semigroup Forum, Theor Comput Sci, Bull Malays Math Sci Soc. They pursued research in Semigroup/Automata Theory (1), Finite Fields (2), Logic (3), Algebraic and Differential Geometry (4):

(1) A 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 V.H. Fernandes, and his former PhD students M.M. Jesus and T.M. 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. Kahle, also 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) A.C. 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 C.M. Saiago works in eigenvalue problems for Hermitian matrices with a given graph; Semigroup Theory, where M.H. Almeida Santos is addressing the influence of certain elements and subsemigroups in the structure of regular semigroups; Algebraic topology, K-theory, homological algebra, and non-abelian algebraic geometry, where G. Tabuada developed a theory of noncommutative motives, following a program of Fields Medalist M. Kontsevich; Higher Categories and Topological Quantum Field theories, where J. Martins works mainly on Higher Gauge Theory and Categorification; Extremal Graph Theory and Combinatorics, where T. Sousa developed research in graph decomposition and its colored or Ramsey version. The following researchers are currently affiliated to CMA as Collaborators: C. Perdigão, M.F. Rodrigues (Linear/Multilinear Algebra); M. Silva, H. Liu (Combinatorics, Number and Graph Theory); J.V. Carvalho, H. Silva (Universal Algebra); J. Cabral (Algebraic Geometry); J. André (Semigroup Theory); J. Gaspar (Proof Theory and Cryptography); B. Gohla (Higher categories). During 2008-12 they published 19 papers in peer-reviewed journals: Commun Algebra, Algebra Univers, Discrete Appl Math, Discrete Math, Linear Algebra Appl, J Graph Theory, Siam J Discrete Math, Theor Comput Sci, Semigroup Forum, Math Log Q, J Comb Number Theory, Comptes Rendus L'Acad sci, Stud Logica, J Symb Log, and Notre Dame J Formal Logic. 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) I 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 $f(n, H)$ 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 stan-

dard/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) 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

Research line

Analysis

Highlights

- Six integrated members and one collaborator joined the group.
- Organization of the International Workshop on Calculus of Variations and its Applications held in Caparica in December 17-19, 2015. This event was dedicated to the 65th anniversary of the former coordinator of CMA, professor Luísa Mascarenhas.
- Organization of three special sessions in the Joint AMS-EMS-SPM International Meeting, Porto, Portugal, June 10-13, 2015.

Team

Integrated Members

1. **Ana Margarida Fernandes Ribeiro** — amfr@fct.unl.pt
2. **Bento José Carrilho Miguens Louro** — bjl@fct.unl.pt
3. **Fabio Augusto da Costa Carvalho Chalub** — chalub@fct.unl.pt
4. **Filipe Serra de Oliveira** — fso@fct.unl.pt
5. **Gonçalo Nuno Rosado Moraes** — gnupest@gmail.com
6. **José Maria Nunes de Almeida Gonçalves Gomes** — jm.gomes@fct.unl.pt
7. **Luís Manuel Trabucho de Campos** — trabucho@fct.unl.pt
8. **Magda Stela de Jesus Rebelo** — msjr@fct.unl.pt
9. **Maria do Céu Cerqueira Soares** — mcs@fct.unl.pt
10. **Maria de Serpa Salema Reis de Orey** — msso@fct.unl.pt
11. **Maria Fernanda Almeida Cipriano Salvador Marques** — mfsm@fct.unl.pt
12. **Maria Luísa Martins Macedo de Faria Mascarenhas** — mlfm@fct.unl.pt
13. **Nadir Arada** — naar@fct.unl.pt
14. **Nuno David de Jesus Lopes** — ndlopes@gmail.com
15. **Nuno Filipe Marcelino Martins** — nfm@fct.unl.pt
16. **Oleksiy Karlovych** — oyk@fct.unl.pt
17. **Paula Cristiana Costa Garcia Silva Patrício Rodrigues** — pcpr@fct.unl.pt
18. **Paulo José Fernandes Louro Ribeiro Doutor** — pjd@fct.unl.pt
19. **Rita Alexandra Gonçalves Ferreira** — ragf@fct.unl.pt
20. **Rogério Ferreira Martins** — roma@fct.unl.pt

Collaborators

1. **Ana Maria de Sousa Alves de Sá** — ams@fct.unl.pt
2. **Ana Maria Manteigas Pedro** — anap@fct.unl.pt

3. **António Manuel Morais Fernandes de Oliveira** — amo@fct.unl.pt
4. **Cláudio António Rainha Aires Fernandes** — caf@fct.unl.pt
5. **João de Deus Mota da Silva Marques** — jdm@fct.unl.pt
6. **Maria Fernanda Alves da Veiga de Oliveira** — mfvo@fct.unl.pt

Projects

Projects led by team members

1. **Game theory and epidemiology**
EXPL/MAT-CAL/0794/2013 (2014-2015)
PI: Paula Rodrigues (CMA)
Total funding: 25.000,00 €— CMA funding: 25.000,00 €
2. **Variational problems in variable exponent Sobolev spaces**
EXPL/MAT-CAL/0840/2013 (2014- 2015)
PI: Ana Margarida Ribeiro (CMA)
Total funding: 24.250,00 €— CMA funding: 24.250,00 €

Projects with the participation of team members

1. **Mathematics in the Making-Mima**
539872-LLP-1-2013-1-IT-COMENIUS-CMP (2013 – 2015)
PI: Emanuela Ughi (Università degli Studi di Perugia, Italy)
Total funding: 369.851,00 €— UNL funding: 54.537,00 €
Group member: Maria do Céu Soares. UNL team consists of 5 members of CMA
2. **Competências Transversais para Ciência e Tecnologia 159/ID/2014**
Total funding: 2665 €— Group Member: Cláudio Fernandes.

Achievements

Several new members joined the group in January of 2015: Nadir Arada, who works on optimization; Fernanda Cipriano, who works on stochastic modelling; Cláudio Fernandes, who works on operator theory; Filipe Oliveira, who works on partial differential equations; Luís Trabucho, Magda Rebelo, and Nuno Martins, who work on numerical analysis. The entrance of new members enlarged the list of research topics of the group, therefore we decided to change the name from “Differential Equations and Numerical Analysis” to a more general term “Analysis”.

Members of the group published 19 papers in international peer-reviewed journals (most of them are indexed in WoS), 5 papers were accepted in international peer-reviewed journals (most of them are indexed in WoS), 14 additional papers were submitted for publication in international peer-reviewed journals.

The group participated very actively in the organization of scientific events:

- Four members of the group served as local organizers of the International Workshop on Calculus of Variations and its Applications held in Caparica in December. This event was dedicated to the 65th anniversary of the former coordinator of CMA, professor Luísa Mascarenhas. In our opinion, the workshop was significant: 24 invited lectures, 16 contributed talks, and 14 posters were presented during the conference. 89 participants representing 14 different countries attended the workshop.
- Five members of the group co-organized three special sessions in the Joint AMS-EMS-SPM International Meeting, Porto, Portugal, June 10-13.
- A member of our group participated in the work of the organizing committee of the Fifth International Workshop on Analysis and Numerical Approximation of Singular Problems, Lagos, Portugal, October 22-24. 2015.

N. Almulla (University of Dammam, Saudi Arabia), **R. Ferreira**, and D. Gomes (KAUST, Saudi Arabia) considered numerical methods for stationary

mean-field games (MFG) and investigated two classes of algorithms. The first one is a gradient-flow method based on the variational characterization of certain MFG. The second one uses monotonicity properties of MFG. The methods are illustrated with various examples, including one-dimensional periodic MFG, congestion problems, and higher-dimensional models.

M.A. Bastos (University of Lisbon), **C.Fernandes**, and **O. Karlovych** studied Wiener-Hopf factorization in decomposing complete metric algebras beyond the class of Banach algebras.

F. Chalub proved that a well know conjecture on the fixation probability in a graph known as “star graph” advanced in [E Lieberman, C Hauert, and MA Nowak. Evolutionary dynamics on graphs. Nature, 433(7023):312–316, 2005] is wrong and provided the correct expression.

F. Chalub, M. Souza (Brazil) and O. Danilkina (Tanzania) submitted a paper where PDEs motivated from population dynamics that are of drift-diffusion type with degenerated diffusion and supplemented by conservation laws are analyzed.

F. Chalub and M. Souza studied fixation probability for evolutionary dynamics and the population is large but without assuming weak selecting principle. Several results show differences between the finite population behavior and the behavior found when diffusion limits are assumed.

F. Cipriano studied a control problem for stationary and non-stationary second grade fluids.

S. Correia (University of Lisbon), **F. Oliveira**, and H. Tavares (University of Lisbon) established a detailed result concerning the existence/non-existence of nontrivial ground states for weakly coupled cubic Schrödinger systems (in the attractive case) with respect to the coupling coefficients. This property is qualitatively optimal.

M. d’Orey, J. Henry (INRIA Bordeaux Sud-Ouest, ANUBIS team), and **B.Louro** continued their work on factorization of over-determined boundary value problems.

J.P. Dias (University of Lisbon) and **F. Oliveira** obtained several results concerning the existence and linearized stability of solitary waves for quasi-linear Benney systems with an absorbing term.

P. Doutor, **P. Rodrigues**, **M.C. Soares** and **F. Chalub** modelled seasonal

epidemics with vaccination. In particular, an “optimal vaccination profile” and a “Nash-equilibrium vaccination profile” were introduced; the former is the vaccination that can prevent outbreaks with minimum effort while the latter is the vaccination profile to be expected in a population in which all individuals simultaneously minimize the joint vaccination and disease risk.

P. Doutor, J.M Gomes, A. Patrício, and P. Pimenta studied obstacle problems for the Euler-Lagrange equation. Some results were established on the existence of solutions of the equations that have a given maximum value.

R. Ferreira, C. Kreisbeck (University of Regensburg, Germany), and **A.M. Ribeiro** derived integral conditions under which a measurable function is a polynomial and provided criteria for an L_p function to belong to a k th-order Sobolev space.

R. Ferreira, I. Fonseca (CNA/CMU, USA), and **L. Mascarenhas**, studied a Chromaticity-Brightness model in image restoration, using calculus of variation relaxation methods.

R. Ferreira, L. Mascarenhas, and A. Piatnitski (Narvik University & P.N. Lebedev Physical Institute) studied the 3D-1D asymptotic analysis of the Dirichlet spectral problem associated with an elliptic operator with axial periodic heterogeneities. They extended previous 3D-2D results to the 3D-1D case and analyzed the special case where the scale of thickness is much smaller than the scale of the heterogeneities and the planar coefficient has a unique global minimum in the periodic cell. These results are of great relevance in the comprehension of the wave propagation in nanowires showing axial heterogeneities.

S.C. Fraga, **L.Trabucho**, C. Brazinha, and C. Crespo worked on a methodology for characterizing solute transport through pervaporation membranes or, more generally, through dense membranes, in the whole transient regime. A real-time characterization of transport through dense membrane is obtained by using on-line mass spectrometry monitoring, which allows to acquire the concentration of solutes in the permeate compartment with time intervals of 2 s (and shorter if required). Time-dependent diffusion coefficients, $D(t)$, were calculated for the whole operation period, including the initial transient period. Based on these values it is possible to infer about the relevance of solute-membrane interactions and rearrangement of the membrane struc-

ture due to the presence of permeant solutes. Finally, based on the information acquired, a mathematical model was developed in order to obtain solute concentration profiles inside the membrane and their evolvement along time.

J.M. Gomes continued to study level sets and steepest ascent pathes of the solution to the non-linear Poisson equation. He has also been studying Geometric Measure Theory and preparing an introductory book to the Calculus of Variations at an undergraduate level.

P.Hästö (University of Turku, Finland) and **A.M.Ribeiro** found a new characterization of variable exponent Sobolev spaces involving certain averaging operator that substitutes the finite difference operator playing a crucial role in the case of corresponding characterization of classical Sobolev spaces.

J. Henry (INRIA Bordeaux Sud-Ouest, ANUBIS team), **B. Louro**, **M.C. Soares** applied the method of invariant embedding to the Poisson problem in a quasi-cylindrical domain, using a Neumann-to-Dirichlet operator instead of a Dirichlet-to-Neumann one.

O. Karlovych proved that the algebra of the Fourier multipliers on variable Lebesgue space is continuously embedded into the space of bounded measurable functions, and as a consequence, it is complete. The above result was used in the study of commutators of convolution type operators with symbols in various subalgebras of the algebra of the Fourier multipliers on variable Lebesgue spaces. Some compactness results for the commutators were proved.

N.D. Lopes, P.J.S. Pereira, and **L. Trabucho** studied wave propagation models of Boussinesq type. This lead to an improved class of nonlinear bidirectional Boussinesq equations of sixth order using a wave surface elevation formulation. New exact travelling wave solutions for the proposed class of nonlinear evolution equations were deduced.

R. Martins obtained a sponsorship for the production of additional four seasons of the TV Show “Isto é Matemática,” to be broadcast in the channel SIC Notícias, SIC Internacional e SIC Radical, during 2016, sponsored by is Fundação Vodafone Portugal. The first of these seasons was written and filmed during 2015.

R. Martins developed a dynamic presentation, on the mathematics of the tracks of bicycles. This talk was presented to more than one thousand high

school students and several hundred professors along the year. He presented several talks and participated in debates with large audiences of high school students and professors.

G. Morais completed the study of the interlacing structure of certain domains related with the synchronization sets. The obtained results create a quite interesting relation between linear algebra, quadratic forms and systems of ordinary differential equations. Domains of this type are also related with partial and general equilibrium solutions in Economics. In the situations where the information is symmetric, it is possible to solve these problems with a computational algorithm that already appeared in **G.Morais'** PhD thesis.

M. Rebelo submitted two papers related with the analytical and numerical analysis of a class of Volterra integral with nonlinear Hammerstein-type kernels. She worked on the development and analysis of a new mathematical model for the Pennes' bioheat equation, assuming a fractional time derivative of single order. She also worked on the development and analysis (stability and convergence) of numerical schemes to approximate the solution of the distributed order Riesz fractional diffusion equations and distributed order in time fractional diffusion equations.

Publications

Publications in Web of Science journals

- [1] P. J. S. Pereira, **N. D. Lopes**, and **L. Trabuco**. Soliton-type and other travelling wave solutions for an improved class of nonlinear sixth-order Boussinesq equations. *NONLINEAR DYNAMICS*, 82(1-2):783-818, OCT 2015.
- [2] Andre M. Lemos, Ana S. Abraao, Bruno R. Cruz, Maria Luisa Morgado, **Magda Rebelo**, and Fernando M. Nunes. Effect of granular characteristics on the viscoelastic and mechanical properties of native chestnut starch (*Castanea sativa* Mill). *FOOD HYDROCOLLOIDS*, 51:305-317, OCT 2015.
- [3] S. T. R. Pinho, **P. Rodrigues**, R. F. S. Andrade, H. Serra, J. S. Lopes, and M. G. M. Gomes. Impact of tuberculosis treatment length and adherence

- under different transmission intensities. *THEORETICAL POPULATION BIOLOGY*, 104:68–77, SEP 2015.
- [4] Luis L. Ferras, Neville J. Ford, Maria L. Morgado, João M. Nobrega, and **Magda S. Rebelo**. FRACTIONAL PENNES' BIOHEAT EQUATION: THEORETICAL AND NUMERICAL STUDIES. *FRACTIONAL CALCULUS AND APPLIED ANALYSIS*, 18(4):1080–1106, AUG 2015.
- [5] Carolin Kreisbeck and **Luisa Mascarenhas**. Asymptotic spectral analysis in semiconductor nanowire heterostructures. *APPLICABLE ANALYSIS*, 94(6):1153–1191, JUN 3 2015.
- [6] S. C. Fraga, **L. Trabuco**, C. Brazinha, and J. G. Crespo. Characterisation and modelling of transient transport through dense membranes using on-line mass spectrometry. *JOURNAL OF MEMBRANE SCIENCE*, 479:213–222, APR 1 2015.
- [7] M. L. Morgado and **M. Rebelo**. Numerical approximation of distributed order reaction-diffusion equations. *JOURNAL OF COMPUTATIONAL AND APPLIED MATHEMATICS*, 275:216–227, FEB 2015.
- [8] N. J. Ford, M. L. Morgado, and **M. Rebelo**. A nonpolynomial collocation method for fractional terminal value problems. *JOURNAL OF COMPUTATIONAL AND APPLIED MATHEMATICS*, 275:392–402, FEB 2015.
- [9] **Alexei Yu. Karlovich**. Maximally Modulated Singular Integral Operators and their Applications to Pseudodifferential Operators on Banach Function Spaces. In Jarosz, K, editor, *FUNCTION SPACES IN ANALYSIS*, volume 645 of *Contemporary Mathematics*, pages 165–178, 2015. 7th Conference on Function Spaces, So Illinois Univ Edwardsville, Edwardsville, IL, MAY 20-24, 2014.
- [10] **Rita Ferreira**, **M. Luisa Mascarenhas**, and Andrey Piatnitski. Spectral analysis in thin tubes with axial heterogeneities. *PORTUGALIAE MATHEMATICA*, 72(2-3):247–266, 2015.
- [11] **Rogério Martins** and **Goncalo Morais**. GENERALIZED SYNCHRONIZATION IN A SYSTEM OF SEVERAL NON-AUTONOMOUS OSCILLATORS COUPLED BY A MEDIUM. *KYBERNETIKA*, 51(2):347–373, 2015.

- [12] **Alexei Yu. Karlovich.** FREDHOLMNESS AND INDEX OF SIMPLEST WEIGHTED SINGULAR INTEGRAL OPERATORS WITH TWO SLOWLY OSCILLATING SHIFTS. *BANACH JOURNAL OF MATHEMATICAL ANALYSIS*, 9(3):24–42, 2015.
- [13] **Rita Ferreira**, Carolin Kreisbeck, and **Ana Margarida Ribeiro.** Characterization of polynomials and higher-order Sobolev spaces in terms of functionals involving difference quotients. *NONLINEAR ANALYSIS-THEORY METHODS & APPLICATIONS*, 112:199–214, JAN 2015.
- [14] **Fernanda Cipriano** and Ivan Torrecilla. Inviscid limit for 2D stochastic Navier-Stokes equations. *STOCHASTIC PROCESSES AND THEIR APPLICATIONS*, 125(6):2405–2426, JUN 2015.
- [15] **Alexei Yu Karlovich.** THE STECHKIN INEQUALITY FOR FOURIER MULTIPLIERS ON VARIABLE LEBESGUE SPACES. *MATHEMATICAL INEQUALITIES & APPLICATIONS*, 18(4):1473–1481, OCT 2015.
- [16] **Nuno F. M. Martins.** Identification results for inverse source problems in unsteady Stokes flows. *INVERSE PROBLEMS*, 31(1), JAN 2015.
- [17] **Nuno F. M. Martins** and David Soares. Localization of immersed obstacles from boundary measurements. *INVERSE PROBLEMS IN SCIENCE AND ENGINEERING*, 23(2):197–213, FEB 17 2015.
- [18] **Alexei Yu. Karlovich.** Commutators of convolution type operators on some banach function spaces. *ANNALS OF FUNCTIONAL ANALYSIS*, 6(4):191–205, 2015.

Other publications in peer-reviewed journals

- [1] **Alexei Karlovich.** Banach algebra of the Fourier multipliers on weighted Banach function spaces. *Concr. Oper.*, 2:27–36, 2015.
- [2] N.J. Ford and M.L. Morgado and **M. Rebelo.** An implicit finite difference approximation for the solution of the diffusion equation with distributed order in time. *ETNA, Electron. Trans. Numer. Anal.*, 44: 289–305, 2015.

Other (international) publications

- [1] Susana Baptista, Ana Capela, Nelson Chibeles-Martins, Gracinda Rita Guerreiro, Carla Neves, Fátima Rodrigues, and **Maria do Céu Soares**. Projeto europeu mima – mathematics in the making. In EMeLP, editor, *CIEMeLP 2015: Conferência Internacional do Espaço Matemático em Língua Portuguesa (poster), 28 a 31 de outubro de 2015, Coimbra, Portugal*, pages 40–44, 2015.

Accepted papers

- [1] **N. Arada**. On the convergence of the two-dimensional second grade fluid model to the Navier-Stokes equation. *Journal of Differential Equations*, 260:2557–2586, 2016.
- [2] **Fabio A. C. C. Chalub** and Max O. Souza. Fixation in large populations: a continuous view of a discrete problem. *Journal of Mathematical Biology*, 72(1):283–330, 2016.
- [3] João-Paulo Dias and **Filipe Oliveira**. Existence and linearized stability of solitary waves for a quasilinear Benney system. *The Royal Society of Edinburgh Proceedings A*, accepted, 2015.
- [4] **Filipe Oliveira**. A note on the existence of traveling-wave solutions to a Boussinesq system. *Differential Integral Equations*, 29(1/2):127–136, 2016.
- [5] **Filipe Oliveira** and Hugo Tavares. Ground states for a nonlinear Schrödinger system with sublinear coupling terms. *Advanced Nonlinear Studies*, accepted, 2015.
- [6] **F. A. C. C. Chalub**. An asymptotic expression for the fixation probability of a mutant in star graphs. *Journal of Dynamics and Games*, accepted, 2015.
- [7] Susana Baptista, Nelson Chibeles-Martins, Gracinda Rita Guerreiro, Maria de Fátima Rodrigues, **Maria do Céu Soares**, and Emanuela Ughi. Mathematics in the making - a view over the portuguese activities. In Associação Ludus, editor, *Proceedings of the Recreational Mathematics*

Colloquium IV (2015) · G4G Europe, Pavilhão do Conhecimento, Portugal, January 24-27, 2015, volume accepted, 2015.

Other (national) publication

- [1] **Fabio Chalub**. Matemática em duas rodas. *Gazeta de Matemática*, 175:17–19, 2015.
- [2] **Fabio Chalub**. Uma epidemia de humanos. *Gazeta de Matemática*, 176:15–17, 2015.
- [3] **Fabio Chalub**. Qual nome para o bebé? *Gazeta de Matemática*, 177:17–19, 2015.
- [4] Susana Baptista, Nelson Chibeles-Martins, Gracinda Rita Guerreiro, Fátima Rodrigues, and **Maria do Céu Soares**. Clubemath: do 1º ciclo à universidade. In EMELP, editor, *CIEMeLP 2015: Conferência Internacional do Espaço Matemático em Língua Portuguesa (Grupos de Discussão)*, 28 a 31 de outubro de 2015, Coimbra, Portugal, pages 112–114, 2015.
- [5] Ruy Araújo Costa, João Sotomayor, **Cláudio Fernandes**, Madalena Dionísio, José Manuel Fonseca, José Carlos Kullberg e Nelson Chibeles Martins. Competências Transversais para Ciências e Tecnologia. *Experiências De Inovação Didática No Ensino Superior*, 117-127. ISBN: 978-972-729-087-1. Ministério da Educação e da Ciência, 2015.

Submitted papers

- [1] Noha Almulla, **Rita Ferreira**, and Diogo Gomes. Two numerical approaches to stationary mean-field games. *Submitted*, <http://arxiv.org/pdf/1511.06576.pdf>, 2015.
- [2] Carlos J.S. Alves, **Nuno F.M. Martins**, and Svilen Valtchev. Two meshfree methods with fundamental solutions for non homogeneous elastic wave propagation problems. *Submitted*, 2015.
- [3] Simão Correia, **Filipe Oliveira**, and Hugo Tavares. Semitrivial vs. fully nontrivial ground states in cooperative cubic Schrödinger systems with $d \geq 3$ equations. *Submitted*, <http://arxiv.org/abs/1508.01783>, 2015.

- [4] O. Danilkina, M. O. Souza, and **F. A. C. C. Chalub**. Conservative parabolic problems: non-degenerated theory and degenerated examples from population dynamics. *ArXiv e-prints*, September 2014.
- [5] João-Paulo Dias and **Filipe Oliveira**. On a quasilinear non-local Benney system. *Submitted*, <http://arxiv.org/abs/1512.00837>, 2015.
- [6] **P. Doutor, P. Rodrigues, M. do Céu Soares**, and **F. A. C. C. Chalub**. Optimal Vaccination Strategies and Rational Behaviour in Seasonal Epidemics. *ArXiv e-prints*, July 2015.
- [7] **Nuno F. M. Martins**. Multifrequency identification of sources. In *Inverse Problems and Computational Mechanics*, volume 2, 2015.
- [8] **Rogério Martins**. Why are we not able to see beyond three dimensions? *Submitted*, 2015.
- [9] Luísa Morgado and **Magda Rebelo**. A finite difference method for the space distributed order Riesz fractional diffusion equation. *Submitted*, 2015.
- [10] Sonia Seyed Allaei, Teresa Diogo, and **Magda Rebelo**. Analytical and computational methods for a class of nonlinear singular integral equations. *Submitted*, 2015.
- [11] Sonia Seyed Allaei, Teresa Diogo, and **Magda Rebelo**. The Jacobi collocation method for a class of nonlinear Volterra integral equations with weakly singular kernel. *Submitted*, 2015.
- [12] Peter Hästö and **Ana Ribeiro**. Characterization of the variable exponent Sobolev norm without derivatives. *Communications in Contemporary Mathematics*, 2015.
- [13] **Alexei Yu. Karlovich**, Yuri I. Karlovich, and Amarino B. Lebre. The generalized cauchy index of some semi-almost periodic functions. *Boletín de la Sociedad Matemática Mexicana*, 2015.

Editing and authorship of books and journals

- [1] Gill Adams, Susana Baptista, Albrecht Beutelispacher, Gracinda Rita Guerreiro, Ferenc Holló-Szabó, Colin Jackson, Carola Kahlen, Nelson Chibeles-Martins, Katalin Munkácsy, Hilary Povey, Fátima Rodrigues, **Maria do Céu Soares**, Emanuela Ughi, Éva Vásárhelyi, Rosina Weber, and Gergely Wintsche. *MiMa - Mathematics in the Making - The Project*. Sheffield Hallam University, City Campus, Sheffield, England, 2015. Translated to Portuguese, Hungarian, Italian and German.

Seminars

Feb 18: *A method of recursive images provides exact solutions for transient heat diffusion in a slab*, Carlos Dias, CENIMAT/I3N, DCM-FCT-UNL, Portugal.

Mar 18: *One-dimensional viscoelastic fluid model where viscosity and normal stress coefficients depend on the shear rate*, Fernando Carapau, U. Évora, Portugal.

Apr 29: *Cálculo Operacional de Mikusinski*, Gabriel Bengochea, Universidad Autónoma de la Ciudad de México, Mexico.

May 06: *On systems of PDEs modeling competitive contaminant transport in porous media*, Juha Videman, CAMGSD, IST-UL, Portugal.

May 27: *Analytical and numerical methods for a class of third-kind Volterra integral equations*, Sonia Seyed Allaei, CEMAT and Hong Kong Baptist University, Portugal & Hong Kong.

Jun 08: *Voluntary and preventive vaccination in an epidemiological model with seasonality*, Paulo Doutor, Departamento de Matemática, CMA/FCT/UNL, Portugal.

Jun 08: *A stochastic epidemic model in a random environment*, Nicolas Bacaer, Univ Paris 06, France.

Jun 30: *Uncertainty inequalities in metric measure spaces*, Mario Milman, Florida Atlantic University, USA.

Sep 16: *A new optimal transport distance between nonnegative measures*, Léonard Monsaingeon, CAMGSD-IST, Portugal.

Dec 16: *Numerical investigation of spatially segregation models*, Farid Bozorgnia, CAMGSD-IST, Portugal.

Short-courses

Sep 17—Sep 24: *Variable Exponent Spaces and Applications to Nonlinear Problems*, Maria-Magdalena Boureau, University of Craiova, Romania.

Internationalization

Conferences participation

Invited talks at international conferences

- **F. Chalub:** Optimal vaccination strategies and rational behavior in seasonal epidemics, Sixth Workshop Dynamical Systems Applied to Biology and Natural Sciences, Lisbon, Portugal, February 4-6, 2015.
- **P. Doutor:** Vaccination in seasonal epidemics with temporary immunity: optimal strategy and rational behavior, Special Session on “Mathematical Models in Epidemiology”, Joint AMS-EMS-SPM International Meeting, Porto, Portugal, June 10-13, 2015.
- **C. Fernandes:** Wiener-Hopf factorization in decomposing complete metric algebras, Special Session on “Convolution Type Operators”, Joint AMS-EMS-SPM International Meeting, Porto, Portugal, June 10-13, 2015.
- **R. Ferreira:** Spectral analysis in thin tubes with axial heterogeneities. Special Session on “Homogenization and Its Contemporary Stochastic

Aspects”, Joint AMS-EMS-SPM International Meeting, Porto, Portugal, June 10-13, 2015.

- **O. Karlovych:** Maximally modulated Hilbert transform and its applications to pseudodifferential operators on variable Lebesgue spaces, Special Session on “Recent Advances in Variable Exponent Spaces and Non-linear Problems”, Joint AMS-EMS-SPM International Meeting, Porto, Portugal, June 10-13, 2015.
- **O. Karlovych:** Banach algebra of the Fourier multipliers on weighted Banach function spaces, Special Session on “Operator Theory and its Applications”, Joint AMS-EMS-SPM International Meeting, Porto, Portugal, June 10-13, 2015.
- **O. Karlovych:** The Stechkin inequality for Fourier multipliers on Nakano spaces, Fifth International Symposium on Banach and Function Spaces, Kitakyushu, Japan, September 2-6, 2015.
- **R. Martins:** Why can’t we visualize beyond three dimensions? Recreational Mathematics Colloquium IV, Lisbon, Portugal, January 24-27, 2015.
- **A.M. Ribeiro:** Characterization of Sobolev spaces through functionals without derivatives dependence, Conference on Partial Differential Equations (COPDE 2015), Munchen, Germany, March 25-29, 2015.
- **A.M. Ribeiro:** An homogenization result in $W^{1,p} \times L^q$, Special Session on “Homogenization and Its Contemporary Stochastic Aspects”, Joint AMS-EMS-SPM International Meeting, Porto, Portugal, June 10-13, 2015.

Special session organization

- *Convolution Type Operators*, American Mathematical Society-European Mathematical Society-Portuguese Mathematical Society joint meeting, Porto, June 10-13, coorganized by Amélia Bastos, Universidade de Lisboa, **Alexei Karlovich**, Universidade Nova de Lisboa and Ilya Spitkovsky, College of William and Mary.

- *Homogenization and Its Contemporary Stochastic Aspects*, American Mathematical Society-European Mathematical Society-Portuguese Mathematical Society joint meeting, Porto, June 10-13, coorganized by Irene Fonseca, Carnegie Mellon University, **Luísa Mascarenhas**, Universidade Nova de Lisboa and **Rita Ferreira**, Universidade de Lisboa, and Universidade Nova de Lisboa.
- *Mathematical Models in Epidemiology*, American Mathematical Society-European Mathematical Society-Portuguese Mathematical Society joint meeting, Porto, June 10-13, coorganized by **Fabio Chalub**, Universidade Nova de Lisboa, Max Souza, Universidade Federal Fluminense and **Paula Rodrigues**, Universidade Nova de Lisboa

Contributed talk (international)

- **F. Chalub**: Optimal vaccination strategies and rational behavior in seasonal epidemics, MPDE-15 Models in Population Dynamics and Ecology, Niterói, Brazil, August 24-28, 2015.
- **O. Karlovych**: The index of weighted singular integral operators with shifts and slowly oscillating data, International Workshop on Operator Theory and Applications, IWOTA 2015, Tbilisi, Georgia, July 6-10, 2015.
- **O. Karlovych**: Commutators of convolution type operators on some Banach function spaces, VI International Conference of the Georgian Mathematical Union, Batumi, Georgia, July 12-16, 2015.
- **R. Martins**: My bike is awesome! MathsJam, Stone, United Kingdom, November 7-8, 2015.
- **M. Rebelo**: Comparative study of numerical methods for time-fractional diffusion equations, International Conference on Differential & Difference Equations and Applications, Amadora, Portugal, May 18-22, 2015.
- **M. Rebelo**: Meshfree methods for Brinkman flows driven by arbitrary forces, 26th Biennial Numerical Analysis Conference, Glasgow, Scotland, June 23-26, 2015.

- **M.C. Soares:** Mathematics in the Making, Recreational Mathematics Colloquium IV, Lisbon, Portugal, January 24-27, 2015.
- **M.C. Soares:** ClubeMath – do 1º ciclo à Universidade, CiEMeLP 2015 - Conferência Internacional do Espaço Matemático em Língua Portuguesa, Coimbra, Portugal, October 28-31, 2015.

Poster

- **M. Rebelo:** A spectral collocation method for the diffusion equation with distributed order in time, Fifth International Workshop on Analysis and Numerical Approximation of Singular Problems, Lagos, Portugal, October 22-24, 2015.
- **M.C. Soares:** Mathematics in the Making – a view over the Portuguese activities, CiEMeLP 2015 - Conferência Internacional do Espaço Matemático em Língua Portuguesa, Coimbra, Portugal, October 28-31, 2015.

Outreach activities

F. Chalub wrote a series of papers published in the “Gazeta de Matemática”, a non-profit publication from the Portuguese Mathematical Society. In the column “Linha de Frente”, a recent scientific paper, related to mathematics in a broad sense, is reviewed and explained in a language proper for undergraduate and high-school teachers.

F. Chalub, R. Martins and **P. Rodrigues** gave talks in the series of lectures “Tardes de Matemática” of the Portuguese Mathematical Society aimed at general public.

R. Martins gave a series of lectures for general public:

- Entra no Ritmo, Universidade do Minho, January 7, 2015.
- Entra no Ritmo, Instituto de Gouveia, January 28, 2015.
- Entra no ritmo, Escola Josefa de Óbidos, March 11, 2015.
- A minha bicicleta calcula áreas! ProfMat2014, Évora, March 26-28, 2015.

- A matemática segundo Rogério Martins, Apresentação do livro Expoente 10, ASA, Lisboa, April 11, 2015.
- A matemática segundo Rogério Martins, Apresentação do livro Expoente 10, ASA, Porto, April 18, 2015.
- A matemática segundo Rogério Martins, Apresentação do livro Expoente 10, ASA, Aveiro, April 21, 2015.
- A matemática segundo Rogério Martins, Apresentação do livro Expoente 10, ASA, Braga, April 22, 2015.
- A minha bicicleta calcula áreas!, Escola Secundária Dr. José Afonso, Seixal, May 14, 2015.
- A minha bicicleta calcula áreas! Algarmat, Armação de Pêra, June 27-28, 2015.
- Porque não conseguimos ver para além das três dimensões?, Escola de verão, IST, June 27, 2015.
- A minha bicicleta calcula áreas! Colóquio Brasileiro de Matemática, Rio de Janeiro, July 27-31, 2015.
- Porque não conseguimos ver para além das três dimensões?, Matnova, FCT/UNL, September 1, 2015.
- A minha bicicleta calcula áreas!, Viva a Matemática, September 26, 2015.
- A minha bicicleta calcula áreas!, II Feira da matemática, October 23-24, 2015.
- A minha bicicleta calcula áreas!, Agrupamento de Escolas de Santo António, Barreiro, November 25, 2015.
- A minha bicicleta calcula áreas!, Escola Básica D. Dinis, Odivelas, December 16, 2015.

R. Martins participated in the preparation of the new seasons of the program “Isto é Matemática” to be broadcast in SIC Notícias from January 2016,

sponsored by Fundação Vodafone Portugal and in collaboration of Sociedade Portuguesa de Matemática

<https://www.facebook.com/istoematematica>

R. Martins and M. Silva wrote 72 articles on mathematical problems for a general audience, Expresso online.

G. Morais was responsible for the interviews in the “Gazeta de Matemática”. As result of this activity he had the opportunity to interview André Neves, Ingrid Debauchies and Carles Simó.

M. Rebelo participated in the organization of the summer school for secondary school pupils “MathIngenious 2015”, FCT, UNL, July 6-8, 2015.

M. Rebelo participated in the organization of the summer school for school teachers “ProfNova 2015”, September 6-8, 2015, FCT, UNL.

A.M. Ribeiro participated in the organization of the summer school for secondary school pupils “MatNova 2015”, FCT, UNL, September 1-5, 2015.

M.C. Soares is a co-organizer of ClubeMath, a Club for basic and high school students, which aims to show a different side of Mathematics, through fun and recreational activities, in order to stimulate skills and interest in this science

<http://eventos.fct.unl.pt/clubemath>

M.C. Soares participated in the Portuguese Mathematical Society’s Fair, in Museu Nacional de História Natural e da Ciência, Lisboa, October 23-24, 2015.

M.C. Soares participated in the Congress “Dream - Uma Educação a pensar no futuro”, Centro Cultural Olga Cadaval, Sintra, Portugal, July 7, 2015.

Other Important Information

Peer-reviewing activities

O. Karlovych: Complex Analysis and Operator Theory; Mathematical Notes (Russian Academy of Sciences); RACSAM - Revista de la Real Academia de Ciencias Exactas, Físicas y Naturales. Serie A. Matemáticas; “Mathematical Reviews” (MathSciNet); “Zentralblatt” (zbMATH).

M. Rebelo: Applied Numerical Mathematics; Journal of Applied Mathemat-

ics; Journal of Computational Mathematics; Numerical Algorithms; Numerical Methods for Partial Differential Equations.

P. Rodrigues: Computational and Applied Mathematics; Journal of Theoretical Biology.

Supervision of Ms.C

Tiago Costa, A large deviation principle for stochastic flows of viscous fluids, FCT-UNL, 26/11/15, supervisor: **F. Cipriano**.

2016 research of IM

The objective of the Analysis Group is to promote high-level scientific research in the area of analysis (in the broad sense) and its applications to Biomathematics, Material Science and Fluid Mechanics. We plan to continue working on existing research projects as well as start new collaborations. One of the main aims of the group is to increase its scientific productivity. We hope that new and emerging collaborations will help us in this difficult task. Another important objective is to disseminate mathematical knowledge through various types of activities. The actively working regular seminar is one of the cornerstones of this task.

F. Chalub, P. Rodrigues and T. Costa (former grant holder from the project “Game theory and epidemiology”, EXPL/MAT-CAL/0794/2013 hosted by CMA) are studying ring vaccination, or, more explicitly how to define a vaccination strategy able to provide a sanitation ring around an epidemic site.

F. Chalub, P. Rodrigues, P. Doutor and **M.C. Soares** will continue to study vaccination strategies in populations with age structure. Explicitly, a population is divided in two groups, Juveniles and Adults. They plan to study the effects of vaccination in the Juvenile class when the vaccination provides only temporary immunization. This study is motivated by the case of varicella (chickenpox).

F. Chalub and **A.M. Ribeiro**, together with L. Monsaignon (Universidade de Lisboa, Portugal) are studying the variational formulation of the Generalized Kimura Equation and its relation with the replicator equation. Both equa-

tions are used in population dynamics and its direct relation was unnoticed until recently. The variational formulation will show that the Kimura Equation minimizes a given degenerated potential function with respect to a modified Wasserstein metric.

F. Chalub and M. Souza (Universidade Federal Fluminense, Brazil) are studying the mathematical models used in the study of the evolution of finite populations. In particular, a general setting is considered able to include all classical models and also time-inhomogeneous processes. A clear link with topics from the group of Algebra and Logic will be explored.

F. Cipriano will study stochastic variational problems in finance, biology and fluid mechanics.

M. d'Orey, B. Louro and J. Henry (France) are planning to work on a new approach to the factorization of over-determined boundary value problems.

P. Doutor, J.M. Gomes, A. Patrício, and P. Pimenta (Universidade Nova de Lisboa, Portugal) will continue to study obstacle problems.

C. Fernandes, O. Karlovych and A. Bastos (Universidade de Lisboa, Portugal) will continue to study relations between factorization and Fredholm properties in decomposing complete metric algebras.

O. Karlovych, Yu. Karlovich (Mexico) and A. Lebre (Universidade de Lisboa, Portugal) plan to complete the paper on the index formula for singular integral operators with slowly oscillating shifts.

O. Karlovych is going to continue his study of convolution operators with oscillating symbols on Banach function spaces, including variable Lebesgue spaces.

N. Lopes and **L. Trabucho** will continue to study Boussinesq-like wave models. This study will include the analytical and the numerical points of view along with the development of the software: DOLFWAVE –“A library for surface water waves”. — <https://launchpad.net/dolfwave>.

B. Louro, M.C. Soares and J. Henry (France) plan to finish the proof of the method of invariant embedding applied to the Poisson problem in a quasi-cylindrical domain, using the Neumann-to-Dirichlet operator.

N. Martins will study inverse source problems for equations with non constant coefficients.

R. Martins will study the dynamics of quadrilaterals and some relations

of the practice of mathematics and neuroscience.

L. Mascarenhas, R. Ferreira (KAUST, Saudi Arabia) and I. Fonseca (CNA/CMU, USA) intend to conclude and submit for publication their research work concerning a CB (Chromaticity-Brightness) model in image restoration.

L. Mascarenhas and G. Bouchitté (IMATH/Univ. du Sud Toulon-Var, France) will study metamaterials, which are new composite materials possessing unusual and convenient properties. Unconventional electromagnetic behaviors can be created by wisely combining configurations of classical materials. **L. Mascarenhas** and G. Bouchitté are interested in the mathematical analysis of such materials, using homogenization, spectral and variational methods, in order to understand and optimize those important effects in electromagnetism. In a first stage they will study a class of diffusion operators with periodic sign changes and the associated spectral problem. The goal is to obtain the effective behavior of the spectrum as the period of the sign oscillations tends to zero and to apply the results to electromagnetism.

G. Morais is going to study the following questions: 1) Symmetric Information among agents in economic scenario is a very special situation. Without some kind of symmetry the interlacing property described before disappears. How to solve the problem when we have a more general structure? 2) May we find a computational algorithm that may be the generalization of the symmetric algorithm?

F. Oliveira will pursue the study of dispersive equations and systems in its different aspects: well-posedness of the initial value-problem, blow up phenomena and existence and stability of solitary waves, with special emphasis on the Schrödinger-Debye system in dimensions 3 and 4, the Boussinesq abcd-system and quasilinear Benney systems.

M. Rebelo intends to finish the analytical and numerical studies, in progress, on a class of nonlinear Volterra integral equations with weakly singular kernel and proceed with the work on the area of differential equations with derivative of non-integer order. She also intends to develop efficient, convergent and stable algorithms, based on spectral and collocation methods, for diffusion equations with distributed order in time (derivative defined in the Caputo sense) and space (derivative defined in the Riesz sense).

A.M. Ribeiro intends to establish existence results in the Calculus of Vari-

ations for functionals defined in variable exponent Sobolev spaces. She also plans to understand, in collaboration with R. Ferreira (KAUST, Saudi Arabia) and P. Hästö (University of Turku, Finland), whether it is possible to generalize her previous results with P. Hästö (Finland) about characterizations of variable exponent Sobolev spaces to the setting of Musielak-Orlicz-Sobolev spaces.

Strategic Plan: 2015-2020

This text was written during the second semester of 2013, as part of the CMA's strategic plan for 2015-2020 and includes all members.

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). 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 ionic-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 Davey-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 \mathbb{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.

Research line

Operations Research

Highlights

- Paula Couto and Rui Rodrigues obtained 3rd place in the real-time PhysioNet/CinC Challenge 2015 (in a total of 38 contestants). <http://www.cinc.org/physionet-cinc-challenge-awards>
- Jorge Orestes Cerdeira is a member of the research team of the funded project SFRH/BPD/104077/2014, Spatial conservation planning: reconciling biodiversity and human development in a dynamic world, to begin in 2016.
- Isabel Correia was invited for the Editorial Advisory Board of the journal Computers & Operations Research (IF 1.861; 5-year IF 2.454), to initiate in 2016.
- The paper “Soft skills for science and technology students: A pedagogical experience”, co-authored by Nelson Chibeles Martins, received the Best Paper Award at the WEEF2015 - World Engineering Education conference.
- The OR Group members supervised 3 Ph.D. theses (one of which was successfully concluded in 2015) and 1 Post-Doc student.
- 2 group members were co-editors of the Portuguese Association of Operations Research (APDIO) Bulletin.
- Jorge Orestes Cerdeira was member of the Awards Committee of Prémio APDIO/IO 2015 for the best Ph.D. thesis in Operations Research concluded in 2013 or 2014.

Team

Integrated Members

1. **Ana Luísa da Graça Batista Custódio** — `alcustodio@fct.unl.pt`
2. **Graça Maria Marques da Silva Gonçalves** — `gmsg@fct.unl.pt`
3. **Isabel Cristina Silva Correia** — `isc@fct.unl.pt`
4. **Jorge Orestes Lasbarreres Cerdeira** — `jo.cerdeira@fct.unl.pt`
5. **Lídia Ludovina Lampreia Caeiro Pica Lourenço** — `lll@fct.unl.pt`
6. **Manuel Valdemar Cabral Vieira** — `mvcv@fct.unl.pt`
7. **Maria do Carmo Proença Caseiro Brás** — `mb@fct.unl.pt`
8. **Maria Isabel Azevedo Rodrigues Gomes** — `mirg@fct.unl.pt`
9. **Nelson Fernando Chibeles Pereira Martins** — `npm@fct.unl.pt`
10. **Paula Alexandra da Costa Amaral** — `paca@fct.unl.pt`
11. **Rui Alberto Pimenta Rodrigues** — `rapr@fct.unl.pt`
12. **Susana Maria Marques Henriques Botelho Baptista** — `sbb@fct.unl.pt`

Collaborators

1. **Maria Paula da Costa Couto** — `mpcc@fct.unl.pt`

Projects

Projects with the participation of team members

1. **Mathematics in the Making-Mima**
539872-LLP-1-2013-1-IT-COMENIUS-CMP (2013 – 2015)
PI: Emanuela Ughi (Università degli Studi di Perugia, Italy)
Total funding: 369.851,00 €— UNL funding: 54.537,00 €
Group member: Nelson Chibeles Martins, Susana Baptista UNL team consists of 5 members of CMA

Scholarships

1. **Erasmus+ Scholarship: Outgoing Staff Mobility (non-teaching):**
09/02/2015 – 13/02/2015, Open University of Catalonia, **Isabel Gomes**,
€725.00

Achievements

During 2015 the research of the OR Group was mainly focused on combinatorial and nonlinear optimization problems.

In nonlinear optimization a copositive reformulation of the mixed-integer fractional quadratic problem under general linear constraints was proposed. Fractional quadratic optimization was also used in linear discriminant analysis for interval and histogram data. A new sufficient condition for the existence of solutions of the Conic Quadratic Eigenvalue Complementarity Problem (CQEiCP) was obtained, and the spectral projected gradient algorithm was used for solving CQEiCP, when the cone of interest is the second-order cone. In derivative-free optimization contributions, relate to a global multiobjective derivative-free optimization method and to nonmonotone directional direct search algorithms for noisy optimization.

Regarding combinatorial optimization, and in particular the area of facility location, new formulations and valid inequalities for a multi-period facility location under delayed demand were developed and a multi-period capacitated hub location problem with uncertain demands was analysed. In the area of project scheduling some priority based heuristics were developed for the multi-skill resource constrained project scheduling problem. Mixed integer linear formulations were also proposed for the problem of clustering with fixed cardinality constraints. A different work focused on finding clusters of feasible solutions, such that the objective function of the worst solution in the clusters is minimized. The multi-floor facility layout problem was also addressed, namely with the proposal of a new model for it.

Some of the group members were also enrolled in applications. In health, research was conducted for the detection of false arrhythmia alarms and for a mental health problem. Ecology problems related to minimum cost/maximum persistence dispersal corridors for species accounting for climate change were

analysed. In logistics, intensive research has been conducted in several topics, namely in the design and planning of closed loop supply chains in the context of risk averse decision making, and in the definition of new social metrics used as objective functions in a multiobjective approach when planning the design of sustainable supply chains. Metaheuristic approaches were considered in the design and planning of green supply chains and in production scheduling. A multi-depot vehicle routing problem, considering heterogeneous depots in terms of commercial offer was also addressed. Finally, in social OR, a chance-constrained model for a shelter site location problem was developed and, in the context of the CMA thematic line “Aging and Independent Living” (AgIL), an application related to the homecare service problem was addressed.

Additionally one of the OR Group members was enrolled in the implementation of a new curricula for science and technology students, and several researchers actively participated in initiatives for society and in particular for schools (organization of scientific courses, seminars and special sessions in conferences, ClubeMath, Summer Schools MatNova and MathIngenious). A noteworthy achievement was the participation in the MiMa project, an EU-sponsored programme which enrolled 40 schools, 110 teachers and 1600 students, across 5 participant countries.

As a result of their work, during 2015 the OR Group published 7 papers in international journals (being 5 more accepted for publication), 5 book chapters, 1 book (with 4 translations), 1 e-book (with 4 translations), 7 proceedings in international conferences, 3 proceedings in national conferences, and 2 computational implementations.

Paula Amaral: A copositive reformulation of the mixed-integer fractional quadratic problem under general linear constraints was addressed. Problems of this type arise when there are modelling density clustering problems with two voting options plus the possibility of an abstention, which is a criterion-based graph tri-partitioning problem. The results obtained add to the rich evidence for the versatility of copositive optimization approaches, and hints at possible novel approximation strategies combining continuous and discrete optimization techniques in the domain of (fractional) polynomial optimization.

A second work focused on finding clusters of feasible solutions, such that

the objective function of the worst solution in the clusters is minimized. Every soft constraint must belong to at least one cluster. The number of clusters can be defined a priori or we may also want to minimize the number of clusters. Formulations for this problem were proposed and tested for a set of infeasible LP problems.

A collaborative work in which fractional quadratic optimization plays a key role in linear discriminant analysis for interval and histogram data was developed. The involvement was only in the optimization part.

Susana Baptista: We pursued our work in the development of solution strategies for the design and planning of supply chains in the context of risk averse decision making. In particular, a collaboration established with the Department of Computer Science (FCT/UNL) allowed the development of the parallel implementation of the branch and fix solution heuristic. As a first step in the algorithm parallelization, the heuristic was restrained to the context of risk neutral decisions. The results regarding the algorithm sequential and parallel implementations were published as a chapter of the Springer “Studies in Big Data” book series.

Furthermore, as a member of the MiMa project, we experienced an EU-sponsored programme that enrolled 40 schools, 110 teachers and 1600 students across the 5 participant countries. Besides being positively perceived by teachers and students, MiMa proposed hands-on activities that changed students’ attitude towards mathematics and improved their mathematical competences. Results point out that 80% of the teachers recorded an improvement in the attention, concentration and engagement of students during or after the activities, that changes were perceived for problem solving and that the large majority of the teachers recognized improvements in students’ mathematical understanding.

Maria do Carmo Brás: A new sufficient condition for existence of solutions of the Conic Quadratic Eigenvalue Complementarity Problem (CQ EiCP) (without assuming symmetry on the matrices defining the problem) was obtained. The Spectral Projected Gradient (SPG) algorithm was used for solving CQ EiCP when the cone of interest is the second-order cone (SOCQ EiCP).

Jorge Orestes Cerdeira: Three alternative network flow models were developed, implemented and tested to determine minimum cost/maximum

persistence dispersal corridors for species accounting for climate change. The work is now published in *Methods in Ecology and Evolution*, a top journal (ISI 2014 Journal Citation Reports Ranking: 9/149) in Ecology, and the corresponding computer implementations are available at:

<http://onlinelibrary.wiley.com/doi/10.1111/2041-210X.12524/supinfo>

Isabel Correia: In 2015 the following topics were studied in the area of facility location: i) Development of formulations and valid inequalities for a multi-period facility location under delayed demand; (ii) Study of a multi-period capacitated hub location problem with uncertain demands. For this problem a model was proposed as well as some sets of additional inequalities; (iii) Development of a chance-constrained model for a shelter site location problem.

In the area of project scheduling some priority based heuristics for the multi-skill resource constrained project scheduling were developed.

Ana Luísa Custódio: The research work focused on three different topics: global multiobjective derivative-free optimization, nonmonotone directional direct search applied to noisy optimization, and an application problem in mental health.

We have completed the convergence analysis of MULTIGLODS algorithm, when considering a globalization strategy based on sufficient decrease, and finalized the corresponding computational implementation. We have also conducted numerical experiments which show the ability for the algorithm to identify multiple Pareto fronts (global and local ones). The results of the work were presented in an international meeting and in a seminar.

Numerical testing of several variants of nonmonotone directional direct search adapted to noisy optimization allowed to identify the most promising algorithms. The corresponding convergence analysis will be the subject of a Master thesis, to be completed in 2016. The estimation of the noise level was addressed and showed to not be relevant for the algorithmic variants selected and the noise levels considered.

An application work was also conducted related to algorithmic aspects of a closed-loop subthalamic nucleus (STN) deep brain stimulation system for advanced Parkinson's disease (PD) and treatment-refractory obsessive-compulsive disorder (OCD), ensuring optimal performance in terms of both

efficiency and selectivity of stimulation, as well as in terms of computational speed. The corresponding work was submitted for publication.

Paula Couto and Rui Rodrigues: In the context of the PhysioNet/CinC Challenge 2015, research work was developed for the detection of false arrhythmia alarms in the intensive care units. We integrated the information from the ECG, arterial blood pressure and photoplethysmogram to detect the false alarms triggered by patient bedside monitors. The algorithm and the associated computer code were tested on 1250 real life registers from four intensive care units. Our algorithm achieved third place in the real-time event of the above mentioned challenge. A paper was published in the proceedings of the corresponding conference.

Graça Gonçalves and Lúcia Lourenço: We have developed and compared from a theoretical and practical point of view different mixed integer linear formulations for the clustering with fixed cardinality constraints problem.

Isabel Gomes: In 2015 the research work developed as expected. The design of sustainable supply chains has been pursued with the definition of new social metrics, integrated in the development model as objective functions. A multiobjective approach has been followed in order to account for the three pillars of sustainability: economic, through Net Present Value; environmental, through Life Cycle Analysis methodology ReCiPe; and social, through a developed GDP-based metric. Within the developed mixed integer linear programming model, we also integrated several interconnected decisions such as facility location and capacity dimensioning, supplier selection and purchase levels definition, technology selection and allocation, transportation network definition including both unimodal and intermodal options, supply planning, and product recovery and remanufacturing. The work developed throughout the year has been published in 1 book chapter and in 2 conferences proceedings and presented in 7 conferences (6 oral presentations and one poster). One paper has been submitted to an international journal. This work is being developed in collaboration with Bruna Mota, Ana Carvalho and Ana Póvoa, (IST, Universidade de Lisboa).

The work in closed loop supply chain design and planning under uncertainty was pursued as planned. In particular, parallelization strategies were

developed and the risk averse model can now be applied to real world problem instances. The work developed was published in two conference papers and (orally) presented in both events. This is a collaborative work with **Susana Baptista** (CMA, FCT, UNL), Pedro Medeiros and Filipe Cabrita (Computer Science Department, FCT, UNL), and Laureano Escudero and Celeste Pizzaro (University Rey Juan Carlos, Madrid).

We have dedicated some time to study the homecare service problem. This work is motivated by a real case study of a Portuguese catholic parish that offers several social services to the population living nearby. One problem within the planning of homecare is the simultaneously allocation of caregivers to the elderly and the definition of the daily work schedule of each caregiver. We have decomposed this case into two smaller problems: weekly visiting schedule plan and caregiver allocation in a rolling horizon context. For each problem a MILP formulation was developed: one is based on VRP with time windows while the other is an extension of the allocation problem. Two objectives were optimized and compared for the weekly visiting plan: minimization of walking time and workload balance among caregivers (minmax problem). Given the computational burden of the weekly VRP, a heuristic approach was developed. This is a joint work with Tânia Ramos (IST, Universidade de Lisboa) that was presented in two conferences (orally) and in one invited seminar.

Lastly we addressed the Multi-Depot Vehicle Routing Problem considering heterogeneous depots in terms of their commercial offer. These differences among depots may lead customers to show different willingness to consume, depending on how well the assigned depot fits their preferences. To solve this extension of the MDVRP, we developed a hybrid approach combining statistical learning techniques with a metaheuristic framework. Firstly, a set of predictive models were developed based on historical data. These statistical models allow the estimation of demand of any given customer depending on the assigned depot. Then, the estimated expenditure of each customer was included as part of an enriched objective function as a way to better guide a stochastic local search procedure embedded in the metaheuristic framework. A set of computational experiments was performed, showing that the solutions proposed by the extended MDVRP differ from the traditional ones (distance minimization). This work was developed in collaboration with Laura

Calvet, David Massip and Angel Juan (Open University of Catalonia) and Alberto Ferrer (Technological University of Catalonia). It was presented in one conference and one paper has been accepted by an international journal.

Nelson Chibeles Martins: The digital version of the paper “A Multi-Objective Meta-Heuristic Approach for the Design and Planning of Green Supply Chains – MBSA” was published on Expert Systems with Applications in December, 2015.

The paper “Soft skills for science and technology students: A pedagogical experience” was presented at WEEF2015 - World Engineering Education, and received the Best Paper Award.

The paper “Simulated Annealing for Production Scheduling: A Case Study” was presented at IO2015 Conference.

Manuel Vieira: During 2015, I searched through all papers on the subject “facility layout problem” published in the last 15 years, and produced the paper entitled “Mathematical Optimization Approaches for Facility Layout Problems: The State-of-the-Art and Future Research Directions”, for the European Journal of Operational Research. I developed a new model for the multi-floor facility layout problem.

Publications

Publications in Web of Science journals

- [1] **Carmo P. Bras**, Masao Fukushima, Alfredo N. Iusem, and Joaquim J. Jude. On the Quadratic Eigenvalue Complementarity Problem over a general convex cone. *APPLIED MATHEMATICS AND COMPUTATION*, 271:594–608, NOV 15 2015.
- [2] **Bruna Mota, Maria Isabel Gomes**, Ana Carvalho, and Ana Paula Barbosa-Povoa. Towards supply chain sustainability: economic, environmental and social design and planning. *JOURNAL OF CLEANER PRODUCTION*, 105:14–27, OCT 15 2015.
- [3] P. F. Vieira, S. M. Vieira, **M. I. Gomes**, A. P. Barbosa-Povoa, and J. M. C. Sousa. Designing closed-loop supply chains with nonlinear dimensioning

factors using ant colony optimization. *SOFT COMPUTING*, 19(8):2245–2264, AUG 2015.

- [4] **Isabel Correia** and Francisco Saldanha-da Gama. A note on “branch-and-price approach for the multi-skill project scheduling problem”. *OPTIMIZATION LETTERS*, 9(6):1255–1258, AUG 2015.
- [5] **A. L. Custodio** and J. F. A. Madeira. GLODS: Global and Local Optimization using Direct Search. *JOURNAL OF GLOBAL OPTIMIZATION*, 62(1):1–28, MAY 2015.
- [6] **Paula Alexandra Amaral** and Immanuel M. Bomze. COPOSITIVITY-BASED APPROXIMATIONS FOR MIXED-INTEGER FRACTIONAL QUADRATIC OPTIMIZATION. *PACIFIC JOURNAL OF OPTIMIZATION*, 11(2, SI):225–238, APR 2015.
- [7] Filipe S. Dias, Miguel N. Bugalho, Patricia M. Rodriguez-Gonzalez, Antonio Albuquerque, and **J. Orestes Cerdeira**. Effects of forest certification on the ecological condition of Mediterranean streams. *JOURNAL OF APPLIED ECOLOGY*, 52(1):190–198, FEB 2015.

Other (international) publications

- [1] Raul Brás and **J. Orestes Cerdeira**. Computational comparison of algorithms for a generalization of the node-weighted steiner tree and forest problems. In João Paulo Almeida, José Fernando Oliveira, and Alberto Adrego Pinto, editors, *Operational Research*, volume 4 of *CIM Series in Mathematical Sciences*, pages 67–83. Springer International Publishing, 2015.
- [2] **J. Orestes Cerdeira**, Manuel Cruz, and Ana Moura. A routing/assignment problem in garden maintenance services. In João Paulo Almeida, José Fernando Oliveira, and Alberto Adrego Pinto, editors, *Operational Research*, volume 4 of *CIM Series in Mathematical Sciences*, pages 145–155. Springer International Publishing, 2015.
- [3] **Isabel Correia** and Francisco Saldanha-da Gama. *Handbook on Project Management and Scheduling*, volume 1 of *International Handbooks on*

Information Systems, chapter A modeling framework for project staffing and scheduling problems, pages 547–564. Springer, 1 edition, 2015.

- [4] **Isabel Correia** and Francisco Saldanha-da Gama. *Location Theory*, volume 1 of *Operations Research and Decision Theory*, chapter Facility location under uncertainty, pages 177–203. Springer, 1 edition, 2015.
- [5] Bruna Mota, Ana Carvalho, **Maria I. Gomes**, and Ana P. Barbosa-Povoa. In Fengqi You, editor, *Sustainability of Products, Processes and Supply Chains Theory and Applications*, volume 36 of *Computer Aided Chemical Engineering*, pages 333–353. Elsevier, 2015.
- [6] Ruy Araujo Costa, José Manuel Fonseca, José Carlos Kullberg, **Nelson Chibeles Martins**, and Fernando Santana. Soft skills for science and technology students: A pedagogical experience. In *Interactive Collaborative Learning (ICL), 2015 International Conference on*, pages 1198–1202, 2015.
- [7] **Susana Baptista**, Ana Paula Barbosa-Póvoa, Laureano Escudero, **Maria Isabel Gomes**, and Celeste Pizarro. A metaheuristic for solving large-scale two-stage stochastic mixed 0-1 programs with the time stochastic dominance risk averse strategy. In Krist V. Gernaey and Rafiqul Gani, editors, *12th International Symposium on Process Systems Engineering and 25th European Symposium on Computer Aided Process Engineering*, volume 37 of *Computer Aided Chemical Engineering*, pages 857–862. Elsevier B.V., 2015.
- [8] **Susana Baptista**, Ana Capela, **Nelson Chibeles-Martins**, Gracinda Rita Guerreiro, Carla Neves, Fátima Rodrigues, and Maria do Céu Soares. Projeto europeu mima – mathematics in the making. In EMELP, editor, *CIEMeLP 2015: Conferência Internacional do Espaço Matemático em Língua Portuguesa (poster)*, 28 a 31 de outubro de 2015, Coimbra, Portugal, pages 40–44, 2015.
- [9] **Susana Baptista**, **Nelson Chibeles-Martins**, Gracinda Rita Guerreiro, Fátima Rodrigues, and Maria do Céu Soares. Clubemath: do 1º ciclo

- à universidade. In EMeLP, editor, *CIEMeLP 2015: Conferência Internacional do Espaço Matemático em Língua Portuguesa (Grupos de Discussão)*, 28 a 31 de outubro de 2015, Coimbra, Portugal, pages 112–114, 2015.
- [10] **Paula Couto**, Ruben Ramalho, and **Rui Rodrigues**. Suppression of false arrhythmia alarms using ecg and pulsatile waveforms. In *Computing in Cardiology 2015*, volume 42 of *Computing in Cardiology*, pages 749–752, 2015.
- [11] Bruna Mota, Ana Carvalho, **Maria Isabel Gomes**, and Ana Paula Barbosa-Póvoa. Green supply chain design and planning. In *Proceedings of the International Conference on Industrial Engineering and Systems Management (IEEE-IESM'2015)*, pages 537–545, Seville, Spain, October 21-23 2015. University of Seville, International Institute for Innovation, Industrial Engineering and Entrepreneurship (I⁴e²).
- [12] Bruna Mota, **Maria Isabel Gomes**, Ana Carvalho, and Ana Barbosa-Póvoa. Supply chain design and planning accounting for the triple bottom line. In Krist V. Gernaey and Rafiqul Gani, editors, *12th International Symposium on Process Systems Engineering and 25th European Symposium on Computer Aided Process Engineering*, volume 37 of *Computer Aided Chemical Engineering*, pages 1841–1846. Elsevier B.V., 2015.
- [13] Diogo Alagador and **Jorge Orestes Cerdeira**. A model to minimize costs and promote species persistence under climate change. In Ana Paula Ferreira Dias Barbosa Póvoa and João Luis de Miranda, editors, *Operations Research and Big Data*, volume 15 of *Studies in Big Data*, pages 1–8. Springer International Publishing, 2015.
- [14] **Susana Baptista**, **Maria Isabel Gomes**, Laureano Escudero, Pedro Medeiros, and Filipe Cabrita. A fix-and-relax algorithm for solving parallel and sequential versions of a multi-period multi-product closed loop supply chain design and operation planning model. In Ana Paula Ferreira Dias Barbosa Póvoa and João Luis de Miranda, editors, *Operations Research and Big Data*, volume 15 of *Studies in Big Data*, pages 9–14. Springer International Publishing, 2015.

- [15] António Santos Marques, **Nelson Chibeles-Martins**, and Tânia Pinto-Varela. Simulated annealing for production scheduling: A case study. In Ana Paula Ferreira Dias Barbosa Póvoa and João Luis de Miranda, editors, *Operations Research and Big Data*, volume 15 of *Studies in Big Data*, pages 107–114. Springer International Publishing, 2015.

Other (national) publication

- [1] Ruy Araújo Costa , João Sotomayor, Cláudio Fernandes , Madalena Dionísio, José Manuel Fonseca, José Carlos Kullberg e **Nelson Chibeles Martins**. Competências Transversais para Ciências e Tecnologia. *Experiências De Inovação Didática No Ensino Superior*, 117-127. ISBN: 978-972-729-087-1. Ministério da Educação e da Ciência, 2015.

Accepted papers

- [1] Diogo Alagador, **Jorge Orestes Cerdeira**, and Miguel Bastos Araújo. Climate change, species range shifts and dispersal corridors: an evaluation of spatial conservation models. *Methods in Ecology and Evolution*, 2015.
- [2] Miguel F. Anjos and **Manuel V.C. Vieira**. An improved two-stage optimization-based framework for unequal-areas facility layout. *Optimization Letters*, 2015.
- [3] M. N. Bugalho, F. S. Dias, Briñas. B., and **J. O. Cerdeira**. Using the high conservation value forest concept and pareto optimization to identify areas maximizing biodiversity and ecosystem services in cork oak landscapes. *Agroforestry Systems*, 2015.
- [4] Laura Calvet, Albert Ferrer, **M. Isabel Gomes**, Angel A. Juan, and David Masip. Combining statistical learning with metaheuristics for the multi-depot vehicle routing problem with market. *Computers & Industrial Engineering*, 2015. available online.
- [5] T. Monteiro-Henriques, M. J. Martins, **J. O. Cerdeira**, P. Silva, P. Arsénio, Á. Silva, A. Bellu, and J. C. Costa. Bioclimatological mapping tackling uncertainty propagation: application to mainland portugal. *International Journal of Climatology*, 36(1):400–411, 2016.

- [6] **Susana Baptista, Nelson Chibeles-Martins**, Gracinda Rita Guerreiro, Maria de Fátima Rodrigues, Maria do Céu Soares, and Emanuela Ughi. Mathematics in the making - a view over the portuguese activities. In Associação Ludus, editor, *Proceedings of the Recreational Mathematics Colloquium IV (2015) · G4G Europe, Pavilhão do Conhecimento, Portugal, January 24-27, 2015*.

Submitted papers

- [1] Bernardo Almeida, **Isabel Correia**, and Francisco Saldanha-da Gama. Priority-based heuristics for the multi-skill resource constrained project scheduling. *Submitted*, 2015.
- [2] **Correia, Isabel** and Melo, Teresa, Multi-period capacitated facility location under delayed demand satisfaction. *Submitted*, 2015.
- [3] **Custódio, A. L.** and Scheinberg, K. and Vicente, L. N., Methodologies and software for derivative-free optimization. *Submitted*, 2015.
- [4] Karamintziou, Sofia D. and **Custódio, Ana Luísa** and Piallat, Brigitte, and Polosan, Mircea and Chabardès, Stéphan and David, Olivier and Stathis, Pantelis G. and Tagaris, George A. and Sakas, Damianos E. and Polychronaki, Georgia E. and Tsirogiannis, George L. and Nikita, Konstantina S., Algorithmic design of a therapeutically- and energy-efficient closed-loop deep brain stimulation system for Parkinson's disease and obsessive-compulsive disorder, *Submitted*, 2015.

Editing and authorship of books and journals

- [1] Gill Adams, **Susana Baptista**, Albrecht Beutelispacher, Gracinda Rita Guerreiro, Ferenc Holló-Szabó, Colin Jackson, Carola Kahlen, **Nelson Chibeles-Martins**, Katalin Munkácsy, Hilary Povey, Fátima Rodrigues, Maria do Céu Soares, Emanuela Ughi, Éva Vásárhelyi, Rosina Weber, and Gergely Wintsche. *MiMa - Mathematics in the Making - The Project*. Sheffield Hallam University, City Campus, Sheffield, England, 2015. Translated to Portuguese, Hungarian, Italian and German.

Software

1. Source code and case study data to formulate and solve *MinCost*, *MaxPersistNetFlow*, *MaxPersistCorridor* and *MinCostPersist* climate change corridor models (submitted 2015).

<http://onlinelibrary.wiley.com/store/10.1111/2041-210X.12524/asset/supinfo/mee312524-sup-0008-DatasetS1.zip?v=1&s=5669ad54723d56c561fe7b35e2fcfce13e4b17a5>

<http://onlinelibrary.wiley.com/store/10.1111/2041-210X.12524/asset/supinfo/mee312524-sup-0004-AppendixS4.pdf?v=1&s=78ff15cdab7ffbc55bd6ad73b9b0096b9a2f9>

2. **subselect**: Selecting Variable Subsets (version 0.12-5, 2015).

<https://cran.r-project.org/web/packages/subselect/index.html>

Seminars

Feb 25: *NovaHealth. Como?!? O que é que isto tem a haver com a IO e a Estatística?*, Isabel Gomes e Miguel Fonseca, Departamento de Matemática, CMA/FCT/UNL, Portugal.

Mar 25: *Combinatorics in the Auto Industry*, Jorge Orestes, Departamento de Matemática, CMA/FCT/UNL, Portugal.

Apr 15: *Two-Stage Optimization-Based Framework for Unequal-Areas Facility Layout Problem*, Manuel Vieira, Departamento de Matemática, CMA/FCT/UNL, Portugal.

May 13: *Tomada de Decisão em Aplicações AeroEspaciais*, Rita Ribeiro, UNI-NOVA, Portugal.

May 27: *k-Clube Triangular - modelos de PLI e desigualdades válidas*, Teresa Almeida, ISEG, ULisboa & CMAF-CIO, Portugal.

Oct 07: *Optimização Global Multiobjectivo Sem Recurso a Derivadas: Incorporando estratégias multistart em algoritmos de procura directa direccional*, Ana Luísa Custódio, Departamento de Matemática, CMA/FCT/UNL, Portugal.

Nov 25: *Can we bridge the gap between ecology and economics in applied research? The cases of fisheries and forestry*, Renato Rosa, CENSE—Center for Environmental and Sustainability Research, FCT-UNL, Portugal.

Dec 09: *Planeamento de rotas na amostragem de espécies marinhas*, Ana Paias, ULisboa, CMAF-CIO, Portugal.

Dec 09: *Identificação de setores e rotas de serviço para problemas reais*, Ana Catarina Nunes, CMAF-CIO, ULisboa & ISCTE-IUL, Portugal.

Dec 09: *Ajudando uma assistente social a planear o seu serviço de apoio domiciliário*, Maria Isabel Gomes, Departamento de Matemática, CMA/FCT/UNL, Portugal.

Short-courses

Dec 18—Dec 18: *Current challenges and recent progress in optimization for the smart grid*, Miguel F. Anjos, École Polytechnique de Montréal, Canada.

Also a short-course organized at Instituto Superior Técnico, U. Lisboa: “Mixed Integer Programming and Disjunctive Programming” and “Mixed Integer Models for Planning and Scheduling” lectured by Ignacio Grossmann (Carnegie Mellon University), IST-UTL, 28th and 29th January 2015. Co-organizer: **Isabel Gomes**.

Internationalization

Several group members collaborate at the international level in research activities, often resulting in collaborative publication. Collaborations in 2015 included:

- Miguel F. Anjos, École Polytechnique de Montréal, Canada (collaboration with **Manuel Vieira**).
- Immanuel Bomze, ISOR, University of Wien, Austria (collaboration with **Paula Amaral**).
- Laura Calvet, Open University of Catalonia, Barcelona (collaboration with **Isabel Gomes**).
- Laureano Escudero, University Rey Juan Carlos, Madrid (collaboration with **Isabel Gomes** and with **Susana Baptista**).
- Alberto Ferrer, Technological University of Catalonia, Barcelona (collaboration with **Isabel Gomes**).
- Masao Fukushima, Faculty of Science and Technology, Nanzan University, Japan (collaboration with **Maria do Carmo Brás**).
- Alfredo N. Iusem, Instituto de Matemática Pura e Aplicada, Rio de Janeiro, Brazil (collaboration with **Maria do Carmo Brás**).
- Angel Juan, Open University of Catalonia (collaboration with **Isabel Gomes**).
- Bahar Kara , Bilkent University, Turkey (collaboration with **Isabel Correia**).
- Sofia D. Karamintziou, Biomedical Simulations and Imaging Laboratory (BIOSIM), School of Electrical and Computer Engineering, National Technical University of Athens, Athens, Greece (collaboration with **Ana Luísa Custódio**).
- David Massip, Open University of Catalonia, Barcelona (collaboration with **Isabel Gomes**).
- Maria Teresa Melo, Business School, Saarland University of Applied Sciences, Germany (collaboration with **Isabel Correia**).
- Stefan Nickel, Institute of Operations Research, Karlsruhe Institute of Technology (KIT), Germany (collaboration with **Isabel Correia**).

- Celeste Pizzaro, University Rey Juan Carlos, Madrid (collaboration with **Susana Baptista** and with **Isabel Gomes**).
- Katya Sheinberg, Department of Industrial and Systems Engineering, Lehigh University, USA (collaboration with **Ana Luísa Custódio**).

Manuel Vieira is associate member of GERAD (Groupe d'Études et de Recherche en Analyse des Décisions), Montréal, Canada.

Jorge Orestes Cerdeira lectured the module “The mathematics behind spatial conservation problems” (lectures 3 & 4), of the course “Concepts and methods in spatial conservation prioritization: An integrative overview of Marxan, Zonation, MultyLink and iC4 software” (5 ECTS), CIBIO/InBIO (Centro de Investigação de Biodiversidade e Recursos Genéticos/Laboratório Associado), Évora, 28th September to 3rd October 2015

<http://www.maraujolab.com/wordpress/wp-content/uploads/2015/04/course-flyer.pdf>

Conferences participation

Invited talks at international conferences

1. An improved two-stage optimization-based framework for unequal-areas facility layout problem”, presented by **Manuel Vieira** at the 13th EUROPT Workshop on Advances in Continuous Optimization, Edinburgh, Scotland, July 2015
2. “MultiGLODS: Clever Multistart in Multiobjective Directional Direct Search”, Custódio, A. L. and Madeira, J. F. A., presented by **Ana Luísa Custódio** at CMN 2015, Congress on Numerical Methods in Engineering, Lisbon, Portugal, June 2015

Special session organization

1. EstudIO, Portalegre, 7th to 9th September 2015 (**Isabel Gomes**, session organizer).
2. IO 2015 - 17^o national congress of APDIO (Associação Portuguesa para o Desenvolvimento da Investigação Operacional), Portalegre, 7th to 9th

September 2015 (**Isabel Gomes, Jorge Orestes Cerdeira, Nelson Chibeles Martins**, members of the Program Committee).

3. Special Session “Speed dating with mathematicians from EU-MATHS-IN”, ICT2015 Innovate, Connect Transform, Lisbon Congress Center, 20th to 22nd October 2015 (**Jorge Orestes Cerdeira**, delegate from EU-MATHS-IN European Service Network of Mathematics for Industry and Innovation).
4. Thematic session in Recent Progresses in Derivative-Free Methods for Engineering Optimization, CMN 2015, Congresso de Métodos Numéricos em Engenharia, University of Lisbon, 29th June to 2nd July 2015 (**Ana Luísa Custódio**, co-organizer).

Seminars of the CMA OR Group, with a total of 9 lectures during 2015, organized by **Jorge Orestes Cerdeira**.

Contributed talk (international)

1. “A metaheuristic for solving large-scale two-stage stochastic mixed 0-1 programs with the time stochastic dominance risk averse strategy”, **Baptista, S.**, Barbosa-Póvoa, A. P., Escudero, L., **Gomes, M. I.** and Pizarro, C., presented by **Isabel Gomes** at the 12th International Symposium on Process Systems Engineering and 25th European Symposium on Computer Aided Process Engineering, Copenhagen, Norway, June 2015
2. “A multi-period stochastic hub location problem: formulation and valid inequalities”, **Correia, I.**, Nickel, S. and Saldanha da Gama, F., EURO XXVII – 27th European Conference on Operational Research, Glasgow, Scotland, July 2015.
3. “Clustering in infeasible LP problems”, presented by **Paula Amaral** at MOD15, Taormina, Sicily, Italy, July 2015.
4. “Green supply chain design and planning”, **Isabel Gomes**, 6th IESM Conference, Sevilha, Spain, October 2015.

5. "Hedging Uncertainty in Shelter Site Location Problem", **Correia, I.**, Kara, B.Y., Kinay, Ö. B. and Saldanha da Gama, F. , XXII EURO Working Group on Locational Analysis Meeting, Budapest, Hungary, May 2015.
6. "Helping a social assistant to plan her homecare service", **Isabel Gomes**, EURO Mini conference on Improving Healthcare, Coimbra, Portugal, March 2015.
7. "Market segmentation issues in the multi-depot vehicle routing problem", **Isabel Gomes**, EURO XXVII - 27th European Conference on Operational Research, Glasgow, Scotland, July 2015.
8. "Multi-objective optimization model for supply chain sustainability policy impact assessment", **Isabel Gomes**, Global Cleaner Production & Sustainable Consumption Conference, Barcelona, Spain, November 2015.
9. "Multi-period capacitated facility location under delayed demand satisfaction", **Correia, I.** and Melo, T., OR2015 - International Conference on Operations Research, Vienna, Austria, September 2015.
10. "Soft skills for science and technology students: A pedagogical experience", Araujo Costa, R., Fonseca, J. M., Kullberg, J. C., **Chibeles Martins, N.** and Santana, F., presented by J. M. Fonseca at ICL 2015 (International Conference on Interactive Collaborative Learning), Florence, Italy, September 2015.
11. "Supply chain optimization accounting for life cycle assessment - The impact of Product Environmental Footprint", **Isabel Gomes**, 2nd Discussion Forum on Industrial Ecology and Life Cycle Assessment, Coimbra, Portugal, March 2015.
12. "Suppression of false arrhythmia alarms using ECG and pulsatile waveforms", presented by **Rui Rodrigues** at Computing in Cardiology 2015, Nice, September 2015.
13. "Sustainable supply chain strategic and tactical decisions", **Isabel Gomes**, 27th European Conference on Operational Research, Glasgow, Scotland, July 2015.

14. “Two-stage optimization-based framework for unequal-areas facility layout problem”, presented by **Manuel Vieira** at EURO XXVII - 27th European Conference on Operational Research, Glasgow, Scotland, July 2015.

Invited talk (national)

1. A general notion of interiority”, presented by **Jorge Orestes Cerdeira** at the 6th Winter School on Technology Assessment, FCT-UNL, Lisbon, December 2015
2. “A network approach to Cerný’s conjecture for synchronizing automata”, presented by **Jorge Orestes Cerdeira** at the 9th Workshop on Statistics, Mathematics and Computation, Universidade Aberta, Lisbon, December 2015

Contributed talk (national)

1. “A bag of (mathematical) tricks for ageing issues”, presented by **Isabel Gomes** at 3º Workshop “Envelhecimento”, Lisbon, November 2015.
2. “A fix and relax algorithm for solving parallel and sequential versions of a multi-period multi-product closed loop supply chain design and operation planning model”, **Baptista, S., Gomes, M. I., Escudero, L., Medeiros, P. and Cabrita, F.**, presented by **Susana Baptista** at IO2015, Portalegre, September 2015.
3. “A model to minimize costs and promote species persistence under climate change”, presented by **Jorge Orestes Cerdeira** at IO2015, Portalegre, September 2015.
4. “Homecare Service Planning with a Non-Loyalty Feature”, **Isabel Gomes**, IO 2015, Portalegre, September 2015.
5. “Integrated sustainable supply chain design and planning”, **Isabel Gomes**, 12th Brainstorming on Optimization, FCT-UNL, 2015.
6. “Multi-objective mixed integer programming model for supply chain sustainability”, **Isabel Gomes**, IO 2015, Portalegre, September 2015.

7. “Simulated annealing for production scheduling: A case study”, Marques, A., **Chibeles Martins, N.**, Pinto-Varela, T., presented by Nelson Chibeles Martins at IO2015, Portalegre, September 2015.
8. “Um problema multi-periódico estocástico de localização de hubs modulares”, **Correia I.**, Nickel S., and Saldanha da Gama, F., presented by Isabel Correia at IO 2015, Portalegre, September 2015.

Poster

1. “Supply chain design and planning accounting for the triple bottom line”, **Isabel Gomes**, 12th International Symposium on Process Systems Engineering and 25th European Symposium on Computer Aided Process Engineering, Copenhagen, Norway, June 2015

Other Important Information

Ana Luísa Custódio is Faculty Advisor of the SIAM Student Chapter at Universidade Nova de Lisboa.

Isabel Correia was member of the Executive Board of the Portuguese Association of Operations Research (APDIO).

Ana Luísa Custódio and **Isabel Correia** were co-editors of the Portuguese Association of Operations Research (APDIO) Bulletin.

Outreach

1. ClubeMath, FCT-UNL, during 2015 (**Susana Baptista** and **Nelson Chibeles Martins**, members of the Organizing Committee).
2. MathIngenious 2015, Summer School in Mathematics for merit senior high school students, FCT-UNL, 6th to 8th July 2015 (**Ana Luísa Custódio**, chair of the Organizing Committee).
3. 5th Journey of Mathematics of FCT-UNL, FCT-UNL, 13th March 2015 (**Isabel Correia**, member of the Organizing Committee).

4. Portuguese Mathematical Society's Fair, National Museum of Natural History and Science, Lisbon, October 2015 (**Susana Baptista** and **Nelson Chibeles Martins**).
5. "Separação", talk at Jornadas de Primavera de MAEG, ISEG, Lisbon, 23rd April 2015 (**Jorge Orestes Cerdeira**).
6. "A Matemática e a Reciclagem", talk at Expo FCT, FCT-UNL, 8th April 2015 (**Isabel Gomes**).
7. "Calculando a idade das estrelas. . . um problema de Optimização", talk at Expo FCT, FCT-UNL, 8th April 2015 (**Ana Luísa Custódio**).
8. "Calculando a Idade das Estrelas: Uma breve introdução à Optimização", talk at MathIngenious 2015, FCT-UNL, 8th July 2015 (**Ana Luísa Custódio**).
9. "A Matemática no estudo e preservação da biodiversidade", talk at MathIngenious 2015, FCT-UNL, 8th July 2015 (**Jorge Orestes Cerdeira**).
10. "A Matemática na selecção de áreas prioritárias para a conservação da biodiversidade", talk at MatNova 2015, FCT-UNL, 1-5 September 2015 (**Jorge Orestes Cerdeira**).
11. "Gestor Logístico (m/f) - Precisa-se", project in Mathematics for MatNova 2015, FCT-UNL, 1-5 September 2015 (**Ana Luísa Custódio** and **Maria do Carmo Brás**).

Peer-reviewing activities

Ana Luísa Custódio: Computational and Applied Mathematics; Engineering Optimization; Mathematical Programming; Pacific Journal on Optimization;

Isabel Correia: Computers & Operations Research; Applied Mathematical Modeling; European Journal of Operational Research; IIE Transactions.

Isabel Gomes: International Transactions in Operational Research; IO2015 Conference Proceedings, Springer International Publishing.

Jorge Orestes Cerdeira: IO2015 Conference Proceedings, Springer International Publishing; Journal of Manufacturing Technology Management; Operations Research.

Manuel Vieira: European Journal of Operational Research; Operations Research; Operations Research Letters.

Maria do Carmo Brás: Mathematical Problems in Engineering; Numerical Algorithms.

Paula Amaral: ISCO Discrete Optimization; Journal of Applied Mathematics and Computing; Journal of Mathematical Extension; Mathematical Problems in Engineering.

Rui Rodrigues: Physiological Measurement.

Supervision of Ph.D. (2015)

Filipe Eduardo Parreiras Silva Dias, “The Role of Certification for the Conservation of Biodiversity and Sustainability of Cork Oak Woodlands”, Doutoramento em Engenharia Florestal e dos Recursos Naturais, Instituto Superior de Agronomia, 2015 (co-supervision of **Jorge Orestes Cerdeira**).

Ongoing supervision of Ph.D. students

Bruna Alexandra Elias Mota, “Integrated Sustainable Supply Chain Design and Planning”, PhD Program MIT Portugal Leaders for Technical Industries – EDAM, co-supervised by **Isabel Gomes**

Bernardo de Almeida, working on the topic “Project Scheduling Problems with Flexible Resources”, FCUL, co-supervised by **Isabel Correia**.

Supervisions of Post-Docs

Jorge Orestes Cerdeira co-supervised the research of Diogo André Alagador, framed in the project SFRH/BPD/104077/2014: Spatial conservation planning: reconciling biodiversity and human development in a dynamic world.

2016 research of IM

In 2016 the research work will mainly pursue already initiated topics.

In nonlinear optimization, a conic optimization approach to the sum of ratios with quadratic functions will be considered and new algorithms for the solution of the symmetric Eigenvalue Complementarity Problem (EiCP) and for

nonmonotone variants of directional direct search applied to noisy optimization will be analyzed. The use of cubic models in derivative-free optimization methods and practical approaches to derivative-free optimization problems with inviolable constraints, will also be addressed.

In combinatorial optimization, metaheuristics will be developed for the multi-skill resource constrained project scheduling problem and more comprehensive models for the multi-period capacitated facility location under delayed demand satisfaction will be proposed. Mixed integer linear formulations for the problem of clustering with fixed cardinality constraints will be extended to the problem of densest clustering with fixed cardinality constraints. A new mathematical optimization model for the multi-floor facility layout problem will be analyzed, both from the theoretical and computational point of view. Decomposition strategies will also be proposed for the p-median problem in disconnected graphs. The work related to infeasible clusters will be finalized.

Applications in the design of strategies for the selection of priority areas for biodiversity conservation will continue and also in pattern recognition in biomedical signals. Logistics will still be a major area for applications, namely in the design and planning of sustainable supply chains, and in the design of supply chains under uncertainty. Metaheuristics will be developed for problems involving scheduling and the design of multipurpose plants. In the context of the thematic line AgIL, new approaches to solve the homecare service problem will be considered, allowing to move to larger instances.

As a result of their work, the group expects to submit 9 papers and publish 12 in international journals.

Paula Amaral: A conic optimization approach to the sum of ratios with quadratic functions. Conclude the work in infeasible clusters. Research other interesting problems in infeasibility analysis.

Susana Baptista: We will continue working on the development of solution strategies for the design and planning of supply chains. In particular we will extend the parallel implementation of the solution algorithm to a risk averse context. The analysis of the impacts of the procedure within a case study will be the subject of a scientific paper to be submitted in 2016. Expected papers: 1 submitted.

Maria do Carmo Brás: A new algorithm for the solution of the symmetric

Eigenvalue Complementarity Problem (EiCP) will be explored. This algorithm tries to combine elements from the Spectral Projected Gradient method and the block active set method. Expected papers: 1 published.

Jorge Orestes Cerdeira: Applications and development of combinatorial optimization techniques to the design of strategies for the selection of priority areas for biodiversity conservation (e.g. flow models and variants of the Steiner tree problem for the design of wildlife corridors for species); development of decomposition strategies for the p-median problem in disconnected graphs. Expected papers: 4 published; 4 submitted.

Isabel Correia: The research plans for 2016 include the following topics: (i) development of a metaheuristic for the multi-skill resource constrained project scheduling problem, and (ii) development of more comprehensive models for the multi-period capacitated facility location under delayed demand satisfaction. This entails considering e.g. multiple commodities and several facility layers (suppliers, plants, warehouses). In addition, the inclusion of some features of the previous models in other types of facility location problems, such as hub location, will be studied. Expected papers: 1 or 2 published; 1 submitted.

Ana Luísa Custódio: We intend to report the work related to global multiobjective derivative-free optimization and establish the convergence of the nonmonotone variants of directional direct search for noisy optimization. In different topics, we plan to explore the use of cubic models in derivative-free optimization methods and we would like to numerically test the practical approaches to derivative-free optimization problems with inviolable constraints, for the strategies previously developed. Expected papers: 1 published; 2 submitted.

Paula Couto and Rui Rodrigues: We intend to continue the research related to pattern recognition in biomedical signals, namely those signals related to cardiology. In particular we plan to resume the research related to application of “deep learning” to biomedical signals.

Graça Gonçalves and Lúcia Lourenço: We intend to extend the study of the different mixed integer linear formulations for the clustering with fixed cardinality constraints problem, to the densest clustering with fixed cardinality constraints problem.

Isabel Gomes: Next year we are planning to: (sustainable supply chains design and planning) further investigate the impact that different social and environmental objective functions have in a supply chain structure; (uncertainty in supply chain design) follow a multiobjective approach, considering both risk neutral and risk averse models already developed. We seek to understand the differences in a supply chain network structure when either risk neutral or risk averse attitudes are followed; (homecare services) develop different solution approaches in order to tackle computational burden, to study a new and larger case. Expected papers: 2 published.

Nelson Chibeles Martins: In 2015 two biobjective simulated annealing based algorithms were developed, one for supply chain design and planning problems and another for scheduling on multi-product and multipurpose plants. For 2016 the main objectives will be: i) generalizing both algorithms to problems involving not only scheduling but also dealing simultaneously with the design of multipurpose plants; ii) expanding both methodologies to alternative meta-heuristics; iii) hybridization. Expected papers: 1 published; 1 submitted.

Manuel Vieira: I plan to analyze, theoretically and computationally, a new mathematical optimization model for the multi-floor facility layout problem. I also intend to enhance mathematical optimization models for the facility layout problem, and to achieve optimal solutions for larger instances of this NP-hard problem.

Strategic Plan: 2015-2020

This text was written during the second semester of 2013, as part of the CMA's strategic plan for 2015-2020 and includes all members.

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>) MulTyLink (<http://pascal.iseg.utl.pt/rbras/MulTyLink/>), 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 infeasibility 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 focus 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 modelling of supply chain following previous work [CPBN12], (3) the modelling of sources of supply chain uncertainty by stochastic formulation with the development of decomposition based solution strategies as previous work follow up [BGB12], (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 (ENVIRON 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 modelling 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 program on Operations Research or integrate Operations Research as a discipline in the PhD program on Mathematics already in place at the Department of Mathematics of FCT/UNL

Research line

Statistics and Risk Management

Highlights

- 55 papers; 28 indexed at Web of Science;
- One new post-doc, fully funded by CMA;
- One Ph.D and 5 M.Sc. theses presented;
- One authored book;
- Participation in an European Project — MiMa.

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Projects

Projects with the participation of team members

- 1. **Mathematics in the Making-Mima**
539872-LLP-1-2013-1-IT-COMENIUS-CMP (2013 – 2015)
PI: Emanuela Ughi (Università degli Studi di Perugia, Italy)
Total funding: 369.851,00 €— UNL funding: 54.537,00 €
Group member: Gracinda Guerreiro.. UNL team consists of 5 members of CMA

Achievements

JBS: Theoretical formulation for the adjusted returns used in the work in progress paper "Bonds Historical Simulation Value at Risk". This formulation allowed establishing theoretical conditions for the method to work.

MLA: Submitted the revision version of Using Weighted Distributions to Model Operational Risk. Joint work with Pedro Corte Real.

RRC: One paper was published in the ASTIN Bulletin where we obtained several results for ruin probabilities, time to ruin and expected present dividend amounts for the dual risk model considering that inter-time jumps follow an Erlang(n) distribution. Joint work with Alfredo D. Egídio dos Reis and Eugenio V. Rodríguez-Martínez.

AFM: The research in 2015 was focused on the study of nonparametric randomness tests aiming to develop a package in R. The main results were published in two peer reviewed conference proceedings.

GRG: Developed the work on open Markov populations considering the inflows on the population as an ARIMA and SARMA time series. Furthermore, as a member of the MiMa project, an EU-sponsored programme that involved 40 schools, 110 teachers and 1600 students across the 5 five participant countries. Besides being positively perceived by teachers and students, MiMa proposed hands-on activities that changed students' attitude towards mathematics and improved their mathematical competences. Results point out that 80% of the teachers recorded an improvement in the attention, concentration and engagement of students during or after the activities, that changes were perceived for problem solving and that the large majority of the teachers recognized improvements in students' mathematical understanding.

MLA, RRC & GRG: Submitted the paper with the results of measuring the impact of a bonus malus system in finite and continuous time ruin probabilities, for large portfolios in motor insurance for the closed model.

SDN: In 2015 I managed to increase knowledge on extreme value theory, an area in which I began to research in late 2013, which allowed me to propose some articles. A few have already been published, other were accepted for publication and other have been submitted. I also worked with teachers of business science which has allowed me to develop applications of statistics

in several areas. I also increased my research in Item Response Theory.

Publications

Publications in Web of Science journals

- [1] **Joao Lita Da Silva**. LIMITING BEHAVIOUR FOR ARRAYS OF UPPER EXTENDED NEGATIVELY DEPENDENT RANDOM VARIABLES (vol 92, pg 159, 2015). *BULLETIN OF THE AUSTRALIAN MATHEMATICAL SOCIETY*, 92(3):524, DEC 2015.
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- [3] **Joao Lita Da Silva**. LIMITING BEHAVIOUR FOR ARRAYS OF UPPER EXTENDED NEGATIVELY DEPENDENT RANDOM VARIABLES. *BULLETIN OF THE AUSTRALIAN MATHEMATICAL SOCIETY*, 92(1):159–167, AUG 2015.
- [4] **J. Lita da Silva**. Almost sure convergence for weighted sums of extended negatively dependent random variables. *ACTA MATHEMATICA HUNGARICA*, 146(1):56–70, JUN 2015.
- [5] **Joao Lita da Silva**. Integer powers of anti-tridiagonal matrices of the form $\text{antitridiag}(n)(a, 0, b)$, a, b is an element of \mathbb{R} . *COMPUTERS & MATHEMATICS WITH APPLICATIONS*, 69(11):1313–1328, JUN 2015.
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- [7] **Joao Lita Da Silva**. REMARKS ON YU MIAO AND SHOUFANG XU'S PAPER "ALMOST SURE CONVERGENCE OF WEIGHTED SUMS". *MISKOLC MATHEMATICAL NOTES*, 16(1):503–506, 2015.
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- [11] Gilberto Capistrano, Celia Nunes, Dario Ferreira, Sandra S. Ferreira, and **Joao T. Mexia**. One-way Random Effects ANOVA with Random Sample Sizes: An Application to a Brazilian Database on Cancer Registries. In Simos, TE and Tsitouras, C, editor, *PROCEEDINGS OF THE INTERNATIONAL CONFERENCE OF NUMERICAL ANALYSIS AND APPLIED MATHEMATICS 2014 (ICNAAM-2014)*, volume 1648 of *AIP Conference Proceedings*, 2015. International Conference on Numerical Analysis and Applied Mathematics (ICNAAM), Rhodes, GREECE, SEP 22-28, 2014.
- [12] Dario Ferreira, Sandra S. Ferreira, Celia Nunes, and **Joao T. Mexia**. Estimation of Variance Components in Normal Linear Mixed Models with Additivity. In Simos, TE and Tsitouras, C, editor, *PROCEEDINGS OF THE INTERNATIONAL CONFERENCE OF NUMERICAL ANALYSIS AND APPLIED MATHEMATICS 2014 (ICNAAM-2014)*, volume 1648 of *AIP Conference Proceedings*, 2015. International Conference on Numerical Analysis and Applied Mathematics (ICNAAM), Rhodes, GREECE, SEP 22-28, 2014.

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- [16] Anibal Areia, **Francisco Carvalho**, and **Joao T. Mexia**. Complete and sufficient statistics and perfect families in orthogonal and error orthogonal normal models. *OPEN MATHEMATICS*, 13(1):135–140, JAN 2015.
- [17] Eugenio V. Rodriguez-Martinez, **Rui M. R. Cardoso**, and Alfredo D. Egidio Dos Reis. SOME ADVANCES ON THE ERLANG(n) DUAL RISK MODEL. *ASTIN BULLETIN*, 45(1):127–150, JAN 2015.
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- [2] **Paulo Ramos, Célia Fernandes**, and **João Mexia**. Algebraic structure for interaction on mixed models. *Journal of Interdisciplinary Mathematics*, 18(1-2):43-52, 2015.
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- [5] **Marta Faias, Pedro Mota**, Alberto Mulenga, and Joaquim Pina. Asymmetry of arch effects and natural resources disease or virtue: Mozambique experience. In Theodore E. Simos, editor, *Proceedings of the International Conference on Numerical Analysis and Applied Mathematics 2015 (ICNAAM-2015)*, AIP Conference Proceedings, 2015.
- [6] **A. Mateus** and **F. Caeiro**. The difference-sign randomness test: A review. In AIP Conference Proceedings, editor, *Proceedings of the International Conference on Numerical Analysis and Applied Mathematics 2015 (ICNAAM-2015)*, volume 1702, 2015.
- [7] **Paula Simões**, Sílvia Shrubbsall, **Isabel Natário** A spatial econometrics analysis for road accidents in Lisbon *International Journal of Business Intelligence and Data Mining* 2015 Vol. 10 No. 2, 152-173. DOI: 10.1504/IJBIDM.2015.069270
- [8] **Frederico Caeiro** and M. Ivette Gomes. Revisiting the maximum likelihood estimation of a positive extreme value index. *Journal of Statistical Theory and Practice*, 9(1):200–218, 2015.
- [9] **Carlos A. Coelho, Filipe J. Marques**, and Barry C. Arnold. Preface for the special issue on distribution theory, estimation, and inference. *Journal of Statistical Theory and Practice*, 9(1):1–1, 2015.
- [10] **Filipe J. Marques** and **Carlos A. Coelho**. Near-exact distributions for the likelihood ratio test statistic for testing multisample independence – the real and complex cases. *Journal of Statistical Theory and Practice*, 9(1):37–58, 2015.
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- [12] Nuno Carvalho and Luísa Carvalho and **Sandra Nunes**. A methodology to measure innovation in European Union through the national innova-

tion system. *International Journal of Innovation and Regional Development*, 6 (2), 159-180, 2015.

Other (international) publications

- [1] **Frederico Caeiro** and **Dora Prata Gomes**. Adaptive estimation of a tail shape second order parameter: A computational comparative study. *AIP Conference Proceedings*, 1702, 2015.
- [2] **Frederico Caeiro** and **Dora Prata Gomes**. A log probability weighted moment estimator of extreme quantiles. In P. Christos Kitsos, A. Teresa Oliveira, Alexandros Rigas, and Sneh Gulati, editors, *Theory and Practice of Risk Assessment: ICRA 5, Tomar, Portugal, 2013*, pages 293–303, Cham, 2015. Springer International Publishing.
- [3] M.I. Gomes, **F. Caeiro**, F. Figueiredo, and D. Pestana. A partially reduced-bias class of value-at-risk estimators. In *Proceedings of the 60th ISI World Statistics Congress*, volume Session STS067, pages 1098–1103, 2015.
- [4] **Carlos A. Coelho** and **Filipe J. Marques**. Preface of the “4th symposium on distribution theory, estimation and inference. *AIP Conference Proceedings*, 1648(1), 2015.
- [5] Susana Baptista, Ana Capela, Nelson Chibeles-Martins, **Gracinda Rita Guerreiro**, Carla Neves, Fátima Rodrigues, and Maria do Céu Soares. Projeto europeu mima - mathematics in the making. In EMeLP, editor, *CIEMeLP 2015: Conferência Internacional do Espaço Matemático em Língua Portuguesa (poster), 28 a 31 de outubro de 2015, Coimbra, Portugal*, pages 40–44, 2015.
- [6] Susana Baptista, Nelson Chibeles-Martins, **Gracinda Rita Guerreiro**, Fátima Rodrigues, and Maria do Céu Soares. Clubemath: do 1º ciclo à universidade. In EMeLP, editor, *CIEMeLP 2015: Conferência Internacional do Espaço Matemático em Língua Portuguesa (Grupos de Discussão), 28 a 31 de outubro de 2015, Coimbra, Portugal*, pages 112–114, 2015.

- [7] S. Pinto, L. Carvalho, and **S. Nunes, S.** Innovation Propensity in Knowledge Intensive Business Services (KIBS): A Comparative Study in Portuguese Service Sector. Handbook of Research on Entrepreneurial Success and its Impact on Regional Development (2 Volumes, 878 pages). Editor: Luísa Carvalho Publishers: IGI Global. Pages: 20–40, 2015.
- [8] **Grilo, L. M.**, Grilo, H. L. e Marques, C. J. (2015). Industrial production of gypsum: quality control charts. Theory and Practice of Risk Assessment: ICRA 5, Tomar, Portugal, 2013. Springer Proceedings in Mathematics & Statistics, Vol. 136. pp. 225-234. Edited by Christos P. Kitsos, Teresa A. Oliveira, Alexandros Rigas, Sneh Gulati.
- [9] Neves, M., Penalva, H. and **Nunes, S.** Extreme value analysis of river levels in a hydrometric station in the north of Portugal. Cuadernos de la Fundación Mapfre, Current Topics on Risk Analysis: ICRA6 and RISK 2015 Conference Proceedings, Montserrat Guillén, Ángel A. Juan, Helena Ramalhinho, Isabel Serra and Carles Serrat (editors), p. 533-540. ISBN: 978-84-9844-496-4
- [10] **Iola Pinto** and Margarida GMS Cardoso. Measuring The Effects Of Marketing Actions: The Role Of Matching Methodologies. Quantitative Modelling in Marketing and Management 2nd Edition Edited by: Luiz Moutinho (University of Glasgow, UK), Kun-Huang Huarng (Feng Chia University, Taiwan), World Scientific. pp 491–506.

Other (national) publications

- [1] Maria Teresa Alves, Carlos Mata, and **Sandra Nunes.** O papel da demonstração dos fluxos de caixa na previsão da falência: O caso do banco privado português. *Revista Universo Contábil*, 11(3), 2015.
- [2] Ana A. Paulo, Diogo S. Martins, **Elsa Moreira**, Tayeb Raziei, Luis S. Pereira. Análise espacial, temporal e de tendências das secas em Portugal usando o índice SPI aplicado a dados observados, PT02 e séries longas, In: *Predictabilidade Sazonal de Secas. Avaliação ao nível regional e agrícola*. Editores: Carlos A. L. Pires, Luís S. Pereira, ISA press, 2015.

- [3] **Elsa E. Moreira**, Diogo S. Martins, Luis S. Pereira. Ciclicidade das secas em Portugal. Análise de Fourier aplicada ao SPI e identificação de relações com a oscilação do Atlântico Norte, In: *Predictabilidade Sazonal de Secas. Avaliação ao nível regional e agrícola*. Editores: Carlos A. L. Pires, Luís S. Pereira, ISA press, 2015.
- [4] **Dora Prata Gomes, Elsa E. Moreira**, M. Manuela Neves. Revisão de metodologias de extremos espaciais aplicadas à modelação de máximos de precipitação em zonas de risco em Portugal In: *Predictabilidade Sazonal de Secas. Avaliação ao nível regional e agrícola*. Editores: Carlos A. L. Pires, Luís S. Pereira, ISA press, 2015.
- [5] **Elsa E. Moreira**. Predição de transições de classes de seca utilizando modelação log-linear aplicada às estações chuvosa e seca In: *Predictabilidade Sazonal de Secas. Avaliação ao nível regional e agrícola*. Editores: Carlos A. L. Pires, Luís S. Pereira, ISA press, 2015.
- [6] **Elsa E. Moreira**, Carlos A. L. Pires, Luis S. Pereira. Previsão de transições de classes de seca SPI condicionadas pelo índice NAO usando modelação log-linear In: *Predictabilidade Sazonal de Secas. Avaliação ao nível regional e agrícola*. Editores: Carlos A. L. Pires, Luís S. Pereira, ISA press., 2015

Accepted papers

1. M. Neves, H. Penalva, and **S. Nunes**. Extreme value analysis of river levels in a hydrometric station in the north of Portugal. Cuadernos de la Fundación Mapfre, Current Topics on Risk Analysis: ICRA6 and RISK 2015 Conference Proceedings, Montserrat Guillén, Ángel A. Juan, Helena Ramalhinho, Isabel Serra and Carles Serrat (editors), p. 533-540.
2. **S. Nunes**. Perspectives and Realities of Teaching Statistics at a Superior School of Business Administration. In Proceedings of 13th INTERNATIONAL CONFERENCE OF NUMERICAL ANALYSIS AND APPLIED MATHEMATICS 2015 (ICNAAM 2015).
3. M. Neves, H. Penalva and a **S. Nunes**. Extreme value analysis of Daily

mean flow discharge rate values in a hydrometric station in the North of Portugal. In REVSTAT - STATISTICAL JOURNAL.

4. Sandra S. Ferreira, Célia Nunes, Dário Ferreira, **Elsa Moreira, João Tiago Mexia**. Estimation and Orthogonal Block Structure. Hacettepe University Bulletin of Natural Sciences and Engineering Series B: Mathematics and Statistics 2015;45(58).

Submitted papers

1. **P. Mota** and **M. L. Esquível**. Model Selection for Stock Prices Data.

Editing and authorship of books and journals

1. **Elsa E. Moreira**. *Structured families of models. Theory and application to the loglinear modelling of drought class transitions*. Scholars' Press., 2015. ISBN:978-3-639-76589-2.
2. Gill Adams, Susana Baptista, Albrecht Beutelspacher, **Gracinda Rita Guerreiro**, Ferenc Holló-Szabó, Colin Jackson, Carola Kahlen, Nelson Chibeles-Martins, Katalin Munkácsy, Hilary Povey, Fátima Rodrigues, Maria do Céu Soares, Emanuela Ughi, Éva Vásárhelyi, Rosina Weber, and Gergely Wintsche. *MiMa - Mathematics in the Making - The Project*. Sheffield Hallam University, City Campus, Sheffield, England, 2015. Translated to Portuguese, Hungarian, Italian and German.

Seminars

Feb 18: *A method of recursive images provides exact solutions for transient heat diffusion in a slab*, Carlos Dias, CENIMAT/I3N, DCM-FCT-UNL, Portugal.

Feb 25: *NovaHealth. Como?!? O que é que isto tem a haver com a IO e a Estatística?*, Isabel Gomes e Miguel Fonseca, Departamento de Matemática, CMA/FCT/UNL, Portugal.

Mar 04: *Robust inference in mixed linear models*, Miguel Fonseca, Departamento de Matemática, CMA/FCT/UNL, Portugal.

Mar 18: *Data Recovery Fuzzy Clustering: an Additive Spectral Method and Applications*, Susana Nascimento, Departamento de Informática and NOVA Laboratory for Computer Science and Informatics (NOVA-LINCS), FCT-UNL, Portugal.

Mar 25: *Inferência para modelos com Ortogonal Block Structure(OBS)*, João Tiago Mexia, Departamento de Matemática, CMA/FCT/UNL, Portugal.

May 06: *Web of Data*, José Alferes, NOVA LINCS, Portugal.

May 20: *História da Modelação Estocástica do Surto de Doença dos Legionários de Outubro/Novembro de 2014 em Vila Franca de Xira*, M. Lucília Carvalho & Paulo Nogueira & Baltazar Nunes, Faculdade de Ciências da Universidade de Lisboa, Centro de Estatística e Aplicações da Faculdade de Ciências & Faculdade de Ciências da Universidade de Lisboa, Centro de Estatística e Aplicações da Faculdade de Ciências & INSA-Ricardo Jorge, Portugal.

Jun 09: *On the bootstrap methodology for the threshold estimation*, Frederico Caeiro, Departamento de Matemática, CMA/FCT/UNL, Portugal.

Jun 18: *Real Option Pricing with Mean-Reverting Investment and Project Value*, Max Souza, Universidade Federal Fluminense, Brazil.

Sep 01: *Equilibrium pricing under relative performance concerns*, Gonçalo dos Reis, Edinburgh University & CMA-FCT-UNL, UK & Portugal.

Sep 03: *The EM Algorithm with Applications to a Banking problem*, Gonçalo dos Reis, Edinburgh University & CMA-FCT-UNL, UK & Portugal.

Oct 28: *Reliability of Large Coherent Systems and Penultimate Approximations in Extreme Value Theory*, M. Ivette Gomes, Centro de Estatística e Aplicações, Faculdade de Ciências Universidade de Lisboa, Portugal.

Nov 11: *Option pricing in processes with regimes*, Pedro Mota, Departamento de Matemática, CMA/FCT/UNL, Portugal.

Nov 27: *Nowcasting Recessions? SSA at Work*, Miguel de Carvalho, Pontificia Universidad Católica de Chile, Chile.

Dec 02: *Dados Parcialmente Sintéticos via Imputação por Plug-in: Inferência para o Modelo de Regressão Multivariada*, Ricardo Moura, CMA/FCT/UNL, Portugal.

Dec 09: *Bayesian bootstrap inference for the ROC surface*, Vanda Inácio, Pontificia Universidad Católica de Chile, Chile.

Short-courses

Dec 17—Dec 18: *A Crash Course on Statistics of Multivariate Extremes*, Miguel de Carvalho, Pontificia Universidad Católica de Chile, Chile.

Internationalization

Conferences participation

Special session organization

- *Stochastic Numerical Methods for Non-linear Equations*, American Mathematical Society-European Mathematical Society-Portuguese Mathematical Society joint meeting, Porto, June 10-13, coorganized by **Goncalo dos Reis**, CMA & University of Edinburgh, Lukasz Szpruch, University of Edinburgh

Invited talks at international conferences

1. Mateus, A. and Caeiro, F. (2015), The difference-sign randomness test: A review, International Conference of Computational Methods In Sciences

and Engineering 2015 (ICCMSE-2015).

2. Grilo, L. M. (2015). Robust approaches to analyse agreement of medical data. 2.a Conferência Internacional da Amazônia e Nordeste em Estatística e Análise de Risco (ANSRA2). Universidade Estadual da Paraíba (UEPB), Brasil, 04-07 de agosto.
3. Grilo, L. M. e Coelho, C. A. (2015). A family of near-exact distributions for the statistic used to test the reality of a covariance matrix in a complex normal distribution. II Workshop on Computational Data Analysis and Numerical Methods, Universidade de Évora, Évora, Portugal, 24 de abril.
4. Grilo, L. M., Henriques, R. S., Correia, P. C. e Grilo, H. L. (2015). Statistical analysis of psychomotor therapy in attention deficit/hyperactivity disorder in children. 17th International Conference on Mathematical Methods, Computational Techniques and Intelligent Systems (MAMECTIS '15), p. 15. Tenerife, Ilhas Canárias, Espanha, 10-12 January.
5. Caeiro, F., Mean of order p reduced bias estimation of the extreme value index: a computational study. Session EO126: MODELLING AND COMPUTATION IN STATISTICS OF EXTREMES. CMStatistics 2015, 12-14 December 2015, Senate House, University of London, UK.
6. Marques, F. J. Asymptotic approximations for the sum of independent Gamma random variables and for the product of independent Beta random variables, South Africa Statistical Association Conference, Special Session, Fit In or Fall Out: Statistical Distributions, Pretoria, South Africa, November 30, 2015.
7. Marques, F. J. Testing elaborate block-structures in covariance matrices by splitting the null hypothesis - an overview, 60th World Statistics Congress ISI2015, STS009, Distribution Theory - still important, of course!, Brazil, July 2015.

Contributed talk (international)

1. J Beleza Sousa. Machine learning Gaussian short rate. International Joint Meeting AMS-EMS-SPM, Porto, Portugal, June 10-13, 2015.

2. M. L. Afonso. Bonus malus systems and finite and continuous time ruin probabilities in motor Insurance; Joint work with Egídio dos Reis, A.; Cardoso, R and Guerreiro, R. Insurance Mathematics and Economics. IME 2015 Liverpool
3. V. Lourenço. "Robust heritability and predictive accuracy estimation in plant breeding". 8th International Conference of the ERCIM WG on Computational and Methodological Statistics (CMStatistics2015), London, UK. 12 - 14 December 2015
4. V. Lourenço. "Robust heritability and predictive accuracy estimation in plant breeding trials: an application to a maize dataset" International Association for Statistical Computing Satellite Conference (IASC2015), Búzios, Brazil. 3 - 4 August 2015
5. V. Lourenço. "Robust heritability estimation in plant studies" 60th World Statistical Meeting of the International Statistical Institute (ISI2015), Rio de Janeiro, Brazil. 26 - 31 July 2015
6. V. Lourenço. "A Robust Linear Mixed Model for Heritability Estimation in Plant Studies" Eastern North American Region Meeting (ENAR2015), Miami, EUA. 15 - 18 March 2015
7. Rui Cardoso. Bonus malus systems and finite and continuous time ruin probabilities in motor insurance," 19th International Congress on Insurance: Mathematics and Economics, University of Liverpool, 24-26 June, 2015. Joint work with M. Lourdes Afonso, Alfredo D. Egídio dos Reis and Gracinda R. Guerreiro.
8. Rui Cardoso. "On the dual risk model, discounted dividends, moments and optimal barriers", PARTY 2015 - Perspectives on Actuarial Risks in Talks of Young researchers, University of Liverpool, 11-16 January, 2015. Joint work with Alfredo D. Egídio dos Reis and Eugenio V. Rodríguez-Martínez.
9. Grilo, L. M. e Grilo, H. L. (2015). Measuring Statistical Agreement of Medical Data. 9th Workshop on Statistics, Mathematics and Computation, Palácio Ceia - Universidade Aberta, Lisboa, 14 15 de December.

10. Grilo, L. M. e Coelho, C. A. (2015). The exact and near-exact distributions for the statistic used to test the reality of a covariance matrix in a complex normal distribution. MatTriad'2015, Universidade de Coimbra, Coimbra, Portugal, 07-11 de Setember.
11. G. Guerreiro. "ClubeMath – do 1o ciclo à Universidade", CiEMeLP 2015 - Conferência Internacional do Espaço Matemático em Língua Portuguesa, Coimbra, Portugal, 28 de Outubro de 2015. Joint work with Maria de Fátima Rodrigues, Maria do Céu Soares, Nelson Chibeles Martins, Susana Baptista. Presented by MC Soares.
12. G. Guerreiro. "Mathematics in the Making - A view over the Portuguese activities", Baptista, Susana; Chibeles-Martins, Nelson; Guerreiro, Gracinda Rita; Rodrigues, Maria de Fátima; Soares, Maria do Céu and Ughi, Emanuela, Presented by MC Soares at Recreational Mathematics Colloquium IV (2015) · G4G Europe, Pavilhão do Conhecimento, Portugal, January 24-27, 2015
13. G. Guerreiro. "An open Markov chain scheme for a credit consumption portfolio fed by ARIMA and SARMA processes" – ICNAAM 2015, Rhodes, Greece, September 2015. Joint work with Esquivel. M.L. and Fernandes, J.M. Presented by Fernandes, J.M.
14. G. Guerreiro. "Bonus Malus Systems and finite and continuous time ruin probabilities in motor insurance" – IME 2015, Liverpool, June 2015. Joint work with Afonso, L.B., Cardoso, R.C. and Egídio dos Reis, A. Presented by Egídio dos Reis, A.
15. F. Caeiro. Adaptive Estimation of a Tail Shape Second Order Parameter: a Computational Comparative Study. 2nd Symposium on Computational Statistical Methods, 10TH INTERNATIONAL CONFERENCE OF COMPUTATIONAL METHODS IN SCIENCES AND ENGINEERING. Athens, Greece, 22 March 2015.

Poster

1. V. Lourenço. "Robust heritability and predictive accuracy estimation in plant breeding" 4th International Conference and Exhibition on Biometrics & Biostatistics, San Antonio, USA 16 - 18 novembro 2015.

2. L. Grilo. Silva, D. S., Nogueira, I. M., Grilo, L. M. e Rosa, A. (2015). Contribuição Estatística no Controlo de Qualidade do Cartão. Seminário de Engenharia Química e do Ambiente: “À Luz da Química”, ESTT-IPT – Tomar, Portugal, 07 May.
3. G. Guerreiro. “Mathematics in the Making – a view over the Portuguese activities”, CiEMeLP 2015 - Conferência Internacional do Espaço Matemático em Língua Portuguesa, Coimbra, Portugal, 28 a 31 de Outubro de 2015. Joint work with Maria de Fátima Rodrigues, Maria do Céu Soares, Nelson Chibeles Martins, Susana Baptista. Presented by MF Rodrigues.
4. F. J. Marques. Near-exact distributions for positive linear combinations of independent non- central Gamma random variables, 13th International Conference of Numerical Analysis and Applied Mathematics, ICNAAM, 23 - 29 September, 2015, Greece.
5. F. J. Marques. Testing the equality of several linear regression models, Joint Meeting of IASC-ABE, Satellite Conference for the 60th ISI WSC 2015, Brazil, 2 - 4 August 2015.
6. I. Sequeira. Juliana Gonçalves, Elsa Moreira, Inês J. Sequeira, António S. Rodrigues, José Rueff and Aldina Brás. Study of preferential integration targets of HIV in human genome - a genetic and statistical analysis. 1o Workshop de Genética promovido pela NOVASaúde, 9 de outubro de 2015, Reitoria da NOVA, Lisboa. ToxOmics Meeting, 28 de setembro de 2015; INSA (Instituto Nacional de Saúde Doutor Ricardo Jorge).
7. S. Nunes, Perspectives and Realities of Teaching Statistics at a Superior School of Business Administration. In 13th INTERNATIONAL CONFERENCE OF NUMERICAL ANALYSIS AND APPLIED MATHEMATICS 2015 (ICNAAM 2015) - 23-29 September 2015, Rhodes, Greece.
8. S. Nunes. Neves, M., Penalva, H. and Nunes, S. Extreme value analysis of flood discharge rate in a hydrometric station – North of Portugal. ICRA 6/RISK 2015 – Barcelona, May 26–29, 2015

Other Important Information

Peer-reviewing activities

1. **MLA**: Annals of Actuarial Science.
2. **RRC**: ASTIN Bulletin.
3. **PPM**: Journal of Applied Statistics.
4. **LMG**: SMTDA (Stochastic Modelling Techniques and Data Analysis) Conference Proceedings; AIP Conference Proceedings. International Conference of Computational; Methods in Sciences and Engineering (ICCMSE); AIP Conference Proceedings. International Conference of Numerical Analysis and Applied Mathematics (ICNAAM).

Editorships of journals

1. **RRC**: Associate Editor of European Actuarial Journal.
2. **LMG**: Editorial Board of Asian Journal of Mathematics and Computer Research; Editor British Journal of Mathematics & Computer Science.
3. **FJM**: Invited Editor, Special Volume of the Journal of Statistical Theory and Practice, entitled Distribution Theory, Estimation and Inference, 2015.

Theses presented

Ph.D.

1. Artur Pereira, Orthogonal Models, Structure, Crossing, Nesting and Inference, FCT-UNL, 18/12/2015, supervisor: **Miguel Fonseca**.

Ms.C

1. Liliana Rebelo, “Rentabilidade dos Clientes de uma Seguradora Automóvel”, Instituto Superior de Estatística e Gestão da Informação, Universidade Nova de Lisboa, 20/2/2015, supervisor: **Gracinda Guerreiro**.

2. Ana Luís, "Impacto da nova lei de acidentes de trabalho", 27/5/2015, supervisor: **Rui Cardoso**.
3. Ana Pereira, "Avaliação do risco: modelos estatísticos e aplicações", Departamento de Ciências e Tecnologia, Universidade Aberta, 4/8/2015, supervisor: **Luís Grilo**.
4. Miguel Castro, "Desenvolvimento e Implementação de Técnicas Avançadas usando desvios com Aplicação a Calibrações no domínio de Metrologia Angular", 25/11/2015, supervisor: **Filipe Marques**.
5. Cidália Tomás, "Intervalos de confiança para rendas vitalícias: aplicação a fundos de pensões", FCT-UNL, 4/12/2015, supervisor: **Lourdes Afonso**.

2016 research of IM

JBS: Construction of a short rate model which meets the theoretical conditions achieved in 2015 on the work in progress paper "Bonds Historical Simulation Value at Risk". Evaluate the performance of the method with real data - a long term portfolio of bonds.

RRC & MLA: To obtain results for the extended model to calculate the ruin probability in a motor insurance portfolio with a bonus malus system now with an open portfolio using the model of Afonso et al. (2009) and the results achieved in 2015. Joint work with Rui M.R. Cardoso, Alfredo D. Egídio dos Reis and Gracinda R. Guerreiro.

RRC: To extend some results obtained for higher moments for the discounted dividends and to develop a numerical method to determine the dividend barrier that maximizes the expected discounted dividends for the Dual Risk Models considering that waiting times and single gains are Phase-Type(n) distributed. Joint work with Alfredo D. Egídio dos Reis and Eugenio V. Rodríguez-Martínez.

Strategic Plan: 2015-2020

This text was written during the second semester of 2013, as part of the CMA's strategic plan for 2015-2020 and includes all members.

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, DFerreira, 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 (Khatri, 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 Afonso 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 methods will be applied in analysis and forecasting in long-term care services. Comfort Keepers, a personal assistance services provider, is involved in this research.

RRCardoso: In one published and 1 acceptor 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.

FCaeiro will work on Second-order Parameters Estimation for reduced-bias pa-

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 modelling spatial extremes in real cases studies.

MBdeCarvalho: will work on Bayesian nonparametrics, multivariate extreme value modelling 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.

Part IV

Activites in the thematic lines

Thematic line

**Mathematical
modelling for the
independent living
of elderly, disable,
and chronic
patients**

During 2015 the work developed under the thematic line “Mathematical modelling for the independent living of elderly, disabled, and chronic patients” followed two lines already under study, “the Homecare planning problem” and “Long term Care portofolio”. Three new projects emerged: the identification of health indicators for functionality evaluation in the elderly, the development of a Selfie Ageing Index, and the definition of an algorithm to support decision making in diagnosis and clinical decision in ageing sarcopenia.

The researchers engaged in these studies are **Maria Isabel Gomes** (PI, Operations Research), **Miguel Fonseca**, **Gracinda Guerreiro** and **Manuel Esquível** (Statistics and Risk Management), and the PhD student **Cristina Nobre** (Statistics and Risk Management).

Some of the work was presented in one international conference, three national conference, one workshop and two CMA seminars.

• **Homecare planning problem**

One problem within the planning of home social care is the simultaneously allocation of caregivers to patients and the definition of the daily work schedule of each caregiver. In literature, the majority assume loyalty between the caregiver and the patient. This is to mean the same person must always visit the patient. In our problem, one of the objectives is exactly the opposite. One wants to define a plan that allows caregivers to rotate (with specific rules) among patients on a weekly basis. Each week, the daily schedule of caregivers teams has then to be planned so that all patients’ requests are met. These visit requests vary from several times a day to twice a week and may comply activities of the daily living and/or transportation to/from the day care centre. This work is motivated by two real case studies of a Portuguese communities nearby by Lisbon. The problems are addressed by MILP formulations based either on VRP with time windows or by an extension of the allocation problem. Given the computational burden of the weekly VRP, a heuristic approach was developed. It was presented in two conferences: Euro Mini Conference, improving healthcare: new challenges, new approaches, Coimbra, 30th March to 1st April (international conference)

and IO 2015, the XVII conference of the Portuguese Association of Operations Research (national conference), Portalegre, 5th to 7th September. This is a collaboration with the Department of Engineering and Management from Instituto Superior Técnico, Lisbon University. Two Master theses are currently under development.

- **Long Term Care Research**

Aiming at the development of a model that could represent a Long Term Care portfolio, some results on the estimation of the expected number of policyholders in each dependence state, as time evolves, has been obtained, using the results on Stochastic Vortices model. Results have been obtained using real data from a Portuguese institution, considering a model with five dependence levels, allowing for recoveries between dependence levels. In particular, a discrete time model (based on the Stochastic Vortices model) considering an open population (modelling entrances and departures from the population) allowed the estimation of some results concerning the absolute and relative dimensions of the dependence levels in time. The long run stability of these dimensions has been also evaluated. Preliminary results were presented at the Portuguese Statistics Society annual conference.

One Ph.D. and two master theses are currently under development.

- **Identification of health indicators for functionality evaluation in the elderly**

Ageing with non-communicable chronic diseases associated with the inherent functionality decline exerts a strong pressure on the health system, contributing to the inevitable increase in social care and health spending and in the financial sustainability of these systems. The identification of health indicators of the population may provide important information for health policy design and more equitable social policies. The International Classification of Functionality is a large questionnaire endorsed by WHO members, which evaluates functionality in the elderly. The obtained database is composed of mixed variables (ordinal, continuous, binary,...) and its size make it very difficult to analyse it. In this

work, the classification of elderly people living in the Alentejo region is being performed using Factor analysis and multiple correspondence analysis (HOMALS).

The work is a collaboration with Escola Superior de Saúde Pública, UNL. One master thesis is currently under development.

- **Selfie Ageing Index (SAI)**

The work concerning the SAI starting in 2015. In this project we are studying the population aged 55 and over from the perspective of the individual and their functionality. More precisely, we are developing in the form of a statistically based indicator, what we call as “desirable aging”. Data has been retrieved from two surveys (SHARE1 and EPEPP2) and given the data structure, a Probit model is being developed having “auto-reported health” as the latent variable.

This is a joint work with the School of Business and Economics and the Nova Medical School, both schools from Nova University of Lisbon.

- **Diagnosis and clinical decision in ageing sarcopenia: an algorithm proposal to support decision making**

Sarcopenia is a highly prevalent process and has been linked with poor health outcomes that include functional impairments, with a risk of adverse outcomes such as physical disability, poor quality of life and death. The societal burden is enormous. As population ages, it underscores the importance of understanding the true prevalence of sarcopenia, its mechanisms and complex interactions and simultaneously the identification of early diagnosis to anticipate health problems and effective preventive and therapeutic strategies. The general goal of this research project is to characterize Sarcopenia determinants and to translate that knowledge into an Algorithm. This algorithm will allow the early detection, prevention and treatment of this process, decreasing its impact on health status and healthcare systems. This characterization will integrate contributions from different fields to allow a comprehensive view of muscle wasting associated with aging. Both the understanding of this widespread process and the creation of the diagnostic tool will prove to

be particularly relevant on individual and societal basis, considering our aging population.

CMA integrates a group of more than 20 researchers from 6 different schools of Nova University of Lisbon. We have the responsibility of analysing the data and developing algorithms.

Activites

Contributed talks in international conferences

- EURO Mini conference on Improving Healthcare: "Helping a social assistant to plan her homecare service".

Contributed talks at national conferences and workshops

- IO2015, Portalegre, "Homecare Service Planning with a Non-Loyalty Feature".
- 3o Workshop "Envelhecimento", Lisboa: "A bag of (mathematical) tricks for ageing issues".
- XXII Congresso da Sociedade Portuguesa de Estatística "Modelo Long Term Care em tempo discreto".

Seminars

- "NovaHealth. Como?!? O que é que isto tem a haver com a IO e a Estatística?" Operations Research and seminar 25 February 2015, "Ajudando uma assistente social a planear o seu serviço de apoio domiciliário", Operations Research and Statistics and Risk Management joint seminar, CMA, FCT, UNL.

Thematic line

**Mathematical
Modelling in
Ecology, Evolution
and Genetics**

A kick off meeting was held in April 2015, where members from CMA shared some experience on their work on topics covered by the TL, and encouraged other CMA researchers to contribute with their expertise to the TL. The goal of this first meeting was to listen about the group expertise and interests and, from there, encourage collaborations and attract other members of CMA to these research topics. This was the starting point to grow into a competent partner for addressing the mathematical issues in internal and external projects on environment, ecology or genetics. Throughout the year, there were other seminars, organized by the different research lines, on TL topics (see detailed list on Part III).

During 2015,

1. Fabio Chalub (FC), Paula Rodrigues (PR), Paulo Doutor (PD) and Maria do Céu Soares (MCS) continued their work on human behavior on the dynamics of infectious diseases in the scope of Exploratory Project EXPL/MAT-CAL/0794/2013: Game theory and epidemiology, funded by FCT-MCTES (2014/15). This is a successful example of taking advantage of the previous expertise to work on a fairly new subject, which lies mainly on the interaction between game theory and epidemiology. A manuscript has been submitted to Journal of Mathematical Biology (Doutor P, Rodrigues P, Soares MC, Chalub FACC (2015) Optimal Vaccination Strategies and Rational Behaviour in Seasonal Epidemics, J Math Biol), and the work was presented by Fabio Chalub (invited speaker) at the Sixth Workshop Dynamical Systems Applied to Biology and Natural Sciences, Lisbon, Portugal. <http://arxiv.org/abs/1507.02940>
2. FC and PR, in collaboration with Max Souza (consultant), organized a Special Session ('Mathematical models in epidemiology') at the Joint International Meeting of the American, European and Portuguese Mathematical Societies, 10 - 13, June 2015 at the University of Porto (Portugal). All researchers from the project were present and PD participated with a contributed talk.
3. Tiago Costa, a research fellow of the project (2014/15), at the end of his contract applied to a new research fellowship. The opportunity resulted from a CMA seminar given by Renato Rosa from CENSE- Center for Envi-

ronmental and Sustainability Research, FCT-UNL. This goes in the direction of establishing collaborations with other departments and Research Centers at the Faculty, which is a main goal of the TL.

4. Ayana Mateus (AM) in collaboration with Frederico Caeiro and Luís Ramos published a paper using statistics of extremes to model the extreme behaviour of the sea level in Venice and quantify risk through the estimation of important parameters such as return periods of high levels. (Caeiro Frederico, Mateus Ayana, Ramos Luís, Extreme value analysis of the sea levels in Venice, AIP Conf. Proc. 1648, 540006 (2015), DOI: 10.1063/1.4912752)
5. Vanda Lourenço VL carried on working on the topic of robust methods for genetic association studies: in particular, robust simple, multiple and mixed linear regression methods (involves robust parameter estimation, robust variance components estimation, robust coefficient of determination and robust tests of association). From this research followed the proceedings paper: Robust heritability estimation in plant studies. Proceedings of ISI 2015, 60 th World Statistics Congress of the International Statistical Institute, p2640. ISBN 978-90-73592-35-3.
6. VL also continued research work related to gene-by-environment studies from where a publication followed: A Robust AMMI model for the analysis of genotype-by-environment data (2016) *Bioinformatics*, 32(1): 58-66 — online in September 2015. Here a robust PCA/SVD approach was proposed to overcome the problem of analyzing two-way contaminated data and to better understand gene-by-environment interactions.
7. During this year, VL also began working in plant genomic prediction studies: the goal is to help reduce the adverse effects of data contamination on the accuracy of genomic prediction by the use of robust modelling approaches. She presented a seminar at the Department of Biostatistics of the University of Hohenheim in Stuttgart, Germany, on this topic. In addition to these contributions, VL presented several contributed talks in international conferences (CMStatistics2015; IASC2015; ISI2015; ENAR2015) and an e-poster, also in an international meeting

(4th International Conference and Exhibition on Biometrics & Biostatistics).

8. PR published a paper in Theoretical Population Biology on a mathematical model for tuberculosis treatment (Pinho STR, Rodrigues P, Andrade RFS, Serra H, Lopes JS, Gomes MGM (2015) Impact of tuberculosis treatment length and adherence under different transmission intensities, Theor Popul Biol. 2015,104 68-77
<http://www.sciencedirect.com/science/article/pii/S0040580915000659>
9. Isabel Natário (IN) has continued her studies on modelling the dynamics of the black scabbardfish in NE Atlantic through a space state mode. A paper (A State Space Model Approach for Modelling the Population Dynamics of Black Scabbardfish in Portuguese Mainland Waters, Dynamics Games and Science) appeared in CIM Series in Mathematical Science <http://link.springer.com/book/10.1007/978-3-319-16118-1>. Isabel Natário has further worked on the evaluation of the exploration state of the UNDULATA ray in the Portuguese continental waters, under the PROMAR project UNDULATA (PROMAR UNDULATA -Nº 31-03-01-FEP-0186 (2014-2015): “UNDULATA, Estudo para o conhecimento da dinâmica populacional da espécie raia curva Raja undulata, na costa continental Portuguesa”; PI: Ivone Figueredo). An invited talk (Sobre a avaliação do estado de exploração da espécie Raja undulata) was presented at the Thematic session in Environment and Ecology, XXII Congresso da Sociedade Portuguesa de Estatística. Olhão. 7-10 October 2015.
10. Jorge Orestes Cerdeira (JOC) continued working on deriving combinatorial optimization tools to address biodiversity conservation issues.
 - (a) He presented some of that work in two lectures (The mathematics behind spatial conservation problems, (lectures 3 & 4)), in the 5 ECTS Course: Concepts and methods in spatial conservation prioritisation: An integrative overview of Marxan, Zonation, MultyLink and iC4 software, CIBIO/InBIO, Évora, 2015, attended by 12 mostly PhD students and Post-docs pursuing their studies or research in different countries (e.g. Mexico, Germany, Italy).

- (b) A novel flow network model to cope with change climate, maximizing species persistence under limit budget was proposed and started to be tested. A description of the model and preliminarily computational results with fictitious data came out as a short publication (D. Alagador, J.O. Cerdeira, A model to minimize costs and promote species persistence under climate change in *Operations Research and Big Data - IO2015-XVII Congress of Portuguese Association of Operational Research*, 1-8, 2015, Switzerland: Springer International Publishing. DOI: 10.1007/978-3-319-24154-8). iii) A critical review of existing quantitative approaches for spatial conservation planning under climate change, and three new approaches to the identification of climate-change corridors, that vary on the objective function (minimum cost or maximum benefit sought) and on the nature of conservation targets (area-based or persistence probabilities) resulted in a paper submitted to *Methods in Ecology and Evolution*.
- (c) A number of approaches for a generalization of the node-weighted Steiner tree and forest problems, with applications to the design of wildlife corridors for multiple-species, together with computational comparison of these methods were the subject of a publication (R. Brás, J.O. Cerdeira, Computational comparison of algorithms for a generalization of the node-weighted Steiner tree and forest problems, in *Operations Research, CIM Series in Mathematical Sciences* 4, 67–83, 2015, Switzerland: Springer International Publishing. DOI: 10.1007/978-3-319-20328-7_5) v) JOC acted as co-supervisor of Filipe Dias' PhD thesis (The Role of Certification for the Conservation of Biodiversity and Sustainability of Cork Oak Woodlands) in *Forestry Engineering and Natural Resources*, ISA University of Lisbon, successfully completed in 2015. As part of the research of that PhD he co-authored a paper (F.S. Dias, M.N. Bugalho, P.M. Rodríguez-González, A. Albuquerque, J.O. Cerdeira, Effects of forest certification on the ecological condition of Mediterranean streams, *Journal of Applied Ecology*, 52 (2015) 190—198), published in 2015.
- (d) JOC acted as referee for *Landscape Ecology*; *Landscape and Urban*

Planning; Operations Research and Ecography.