



# Center for Mathematics and Its Applications

**CMA/FCT/UNL**

## **2014 Report**

**FCT** Fundação para a Ciência e a Tecnologia

MINISTÉRIO DA EDUCAÇÃO E CIÊNCIA



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# Report structure

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**Part I**

**Activities at CMA**





# **General Information**

## Highlights

- 4 members of CMA are part of the European project: Mathematics in the Making - MiMa -, involving universities from U.K., Germany, Italy and Hungary.
- CMA received "Very Good" in the 2013 FCT Evaluations, with an increase in the 2015 budget of 20 percent, when compared to the 2014 budget.
- 57 papers are indexed at WoS, representing 0.9 papers at WoS per Integrated Member in 2014.
- 3 Ph.D. theses were defended supervised by CMA members.
- One "Investigador FCT" was hired (5 years contract) and 18 new members will join CMA starting from 1/1/2015.
- 7 national and binational projects are led by CMA members, and 7 other projects (national, binational and European) have the participation of CMA members.
- 2 CMA members were elected for the International Statistical Institute.

# 1 Objectives and Achievements

## 1.1 Unit Description

The Center for Mathematics and Its Application (*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, where is also located the Department of Mathematics (DM).

CMA/FCT/UNL has 63 Ph.D. active researchers and 18 internal collaborators.

The center is organized into four research lines/groups: **Algebra (A)**, **Differential Equations and Numerical Analysis (DENA)**, **Operations Research (OR)**, and **Statistics and Risk Management (SRM)**.

Each group has one elected line coordinator, responsible primarily to guarantee that the team budget is used according to the Center's strategic project (approved by FCT). The center is led by one General Coordinator which to 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 2014, a new coordinator was elected and subsequently a new executive commission was appointed and new line/group coordinators were elected.

An External Permanent Advising Scientific Committee including five internationally recognized high-level researchers assesses the scientific activities of the center. The secretariat of the Department of Mathematics supervises accounting. General administrative support is provided by a BGCT (*Bolsa de Gestão em Ciência e Tecnologia*, ou, Science and Technology Management Fellowsh) grant. CMA bylaw 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 Ph.D. active researchers. For more information please visit the CMA/FCT/UNL web site:

## 1.2 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 WoS<sup>1</sup> 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 definition<sup>2</sup> (see Registration Guide<sup>3</sup> 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.

The members that do not satisfy the criterion are invited to present a 3 years work plan, in the scope of the group project. The plan should present a credible strategy to recover scientific productivity (as measured by the Unit 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 PhD students supervised

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<sup>1</sup>Web of Science

<sup>2</sup>International publication with referees, books, book chapters, patents.

<sup>3</sup>The 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](http://www.fct.pt/apoios/unidades/avaliacoes/2013/docs/GuiaoRegisto_AvaliacaoUnidades2013.pdf).

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

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

### **1.3 General Objectives**

The objective of CMA/FCT/UNL is to promote international level scientific research in the areas of pure and applied mathematics and its ulterior national and international projection. Together with strong support provided to traditional areas in the unit such as Actuarial Science, Financial Mathematics and Statistics (team Statistics and Risk Management) and Combinatorial and Nonlinear Optimization (team Operations Research), more abstract research is developed within the team Algebra, like Combinatorial Number Theory, Linear Algebra and Matrix Theory, Non-commutative Algebraic Geometry, Ockham Algebras, Semigroups, Combinatorics and Graph Theory, Discrete Geometry and Algebraic and Differential Geometrical Methods for Topological Quantum Field Theories. We also have expanded the scope of our applications concerning Differential Equations and Numerical Analysis: research has been oriented to Biomathematics, Material Science and Fluid Mechanics.

An effective interaction with high level international research centers and universities, including Massachusetts Institute of Technology, Carnegie Mellon University, University of Texas at Austin, École Polytechnique Fédérale de Lausanne (EPFL) has been successfully promoted through direct collaboration and/or the approval of several international research projects. Also the internal interaction among the research teams is steadily increasing, always preserving their own scientific strategy. To reinforce this direction and to extend it to other disciplines inside and outside the FCT/UNL, weekly seminars are organized by the different research teams. CMA/FCT/UNL collaborates with the Ph.D. and Post Doc Programs in Applied Mathematics, in the scope of CoLab University of Texas at Austin-Portugal and ICTI Carnegie Mellon University-Portugal. Despite the enormous teaching load, our researchers generally honor their commitments and develop an interesting scientific work.

## 2 Indicators

### 2.1 Scientific productivity

CMA has experienced a steady increase in the ratio of publications (total number of publications in peer reviewed journals per integrated member). Year 2013 seems to be atypical, and in 2014 the average number of publication returned to its normal value (1 per IM). In table 1, we show the evolution of publications indexed at Web of Science (WoS). Note that only WoS publications are counted in the definition of Integrated Members (IM).

	<b>2009</b>	<b>10</b>	<b>11</b>	<b>12</b>	<b>13</b>	<b>14</b>
<b>Publications in international peer reviewed journals</b>	46	41	39	57	38	76
<b>Publications in international peer reviewed journals per IM</b>	0.96	0.84	0.80	1.03	0.62	1.25
<b>WoS publications</b>					36	63
<b>WoS per IM</b>					0.59	1

All groups experienced an increase in the number of publications indexed at Web of Science and peer reviewed publications when compared to 2013. For 2014, the number of publications per group is indicated below:

<b>Group</b>	<b>WoS</b>	<b>WoS per capita</b>	<b>Peer reviewed</b>	<b>Per capita</b>
<b>A</b>	18	1.8	21	2.1
<b>DENA</b>	11	1.0	14	1.3
<b>OR</b>	9	1.12	12	1.5
<b>SRM</b>	25	0.78	29	0.9

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

### 2.2 Funding

For the first time, 4 investigators associated to CMA jointly integrate one European project: MiMa — Mathematics in the Making —, with a total funding

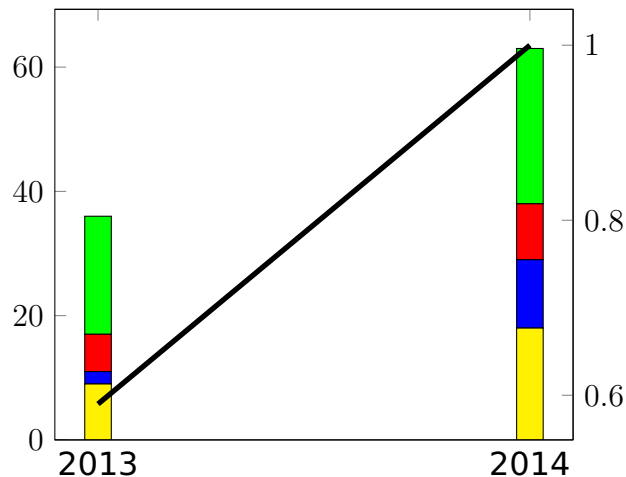


Figure 1: WoS Publications - Evolution 2013-2014: ■ — Algebra; ■ — Differential Equations and Numerical Analysis; ■ — Operations Research; ■ — Statistics and Risk Management. The solid line indicates the evolution in the WoS publications per capita. Left: total number of WoS publications; right: WoS publications per capita. Prior data is not available for WoS publications.

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. From the website<sup>4</sup>: “The aim of the project ‘MiMa - Mathematics in the Making’ is to counteract early resignation from Mathematics. It intends to help elementary school students in developing a stronger interest and competence in Mathematics, also enhancing their social and civic skills, and so contributing to increase students’ chances to success both in school and in life.”

7 projects led by CMA members are responsible for a budget of more than €300 000, and members of CMA participate in other 7 projects. It is important to note that in the 2013 FCT call for projects, CMA received the largest share of the budget among all Portuguese centers of mathematics. In the 2014 FCT call, 11 projects were submitted with CMA as the host institution (evaluation is still pending). See table 1 for the 2009-14 evolution and see part II for details on the projects.

<sup>4</sup>See <http://www.mathematicsinthemaking.eu>.

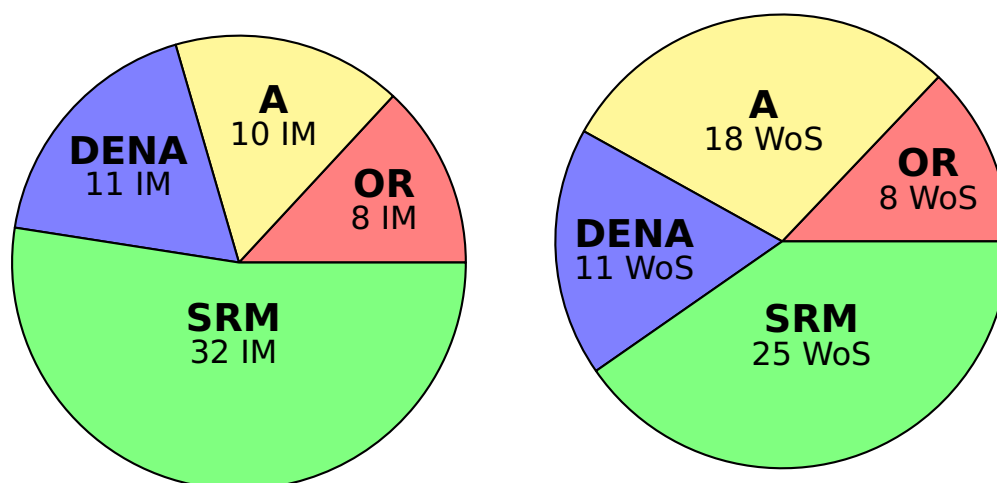


Figure 2: Left: Number of Integrated Member per group. Right: Number of publications indexed at Web of Science per group. Year: 2014.

## 2.3 Researchers

In the table below, we present the evolution, from 2007 to 2014 of the number of Integrated Members. Note that the productivity criterion was implemented starting from 2010. In the second line, we present the number of full-time researcher in the CMA team with salary directly paid by the Ministry of Science, Technology and Higher Education (up to 2011) of Ministry of Education and Science (from 2011) — programs “Ciência” and “Investigador FCT”. Post-docs paid by projects are not included in this table.

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

## 2.4 Other relevant information

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



	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>
<b>LA FCT</b>	0	0	0	0	0	0
<b>Units FCT</b>	187688	131381	126348	126348	162438	162504
<b>Projects FCT</b>	34125	34125	39743	39743	65858	46625
<b>Other (National)</b>	0	0	2850	0	0	0
<b>Other (International)</b>	5000	12000	9500	19965	19965	54537
<b>National Industry</b>	0	25000	25000	0	0	0
<b>International Industry</b>	0	0	0	0	0	0
<b>Total</b>	<b>226813</b>	<b>202506</b>	<b>203441</b>	<b>186056</b>	<b>248327</b>	<b>263666</b>

Table 1: Funding evolution 2009-14. Values in euros.

## 3 Activities

### 3.1 Organization of events

CMA/FCT/UNL is member of the Associação Portuguesa de Investigação Operacional (APDIO) and of the Comissão Nacional de Matemática (CNM). Collaborates with the Centro Internacional de Matemática (CIM) and with the Sociedade Portuguesa de Matemática (SPM).

Members of all research groups participated in the projects below. Some of them received CMA's financial support. Those projects involve scientific vulgarization or special training in mathematics, addressed to young students from schools:

1. The organization of the 2014 National meeting of the Portuguese Mathematical Society (<http://enspm14.spm.pt/pt/>);
2. The organization of the first SIAM student chapter in Portugal ([http://ferrari.dm.fct.unl.pt/siam\\_chapter\\_unl/](http://ferrari.dm.fct.unl.pt/siam_chapter_unl/));
3. ClubeMath (<http://eventos.fct.unl.pt/clubemath/>);

4. DivMAT (<https://sites.google.com/site/divmatfct/home/o-grupo-divmat>);
5. ESCOLA ALEPH (<http://aleph.ptmat.fc.ul.pt>);
6. ExpoFCT (<http://eventos.fct.unl.pt/expofct>);
7. Summer School MatNova 2014 (<http://eventos.fct.unl.pt/matnova2014>);
8. Scientific diffusion in high schools;
9. Several lectures for students or general public.

### 3.2 Seminars

During the year 2014, 60 seminars and 2 colloquia were organized by CMA. We do not count seminar for the students, or seminars as part of larger events (e.g., conferences, Jornadas da Matemática, MatNova etc). Colloquia are supposed to be for a broader audience of mathematicians, while seminars are oriented toward research lines.

42 seminars were given by specialists outside CMA, including 18 from visitors from abroad. Here we present the (very short) list of Colloquia. In the second part of this report, we present a full list of seminars.

**7 May:** *Modelos de crescimento e de pescas em ambiente aleatório usando equações diferenciais estocásticas*, Carlos A. Braumann, CIMA - U. Évora, Portugal

**28 May:** *Processamento da aquisição simultânea de EEG e IRM funcional em Epilepsia*, Mario Secca, Physics - U. Nova Lisboa, Portugal

## 4 Perspectives

Research centers in Portugal are funded by the so called “Strategic Projects”. During the first semester of 2013, CMA started to draft the proposal for the years 2015 to 2020, that was finally submitted in the end of 2013. This project was evaluated in detail by a panel from the European Science Foundation (ESF), specially hired by the Portuguese Science Foundation (FCT). More details can be found in the FCT and ESF webpages.

We received the final evaluation in the end of 2014, as follows:

A. Productivity and contribution to the National Scientific and Technological System (NSTS)	Very Good
B. Scientific and technological merit of the research team	Very Good
C. Scientific merit and innovative nature of the strategic program	Very Good
D. Feasibility of the work plan and reasonability of the requested budget	Very Good/Excellent
E. Impact of the scientific, technological and cultural output	Excellent
<b>Final classification:</b>	<b>Very Good</b>

As a result of this evaluation, our budget (directly funded by FCT) for 2015 will increase from €162.504,00 in 2014 to €185.787,00, representing an increase in 14% in the total budget and in 11% in the budget per integrated member.

As a preparation for the evaluation processes, the Center was fully restructured, including the change of denomination of two lines/groups:

1. Algebra changed to Algebra and Logic,
2. Differential Equations and Numerical Analysis changed to Analysis,

since these new designations were considered more representative of the new research groups. Furthermore, 18 new integrated members joined CMA, starting from 1 January 2015. See figure 3 for the numbers and see Part II for details in the research of the new members.

As consequence of the new Strategic Plan, some changes will be implemented during the year 2015:

1. We expect to fully support two post-docs within the Center budget.
2. We will create two temporary positions for invited researchers (one month each), with the possibility of more positions, according to the needs and budgeted availability.

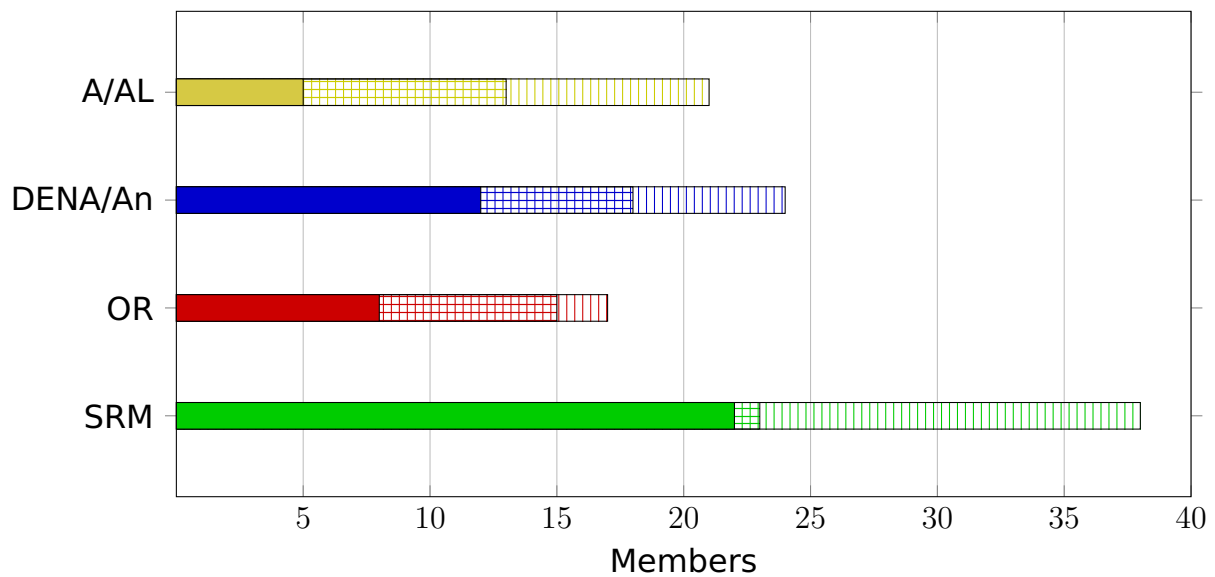


Figure 3: Constitution of the groups in 2015: ■ — Old members that continues as Integrated Members (IM); ▩ — New IM; ▨ — Collaborators (Col).

3. A maximum budget to be used in *missions* (air ticket, hotel, conference registration, per diem etc) will be imposed to each group. The maximum in each group is given by  $\text{€}1000 \times \#IM + \text{€}500 \times \#Col$ . This follows a recommendation from the ESF/FCT panel.
4. All request for equipment (desktops and laptops) with values clearly above the average will be reviewed by the Executive Commission.
5. The Center will integrate two new *thematic lines*: *Mathematical modeling for the independent living of elderly, disable, and chronic patients* and *Mathematical Modeling in Ecology, Evolution and Genetics*. A small budget will be given to each thematic lines to start their activities. Thematic lines must involve more than one research groups and are forbidden to fund individual research (missions and personal equipment).

## **Part II**

# **Activities in the research lines**



# Research line

# Algebra

*The Algebra team develops research in Algebraic and Differential Geometry applied to Topological Quantum Field Theory, Combinatorics and Graph Theory, Linear Algebra and Matrix Theory, Non-commutative Algebraic Geometry, Semigroup Theory, and Logic. In 2015 the Algebra team will integrate 8 new members. The areas that will receive more members are Semigroup theory and Logic.*

### Highlights

- A new Investigador FCT grantee - Alan Cain - joined the group; his project is fully funded by FCT: 100% salary plus €10 000.00 per year for research.
- New 8 Integrated Members will join the group in 2015.
- 18 articles were published in 2014;



## **1.1 Team**

### **1.1.1 Integrated Members**

1. Alan James Cain
2. Carlos Manuel Saiago
3. Gonçalo Jorge Trigo Nery Tabuada
4. Henry Liu
5. Herberto de Jesus da Silva
6. Jaime da Gama Gaspar
7. João Nuno Gonçalves Faria Martins
8. Manuel Almeida Silva
9. Maria Helena Coutinho Gomes de Almeida Santos
10. Teresa Maria Jerónimo Sousa

### **1.1.2 Collaborators**

1. Maria Cecília Perdigão Dias da Silva

## **1.2 Projects**

### **1.2.1 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.

### 1.2.2 Projects with the participation of team members

1. **EXCL/MAT- GEO/0222/2012**, *Geometry and Mathematical-Physics*, led by Miguel Tribolet Abreu (CGASMD/IST-U. Lisboa), with participation of **João Nuno Gonçalves Faria Martins** (2013-2016). Total funding €326 000.00

## 1.3 Achievements

**Alan Cain:** Proved that plactic monoids of types  $A_n$ ,  $B_n$ ,  $C_n$ ,  $D_n$ , and  $G_2$  admit presentations via finite complete rewriting systems and are biautomatic, using the theory of crystal bases for the core of the proofs (with R.D. Gray and A. Malheiro). Showed that within the class of homogeneous monoids, the properties of automaticity, biautomaticity, admitting a finite complete rewriting systems, and having finite derivation type, are all mutually independent, and developed techniques to transfer the independence proofs to the more restricted class of  $n$ -ary multihomogeneous monoids (with R.D. Gray and A. Malheiro). Studied the asymptotic growth of endomorphisms of finitely generated semigroups and characterized the possible values for growth in the classes of finitely generated semigroups and finitely generated homogeneous semigroups (with V. Maltcev).

**Carlos Saiago:** In 2014 finished the paper “Questions, Conjectures, and Data about Multiplicity Lists for Trees” (submitted for publication) discussing several questions and conjectures about multiplicity lists occurring among Hermitian matrices whose graph is a tree. Given an Hermitian matrix  $A$  whose graph is a tree  $T$ , it was also started the study of the number of eigenvalues of  $A$  whose multiplicity decreases when a particular vertex is deleted from  $T$ .

**Gonçalo Tabuada:** During 2014 performed several computations concerning Kontsevich’s noncommutative motives (e.g. Azumaya algebras, separable field extensions, purely inseparable field extensions, etc), developed a theory of noncommutative Artin motives, and extended the classical theory of (intermediate) Jacobians to the noncommutative setting.

**Henry Liu:** Five research papers were accepted or published in international journals.

**Herberto Silva:** Continuing the work of scientific research on Ockham al-

gebras in the context of Universal Algebra and Lattice Theory, various problems about congruences of Ockham algebras were studied.

**Jaime Gaspar:** Three articles published.

**João Faria Martins:** Construction of an ansatz for the 2-dimensional holonomy of a 2-connection with values on a Lie-2-algebra. This is a primary step towards defining topological invariants from infinitesimal 2-braidings.

**Manuel Silva:** Two articles published.

**Maria Helena Santos:** Generalise the notion of inverse transversal and associate subgroup.

**Teresa Sousa:** Solved the problem of decomposing  $k$ -edge-colored graphs into monochromatic cliques has been for all choices of  $k$  and possible  $k$ -tuples of cliques.

**Cecília Perdigão:** Investigated matrices associated with graphs and their properties.

## 1.4 Publications

### 1.4.1 Publications in Web of Science journals

- [1] **Alan J. Cain** and Nik Ruskuc. Subalgebras of  $fa$ -presentable algebras. *Algebr. Univ.*, 72(2):101–123, 2014.
- [2] Ivo Dell’Ambrogio and **Goncalo Tabuada**. A quillen model for classical morita theory and a tensor categorification of the brauer group. *J. Pure Appl. Algebr.*, 218(12):2337–2355, 2014.
- [3] **Goncalo Tabuada**. Additive invariants of toric and twisted projective homogeneous varieties via noncommutative motives. *J. Algebra*, 417:15–38, 2014.
- [4] **Goncalo Tabuada**. Voevodsky’s mixed motives versus kontsevich’s noncommutative mixed motives. *Adv. Math.*, 264:506–545, 2014.
- [5] **Henry Liu**, Angela Mestre, and **Teresa Sousa**. Total rainbow  $k$ -connection in graphs. *Discret Appl. Math.*, 174:92–101, 2014.
- [6] Andrew J. Blumberg, David Gepner, and **Goncalo Tabuada**. Uniqueness of the multiplicative cyclotomic trace. *Adv. Math.*, 260:191–232, 2014.

- [7] Rui Pedro Carpentier, **Henry Liu**, **Manuel Silva**, and **Teresa Sousa**. Rainbow connection for some families of hypergraphs. *Discret. Math.*, 327:40–50, 2014.
- [8] Matilde Marcolli and **Goncalo Tabuada**. Jacobians of noncommutative motives. *Mosc. Math. J.*, 14(3):577–594, 2014.
- [9] **Goncalo Tabuada**. Galois descent of additive invariants. *Bull. London Math. Soc.*, 46(2):385–395, 2014.
- [10] **Goncalo Tabuada**. Witt vectors and k-theory of automorphisms via noncommutative motives. *Manuscr. Math.*, 143(3-4):473–482, 2014.
- [11] Matilde Marcolli and **Goncalo Tabuada**. Noncommutative motives, numerical equivalence, and semi-simplicity. *Am. J. Math.*, 136(1):59–75, 2014.
- [12] Ivo Dell’Ambrogio and **Goncalo Tabuada**. Morita homotopy theory of  $c^*$ -categories. *J. Algebra*, 398:162–199, 2014.
- [13] **Goncalo Tabuada**. E-n-regularity implies e (n-1)-regularity. *Doc. Math.*, 19:121–139, 2014.
- [14] Matilde Marcolli and **Goncalo Tabuada**. Noncommutative artin motives. *Sel. Math.-New Ser.*, 20(1):315–358, 2014.
- [15] **Alan J. Cain** and Victor Maltcev. Markov semigroups, monoids and groups. *Int. J. Algebr. Comput.*, 24(5):609–653, 2014.
- [16] **Henry Liu** and **Teresa Sousa**. Monochromatic k-r-decompositions of graphs. *J. Graph Theor.*, 76(2):89–100, 2014.
- [17] **Alan J. Cain** and Victor Maltcev. Finitely presented monoids with linear dehn function need not have regular cross-sections. *Semigroup Forum*, 88(2):300–315, 2014.
- [18] Andre Bernardino, Rui Pacheco, and **Manuel Silva**. The gap structure of a family of integer subsets. *Electron. J. Comb.*, 21(1), 2014.

### 1.4.2 Other publications in peer-reviewed journals

- [1] **A.J. Cain** and V. Maltcev. Hopfian and co-hopfian subsemigroups and extensions. *Demonstratio Mathematica*, 47(4):791-804, 2014.
- [2] **J. Gaspar**. Non-recursive polynomial formula for the sum of the powers of the integers. *The American Mathematical Monthly*, 121(2):144 2014.
- [3] **J. Gaspar**. Direct proof of the uncountability of the transcendental numbers. *The American Mathematical Monthly*, 121(1):80 2014.

### 1.4.3 Other (international) publications

- [1] **J. Gaspar**. Copies of classical logic in intuitionistic logic, 14th Congress of Logic. *Methodology and Philosophy of Science 2011 Proceedings, Philosophia Scientiae*, volume 18, number 3, pages 5-11, November 2014
- [2] **J. Gaspar**. Does not suffice to run latex a finite number of times to get cross-references right. *letter, TUGboat*, volume 35, number 1, page 16, April 2014.

### 1.4.4 Accepted papers

1. **A.J. Cain**, R.D. Gray, and A. Malheiro. 'Finite Gröbner-Shirshov bases for Plactic algebras and biautomatic structures for Plactic monoids' *Journal of Algebra*, 423 (February 2015), pp. 37-53. DOI: 10.1016/j.jalgebra.2014.09.037.
2. **A.J. Cain**, and V. Maltcev. 'A simple non-bisimple congruence-free finitely presented monoid'. *Semigroup Forum*, To appear. DOI: 10.1007/s00233-014-9607-y.
3. **A.J. Cain**, R.D. Gray, and A. Malheiro. 'Rewriting systems and biautomatic structures for Chinese, hypoplactic, and sylvester monoids' *International Journal of Algebra and Computation*, To appear. arXiv: 1310.6572.
4. **A.J. Cain**, and T.Brough. 'Automaton semigroup constructions' *Semigroup Forum*, To appear. arXiv: 1310.4852.

5. **H. Liu**, O. Pikhurko, and **T. Sousa**. "Monochromatic Clique Decompositions of Graphs." *Journal of Graph Theory* (In Press).
6. **H. Liu**, S. Fujita, and C. Magnant. "Rainbow  $k$ -connection in dense graphs". *J. Combin. Math. Combin. Comput.* (to appear).
7. **J. Gaspar**, F. Ferreira. ' Nonstandardness and the bounded functional interpretation' to appear in *Annals of Pure and Applied Logic*.

#### 1.4.5 Submitted papers

1. **A. J. Cain**, R.D. Gray, A. Malheiro. 'Crystal bases, finite complete rewriting systems, and biautomatic structures for Plactic monoids of types  $A_n$ ,  $B_n$ ,  $C_n$ ,  $D_n$ , and  $G_2$ . Submitted. arXiv: 1412.7040.
2. **A. J. Cain**, R.D. Gray, A. Malheiro. 'On finite complete rewriting systems, finite derivation type, and automaticity for homogeneous monoids' Submitted. arXiv: 1407.7428.
3. İ. İlker Akça, Kadir Emir, **J. Martins**. "Pointed Homotopy of Maps Between 2-Crossed Modules of Commutative Algebras"
4. Lucio S. Cirio, **J. Martins** "Categorifying the  $sl(2, C)$  Knizhnik-Zamolodchikov Connection via an Infinitesimal 2-Yang-Baxter Operator in the String Lie-2-Algebra"
5. **J. Martins**, Roger Picken, "Link invariants from finite categorical groups".
6. Lucio S. Cirio, **J. Martins**, "Infinitesimal 2-braidings and differential crossed modules".

#### 1.4.6 Editing and authorship of books and journals (national)

1. **João Faria Martins** (Editor): *Actas do Encontro Nacional da Sociedade Portuguesa de Matemática. Geometria e Topologia*.
2. Isabel Cabral, **Cecília Perdigão**, **Carlos Saiago**, "Álgebra Linear", 4ª Edição (2014), Escolar Editora.

## 1.5 Seminars

**10 January:** *The Landscape of Mathematical Logic from a Proof-Theoretic Perspective*, Reinhard Kahle, CENTRIA/FCT/UNL, Portugal

**17 January:** *Conjugação em semigrupos sob a perspectiva dos sistemas de reescrita*, António Malheiro, CAUL/FCT/UNL, Portugal

**24 January:** *Invariantes Quânticos de Enlaces e de Variedades*, João Faria Martins, CMA/FCT/UNL, Portugal

**5 February:** *Hollow Symmetric Nonnegative Matrices*, Charles Johnson, Charles Johnson - College of William and Mary, USA

**12 February:** *Teoria das Categorias: Adjunções, Mónadas e Álgebra*, Ricardo Guilherme, Master Student - DM/FCT/UNL, Portugal

**14 February:** *Classificação de aplicações entre espaços projectivos e classificantes*, Gustavo Granja, CAMGSD/IST - U. Lisboa, Portugal

**21 February:** *Proof interpretations: what they are and what they are good for*, Jaime Gaspar, CMA/FCT/UNL and Universitat Rovira i Virgili, Portugal/Spain

**28 February:** *Resolução de Variedades Legendrianas*, João Cabral, CMAF/FC - U. Lisboa, Portugal

**12 March:** *What can higher categories do for physics?*, John Huerta, CAMGSD/IST-UL, Portugal

**26 March:** *O que é um Matróide?*, Rosário Fernandes, DM/FCT-UNL, Portugal

**9 April:** *Grupos gerados por recorrências lineares de 2ª ordem*, Eurico Nogueira, CELC/DM/FCT-UNL, Portugal

**16 April:** *From Simplicial Homotopy to 2-Crossed Module Homotopy*, Kadir Emir, Dept. of Mathematics - Computer Sciences - Eskişehir Osmangazi University, Turkey

**7 May:** *Derivatives of Functions of Matrices*, Pedro Freitas, CELC/FC-U. Lisbon, Portugal

**21 May:** *Apresentações para semigrupos de transformações sobre uma cadeia finita*, Manuel Messias, CAUL/FC-U. Lisbon, Portugal

**28 May:** *GIT and stability*, Alfonso Zamora, CAMGSD/IST-U. Lisbon, Portugal

**4 June:** *Rainbow Connection in Graphs*, Henry Liu, CMA/FCT/UNL, Portugal

**18 June:** *Algebra and logic – some connections leading up to gaggle theory*, Wilfried Keller, Universität Göttingen, Germany

**8 October:** *Automatic presentations for algebraic and relational structures*, Alan Cain, CMA/FCT/UNL, Portugal

**29 October:** *Stochastic Matrices and Evolutionary Processes*, Fabio Chalub, CMA/FCT/UNL, Portugal

**5 November:** *On ideals and congruences of distributive demi-p-algebras*, Thomas Scott Blyth, University of St. Andrews, UK

**12 November:** *Forcing - o legado de Cohen*, António Fernandes, IST-U. Lisbon, Portugal

**19 November:** *New results on Hilbert's 24th problem*, Jesse Alama, Technical University of Vienna, Austria

**3 December:** *Spaces as enriched categories*, Dirk Hofmann, CIDMA - U. Aveiro, Portugal

**12 December:** *A natural characterization of semilattices of rectangular bands and groups of exponent 2*, João Araújo, High school student – winner of "26th European Union Contest for Young Scientists", Portugal



## 1.6 Internationalization

**Maria Helena Santos** and **Herberto Silva** did collaborative research with Professor T. S. Blyth of St Andrews University.

**Alan Cain** did collaborative research and/or publications with: Tara Brough (University of St Andrews, U.K.), Robert D. Gray (University of East Anglia, U.K.), Victor Maltcev (Technion – Israel Institute of Technology, Israel), Markus Pfeiffer (University of St Andrews, U.K.), Nik Ruškuc (University of St Andrews, U.K.) and Richard M. Thomas (University of Leicester, U.K.).

**Manuel Silva** had a Visiting Professor position between September and December 2014 at Department of Mathematics and Informatics of the University of Palermo.

**João Martins:** Visited MPI-Bonn, May 6th-10th 2014, and presented the talk *Categorifications of the 4-term relations via infinitesimal 2-braidings*.

## 1.7 Conferences participation

### 1.7.1 Invited talks at international conferences

1. **A. J. Cain:** *Computing with automatic and word-hyperbolic semigroups*, Invited conference talk: Workshop on Computational Algebra, Centro de Álgebra da Universidade de Lisboa, 22nd July 2014.

### 1.7.2 Contributed talk (international)

1. **G. Tabuada:** Algebraic geometry seminar, California Institute of Technology, January 2014.
2. **G. Tabuada:** Colloquium, California Institute of Technology, January 2014.
3. **G. Tabuada:** Conference Reimagining the Foundations of Algebraic Topology, MSRI, Berkeley, April 2014.
4. **G. Tabuada:** Conference K-theory and related topics, Beijing, China, August 2014

5. **G. Tabuada**: Algebra and number theory seminar, University of Maryland, October 2014
6. **G. Tabuada**: Colloquium, University of Maryland, October 2014
7. **G. Tabuada** Workshop Cohomological Realizations of Motives, Banff Institute, Canada, December 2014.
8. **J. Gaspar**: "Short introduction by example to Coq", The Notion of Proof, Coimbra, Portugal.

### 1.7.3 Contributed talk (national)

1. **J. Gaspar**: "Topological models of intuitionistic logic", Encontro Nacional SPM 2014.
2. **J. Gaspar**: "Mathematical candies", Encontro Nacional da SPM 2014.
3. **J. Gaspar**: "Proofs of  $1 + 2 + \dots + n = n(n + 1)/2$ ", Encontro Nacional da SPM.
4. **J. Gaspar**: "Shoenfield functional interpretation", Mathematical Logic Seminar, Lisbon, Portugal.
5. **J. Gaspar**: "Proof interpretations: what they are and what they are good for", Algebra and Logic Seminar, Caparica, Portugal.
6. **J. Gaspar**: "Completeness of Peano arithmetic with the  $\omega$ -rule", Days in Logic 2014, Braga, Portugal.
7. **J. Gaspar**: "Refuting Cantor", Seminar of Algebra, Logic and Computation, Braga, Portugal.

## 1.8 Other Important Information

### 1.8.1 Peer-reviewing activities

**Alan Cain**: Referee for Asian-European Journal of Mathematics, International Journal of Algebra and Computation, International Journal of Foundations of Computer Science, Journal of Algebra, (Proceedings of) Language and

Automata Theory and Applications 2015, Rendiconti del Seminario Matematico di Padova, Semigroup Forum, Theory of Computing Systems.

**Jaime Gaspar:** Review for Zentralblatt.

**Herberto Silva:** Referee for the journal Communications in Algebra. Review for MathSciNet

**Teresa Sousa:** Review for MathSciNet

**João Martins:** Referee for Homology, Homotopy and its applications.

### 1.8.2 Outreach activities

**João Martins:** Organizing comission “Encontro Nacional da SPM”; Seminar Matnova 2014 (Summer high school): “O Principio da Relatividade”.

**Manuel Silva:** Organization of Escola Aleph: solving mathematics problems for high school students.

### 1.8.3 Supervision of Ph.D. (2014)

The Erasmus student Kadir Emir from Eskisehir, Turkey was supervised by **J. Faria Martins** during his Erasmus Interchange Year at Universidade Nova de Lisboa.

## 1.9 2015 research of IM

**Alan Cain:** Develop a theory of abstract crystal monoids, extending the class of monoids that arise from the use of Kashiwara’s crystal bases in representation theory. Continue the study of monoids with important connections to combinatorics and ring theory, such as the various types of Plactic monoids, sylvester monoids, hypoplactic monoids. In particular, study conjugacy in such monoids, and the deep question of whether they satisfy semigroup identities. Study semigroups and groups generated by mappings that admit automatic presentations, with particular focus on classification theorems and decision problems.

**Carlos Saiago:** Given an Hermitian matrix  $A$  whose graph is a tree  $T$ , investigate the number of eigenvalues of  $A$  whose multiplicity decreases when

a particular vertex is deleted from  $T$ . A vertex in a tree is Parter, neutral or downer. The main goal will be to study the properties of downer vertices.

**Gonçalo Tabuada:** In 2015 will continue the study of Kontsevich's recent theory of noncommutative motives. The main goal is to construct a fully-faithful functor relating the triangulated category of noncommutative motives with the classical triangulated category of Voevodsky motives. Making use of this functor, it is expected to establish new cases of the Kimura-Sullivan conjecture.

**Herberto Silva:** Investigate some particular connections between Ockham congruences and ideals. Study the strong endomorphism kernel property in Ockham algebras. Consider the lattice of subalgebras of an Ockham algebra.

**Jaime Gaspar:** Plan to work on provable security applied to the transformation of cryptographic objects.

**João Faria Martins:** Understand crossed modules of Hopf algebras. Understand Simplicial Hopf algebras. Understand geometrically the Lie-2-algebras of chord diagrams, categorifying the Kontsevich algebra of chord diagrams.

**Manuel Silva:** Develop the study of connections between classical Ramsey Theory and Combinatorics on infinite words.

**Maria Helena Santos:** Prosecute ongoing research in regular and ordered semigroups.

**Teresa Sousa:** Prosecute ongoing research in decompositions of graphs.

**Cecília Perdigão:** Will continue the investigation on matrices associated with graphs and their properties and pretend to study these properties in an enlarged set of graphs.

## 1.10 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 VH Fernandes, and his former PhD students MM Jesus and TM Quinteiro, was devoted to the study of transformation semigroups in the special case of monotone transformations; he also obtained results on aspects of special classes of semigroups, such as block-groups and quotient numerical semigroups.

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

(3) The team consists of 2 Integrated Members, I Oitavem, working in computational complexity and R 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) AC Casimiro proved the equivalence between the (poly)stability notion for points of a character variety with respect to the action of an algebraic group  $G$ , and the (complete reducibility) irreducibility notion of subgroups of  $G$ . She also obtained a discrete geometric formulation of variational calculus in several independent variables. The research carried out by the remaining Integrated Members focus in the areas of: Linear Algebra, where CM Saiago works in eigenvalue problems for Hermitian matrices with a given graph; Semigroup Theory, where MH 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 de-

veloped research in graph decomposition and its colored or Ramsey version. The following researchers are currently affiliated to CMA as Collaborators: C Perdigão, MF Rodrigues (Linear/Multilinear Algebra); M Silva, H Liu (Combinatorics, Number and Graph Theory); JV 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 standard/nonstandard, their link with the restricted period and with cyclic linear codes.

8) In Semigroup Theory and Universal Algebra, the group plans to: a) Study transformation semigroups under several different aspects: combinatorial properties, congruences, presentations, maximal subsemigroups, automorphisms, endomorphisms, semidirect products, and other constructions, pseudovarieties generated by, etc. We note that transformation semigroups are strongly connected with automata, this being one of the deep links between Theoret Comp Sci and Abstract Algebra. b) Study special classes of semigroups, for instance block-groups or ordered semigroups. In particular, investigate elements of a semigroup that are structurally important (e.g. idempotents or the biggest idempotent with respect to a particular property). c) Study known algebras with an additional unary operation, such as semigroups, distributive lattices and Ockham algebras.

9) 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**

# **Differential Equations and Numerical Analysis**

*The objective of group of Differential Equations and Numerical Analysis 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. One of the main aims of the group is to increase its scientific productivity. The 6 new researchers, who will join CMA in 2015, will help the group in this task.*

### Highlights

- Three PhD theses defended in the group or advised by members of the group.
- 11 papers in peer reviewed journals: 8 indexed at Web of Science.
- 6 new members will join the group in 2015.

## **2.1 Team**

### **2.1.1 Integrated Members**

1. Ana Margarida Fernandes Ribeiro
2. Bento José Carrilho Miguens Louro
3. Fabio Augusto da Costa Carvalho Chalub
4. José Maria Nunes de Almeida Gonçalves Gomes
5. Maria do Céu Cerqueira Soares
6. Maria de Serpa Salema Reis de Orey
7. Maria Luísa Martins Macedo de Faria Mascarenhas
8. Oleksiy Karlovych
9. Paula Cristiana Costa Garcia Silva Patrício Rodrigues
10. Rita Alexandra Gonçalves Ferreira
11. Rogério Ferreira Martins

### **2.1.2 Collaborators**

1. Paulo José Fernandes Louro Ribeiro Doutor
2. Ana Maria de Sousa Alves de Sá
3. João de Deus Mota da Silva Marques
4. Maria Fernanda Alves da Veiga de Oliveira

## 2.2 Projects

### 2.2.1 Projects led by team members

1. **UTA\_CMU/MAT/0005/2009**: *Thin structures, homogenization and multi phase problems*, led by **M. Luísa Mascarenhas** (2011-2014). Total funding: €168.200,00, CMA funding: €78 104.00
2. **PTDC/MAT/109973/2009**: *Optimization methods in Continuum Mechanics*, led by **M. Luísa Mascarenhas** (2011-2014). Total funding: €70 000.00 (CMA only).
3. **EXPL/MAT-CAL/0794/2013**: *Game theory and epidemiology*, led by **Paula Rodrigues** (2014-2015). Total funding: €25 000.00 (CMA only).
4. **EXPL/MAT-CAL/0840/2013**: *Variational problems in variable exponent Sobolev spaces*, led by **Ana Margarida Ribeiro** (2014-2015). Total funding: €24 250.00 (CMA only).

### 2.2.2 Projects with the participation of team members

1. **PTDC/MAT/113383/2009**: *Nonlinear dynamics of ordinary differential equations and applications*, led by Alessandro Margheri (Faculdade de Ciências da Universidade de Lisboa), with the participation of **Rogério Ferreira Martins** and **Gonçalo Nuno Rosado Morais** (2011-2014). Total funding: €60 600.00, CMA funding: €6 004.00.
2. **539872-LLP-1-2013-1-IT-COMENIUS-CMP**: *Mathematics in the Making-Mima*, led by Emmanuela Ughi, Università degli Studi di Perugia (Italy), with participation of **Maria do Céu Soares** (2013-2015). Total funding: €369 851.00, UNL funding: €54 537.00.

## 2.3 Achievements

**F. Chalub** and Max Souza finished the paper described in the previous report ("Fixation in Large Populations: A continuous view of a discrete problem") where they study in detail the fixation probability for certain classes of

evolutionary processes (generalized Moran processes) when the population is large. It has been submitted in the first days of 2015, following referee's advice. Also with respect of the previous report, the joint work with O. Danilkina (Dodoma University, Tanzania) was submitted.

**F. Chalub, P. Doutor, P. Rodrigues, and M. C. Soares** studied periodic SIR models with vaccination, as part of the project EXPL/MAT-CAL/0794/2013 (Game Theory and Epidemiology), led by P. Rodrigues. They considered a SIR model with temporary immunity and periodic transmission rate  $\beta(t)$ . They introduced a vaccination that confers the same immunity as natural infection. They looked for two types of vaccination strategies: optimal vaccination, in the sense that it minimizes the effort of vaccination in the set of preventive vaccination functions defined as vaccination functions for which, for any sufficiently small initial condition, the number of infectious individuals monotonically decreases; and voluntary vaccination, where individuals choose to be or not vaccinated upon the risk of vaccination versus the risk of the diseases and we define a Nash equilibrium vaccination function as a function such that all individuals behave in a rational manner. They were able to show the existence of an optimal and Nash functions  $p$  in a general setting. As a matter of fact, in general  $p$  will not be a function but a Radon measure. For specific forms of the transmission rate, explicit formulas for the optimal and the Nash functions were provided.

Using Domain Variation techniques, **J.M. Gomes** obtained general Pohozaev Type Identities for the solutions of the non-linear Poisson with Dirichlet Boundary conditions. Using these Identities, local isoperimetric properties of level sets and steepest ascent paths of the solutions were derived.

**A. Karlovich** proved that a simplest weighted singular integral operator with two slowly oscillating shifts is Fredholm and its index is equal to zero. The paper on this work was accepted in "Banach Journal of Mathematical Analysis". **A. Karlovich** studied the boundedness and compactness of pseudodifferential operators with non-regular symbols on Banach function spaces. This work was accepted for publication in the Proceeding of "Function spaces VII", which will appear as a volume of "Contemporary Mathematics".

**A. Karlovich, Yu. Karlovich, and A. Lebre** described all regularizers for a Mellin pseudodifferential operator with a slowly oscillating symbol of limited

smoothness. This result was published in "Communications in Mathematical Analysis". Further, A.Karlovich, Yu. Karlovich, and A.Lebre with the aid of the above mentioned result described all regularizers of a weighted singular integral operator with shifts and slowly oscillating data. The paper on this work will be submitted in the beginning of 2015.

**B. Louro, M.C. Soares** and Jacques Henry began writing a paper on the full proof of the method of invariant embedding applied to the Poisson problem in a quasi-cylindrical domain.

**M. d'Orey, B. Louro** and Jacques Henry continued their work on the factorization of over-determined boundary value problems.

**L. Mascarenhas** in collaboration with C. Kreisbeck published the paper "Asymptotic spectral analysis in semiconductor nanowire heterostructures" about the spectral behavior of the divergence operator in a thin tubular domain, presenting transversal heterogeneities. **L. Mascarenhas** in collaboration with **R. Ferreira** and Andrey Piatnitski submitted the paper "Spectral Analysis in thin tubes with axial heterogeneities", about the spectral behavior of the divergence operator in thin tubular domains, presenting periodic axial heterogeneities (quite different from the transversal case mentioned above). **L. Mascarenhas** in collaboration with I. Fonseca and **R. Ferreira** concluded the study of the imaging processing problem of denoising colored images using a "u + v" model coupled with a chromaticity-brightness decomposition approach. A paper will be submitted soon.

**A.M. Ribeiro**, in collaboration with **R. Ferreira** and C. Kreisbeck, has studied certain integral conditions involving the difference quotients of a measurable function. These conditions are related with certain non-local functionals used in image restoration and, as proved, provide a new characterization of kth-order Sobolev spaces. This work was accepted for publication in "Nonlinear Analysis: Theory, Methods & Applications". A.M. Ribeiro, in collaboration with E. Zappale, has investigated, in the vectorial setting, the existence of minimizers for supremal functionals in the lack of the appropriate convexity condition which ensures lower semi-continuity. However, in this setting, the question gives rise to some very difficult problems on differential inclusions which are not understood at present.

As part of the research project 'Molecular epidemiology of Mycobacterium

tuberculosis in Portugal: Implementing and analysing a database' (PTDC/SAU-ESA/71208/2006), **P. Rodrigues** has published in collaboration the paper 'Interpreting measures of tuberculosis transmission: a case study on the Portuguese population', where we have showed that the proposed model, based on previous work of some of the authors, reproduces well the observed dynamics of the Portuguese data, thus demonstrating its adequacy for devising control strategies for TB and predicting the effects of interventions. P. Rodrigues has recently resubmitted, in collaboration, the manuscript for publication where we present our results on the impact of the reduction of treatment length on tuberculosis incidence. This work results from the research project 'Sistemas complexos na dinâmica de infecção de tuberculose e dengue' (funded by the Bilateral Agreement Portugal-Brazil FCT/CAPES). In collaboration with researchers from Aveiro's University **P. Rodrigues** have published the paper 'Cost-effectiveness analysis of optimal control measures for tuberculosis', where control measure theory is used to evaluate the cost-effectiveness of strategies for tuberculosis control for different epidemiological scenarios.

**M.C. Soares** and the other members of the MIMA project completed the first working packages of the project, namely WP 2 - Definition and validation of the common MiMa teaching methodology in primary schools and WP 3 - Development of the MiMa course contents and tools.

## 2.4 Publications

### 2.4.1 Publications in Web of Science journals

- [1] **Rita Ferreira** and Diogo A. Comes. On the convergence of finite state mean-field games through gamma-convergence. *J. Math. Anal. Appl.*, 418(1):211-230, 2014.
- [2] **Telma Guerra**, Jorge Tiago, and Adelia Sequeira. Optimal control in blood flow simulations. *Int. J. Non-Linear Mech.*, 64:57-69, 2014.
- [3] **Fabio A. C. C. Chalub** and Max O. Souza. Discrete and continuous sis epidemic models: A unifying approach. *Ecol. Complex.*, 18(SI):83-95, 2014.

- [4] **Fabio A. C. C. Chalub** and Max O. Souza. The frequency-dependent Wright-Fisher model: diffusive and non-diffusive approximations. *J. Math. Biol.*, 68(5):1089–1133, 2014.
- [5] **Ana Margarida Ribeiro** and Elvira Zappale. Existence of minimizers for nonlevel convex supremal functionals. *SIAM J. Control Optim.*, 52(5):3341–3370, 2014.
- [6] **Paula Rodrigues**, Cristiana J. Silva, and Delfim F. M. Torres. Cost-effectiveness analysis of optimal control measures for tuberculosis. *Bull. Math. Biol.*, 76(10):2627–2645, 2014.
- [7] **Alexei Yu. Karlovich**, Yuri I. Karlovich, and Amarino B. Lebre. Fredholmness and index of simplest singular integral operators with two slowly oscillating shifts. *Oper. Matrices*, 8(4):935–955, 2014.
- [8] Joao Sollari Lopes, **Paula Rodrigues**, Suani T. R. Pinho, Roberto F. S. Andrade, Raquel Duarte, and M. Gabriela M. Gomes. Interpreting measures of tuberculosis transmission: a case study on the portuguese population. *BMC Infect. Dis.*, 14, 2014.

### 2.4.2 Other publications in peer-reviewed journals

- [1] **T. Guerra**, J. Tiago, A. Sequeira. On the optimal control of a class of non-Newtonian fluids. *Journal Annali dell' Università di Ferrara*, Vol. 60, No. 1, 133-147 (2014).
- [2] **A.Yu. Karlovich**, Yu.I. Karlovich, A.B Lebre. On regularization of Mellin PDO's with slowly oscillating symbols of limited smoothness. *Communications in Mathematical Analysis*, Vol. 17, No. 2, 189-208 (2014).
- [3] A. Almeida, **F.A.C.C. Chalub**, R. Teixeira. (2014), Much or More? Experiments of rationality and spite with school children. *North American Journal of Psychology*, Vol. 16, No.1, 163-178. (2014).

### 2.4.3 Other (international) publications

1. **T. Guerra**, J. Tiago, Improving blood flow simulations using known data, Proceedings of the Comsol Conference Cambridge 2014.



2. **A. Yu. Karlovich**, I. M. Spitkovsky. The Cauchy singular integral operator on weighted variable Lebesgue spaces, In: Concrete Operators, Spectral Theory, Operators in Harmonic Analysis and Approximation. Operator Theory: Advances and Applications. Basel: Birkhäuser/Springer, Vol. 236, pp. 275-291 (2014).
3. **A. Yu. Karlovich**, Boundedness of pseudodifferential operators on Banach function spaces, In: Operator Theory, Operator Algebras and Applications. Basel: Birkhäuser/ Springer. Operator Theory: Advances and Applications, Vol. 242, pp. 185-195 (2014).
4. **A. M. Ribeiro**, E. Zappale. Lower semicontinuous envelopes in  $W^{1,1} \times L^p$ , In: Calculus of Variations and PDEs, Editors: Tomasz Adamowicz, Agnieszka Kałamajska, Stanisław Migórski, Anna Ochal, Banach Center Publications, vol. 101, pp. 187-206 (2014).

#### 2.4.4 Accepted papers

1. **R. Ferreira**, C. Kreisbeck, **A. M. Ribeiro**, Characterization of polynomials and higher-order Sobolev spaces in terms of functionals involving difference quotients, Nonlinear Analysis: Theory, Methods & Applications, Vol. 112, 199–214 (2015).
2. **A. Yu. Karlovich**, Fredholmness and index of simplest weighted singular integral operators with two slowly oscillating shifts, Banach Journal of Mathematical Analysis, Vol. 9, no. 3, 24-42 (2015).
3. C. Kreisbeck, **L. Mascarenhas**, Asymptotic spectral analysis in semiconductor nanowire heterostructures, Applicable Analysis, published online on 2.06.2014.
4. **R. Martins**, **G. Morais**, Generalized synchronization in a system of several non-autonomous oscillators coupled by a medium, Kybernetika.
5. **A. Yu. Karlovich**, Maximally modulated singular integral operators and their applications to pseudodifferential operators on Banach function spaces, Proceedings of Function Spaces VII, Contemporary Mathematics.

### 2.4.5 Submitted papers

1. **T. Guerra**, A. Sequeira, J. Tiago, Existence of optimal boundary control for Navier-Stokes with mixed boundary conditions.
2. S.T.R. Pinho , **P. Rodrigues**, R. F. S. Andrade, H. Serra, J. S. Lopes, M. G. M. Gomes, Impact of tuberculosis treatment length and adherence under different transmission intensities.

### 2.4.6 Other publications

1. **F. Chalub** (2014), A medalha que veio do frio, *Gazeta de Matemática* 172, pp 14-16.
2. **F. Chalub** (2014), O ano da virada de Turing, *Gazeta de Matemática* 173, pp 14-16.
3. **F. Chalub** (2014), Da terceira para a quarta dimensão, *Gazeta de Matemática* 174, pp 13-15.

## 2.5 Seminars

**19 February:** *Modelling dengue fever epidemiology: complex dynamics and its implication for data analysis*, Maíra Aguiar, CMAF/FC - U. Lisboa, Portugal

**26 February:** *Relaxation of models infinite plasticity with two active slip systems*, Carolin Kreisbeck, Universitat Regensburg, Germany

**5 March:** *Optimal design for energies with linear growth with perimeter penalization.*, Elvira Zappale, Universidade de Salerno, Italy

**26 March:** *Pseudodifferential operators on Banach function spaces*, Oleksiy Karlovych, CMA/FCT/UNL, Portugal

**9 April:** *Numerical solution of time-dependent Maxwell's equations for modeling scattered electromagnetic wave's propagation*, Sílvia Barbeiro, CMUC - U. Coimbra, Portugal

**30 April:** *Local Isoperimetric Properties of the Solutions to the Nonlinear Poisson Equation*, José Maria Gomes, CMA/FCT/UNL, Portugal

**14 May:** *Gamma-convergence approach to dilute spin systems*, Andrey Piatnitski, Narvik University College and Lebedev Physical Institute RAS, Norway/Russia

**21 May:** *Contar e Contar: contributo para uma antropologia dos Números*, José Maria Gomes, CMA/FCT/UNL, Portugal

**28 May:** *Modelo para transmissão de dengue com vacinação*, Tiago Costa, Master Student - DM/FCT/UNL, Portugal

**4 June:** *Inverse Problem in Electrocardiography via Factorization Method of Boundary Value Problems*, Jacques Henry, Université de Bordeaux, France

**11 June:** *A duality principle for non convex variational problems*, Guy Bouchitte, Université du Sud-Toulon-Var, France

**30 June:** *Point-wise behavior of the Geman-McClure and the Herbert-Leahy image restoration models*, Peter Hasto, University of Oulu, Finland

**23 July:** *Modelo para transmissão de dengue com vacinação II*, Tiago Costa, Master Student - DM/FCT/UNL, Portugal

**17 September:** *Hamiltonian Evolutionary Games.*, Hassan Najafi Al-ishah, CAMGSD/IST-U. Lisbon, Portugal

**1 October:** *Optimal control of quasi-Newtonian fluids.*, Nadir Arada, CEAF/IST-U. Lisbon, Portugal

**15 October:** *A mathematical model approach to understand human blood clotting dynamics*, Jevgenija Pavlova, CEMAT/IST - U. Lisbon, Portugal

**19 October:** *Existência de ondas solitárias para um sistema de Boussinesq*, Filipe Oliveira, CMAF/FC - U. Lisbon, Portugal

**29 October:** *Stochastic Matrices and Evolutionary Processes*, Fabio Chalub, CMA/FCT/UNL, Portugal

**3 Dezember:** *Lower Semicontinuity in Variable Lebesgue Spaces*, David Soares, Master Student – DM/FCT/UNL, Portugal

**10 December:** *Conservative Parabolic Problems*, Max Souza, Universidade Federal Fluminense, Brazil

## 2.6 Internationalization

Collaborations: **Fabio Chalub** with Brazil and Tanzania, **R. Ferreira** with Germany and Saudi Arabia, **A. Karlovich** with Mexico and U.S.A., **A. M. Ribeiro** with Germany and Italy, **L. Mascarenhas** with France, U.S.A.A, Norway and Germany, **M. C. Soares**, **M. d'Orey** and **B. Louro** with France, **R. Martins** with Spain.

Visits: **L. Mascarenhas** to U.S.A and Norway; **A. M. Ribeiro** to Finland.

## 2.7 Conferences participation

### 2.7.1 Invited talks at international conferences

1. **A. M. Ribeiro**, Existence of solutions for non level-convex problems in the supremal form, 8th European Conference on Elliptic and Parabolic Problems, 26-30 May 2014, Gaeta, Italy.
2. **P. Rodrigues**, Impact of tuberculosis treatment length and adherence under different transmission intensities, Fifth Workshop Dynamical Systems Applied to Biology and Natural Sciences, DSABNS 2014, Lisbon, Portugal, February 10-12, 2014.
3. **F. Chalub**, Fifth Workshop Dynamical Systems Applied to Biology and Natural Science, Lisbon, Portugal, February 2014.
4. **F. Chalub**, Kinetics, non standard diffusions and stochastics: emerging challenges in the sciences, Austin-TX, USA, May 2014.
5. **A. Karlovych**, The Cauchy singular integral operator on weighted variable Lebesgue spaces, Workshop on Analysis, Differential Equations and

Control, Morelia, México, February 19-21, 2014.

6. **A. Karlovych**, Pseudodifferential operators on Banach function spaces, Analysis, Operator Theory, and Mathematical Physics, Park Royal Hotel, Ixtapa, México, February 24 - 28, 2014.
7. **L. Mascrenhas**, Asymptotic spectral analysis in nanowires with axial heterogeneities, Trends in Nonlinear Analysis, IST, Lisboa, Portugal, 31 July, 2014.

### 2.7.2 Contributed talk (international)

1. **F. Chalub**, 9th European Conference in Mathematical and Theoretical Biology, Gothenburg, Sweden, June 15-19, 2014.
2. **A. Karlovich**, Fredholmness and index of simplest singular integral operators with two slowly oscillating shifts, 16th Annual Workshop on Applications and Generalizations of Complex Analysis, Universidade de Aveiro, Portugal, March 21-22, 2014.
3. **A. Karlovych**, Pseudodifferential operators on Banach function spaces, Function Spaces VII, Southern Illinois University at Edwardsville, USA, May 20-24, 2014.
4. **A. Karlovych**, Pseudodifferential operators on variable Lebesgue spaces, School on Nonlinear Analysis, Function Spaces and Applications 10, Trest, Czech Republic, June 9-15, 2014.
5. **A. Karlovich**, On a weighted singular integral operator with shifts and slowly oscillating data, Workshop on Operator Theory, Complex Analysis, and Applications, WOTCA 2014, Instituto Superior Técnico, Lisboa, Portugal, June 19-21, 2014.
6. **A. Karlovych**, Fredholmness and index of simplest weighted singular integral operators with two slowly oscillating shifts, Wiener-Hopf Workshop, Universidade de Aveiro, Portugal, June 23-24, 2014.
7. **A. Karlovych**, On a weighted singular integral operator with shifts and slowly oscillating data, International Workshop on Operator Theory and

Applications, IWOTA 2014, VU University, Amsterdam, The Netherlands, June 19-21, 2014.

8. **A. Karlovych**, Toeplitz operators on locally bounded Orlicz sequence spaces, The 19th International Linear Algebra Society Conference, Sungkyunkwan University, Seoul, Korea, August 6-9, 2014.
9. **P. Rodrigues**, Impact of treatment length and treatment default on drug-resistant tuberculosis epidemiology, 9th European Conference on Mathematical and Theoretical Biology, ECMTB 2014 Gothenburg, Sweden, June 15-19, 2014.

### 2.7.3 Invited talk (national)

1. **A. Karlovych**, Fredholmness and index of simplest singular integral operators with two slowly oscillating shifts, CEAF, Instituto Superior Técnico, Lisboa, Portugal, 4 April, 2014.
2. **L. Mascarenhas**, Asymptotic spectral analysis in nanowires with axial heterogeneities, CMAF, Lisboa, Portugal, 17 July, 2014.
3. **L. Mascarenhas**, Asymptotic spectral analysis in nanowires with axial heterogeneities, Dia das Equações, Braga, Portugal, 24 September, 2014.

### 2.7.4 Contributed talk (national)

1. **F. Chalub**, Encontro Nacional da SPM 2014, 14-16 July 2014, Caparica, Portugal.
2. **T. Guerra**, J. Tiago, Aplicação de problemas de controlo a uma estenose idealizada, Encontro Nacional da SPM 2014, 14-16 July 2014, Caparica, Portugal.
3. **A. M. Ribeiro**, Caracterização de polinómios e espaços de Sobolev de ordem superior em termos de funcionais não locais envolvendo razões incrementais, Encontro Nacional da SPM 2014, 14-16 July 2014, Caparica, Portugal.

## 2.8 Other Important Information

### 2.8.1 PhD theses completed

1. **Telma Margarida Cotovio Guerra Santos**, Controle óptimo de fluidos não newtonianos, 28/05/2014, Universidade Nova de Lisboa.
2. **Gonçalo Nuno Rosado Morais**, advised by **R. Martins**, Dinâmica de osciladores acoplados, 11/12/2014, Universidade Nova de Lisboa.
3. André d'Almeida, advised by **F. Chalub**, "Spiteful strategies. The ontogeny and the practice of spite in human interaction: an experimental game theory approach and empirical applications.", Anthropology Department, FCSH/UNL.

### 2.8.2 Conference organization

**M. C. Soares, P. Rodrigues**: Encontro Nacional da Sociedade Portuguesa de Matemática 2014, FCT-UNL campus da Caparica, Portugal, July 14-16, 2014. Organizing committee.

### 2.8.3 Supervision of Ph.D. (2014)

**F. Chalub** co-supervised a PhD thesis in Anthropology at Faculdade de Ciências Sociais, Universidade Nova de Lisboa and as the result he coauthored a paper published in Psychology journal.

### 2.8.4 Outreach activities

**R. Martins** presented 16 scientific diffusion talks (mainly at secondary schools and general public events), participate in the juri of Famelab Portugal.

**P. Rodrigues** and **M. C. Soares** participated in several events organized by FCT/UNL.

**F. Chalub** continued his activity as a regular writer at Gazeta de Matemática, where he has a regular column aimed to undergrad students and high school teachers.

### 2.8.5 Peer-reviewing activities

**F. Chalub**: Ecological Complexity; Journal of Mathematical Biology; Mathematical Reviews (MathSciNet). **J.M. Gomes**: Boundary Value Problems. **A. Karlovich**: Archivum Mathematicum; Banach Journal of Mathematical Analysis; Journal of Taibah University for Science; Mathematical Reviews (MathSciNet); Zentralblatt (zbMATH). **R. Martins**: Mathematical Reviews (MathSciNet). **P. Rodrigues**: Journal of Mathematical Biology.

## 2.9 2015 research of IM

As a follow up of the paper "Fixation in Large Populations: A continuous view of a discrete problem", **F. Chalub** and M. Souza will show that the fixation probability for certain classes of evolutionary models can be qualitatively described using the concept of fitness potential and the value of the effective population. In a different work, Wright-Fisher processes will be studied using techniques from Markov chains. They are going to show, in particular, that a certain subclass of these matrices form an algebra. Elements not in this class, however, possess interesting properties.

**F. Chalub**, **P. Doutor**, **P. Rodrigues** and **M. C. Soares** will continue the work on SIR models with vaccination. In particular, for the optimal vaccination we want to compare our previous results with a more classical approach, for which the vaccination effort is minimized in the set of vaccination functions that have basic reproductive number,  $R_0$ , smaller than 1. For this they will use techniques from optimal control theory to minimize the vaccination effort. Plus, they will introduce compartmental models where individuals can have different types of risk behaviors. They will study how the voluntary change of behavior, depending on the evaluation individuals do of the disease incidence, affects the epidemic. Moreover, they want to study the amount of vaccination need in each group (or as a function of the risk propensity) in order to control the disease.

**F. Chalub** and **P. Rodrigues** are currently supervising a scholarship project, as part of the project EXPL/MAT-CAL/0794/2013 (Game Theory and Epidemiology). They are working on a spatial SIR model with vaccination and diffusion. They consider a spatial model where an area with high transmission is circled



by a region with low transmission. They plan to obtain the size of a vaccination area in order to isolate an epidemic region from the neighbor regions. They start by consider vaccination point wise and then show that the stability of the disease free solution is not affected by the diffusion terms for small enough diffusivity parameters, using a prior estimates of the difference of both model solutions.

It is the purpose of **J. M. Gomes**, in collaboration with A. Patrício and **P. Pimenta**, to study the existence of Maximum Principles for radially symmetric mountain-pass solutions for Dirichlet boundary value problems on a ball or on the whole space  $R^n$ . They expect to prove that the maximum of the positive ground-state to the non-linear Klein-Gordon equation is the infimum of the set of maximums of regular functions lying on the Nehari manifold.

**A. Karlovich** is going to study convolution operators with oscillating symbols on Banach function spaces, including variable Lebesgue spaces.

M. A. Bastos, C.Fernandes, and **A.Karlovich** 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.

**A. Karlovich**, Yu. Karlovich and A. Lebre plan to complete the paper on the index formula for singular integral operators with slowly oscillating shifts.

**B. Louro, M. C. Soares** and Jacques Henry plan to submit a paper on the full proof of the method of invariant embedding applied to the Poisson problem in a quasi-cylindrical domain. **M. d'Orey, B. Louro** and Jacques Henry are planning to submit a paper on the factorization of over-determined boundary value problems.

**N. Martins** will use mesh-free inverse numerical methods to identify thermal and acoustic sources and obstacles.

**R. Martins** will continue the study of a discretization of the dissipative sine-Gordon equation, looking for conditions under which there is a one-dimensional global attractor.

**L. Mascarenhas, R.Ferreira**, and A.Piatnitski (Univ. Narvik and P.N. Lebedev Physical Institute) will work on dimension reduction and spectral problems. Development of previous work in spectral problems for elliptic operators in thin longitudinally heterogeneous domains, under less restrictive con-

ditions. It is important to describe the asymptotic behavior of the bottom of the spectrum and to show that the problem admits a 3D-1D dimension reduction. Those problems model the energy levels in thin quantum waveguides.

**L. Mascarenhas**, in collaboration with G. Bouchitté (IMATH/Univ. Toulon, France) and C. Bourel (LMPA/Univ. Littoral, France), is going to study a class of diffusion operators with signal changes. They are interested in the well-posedness of the problem; in the related spectral problem in a Sobolev space of periodic or quasi periodic functions; in the corresponding homogenization process. Those operators model the behavior of metamaterials.

**F. Oliveira** plans to study singularity formation of solutions and is interested in adapting these methods to Schrodinger-Debye and Davey-Stewartson systems.

**M. Rebelo** 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.

**A. M. Ribeiro** intends to pursue the study of certain characterizations of variable exponent Sobolev spaces with possible applications to imaging problems. These characterizations rely on some integral functionals with no derivatives dependence. This work, carried out in collaboration with P. Hästö and **R. Ferreira**, may also be extended to Sobolev-Orlicz spaces.

**P. Rodrigues** will continue the work, in collaboration, on the study of the impact of tuberculosis interventions on the dynamics of the disease using optimal control measures. In particular, we want to find the optimal control strategy when comparing two possible interventions: decrease of treatment duration and prevention of treatment default.

**M. C. Soares** and the other members of the MIMA project will work in the remaining packages of the MiMa project, namely WP 4 - Teachers training course and WP - 5 Implementation of the MiMa laboratories. It will be organized a transnational meeting in Portugal, in September 2015, aimed at the sharing of the results of field-testing in schools.

**L. Trabucho** 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.

## 2.10 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 constrains (or shape constrains such as quasi-concavity). The approach consists in using small perturbations of Lipschitz functions that preserve the imposed constrains 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**

*The Operations Research team members will develop research in the areas of Combinatorial Optimization and Non-Linear Optimization with particular focus on the following main topics: network design models, hub location and vehicle routing problems, resource constrained project scheduling, derivative-free optimization, complementary problems and semi-definite programming. Three new members will contribute in this task.*

### Highlights

- 9 papers published in 2014, all of them indexed at Web of Science.
- The team hosted the 101th European Study Group with Industry.
- Partnership with Industry to fund 2 MSc grants.

## 3.1 Team

### 3.1.1 Integrated Members

1. Paula Amaral
2. Susana Baptista
3. Carmo Proença Brás
4. Nelson Chibeles-Martins
5. Isabel Correia
6. Ana Luísa Custódio
7. Maria Isabel Gomes
8. Manuel V. C. Vieira

### 3.1.2 Collaborators

1. Paula Couto
2. Rui Rodrigues

## 3.2 Projects

### 3.2.1 Projects with the participation of team members

1. **539872-LLP-1-2013-1-IT-COMENIUS-CMP**: *Mathematics in the Making-Mima*, led by Emmanuela Ughi, Università degli Studi di Perugia (Italy), with participation of **S. Baptista, N. Chibeles-Martins** (2013-2015). Total funding: €369 851,00, UNL funding: €54 537,00.
2. **PTDC/MAT/116736/2010**: *parse and smoothing methods for nonlinear optimization of complex models*, led by Luís Nunes Vicente, University of Coimbra, with participation of **A. L. Custódio** (2012-2014). Total funding: €78 500.00.

### 3.3 Achievements

**P. Amaral:** The study on fractional quadratic problems progressed and some results on ternary variables were obtained. The organization of a meeting on “Mathematics in Industry” provided an interesting problem related with continuous team work schedule. After the meeting the research on this problem continued, namely exploiting exact formulations and Tabu Search approaches. This problem was not related on 2014 objectives since she had no previous intention on following this line of research.

**S. Baptista and M.I. Gomes:** We developed a two-stage stochastic model for the design and planning of a multi-period, multi-product closed loop supply chain, where a risk averse attitude is considered. The novelty of this work concerns the way we modeled risk averse attitude. We introduced a new Stochastic Dominance Constraint strategy, named Time Stochastic Dominance that simultaneously considers both bounding as well as upper bounding on any profit shortfall and considered them as soft constraints by heavily penalizing their violation in the objective function. We developed a first solving approach based on a Branch and Fix heuristic. This work was presented in two international conferences and two papers are being prepared to be submitted to international peer-reviewed journals.

**C.P. Brás:** Copositivity tests based on necessary and sufficient conditions requiring the solution of Linear Complementarity Problems (LCP) have been developed as well as methodologies involving Lemke’s method and an enumerative algorithm to solve the required LCPs.

**N. Chibeles-Martins:** The paper "Multi-Objective Meta-Heuristic Approach of a Flexible Supply Chain Network Design and Planning" was presented in ESCAPE24 conference, held at Budapest on June, and published in the conference proceedings. The paper “A Multi-Objective Meta-Heuristic Approach for the Design and Planning of Green Supply Chains – MBSA” was submitted to Expert Systems with Applications on October.

**I. Correia:** The review paper on facility location under uncertainty was concluded and accepted for publication. The work on a variant of the classical multi-period facility location problem is on progress. For this problem several formulations were developed as well as some sets of valid inequalities.



**A.L. Custódio:** In 2014 the theoretical aspects related to the optimization of problems subject to inviolable constraints were addressed. The error associated to the solution of a family of perturbed approximated problems was quantified, leading to the development of practical approaches for solving this class of problems. The generalization of GLODS algorithm to global multiobjective derivative-free optimization was also analyzed. The convergence analysis of the proposed algorithm was established, when the globalization strategy is based in the use of integer lattices. A numerical study for noisy derivative-free optimization was also conducted, testing different nonmonotone variants of directional direct search, in order to access the corresponding performance. In the domain of applications, namely in civil engineering, direct search methods of directional type and an inverse analysis methodology were used for characterizing the tensile behavior of steel fiber reinforced concrete. Finally, a survey on methodologies and software for derivative-free optimization was finalized. The purpose was to give an overview of the main classes of state-of-the-art derivative-free optimization methods, with a focus on the underlying ideas and on the respective classes of problems to which these methods are applicable, providing references to detailed algorithmic descriptions, theoretical results, and available software packages.

**M.I. Gomes:** A generic multi-objective MILP model for the design and planning of closed loop supply chains, integrating the three dimensions of sustainability was developed. The economic objective is measured by the net present value (to be maximized), the environmental objective assesses the system impact through a methodology named as ReCiPe (to minimized), and the social objective is model by three different functions to be maximized: job creation, GDP and employment. Notice a supply chain is a large system with facilities spread over several countries that although job creation and employment may seem similar, when maximizing the former one is not favoring locations with the highest unemployment rate. The novelty of this work is threefold: the assessment of social impact within a supply chain context, the change of the traditional environment perspective which is the product into a more complex perspective which is a supply chain, and lastly the investigation of the best network configuration having sustainability has a maximization objective. This work will be presented in two conferences and a paper is

being prepared to be submitted to a international peer-review journal.

**M.V.C. Vieira:** A mathematical optimization framework to the Facility Layout Problem was developed. This framework is composed by two mathematical optimization models, where the first model gives an approximation layout (in general, not feasible) and the second mathematical optimization model, using the solution of the first model, returns a final layout. Solutions of previously published works for large instances have been improved.

## 3.4 Publications

### 3.4.1 Publications in Web of Science

- [1] Tania Rodrigues Pereira Ramos, **Maria Isabel Gomes**, and Ana Paula Barbosa-Povoa. Planning a sustainable reverse logistics system: Balancing costs with environmental and social concerns. *Omega-Int. J. Manage. Sci.*, 48:60–74, 2014.
- [2] **Paula Amaral**, Immanuel M. Bomze, and Joaquim Judice. Copositivity and constrained fractional quadratic problems. *Math. Program.*, 146(1-2):325–350, 2014.
- [3] **Carmo P. Bras**, Joaquim J. Judice, and Hanif D. Sherali. On the solution of the inverse eigenvalue complementarity problem. *J. Optim. Theory Appl.*, 162(1):88–106, 2014.
- [4] **Isabel Correia** and Francisco Saldanha-da Gama. The impact of fixed and variable costs in a multi-skill project scheduling problem: An empirical study. *Comput. Ind. Eng.*, 72:230–238, 2014.
- [5] Tania Rodrigues Pereira Ramos, **Maria Isabel Gomes**, and Ana Paula Barbosa-Povoa. Assessing and improving management practices when planning packaging waste collection systems. *Resour. Conserv. Recycl.*, 85(SI):116–129, 2014.
- [6] **Isabel Correia**, Stefan Nickel, and Francisco Saldanha-da Gama. Multi-product capacitated single-allocation hub location problems: Formulations and inequalities. *Netw Spat. Econ.*, 14(1):1–25, 2014.

- [7] Tania Rodrigues Pereira Ramos, **Maria Isabel Gomes**, and Ana Paula Barbosa-Povoa. Economic and environmental concerns in planning recyclable waste collection systems. *Transp. Res. Pt. e-Logist. Transp. Rev.*, 62:34-54, 2014.
- [8] **Rui Rodrigues**. Fetal beat detection in abdominal ecg recordings: global and time adaptive approaches. *Physiol. Meas.*, 35(8):1699-1711, 2014.
- [9] Pedro Costa, **Maria Isabel Gomes**, Ana Carvalho, and Ana Barbosa-Povoa. Decision support tool for strategic planning in supply chains. In JJ Klemes, PS Varbanov, and PY Liew, editors, *24TH EUROPEAN SYMPOSIUM ON COMPUTER AIDED PROCESS ENGINEERING, PTS A AND B*, volume 33 of *Computer-Aided Chemical Engineering*, pages 895-900, 2014. 24th European Symposium on Computer Aided Process Engineering (ESCAPE), Budapest, HUNGARY, JUN 15-18, 2014.

### 3.4.2 Other international publications

1. **N. Chibeles-Martins**, T. Pinto-Varela, A. P. Barbosa-Póvoa and A. Novais, Multi-Objective Meta-Heuristic Approach supported by an Improved Local Search Strategy for the Design and Planning of Supply Chain Networks, *Computer Aided Chemical Engineering*, Elsevier, Vol. 33, pp. 313-318, June 2014.
2. B. Mota, A. Carvalho, **M.I. Gomes**, and A. P. Barbosa-Póvoa, Supply chain environmental assessment, Proc of avniR Conference. Lille, France, pp. 1-4, October 2014
3. B. Mota, **M.I. Gomes** and A. P. Barbosa-Póvoa, Supply Chain Design towards sustainability: Accounting for growth and jobs, Proc of the 8th International Conference on Foundations of Computer-Aided Process Design. Washington, USA, Elsevier, Vol. 34, pp. 789-794. January 2014.
4. B. Mota, **M.I. Gomes**, A. Carvalho, and A. P. Barbosa-Póvoa, The influence of Corporate Social Responsibility on economic performance within supply chain planning, Proc. of 11th International Conference on Computational Management Science. Lisbon, Portugal, pp. 1-7, May 2014.

### 3.4.3 Other national publications

1. **M.I. Gomes** and A. P. Barbosa-Póvoa, Projecto de uma rede logística para a recolha de equipamentos eléctricos e electrónicos, in Oliveira, R.C., Ferreira, J.S. (Eds.), *Investigação Operacional Em Ação. Casos de Aplicação*. Imprensa da Universidade de Coimbra, Coimbra, Portugal, pp. 399–434. November 2014.
2. T.R.P. Ramos, **M.I. Gomes**, A. P. Barbosa-Póvoa, Reestruturação de áreas de influência e de rotas de veículos num sistema de recolha de resíduos recicláveis, in Oliveira, R.C., Ferreira, J.S. (Eds.), *Investigação Operacional Em Ação. Casos de Aplicação*. Imprensa da Universidade de Coimbra, Coimbra, Portugal, pp. 435–471. November 2014.
3. N.D. Gouveia , **A.L. Custódio** , D. M. Faria and A. P. Ramos, Determinação de relações tensão-abertura de fenda de BRFA através de análise inversa, Proceedings of the 9<sup>o</sup> Congresso Nacional de Mecânica Experimental, Aveiro, Portugal, Outubro 2014.

### 3.4.4 Accepted papers

1. **S. Baptista**, A. Barbosa-Póvoa, L. Escudero, **M. I. Gomes** and C. Pizarro, A metaheuristic for solving large scale two-stage stochastic mixed 0-1 programs with the time stochastic dominance risk averse strategy, (submitted November 2014 - acceptance notification 15 January 2015) 25th European Symposium on Computer Aided Process Systems Engineering, Copenhagen, Denmark, June 2015.
2. **C. P. Brás**, A. N. Iusem and J. J. Júdice, On the quadratic eigenvalue complementarity problem, *Journal of Global Optimization*, Springer.
3. **I. Correia**, and F. Saldanha da Gama, A note on “Branch-and-price approach for the multi-skill project scheduling problem”, *Optimization Letters*, Springer.
4. **I. Correia**, and F. Saldanha da Gama, Facility location under uncertainty, in Gilbert Laporte, Stefan Nickel, Francisco Saldanha da Gama (eds): *Location Theory*, Springer.

5. **I. Correia**, and F. Saldanha da Gama, "A Modeling Framework for Project Staffing and Scheduling Problems", in C. Schwindt, J. Zimmermann (eds.): Handbook on Project Management and Scheduling, Vol.1, International Handbooks on Information Systems, Springer.
6. **A.L. Custódio** and J. F. A. Madeira, GLODS: Global and Local Optimization using Direct Search, Journal of Global Optimization, Springer.
7. B. Mota, **M.I. Gomes**, A. Carvalho, and A.P. Barbosa-Póvoa, Towards supply chain sustainability: economic, environmental and social design and planning. Journal of Cleaner Production, Elsevier, August 2014.
8. P. F. Vieira, S. M. Vieira, **M.I. Gomes**, A. P. Barbosa-Póvoa, and J.M.C. Sousa, Designing closed-loop supply chains with nonlinear dimensioning factors using ant colony optimization, Soft Computing, Springer, August 2014.

### 3.4.5 Submitted papers

1. **N. Chibeles-Martins**, T. Pinto-Varela, A. P. Barbosa-Póvoa, and A. Novais, A Multi-Objective Meta-Heuristic Approach for the Design and Planning of Green Supply Chains - MBSA, Expert Systems with Applications, Elsevier.
2. **A.L. Custódio**, K. Scheinberg, and L. N. Vicente, Methodologies and software for derivative-free optimization, 2014.

### 3.4.6 Editing and authorship of books and journals (national)

**I. Correia** and **A.L. Custódio** are the editors of the Portuguese Operational Research Society Bulletin, since 2012.

### 3.4.7 Other publications

1. **Amaral, P.A.**, and Bomze, I. M., Copositivity-based approximations for mixed-integer fractional quadratic optimization, Preprint Series of the Isaac Newton Institute for Mathematical Sciences. 2014.

2. Gouveia, N., Brás, A., **Custódio, A.**, Faria, D. and Ramos, A., Avaliação do comportamento de ligações laje-pilar em BRFA com aplicação de relações  $\sigma - \omega$  provenientes de análise inversa, FCT-UNL, Portugal, 2014.
3. Anjos, M.F., **Vieira, M.V.C.**, On semidefinite least squares and minimum unsatisfiable subformulas, Cahiers Du GERAD, G-2014-33.

### 3.5 Seminars

**26 March:** *Using cliques for mining biological networks*, Pedro Martins, ISCAC-Instituto Politécnico de Coimbra , Portugal

**30 April:** *On the Two-Stage Adaptive Robust Optimization Applied to an Electricity Producer*, Ricardo Lima, Laboratório Nacional de Energia e Geologia, Portugal

**28 May:** *Computing pairs of disjoint paths by order of cost*, Marta Pascoal, INESCC - U. Coimbra, Portugal

**1 August:** *Optimal basis algorithm and its application to matrix scaling*, Oleg Burdakov, Linköping University, Sweden

### 3.6 Internationalization

**S. Baptista** has collaborative research with Laureano Escudero and Celeste Pizarro from Universidad Rey Juan Carlos, Madrid, Spain. She is also a member of the MiMa Project – project partners of Università degli Studi di Perugia (Italy), Sheffield Hallam University (United Kingdom), Eotvos Lorand University, Mathematikum (Germany), P3 Poliedra Progetti in Partenariato (Italy).

**C.P. Brás** has collaborative research with Alfredo N. Iusem from Instituto de Matemática Pura e Aplicada, Rio de Janeiro, Brazil and with Masao Fukushima from Faculty of Science and Technology, Nanzan University, Japan.

**I. Correia** collaborates with Stefan Nickel, from the Institute of Operations Research, Karlsruhe Institute of Technology (KIT), Germany and with

Maria Teresa Melo from the Business School, Saarland University of Applied Sciences, Germany.

**M.I. Gomes** presented two seminars in Austria, invited by professors Immanuel Bomze, Ivanna Ljubic and Patrick Hirsch.

**M.V.C. Vieira** develops research with Miguel F. Anjos from the École Polytechnique de Montreal, Canada. M.V.C. Vieira is also an associate member of GERAD (Group for Research in Decision Analysis, Montreal, Canada).

## 3.7 Conferences participation

### 3.7.1 Invited talks at international conferences

1. **P. Amaral**, On Fractional Quadratic Problems, XII Global Optimization Workshop Mathematical Applied Global Optimization, MAGO 2014, Malaga, September 2014.
2. **P. Amaral**, Optimization of constrained fractional quadratic problems, Optimization 2014, School of Engineering, University of Minho, July 2014.
3. **A.L. Custódio** and J. F. A. Madeira, GLODS: Clever Multistart in Directional Direct Search, EngOpt 2014, 4th International Conference on Engineering Optimization, Lisbon, Portugal, September 2014.
4. **A.L. Custódio** and J. F. A. Madeira, GLODS: Clever Multistart in Directional Direct Search, Optimization 2014, Guimarães, Portugal, July 2014.
5. B. Mota, **M.I. Gomes**, Carvalho, A., and Barbosa-Póvoa, A.P., The influence of Corporate Social Responsibility on economic performance within supply chain planning, 11th International Conference on Computational Management Science. Lisbon, Portugal, May 2014.

### 3.7.2 Contributed talk (international)

1. **S. Baptista**, A. Barbosa-Póvoa, L. Escudero, **M. I. Gomes** and C. Pizarro, On risk management for a two-stage stochastic mixed 0-1 model for the

design and planning of a closed loop supply chain – 1st European Conference of Stochastic Programming, Institute Henri Poincaré, Paris, September 2014.

2. **S. Baptista, M. I. Gomes**, L. F. Escudero, and A. P. Barbosa-Póvoa, A.P., Modeling uncertainty in closed loop supply chain design, XIII ISOLDE Symposium, Naples/Capri, Italy, June 2014.
3. **S. Baptista**, Barbosa-Póvoa, A.P., Escudero, L.F., Gomes, M.I., and Pizarro, C., On risk management for a two-stage stochastic mixed 0-1 model for the design and operation planning of a closed-loop supply chain, Proc. of EURO Mini Conference on Stochastic Programming, Paris, France, September 2014.
4. **C.P. Brás**, A. N. Iusem and J. J. Júdice, On the quadratic eigenvalue complementarity problem, Optimization 2014, Guimarães, Portugal, July 2014.
5. **N. Chibeles-Martins**, Pinto-Varela, T., Barbosa-Póvoa, A. P., and Novais, A., Multi-Objective Meta-Heuristic Approach of a Flexible Supply Chain Network Design and Planning, European Symposium on Computer Aided Process Engineering 24, Budapest, Hungary, June 2014.
6. **I. Correia**, and F. Saldanha da Gama, The impact of fixed and variable costs in a multi-skill project scheduling problem, Optimization 2014, Guimarães, Portugal, July 2014.
7. **I. Correia**, S. Nickel, F. Saldanha da Gama, Capacitated single-allocation hub location problems with different types of products, Optimization 2014, Guimarães, Portugal, July 2014.
8. **I. Correia**, S. Nickel, and F. Saldanha da Gama, Multi-product capacitated single-allocation hub location problems, XIII ISOLDE Symposium, Naples/Capri, Italy, June 2014.
9. **A. L. Custódio** and J. F. A. Madeira, GLODS: Clever Multistart in Directional Direct Search, CMS 2014, 11th International Conference on Computational Management Science, Lisbon, Portugal, May 2014.



### 3.7.3 Poster (international)

1. N. D. Gouveia, **A.L. Custódio**, D. M. Faria and A. P. Ramos, A minimization procedure for the determination of SFRC tensile behaviour, EngOpt 2014, 4th International Conference on Engineering Optimization, Lisbon, Portugal, September 2014.
2. P. Costa, **M. I. Gomes**, A. Carvalho, and A. Barbosa-Póvoa, Decision Support Tool for Strategic Planning in Supply Chains, European Symposium on Computer Aided Process Engineering 24, Budapest, Hungary, June 2014.
3. B. Mota, A. Carvalho, **M. I. Gomes** and A. P. Barbosa-Póvoa, Supply chain environmental assessment, Proc of avniR Conference. Lille, France, October 2014.

### 3.7.4 Invited talk (national)

1. **A.L. Custódio** and J. F. A. Madeira, GLODS: Um novo algoritmo para procura directa local e global, National Meeting of the Portuguese Mathematical Society, Caparica, Portugal, July 2014.

### 3.7.5 Contributed talk (national)

1. **M.I. Gomes** and M. Fonseca, A Bag of (Mathematical) Tricks for Ageing Issues, 3<sup>o</sup> Workshop about “Envelhecimento”, Lisbon, Portugal, November 2014.

## 3.8 Other Important Information

### 3.8.1 Conference and seminar organization

1. ANTS 2014, Ninth International Conference on Swarm Intelligence, Université Libre de Bruxelles, Belgium, 10 to 12 September 2014. (A.L.Custódio was member of the scientific committee).

2. CMS 2014, 11th International Conference in Computational Management Science, University of Lisbon, Portugal, 29 to 31 May 2014. (A.L.Custódio was member of the scientific committee).
3. EngOpt 2014, 4th International Conference on Engineering Optimization, University of Lisbon, Portugal, 8 to 11 September 2014. (A.L.Custódio (was co-organizer of the Mini-Symposium on New Advances in Derivative-Free Optimization Methods for Engineering Optimization and member of the scientific committee)).
4. ENSPM14, Nacional meeting of the Portuguese Mathematica Society, FCT, UNL, Portugal, 14 to 16 July. (P. Amaral was co-chair of the organizing committee).
5. Mathematics for Industry, FCT, Caparica, Portugal, 5 to 9 May, co-chair of the organizing committee. (P. Amaral (co-chair), N. Chibeles-Martins (co-chair), R. Rodrigues (member of the local organizing committee)).
6. Optimization 2014, University of Minho, Portugal, 28 to 30 July 2014. (A.L.Custódio, P. Amaral, and M.V.C. Vieira were members of the scientific committee).
7. Short course “Is CPLEX like a box of chocolates?”, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 4 th June 2014. URL: <http://www.cma.fct.unl.pt/noticias/2014/04/curso-cplex-box-chocolates> (S. Baptista and M. I. Gomes were the organizers)

### 3.8.2 Peer-reviewing activities

**M. I. Gomes:** Applied Mathematical Modelling, International Journal of Operations Research, Journal of the Operational Research Society, Omega, Operational Research: An International Journal, Journal of Cleaner Production.

**P. Amaral:** Applied Mathematics and Computation, Mathematical Problems in Engineering, European Journal of Operational Research, International Journal of Production Research.

**M. Vieira:** International Journal of Production Research.

**I. Correia:** Computers and Operations Research, Transportation Science.

**A. L. Custódio:** Optimization and Engineering, Optimization Letters, Proceedings of ANTS 2014, Proceedings of CMS 2014, Proceedings of EngOpt 2014, Computational and Applied Mathematics, Computational Optimization and Applications.

### 3.8.3 Supervision of Ph.D. (2014)

**I. Correia** is co-adviser, with F. Saldanha da Gama (FC-UL), of Bernardo de Almeida who is working on project scheduling problems with flexible resources.

**M.I. Gomes** is co-adviser, with Ana Póvoa (IST-FC), of Bruna Mota who is working in the topic Incorporating the three pillars of sustainability into supply chain design and planning.

### 3.8.4 Computer applications

1. **Custódio, A.L.** and Madeira, J. F. A., GLODS: Global and Local Optimization using Direct Search (MATLAB), Version 0.2

URL: <http://ferrari.dmat.fct.unl.pt/personal/alcustodio/glods>

2. **Custódio, A.L.** and Vicente, L. N., SID-PSM: A pattern search method guided by simplex derivatives for use in derivative-free optimization (MATLAB), Version 1.3.

URL: [URL: http://www.mat.uc.pt/sid-psm](http://www.mat.uc.pt/sid-psm)

### 3.8.5 Outreach activities

**A.L. Custódio:** Faculty Advisor of the SIAM Student Chapter at Universidade Nova de Lisboa.

**C.P. Brás** and **A.L. Custódio:** *Otimização em sala de aula: Uma introdução à Programação Linear e suas extensões, short course aimed at high school teachers*, lectured in ProfNova 2014, integrated in ENSPM2014 in a partnership with the National Portuguese Society of Mathematics (SPM), FCT-UNL, July 2014.

**N. Chibeles-Martins** and **S. Baptista:** Coordinator of ClubeMath, FCT-UNL Mathematics Club for pre-university students.

**I. Correia:** Member of the Executive Board of the Portuguese Association of Operations Research (APDIO). Member of the organizing committee of the “4th Journey of Mathematics of FCT-UNL”, FCT-UNL, March 2014.

**A.L. Custódio:** *Optimização: Porque queremos fazer mais e melhor?*, Seminar in MatNova 2014, Summer School in Mathematics for merit high school students, Portugal, September 2014. *Calculando a idade das estrelas... um problema de Optimização*, Seminar in EXPOFCT 2014, Portugal, April 2014. Collaborator of ClubeMath, Mathematics Club of FCT-UNL for high school students.

### 3.9 2015 research of IM

**P. Amaral:** To develop global optimization methods for constrained fractional quadratic problems to understand the performance of lower bounds based on SDP relaxations in Branch and Bound methods. To extend the study on fractional quadratic problems (FQP) to special cases like ternary variables or the maximum of FQP.

**S. Baptista** and **M.I. Gomes:** We will continue working on the development of solution strategies for the design and planning of supply chains in the context of risk averse strategies. We will pursue a recent collaboration with the Department of Computer Science (FCT/UNL) in order to develop the parallel implementation of the solution algorithm.

**C.P. Brás:** The Quadratic Conic Eigenvalue Complementarity Problem is investigated without assuming symmetry on the matrices defining the problem and also the Conic Eigenvalue Complementarity Problem will be addressed when the matrices are symmetric.

**J.O. Carneiro:** The research plans for 2015 include the following topics: work on generalizations of the (node version of the) minimum Steiner tree and minimum Steiner forest applied to connectivity problems in Conservation Biology will continue; study of injective edge coloring of graphs (the edge version of injective vertex coloring) will start and work on the shortest path with side constraints will be carried out with the establishment of novel formulations and algorithms.

**N. Chibeles-Martins:** During 2014 a Multistart Biobjective Simulated An-

nealing (MBSA) based algorithm was developed for Supply Chain Design and Planning problems. For 2015, the main objective will be submitting a paper adapting MBSA to the design and scheduling of multi-product multipurpose plants.

**I. Correia:** The research plan for 2015 includes the following topics: to finish the work on a variant of the classical multi-period facility location problem, to study a hub location problem with uncertain parameters and to develop new algorithms to compute feasible solutions for a resource constrained project scheduling with flexible resources.

**P. Couto** will continue to do a review of methods used in human identification based on ECG (electrocardiograms) and try to perform improvements using neural networks. She will still continue the work related to ECG.

**A.L. Custódio** will be devoted to finish some of the work already initiated. We intend to numerically test the practical approaches to derivative-free optimization problems with inviolable constraints, stating the usefulness of the proposed strategies. The convergence analysis of MULTIGLODS, a generalization of GLODS to multiobjective derivative-free optimization, is going to be analyzed when considering the imposition of a sufficient decrease condition as globalization strategy. A numerical implementation will be developed and numerically tested. The development of derivative-free algorithms for noisy optimization will continue, by establishing the convergence of the most numerically promising versions of the algorithms proposed. Additionally, strategies for estimating the level of noisy during the course of the optimization will be addressed.

**M.I. Gomes:** The model developed for the design of sustainable supply chains will be applied to (at least) one company. We envisage that new constraints will be added to the model so that it will reflect this particular reality. Pursue the work on the modelling of the homecare problem started in 2014. I plan to finish a first formulation that models the problem of a social assistant in charge of the homecare assistance service of a Portuguese parish. This model can be viewed as a weekly “vehicle” routing problem where patients have to be visited by the same nurse team during the planning period. Each team is composed by two nurses that should change on a weekly basis. Therefore a second problem of combinatorial nature has to be tackled.

**G. Gonçalves:** The study of a water distribution network design problem for irrigation purposes will be continued. This problem was modeled as a MINLP involving bilinear and concave terms. Bounding problems will be defined by considering piecewise-linear underestimators of these nonconvex terms.

**G. Gonçalves** and **L. Lourenço:** Develop and compare from a theoretical and practical point of view different mixed integer linear formulations for the clustering with fixed cardinality constraints problem. Extend the study to the densest clustering with fixed cardinality constraints problem.

**R. Rodrigues:** The plan for 2015 is to continue the research in pattern recognition applied to biomedical signs and big data.

**M.V.C. Vieira:** For 2015, I plan to enhance the techniques developed during 2014, for the Facility layout problem. This is expected to be done by changing the barrier function used in the first model, and using different techniques to use the solution of the first model in order to obtain an improved second model.

### 3.10 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 modeling of supply chain following previous work [CPBN12], (3) the modeling of sources of supply chain uncertainty by stochastic formulation with the development of decomposition based solution strategies as previous work follow up [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 modeling of multi-compartment vehicles and periodic issues intrinsic to collection problems, and on the dial-a-ride problem arising within the context of medical services. RPS will, in particular, focus on (1) the formulation of new variants for the resource constrained project scheduling problem with flexible resources following the previous work, (2) the tailoring of solution procedures to improve the quality of obtained feasible solutions.

The group will develop a PhD 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**

*The researchers in the Statistics and Risk Management group carry out their research mainly in the themes "Statistical Inference in Linear Models, in Generalized Models and in Diffusion Models", "Distribution Theory", "Extreme Value Theory", and "Actuarial and Financial Mathematics"; a substantial number of papers considers models for real world problems and in some cases applications of the models studied to real data situations. Some examples of applied studies are in "Forest and Droughts Management", "Genetics and Bio-Medical Studies" and "Credit Risk Management". The main goal of the group is the consolidation of high level research, with strong and steady internationalization of the team members; external funding of research projects in the main themes; enlarged collaboration with industry and other non-academic institutional partners.*

### Highlights

- More than 40 international publications; half of them indexed at WoS.
- 9 publications at WoS results from collaboration among team members,
- Carlos Agra Coelho and Miguel Brás de Cravalho became Elected Members of the International Statistical Institute.
- One new member will join the group in 2015.

## **4.1 Team**

### **4.1.1 Integrated Members**

1. João Tiago Praça Nunes Mexia
2. Carlos Manuel Agra Coelho
3. Manuel Leote Tavares Ingles Esquivel
4. Ayana Maria Xavier Furtado Mateus
5. Carla Maria Lopes da Silva Afonso dos Santos
6. Célia Maria da Silva Fernandes
7. Dora Susana Raposo Prata Gomes
8. Elsa Estevão Fachadas Nunes Moreira
9. Filipe José Gonçalves Pereira Marques
10. Francisco Paulo Vilhena Antunes Bernardino Carvalho
11. Frederico Almeida Gião Gonçalves Caeiro
12. João Filipe Lita da Silva
13. Luís Pedro Carneiro Ramos
14. Maria de Lourdes Belchior Afonso
15. Marta Cristina Vieira Faias Mateus
16. Miguel dos Santos Fonseca
17. Paulo Jorge Canas Rodrigues
18. Paulo José Raimundo Ramos
19. Pedro José dos Santos Palhinhos Mota
20. Ricardo Jorge Viegas Covas

21. Rui Manuel Rodrigues Cardoso
22. Vanda Marisa da Rosa Milheiro Lourenço
23. Dina Maria Morgado Salvador
24. João Beleza Teixeira Seixas e Sousa
25. Gracinda Rita Diogo Guerreiro
26. Luís Miguel Lindinho da Cunha Mendes Grilo
27. Inês Jorge da Silva Sequeira
28. José Moniz Lopes Fernandes
29. Gonçalo José Nunes dos Reis
30. Miguel Brás de Carvalho
31. Vera da Conceição Vilelas Montes de Jesus
32. Maria de Fátima Varregoso Miguens

#### **4.1.2 Collaborators**

1. Philippe Laurent Didier
2. Cristina Paula da Silva Dias
3. Carlos Manuel Antunes Veiga
4. Rita Cristina Pinto de Sousa
5. Sandra Cristina Dias Nunes
6. Rui Manuel Pesado Alberto
7. Iola Maria Silvério Pinto
8. Cláudia Vanessa Rosa Leitão de Macedo Roçadas

## 4.2 Projects

### 4.2.1 Projects led by team members

1. **11121186 (Fondecyt, Fondo Nacional de Desarrollo Científico y Tecnológico - Chile):** *Constrained Inference Problems in Extreme Value Modeling*, led by **Miguel de Carvalho** (2012-2015). Total funding: USD 100,000.00 (approx.), CMA funding: €0.
2. **PTDC/MAT-STA/0568/2012:** *Métodos robustos em estatística genética*, led by **Vanda Lourenço**, with participation of **Paulo Canas Rodrigues** (2013-2015). Total funding: €40 000,00, CMA funding: €36 000.00.

### 4.2.2 Projects with the participation of team members

1. **PTDC/GEO-MET/3476/2012:** *Predictability assessment and hybridization of seasonal drought forecasts in western Europe*, led by Carlos Pires (Instituto D. Luis, University of Lisbon), with participation of **Elsa Moreira** (2013-2015). Total funding: €90 000.00, CMA funding: €4 440.00.
2. **PTDC/EPH-HIS/3697/2012:** *Population and Empire. Demographics and statistical processes in Portuguese overseas, 1776-1875*, led by Paulo Matos (FCSH/UNL), with participation of **Miguel Fonseca** (2013-2015). Total funding: €75 929.00, CMA funding: €0.
3. **539872-LLP-1-2013-1-IT-COMENIUS-CMP:** *Mathematics in the Making-Mima*, led by Emmanuela Ughi, Università degli Studi di Perugia (Italy), with participation of **Gracinda Guerreiro** (2013-2015). Total funding: €369 851.00, UNL funding: €54 537.00.
4. **ECO2012-38860-C02-01:** *Competencia, Cooperación y Negociación en la Formación de Precios*, led by Emma Moreno-García, Universidad de Salamanca (Spain), with participation of **Marta Faias** (2013-2015). Total funding: €15 000.00. CMA funding: €1 000.00.

### 4.3 Achievements

**Ayana Mateus:** The research in 2014 was focused in the study of non-parametric randomness tests based on the sign of the difference of observations. As a consequence an R package with several nonparametric randomness tests was developed, namely *randtests*. The main results were published in two peer reviewed conference proceedings.

**Carla Santos:** Participation in scientific research groups. Promotion of Mathematics and its Applications among students of the Polytechnic Institute of Beja and high school students.

**Carlos Agra Coelho and Filipe Marques:** In 2014 were concluded the studies on the exact distributions and developed near-exact distributions for a number of likelihood ratio statistics used with complex normal random variables and which may find applications in a wide range of areas, from satellite image to time series studies, with the concomitant acceptance and publication of a number of papers. Some of the tests studied already address the study and test of somehow elaborate covariance structures for complex random variables.

**Dora Gomes:** When modeling extreme events there are a few primordial parameters, among which we refer the extreme value index and the extremal index. Choosing some well-known estimators of those two parameters I revisit the application of a heuristic algorithm for the adaptive choice of  $k$ . A simulation study was published, illustrating the performance and a procedure that allows not only to obtain more stable estimators for the extremal index but also enables the development of reduced bias estimators. In a further publication, a general method for estimating the optimal block size for resampling in situation of dependence was used in a simulation study for estimating the extremal index.

**Elsa Moreira:** Improvements in the loglinear modeling of drought class transitions were made, namely testing the introduction of new categories in the contingency tables, one representing the state of the atmospheric circulation regime, like NAO and AO and another representing the period of the year, i.e., the wet and dry seasons. Several alternative loglinear models were tested in order to obtain the best goodness of fit as well as the forecasting

skill for one ( $t + 1$ ), two ( $t + 2$ ) and more ( $t + k$ ) step transitions.

**Frederico Caeiro:** I have fulfilled my objective of working on threshold selection and published one proceeding and a preprint (already submitted). I was also able to work on randomness tests and in the estimation of parameters of Pareto type models.

**Gonçalo dos Reis:** Obtained a permanent position and am now supervising a PhD student. Research was slower than expected. Published one article in a high level journal and encountered problems (elevated review times) with the second article on the Skorohod embedding problem.

**Gracinda Guerreiro, Maria de Fátima Miguens and João Tiago Mexia:** We published the works on Statistical approach to Bonus Malus Systems.

**Gracinda Guerreiro, Manuel Esquível and José M. Fernandes:** We published the works about Asymptotic behaviour of Stochastic Vortices model with applications to Credit Consumption Risk using real data from a Cape Verde Bank.

**Gracinda Guerreiro, Rui Cardoso and Maria de Lourdes Afonso:** The work on modeling the spread on a consumption credit portfolio has been accepted for publication. We extended the model to calculate the ruin probability in a motor insurance portfolio with a bonus malus system with an open portfolio. Joint work with Alfredo D. Egídio dos Reis.

**Inês Sequeira:** Fragile sites (FSs) are preferential targets for some viruses as Hepatitis B, yet it is still not clear if they are a target for Human Immunodeficiency Virus (HIV). This retrovirus needs to integrate its genome in human host to complete its life cycle. Thus, using integration positions from HIV isolated from different cell types we aimed to study HIV integration preferences in FSs and in Giemsa bands. The results of the application of the statistical methods, namely two non-parametric tests and ANOVA led us to conclude that HIV-1 isolated from Peripheral Mononuclear Blood Cells (PBMCs) integrates more in Giemsa light bands and in non-fragile regions (NFRs). HIV-2 isolated from PBMCs and HIV-1 isolated from Jurkat T cells integrates with equal intensity in fragile regions (FRs) and in NFRs. We observe that the results for HIV-1 are different from the results for HIV-2, either in Giemsa bands and in FSs, which could be related to differences between these two types of viruses. The results were submitted in 1 paper.

**João Beleza Sousa:** Proceed the research topic "Bonds Historical Simulation Value at Risk" so that statistical tests to single bonds confirmed the validity of the proposed method.

**Luis Grilo:** We continued to study the near-exact distributions for the statistic used to test the real character of the entries of a covariance matrix in a complex normal distribution. Some studies were also realized in Computational Statistics and Applied Statistics in engineering (using individual and moving range control charts) and health (comparison analysis based on Bland-Altman's nonparametric approach of limits of agreement) with real data.

**João Lita da Silva:** Some strong consistency results in stochastic regression models were achieved which allowed us to study also the strong consistency of ridge estimates in ridge regression models, resulting in two publications.

**Manuel Esquível, Pedro P. Mota and João Tiago Mexia:** In the theme of statistical models we finished the paper "On some Statistical Models with a Random Number of Observations", currently under revision.

**Manuel Esquível and Pedro P. Mota:** In the theme of evaluation of regime switching models we submitted a paper named "Model Selection for Stock Prices Data".

**Manuel Esquível:** In the subject of teaching methods for PDE we submitted a paper "Synthesis of Fast Convergence Series Solutions of the Transient Heat Diffusion Equation, using the Superposition Principle", with Carlos Dias.

**Marta Faias:** In the context of endogenous formation of trading markets we considered a simple model where two possible exchanges can be formed. One exchange can gather and disclose information about the per capita supply of securities by incurring a fixed cost. We showed that the pre-trade transparent exchange is more likely to form, the lower the cost to gather and reveal information, the more liquid the market, and the greater is the uncertainty about the per capita supply of the security. We stated a game with incomplete information where firms compete in prices. We assumed that residual demands are continuous and we elaborated on consumers' behavior that ensures such a continuity property. We showed existence of equilibrium in distributional strategies and we also prove that there exists an approximate



equilibrium in pure strategies.

**Miguel Brás de Carvalho:** The two main achievements in 2014 were the publication of an important paper on nonstationary dependence structures for multivariate extremes, and concluding some of the chapters for a book on Bayesian modeling of diagnostic data (to be published in 2015). Some chapters have been used to lecture a short course at CEAUL, University of Lisbon.

**Miguel Fonseca:** Results on algebraic properties of linear mixed models and on inference with constraints for linear models. Derivation of robust inference methods for mixed models on genetic data.

**Pedro Mota:** We studied stochastic models with regimes, useful for the characterization of price evolution of stocks, by dividing the phase space in two regions and considering that the solution process follows, in each region, a different diffusion. For these models the regime switching occurred, by a change in the diffusion drift and volatility. We developed practical and well behaved procedures for the estimation of all the parameters of the models (diffusion parameters for the two regimes, threshold and delay) in the particular case in which the SDE defining the diffusion, in each region, corresponds to a geometric Brownian motion SDE.

**Rui Cardoso:** In a joint work with Alfredo D. Egídio dos Reis and Eugenio V. Rodríguez, we extended some results for Renewal Risk Insurance Model and the Sparre-Anderson Risk Model.

**Sandra Dias Nunes:** In 2014 I managed to increase knowledge on extreme value theory which allowed me to propose some articles. A few are already published, other were accepted for publication and other are submitted.

**Vanda Lourenço:** Under the scope of the project (ROBSTATGEN) a paper was published regarding the first task of the project. A student and a post-doctoral researcher were hired. The research resulted in the publication of a proceedings paper and in the submission of a second one. The pos-doc built up on already previous R code. He also completed the implementation of a robust plug-in method that will be used in the R package to be developed in this project. Additionally, research results were presented in several international conferences and two seminars on robust statistics with application to

genetics were given (one in Brazil at UFBA and another at the now IST-UL).

## 4.4 Publications

### 4.4.1 Publications in Web of Science journals

- [1] **V. M. Lourenco** and A. M. Pires. M-regression, false discovery rates and outlier detection with application to genetic association studies. *Comput. Stat. Data Anal.*, 78:33–42, 2014.
- [2] **Paulo C. Rodrigues, Elsa E. Moreira**, Vera M. Jesus, and **Joao T. Mexia**. Structured orthogonal families of one and two strata prime basis factorial models. *Stat. Pap.*, 55(3):603–614, 2014.
- [3] **Paulo C. Rodrigues**, Marcos Malosetti, Hugh G. Gauch, Jr., and Fred A. van Eeuwijk. A weighted ammi algorithm to study genotype-by-environment interaction and qtl-by-environment interaction. *Crop Sci.*, 54(4):1555–1570, 2014.
- [4] **Joao Lita da Silva** and **Luis Pedro Ramos**. Uniform approximations for distributions of continuous random variables with application in dual statis method. *REVSTAT-Stat. J.*, 12(2):101–118, 2014.
- [5] **Carlos A. Coelho** and Barry C. Arnold. On the exact and near-exact distributions of the product of generalized gamma random variables and the generalized variance. *Commun. Stat.-Theory Methods*, 43(10-12, SI):2007–2033, 2014.
- [6] **Joao Lita da Silva**. On sufficient conditions for the strong consistency of least-squares estimates. *Statistics*, 48(3):657–667, 2014.
- [7] **Rui M. R. Cardoso**. Dividends in finite time horizon. *Appl. Stoch. Models. Bus. Ind.*, 30(2):172–182, 2014.
- [8] **Joao Lita da Silva** and **Luis Pedro Ramos**. On the rate of convergence of uniform approximations for sequences of distribution functions. *J. Korean Stat. Soc.*, 43(1):47–65, 2014.

- [9] **Frederico Caeiro**, M. Ivette Gomes, and Bjoern Vandewalle. Semi-parametric probability-weighted moments estimation revisited. *Methodol. Comput. Appl. Probab.*, 16(1):1-29, 2014.
- [10] **Manuel L. Esquivel**, **Joao Lita Da Silva**, **Joao Tiago Mexia**, and **Luis Ramos**. The rate of convergence of some asymptotic expansions for distribution approximations via an esseen type estimate. *Commun. Stat.-Theory Methods*, 43(2):266-290, 2014.
- [11] **Dora Prata Gomes** and Manuela Neves. Exploring r for modeling spatial extreme precipitation data. In TE Simos, Z Kalogiratou, and T Monovasilis, editors, *INTERNATIONAL CONFERENCE OF COMPUTATIONAL METHODS IN SCIENCES AND ENGINEERING 2014 (ICCMSE 2014)*, volume 1618 of *AIP Conference Proceedings*, pages 547-550, 2014.
- [12] **Gracinda Rita Guerreiro**, **Joao Tiago Mexia**, and **Maria de Fátima Miguens**. Statistical approach for open bonus malus. *Astin Bull.*, 44(1):63-83, 2014.
- [13] **Celia Nunes**, **Dario Ferreira**, **Sandra S. Ferreira**, and **Joao T. Mexia**. Fixed effects anova: an extension to samples with random size. *J. Stat. Comput. Simul.*, 84(11):2316-2328, 2014.
- [14] **Pedro P. Mota** and **Manuel L. Esquivel**. On a continuous time stock price model with regime switching, delay, and threshold. *Quant. Financ.*, 14(8, SI):1479-1488, 2014.
- [15] **Manuel L. Esquivel**, **Jose M. Fernandes**, and **Gracinda R. Guerreiro**. On the evolution and asymptotic analysis of open markov populations: Application to consumption credit. *Stoch. Models*, 30(3):365-389, 2014.
- [16] **Miguel de Carvalho** and Antonio Rua. Extremal dependence in international output growth: Tales from the tails. *Oxf. Bull. Econ. Stat.*, 76(4):605-620, 2014.
- [17] **Joao Lita da Silva**. Some strong consistency results in stochastic regression. *J. Multivar. Anal.*, 129:220-226, 2014.

- [18] **Miguel de Carvalho** and Anthony C. avison. Spectral density ratio models for multivariate extremes. *J. Am. Stat. Assoc.*, 109(506):764–776, 2014.
- [19] **Joao Lita da Silva**. Strong consistency of least squares estimates in multiple regression models with random regressors. *Metrika*, 77(3):361–375, 2014.
- [20] Nursel Koyuncu, Sat Gupta, and **Rita Sousa**. Exponential-type estimators of the mean of a sensitive variable in the presence of nonsensitive auxiliary information. *Commun. Stat.-Simul. Comput.*, 43(7):1583–1594, 2014.
- [21] **Frederico Caeiro**, **Ayana Mateus**, and **Luis Ramos**. Extreme value analysis of the sea levels in venice. In TE Simos and C Tsitouras, editors, *PROCEEDINGS OF THE INTERNATIONAL CONFERENCE OF NUMERICAL ANALYSIS AND APPLIED MATHEMATICS 2014 (ICNAAM-2014)*, volume 1648 of *AIP Conference Proceedings*, 2015.
- [22] **Filipe J. Marques** and **Carlos A. Coelho**. A note on the distribution of the linear combination of independent gamma random variables. In TE Simos, Z Kalogiratou, and T Monovasilis, editors, *INTERNATIONAL CONFERENCE OF COMPUTATIONAL METHODS IN SCIENCES AND ENGINEERING 2014 (ICCMSE 2014)*, volume 1618 of *AIP Conference Proceedings*, pages 527–530, 2014.
- [23] **Ayana Mateus** and **Frederico Caeiro**. An r implementation of several randomness tests. In TE Simos, Z Kalogiratou, and T Monovasilis, editors, *INTERNATIONAL CONFERENCE OF COMPUTATIONAL METHODS IN SCIENCES AND ENGINEERING 2014 (ICCMSE 2014)*, volume 1618 of *AIP Conference Proceedings*, pages 531–534, 2014.
- [24] **Luis M. Grilo**, Dina M. R. Mateus, Ana C. Alves, and Helena L. Grilo. Robust control charts in industrial production of olive oil. In TE Simos, Z Kalogiratou, and T Monovasilis, editors, *INTERNATIONAL CONFERENCE OF COMPUTATIONAL METHODS IN SCIENCES AND ENGINEERING 2014 (ICCMSE 2014)*, volume 1618 of *AIP Conference Proceedings*, pages 539–542, 2014.

- [25] **Frederico Caeiro** and M. Ivette Gomes. Comparison of asymptotically unbiased extreme value index estimators: a monte carlo simulation study. In TE Simos, Z Kalogiratou, and T Monovasilis, editors, *INTERNATIONAL CONFERENCE OF COMPUTATIONAL METHODS IN SCIENCES AND ENGINEERING 2014 (ICCMSE 2014)*, volume 1618 of *AIP Conference Proceedings*, pages 551-554, 2014.

#### 4.4.2 Other publications in peer-reviewed journals

- [1] **C. Fernandes**, **P. Ramos** and **J. Mexia**, Algebraic structure for the crossing of balanced and stair nested designs, *Discussiones Mathematicae Probability and Statistics*, Vol. 1-2, N° 34, pp. 71-88, December 2014.
- [2] **M. Faias**, E. Moreno-García and M. Wooders: A strategic market game approach for the private provision of public goods. *Journal of Dynamics and Games* 1(2), 283-298 (2014).
- [3] **M. Esquível** and **P. Mota** On Some Auto-Induced Regime Switching Double-Threshold Glued Diffusions, *Journal of Statistical Theory and Practice*, Taylor & Francis, Volume 8, Issue 4, pp.760-771 (2014).
- [4] J. Paderewski and **P. C. Rodrigues**. The usefulness of EM-AMMI to study the influence of missing data pattern and application to Polish post-registration winter wheat data. *Australian Journal of Crop Science* 8:640-645 (2014).

#### 4.4.3 Other (international) publications

1. **F. Caeiro** and M. I. Gomes, A semi-parametric estimator of a shape second order parameter, In Pacheco, A., Santos, R., Rosário Oliveira, M. and Paulino, C.D. (Eds.), *New Advances in Statistical Modeling and Applications*, *Studies in Theoretical and Applied Statistics*, 137-144, 2014.
2. **F. Caeiro**. Preface of the “Symposium on computational statistical methods”. In T. E. Simos, Z. Kalogiratou and T. Monovasilis (eds.), *AIP Conf. Proc. 1618 (ICCMSE 2014)*, 521-522 (2014).

3. **F. Caeiro** and M. I. Gomes. On the bootstrap methodology for the estimation of the tail sample fraction. In Gilli, M., Gonzalez-Rodriguez, G. and Nieto-Reyes, A. (Eds.), Proceedings of COMPSTAT 2014: 21th International Conference on Computational Statistics, 545-552 (2014).
4. M. I. Gomes and **F. Caeiro**. Efficiency of partially reduced-bias mean-of-order-p versus minimum-variance reduced-bias extreme value index estimation. In Gilli, M., Gonzalez-Rodriguez, G. and Nieto-Reyes, A. (Eds.), Proceedings of COMPSTAT 2014: 21th International Conference on Computational Statistics, 289-298 (2014).
5. **C. A. Coelho**. Near-exact distributions - what are they and why do we need them? Proceedings 59th ISI World Congress, Session STS084, 2879-2884 (2014).
6. **Carlos A. Coelho** and **Filipe J. Marques**. A double decomposition of the test of independence of sets of variables that allows for a modeling view of this test, Mathematics and Computers in Science and Engineering Series, Vol. 33, 13-19 (2014).
7. **M. Faias** and A. Seghir: Collateral versus default history - 1st volume CIM-MPE: Dynamics, Games and Science - International Conference and Advanced School Planet Earth DGS II, accepted (Junho 2014).
8. H. Penalva, **S. Nunes** and M. Neves. Statistical Modeling and Inference in Extremes: Applications with R. In Biometrie und Medizinische Informatik - Greifswalder Seminarberichte - Statistical and Biometrical Challenges - Theory and Applications, Shaker - Verlag, No.23, pp. 281-309 (2014).
9. **P. C. Rodrigues**, A. Monteiro and **V. M. Lourenço**. New insights into the usefulness of robust singular value decomposition in statistical genetics. Proceedings of COMPSTAT 2014, 21st International Conference on Computational Statistics, 53-59 (2014).
10. **J. Beleza Sousa**, **Manuel L. Esquível**, Raquel Medeiros Gaspar and P. Corte Real, Historical VaR for Bonds - a new Approach. Proceedings of the 8th Finance Conference of the Portuguese Finance Network. Pgs. 1951-

1970. Edited by Luís Coelho and Rúben Peixinho, ISBN 978-989-20-4584, Portuga (2014)l.

11. **J. Beleza Sousa, Manuel L. Esquível** and Raquel Medeiros Gaspar. One Factor Machine Learning Gaussian Short Rate, Proceedings of the 8th Finance Conference of the Portuguese Finance Network. Pgs. 2750-2770. Edited by Luís Coelho and Rúben Peixinho, ISBN 978-989-20-4584, Portugal (2014).

#### 4.4.4 Other national publications

1. C. Cardoso, **S. Nunes** e T. Alves (2014). Riscos de corrupção e infracção conexas: o caso dos institutos politécnicos portugueses. Na Revista Contemporânea de Contabilidade, UFSC, Florianópolis, Brasil, Vol. 11, No.24, pp. 143-169.
2. H. Penalva, **S. Nunes**, M. Neves. (2014). Estimação paramétrica e semi-paramétrica do índice de cauda utilizando o R. No Livro de Resumos das XXI Jornadas de Classificação e Análise de Dados (JOCLAD2014), pp. 199-202.
3. P. Oliveira, J. Cunha, J. Alves, L. Carvalho, R. Carvalho, F. Correia, L. Farinha, J. Fernandes, M. Ferreira, E. Lucas, J. Mourato, A. Nicolau, **S. Nunes**, C. Pereira, S. Pinto and J. M. Silva. (2014). Polytechnic Institutes Impact on Local Economy: a common framework analysis of seven institutions in Portugal. In Abstract Book of SMSW'14 - Statistics and Mathematical Sciences Workshop, pp. 37.
4. M. I. Gomes, **F. Caeiro**, Henriques-Rodrigues, L. and Manjunath, B.G. (2014). Bootstrap Methods in Statistics of Extremes. Notas e Comunicações 03/14, CEAUL.
5. M. I. Gomes, **F. Caeiro** (2014). Threshold Selection in Extreme Value Analysis. Notas e Comunicações 07/14, CEAUL.

#### 4.4.5 Accepted papers

1. A. Areia, **F. Carvalho, J. T. Mexia**. Complete and sufficient statistics and perfect families in orthogonal and error orthogonal normal models. *Open Mathematics*, 13 (1), 135-140 (2015).
2. **João Lita Da Silva, João Tiago Mexia, Luís Pedro Ramos**. On the Strong Consistency of Ridge Estimates. *Communications in Statistics - Theory and Methods*. Volume 44(3): 617-626 (2015).
3. **Luís P. Ramos, Pedro P. Mota and João T. Mexia**. Sample Partitioning Estimation for Ergodic Diffusions. *Communications in Statistics - Simulation and Computation*, Volume 44(1): 105-117 (2015).
4. **F. J. Marques, C. A. Coelho**. Near-exact Distributions for the Likelihood Ratio Test Statistic for Testing Multi-Sample Independence The Real and Complex Cases, *Journal of Statistical Theory and Practice*, 9, 1, 37-58 (2015).
5. **F. Caeiro** and M. I. Gomes, Revisiting the maximum likelihood estimation of a positive extreme value index. *Journal of Statistical Theory and Practice*, 9(1), 200-218, 2015.
6. **F. Carvalho, J. T. Mexia, C. Santos** and C. Nunes. Inference for types and structured families of commutative orthogonal block structures . *Metrika*.
7. **F. Caeiro**, A. Martins and **I. Sequeira**. Finite sample behaviour of Classical and Quantile Regression Estimators for the Pareto distribution. In *AIP Conference Proceeding*.
8. M. I. Gomes, M. F. Brilhante, **F. Caeiro** e D. Pestana. A New Partially reduced-bias Mean-of-order  $p$  Class of Extreme Value Index Estimators. *Computational Statistics & Data Analysis*, 82, 223-237 (2015).
9. Roman Zmyślony, **João T. Mexia, Francisco Carvalho, Inês J. Sequeira**. Mean driven balance and uniformly best linear unbiased estimators. *Statistical Papers*.



10. **F. J. Marques, C. A. Coelho, M. de Carvalho.** On the distribution of linear combinations of independent Gumbel random variables, *Statistics and Computing*.
11. **P. Ramos, C. Fernandes, and J. Mexia.** Algebraic structure for interaction on mixed models, *Journal of Interdisciplinary Mathematics*.
12. **C. A. Coelho, F. J. Marques,** B. C. Arnold. The exact and near-exact distributions of the main likelihood ratio test statistics used in the complex multivariate normal setting, *Test*.
13. **F. J. Marques, C. A. Coelho.** The sphericity versus equivariance-equicorrelation test, *AIP Conference Proceedings*
14. **C. A. Coelho, F. J. Marques, R. P. Alberto.** On sharp and highly manageable asymptotic approximations for instances of the Meijer G function, *AIP Conference Proceedings*
15. E. V. Rodríguez-Martínez, **R. M. Cardoso,** and A. D. Egídio dos Reis, Some Advances on the Erlang(n) Dual Risk Model, *ASTIN Bulletin*.
16. **F. Caeiro,** M. I. Gomes and L. Henriques-Rodrigues, A Location Invariant Probability Weighted Moment EVI-Estimator. *International Journal of Computer Mathematics*, in press.
17. **F. Caeiro** and M. I. Gomes, Bias Reduction in the Estimation of a Shape Second-order Parameter of a Heavy Tail Model. *Journal of Statistical Computation and Simulation*, in press.
18. M. M. Neves, M. I. Gomes, F. Figueiredo, and **D. Prata Gomes.** Modeling Extreme Events: Sample Fraction Adaptive Choice in Parameter Estimation. *J. Stat.Theory Pract.*,
19. **D. Prata Gomes,** and M. M. Neves. Bootstrap and other resampling methodologies in statistics of extremes. *Communications in Statistics - Simulation and Computation*.
20. **N. Carvalho,** L. Carvalho, and **S. Nunes.** A methodology to measure innovation in European Union through the National Innovation System. In *International Journal of Innovation and Regional Development*.

21. A. Lionet, **G. dos Reis** and L. Szpruch, Time discretization of FBSDE with polynomial growth drivers and reaction-diffusion PDEs, To appear in *Annals of Applied Probability (AAP)*,
22. A. Pereira, **M. Fonseca, J. T. Mexia**. Orthogonal Models: Algebraic structure and explicit estimators for estimable vectors. Accepted for publication in *Discussiones Mathematicae*, 2014.
23. **J. Beleza Sousa, M. L. Esquivel** and Raquel Medeiros Gaspar Brownian Bridge and other Path Dependent Gaussian Processes Vectorial Simulation. , revised second version, to appear in *Communications in Statistics - Simulation and Computation*.
24. **M. Fonseca**, B. K. Sinha, **J. T. Mexia**, Zmyslony, Roman. Likelihood ratio tests in linear models with linear inequality. Accepted for publication in *REVSTAT*, 2014
25. **E. E. Moreira**, D. S. Martins, L. S. Pereira, Assessing drought cycles in SPI time series using a Fourier analysis. *Nat. Hazards Earth Syst. Sci.* (Impact Factor 2013: 1.826).
26. **L. M. Grilo**, R. S. Henriques, P. C. Correia and L. H. Grilo. Attention deficit/hyperactivity disorder in children. A statistical approach. 12th International Conference of Numerical Analysis and Applied Mathematics (ICNAAM 2014), AIP (American Institute of Physics) Conference Proceedings.
27. C. Nunes, G. Capistrano, D. Ferreira, **S.S. Ferreira, J. T. Mexia**. One-way Fixed Effects ANOVA with Missing Observations, in AIP Conf. Proc. 12th International Conference on Numerical Analysis and Applied Mathematics, Rodos Palace Hotel, Rhodes, Greece, 22-28 September. To appear.
28. G. Capistrano, C. Nunes, D. Ferreira, **S.S. Ferreira, J. T. Mexia**. One-way Random Effects ANOVA with Random Sample Sizes: An Application to a Brazilian Database on Cancer Registries, in AIP Conf. Proc. 12th International Conference on Numerical Analysis and Applied Mathematics, Rodos Palace Hotel, Rhodes, Greece, 22-28 September. To appear.

29. **F. Carvalho, R. Covas**. B-matrices and its applications to linear models. AIP Conf. Proc. Numerical Analysis and Applied Mathematics: International Conference of Numerical Analysis and Applied Mathematics, 22-28 September 2014.
30. D. Ferreira, S.S. Ferreira, C. Nunes, **J. T. Mexia**. Estimation of variance components in normal linear mixed models with additivity, in AIP Conf. Proc. 12th International Conference on Numerical Analysis and Applied Mathematics, Rodos Palace Hotel, Rhodes, Greece, 22-28 September. To appear.
31. Aníbal Areia, **Francisco Carvalho, João T. Mexia**. Influence of Cancer Location, Sex and Country on the Death Age, in AIP Conf. Proc. 12th International Conference on Numerical Analysis and Applied Mathematics, Rodos Palace Hotel, Rhodes, Greece, 22-28 September. To appear.
32. **L. M. Grilo** and H. H. Grilo. Individual and moving range control charts in the production of olive oil. 12th International Conference of Numerical Analysis and Applied Mathematics (ICNAAM 2014), AIP (American Institute of Physics) Conference Proceedings.
33. **L. M. Grilo**, H. L. Grilo and C. J. Marques. Industrial production of gypsum: quality control charts. Risk Assessment Challenges: Theory and Practice, "Springer Proceedings in Mathematics and Statistics" - Christos, Teresa Oliveira, Alex Rigas and Sneh Gulati (2014).
34. H. Penalva, **S. Nunes** e M. Neves. Estimação do índice de valores extremos em ambiente R – as abordagens paramétricas e semi-paramétricas. Nas Actas do XXI Congresso da Sociedade Portuguesa de Estatística (2014).
35. **F. Caeiro** and **D. Prata Gomes**. A Log Probability Weighted Moment Estimator of Extreme Quantiles. arXiv:1401.3383 [stat.ME]. Accepted in Risk Assessment Challenges: Theory and Practice, Springer Proceedings in Mathematics and Statistics, Springer (2014).
36. M. I. Gomes, **F. Caeiro** and F. Figueiredo: A New Value-at-Risk Semi-parametric Estimation Procedure. Accepted in a Book Series devoted to SMTDA2014.

37. **D. Prata Gomes** and M. M. Neves. Adaptive choice and resampling techniques in extremal index estimation. In Kitsos, C., Oliveira, T., Rigas, A. and Gulati, S. eds.), Theory and Practice of Risk Assessment, Springer Proceedings in Mathematics and Statistics.
38. **D. Prata Gomes** and M. M. Neves Computer intensive methods for improving the extremal index estimation. In AIP Conf. Proc. (2014).
39. **Manuel L. Esquível, Gracinda R. Guerreiro, José Moniz Fernandes** and Ana Filipa Silva. On a Spread Model for Portfolio Credit Risk Modeling, (To appear in the AIP Conference Proceedings of ICNAAM 2014).

#### 4.4.6 Submitted papers

1. **C. Nunes**, D. Ferreira, S. Ferreira, **E. Moreira**, **J. T. Mexia**. Mixed models a with random sample sizes.
2. J. Gonçalves, **E. Moreira**, **I. Sequeira**, J. Rueff, A. Brás. Integration of HIV in the human genome – which sites are preferential? A genetic and statistical assessment.
3. **P. C. Rodrigues**, **V. M. Lourenço** and Monteiro (2015). A Robust additive main effects and multiplicative interaction model for the analysis of genotype-by-environment data.
4. **L. Afonso** and P. Corte Real. Using Weighted Distributions to Model Operational Risk (Jul-2014).
5. H. Oberhauser and **G. dos Reis**, Root's barrier, viscosity solutions of obstacle problems and reflected FBSDEs.

#### 4.4.7 Editing and authorship of books and journals (international)

**Luis Grilo**: Member of Editorial Board of Asian Journal of Mathematics and Computer Research, since November 2014; Academic Editor of British Journal of Mathematics & Computer Science.

**Carlos Agra Coelho:** Associate Editor of Journal of Statistical Theory and Practice (publ. by Taylor & Francis); : Associate Editor of Journal of Interdisciplinary Mathematics (publ. by Taylor & Francis); Member of the Editorial Board of American Journal of Mathematical and Management Sciences (publ. by Taylor & Francis); Member of the Editorial Board of *Discussiones Mathematicae - Probability and Statistics* (publ. by University of Zielona Gora).

**Francisco Carvalho:** Member of the Editorial Board of the Journal of Mathematics and Statistics (2011 - )

**Ricardo Covas:** Member of the Editorial Board of the Journal of Mathematics and Statistics (2011 - )

**Rui Cardoso:** Associate Editor of European Actuarial Journal

#### 4.4.8 Report

1. J. Bravo, **G. Guerreiro, M. L. Afonso.** Avaliação Actuarial do Sistema Previdencial da Segurança Social, Official Government Report 2014 (Confidential).

### 4.5 Seminars

**9 April:** *Orthogonal Combination of Homocedastic Models: Estimation.*, João Tiago Mexia, CMA/FCT/UNL, Portugal

**7 May:** *Statistics of univariate extremes: an overview and some recent advances*, Frederico Caeiro, CMA/FCT/UNL, Portugal

**21 May:** *High quantile estimation and spatial aggregation applied to precipitation extremes*, Ana Ferreira, CEAUL - U. Lisboa, Portugal

**9 June:** *Functional partial area under the curve regression: a metabolic syndrome case study*, Vanda Inácio, Pontificia Universidad Católica de Chile, Chile

**9 June:** *Bayesian Nonparametric Youden Index Modeling*, Miguel de Carvalho, Pontificia Universidad Católica de Chile and CMA/FCT/UNL, Portugal/Chile

**19 June:** *An Application on an Order Statistics Based Distribution-Free Control Charts*, Senem Sahan Vahaplar, Dokuz Eylül University, Turkey

**1 August:** *Some Aspects of Data Analysis under Confidentiality Protection*, Bimal Sinha, UMBC & Senior Research Fellow – Center for Disclosure Avoidance Research – US Census Bureau, USA

**8 October:** *Arquitectura do Modelo de Asset Liability Management*, Vanessa Silva, Banco Privado Atlântico Europa, Portugal

**15 October:** *Construção das Tábuas de Mortalidades: Aplicação aos dados de Moçambique*, Vasco Chimenes, Master Student - DM/FCT/UNL, Portugal

**12 November:** *Parameter Estimation for the Jones and Faddy's Skew  $t$  Distribution based on Type II Censored Samples*, Talha Arslan, Department of Statistics - Eskisehir Osmangazi University, Turkey

**10 December:** *From throwing dices to options trading?*, Christopher Claude, BNP Paribas, Portugal

## 4.6 Internationalization

From November 29 to December 6, 2014 **Filipe Marques** was a visiting professor of the Department of Statistics of the University of Pretoria, South Africa.

From November 17 to 21, 2014 **Manuel L. Esquível** was a visiting professor of the Department of Sciences and Technologies of the University of Cape Verde.

In 2014 **Miguel Fonseca** was a Research Visitor at Polish Academy of Sciences, Institute of Mathematics,

**Miguel de Carvalho** has received a visit from J. Wadsworth, from the University of Cambridge and also has visited Professor I. Dryden, at the University of Nottingham, School of Mathematical Sciences, during 11–28 February 2014.

**Marta Faias** works with Professor Emma Moreno-García from Universi-

dade de Salamanca, Spain, Professor Myrna Wooders from Vanderbilt University, USA, Jaime Luque from University of Wisconsin – Madison, USA, Mário Pascoa from University of Surrey, UK and Juan Pablo Torres-Martínez from Universidad de Chile, Chile.

## 4.7 Conferences participation

### 4.7.1 Invited talks at international conferences

1. **Carlos Agra Coelho:** A double decomposition of the test of independence of sets of variables that allows for a modeling view of this test, 16th International Conference on Mathematical Methods, Computational Techniques and Intelligent Systems (MAMECTIS '14) – Lisboa October 30–November 1, 2014 (joint work with Filipe J. Marques).
2. **Francisco Carvalho:** SMSW'14 – Statistics and Mathematical Sciences Workshop, July 7th, 2014, Covilhã (Portugal).
3. **Francisco Carvalho:** 2as Jornadas de Estatística e Computação da Universidade Aberta, June 7th de 2014, Porto de Mós (Portugal). Models with Commutative Orthogonal Block Structure: Inference.
4. **Francisco Carvalho:** WSMC8 – 8th Workshop on Statistics, Mathematics and Computation, March, 12 – 15, 2014, Cidade da Praia (Cabo Verde). Inference for structured families of models with COBS.
5. **Frederico Caeiro:** A Log Probability Weighted Moment Estimator of Extreme Quantiles. Conference on Extreme Events in Finance, Royaumont Abbey - France - December 15, 2014.
6. **Frederico Caeiro:** On the bootstrap methodology for the estimation of the tail sample fraction. COMPSTAT 2014: 21th International Conference on Computational Statistics, 21 Aug. 2014.
7. **Gonçalo dos Reis:** 11th International Conference on Monte Carlo and Quasi-Monte Carlo Methods in Scientific Computing (MCQMC2014), Leuven (Belgium), 6-11 April.

8. **Luís Grilo:** Grilo, L. M. and Grilo, H. L. (2014). Quality control charts in the production of olive oil. 44th International Biometrical Colloquium and IV Polish Portuguese Workshop on Biometry, Kraków, Poland, September 07-10 (p. 17, Abstract book).
9. **Luís Grilo:** Grilo, L. M., Henriques, R. S., Correia, P. C. and Grilo, H. L. (2014). Nonparametric methods to evaluate attention deficit/hyperactivity disorder in children. Workshop on Statistical methods as the tools of inference in natural and social sciences, Poznan, Poland, September 03-06.
10. **Miguel de Carvalho:** II ISNPS (International Society of NonParametric Statistics) Conference, Cadiz, España, 12-16 junio, 2014.
11. **Marta Faias:** V Workshop on Equilibrium Analysis. (Dipartimento di Scienze Economiche e Statistiche, Universit degli Studi di Napoli Federico II, Naples, Italy, 24-25. January, 2014). "Risk diversification across the exchanges with cross-listings"
12. **Marta Faias:** International Conference on Dynamics, Games and Science III (DGS III 2014). (University of Porto, Porto, Portugal, 17-21 February, 2014). (Keynote Speaker.) "Stability in price competition and incomplete information"
13. **Marta Faias:** UECE Lisbon Meetings 2014: Game Theory and Applications. ( Lisboa School of Economics & Management (ISEG)- University of Lisbon (UL), Lisboa, Portugal, 6-8, November, 2014). "On a further neutrality theorem".
14. **Vanda Lourenço:** 11 - 14 June 2014 3rd Stochastic Modeling Techniques and Data Analysis International Conference (SMTDA) Lisboa, Portugal. Talk title: 'A robust coefficient of determination for heritability estimation in genetic association studies'
15. **Vanda Lourenço:** 12 - 15 March 2014 8th Workshop on Statistics, Mathematics and Computation (WSMC8) Praia, Cabo Verde. Talk Title: 'Robust outlier detection in genetic association studies'



16. **João Beleza Sousa**: “Bonds Historical Simulation Value at Risk ”, International Conference on Advances in Interdisciplinary Statistics and Combinatorics, Greensboro NC, EUA, October 10-12 2014.
17. **João Beleza Sousa**: “One Factor Machine learning Gaussian short rate”, 8th Portuguese Finance Network Conference, Vilamoura, June 18-20 2014.

#### 4.7.2 Contributed talk (international)

1. **Ayana Mateus**: An R implementation of several randomness tests, International Conference of Computational Methods In Sciences and Engineering 2014 (ICCMSE-2014).
2. **Ayana Mateus**: Extreme Value Analysis of the sea Levels in Venice, International Conference on Numerical Analysis and Applied Mathematics 2014 (ICNAAM-2014).
3. **Dora Prata Gomes**: Neves, M., Gomes, I., Figueiredo, F. and Prata Gomes, D. Computer Intensive procedures in threshold selection. 7th International Conference of the ERCIM Working Group on Computing and Methodological Statistics (ERCIM 2014), University of Pisa, Italy, 6-8 December 2014.
4. **Dora Prata Gomes**: Prata Gomes, D and Neves, M. Max-Stable Processes. An application to extreme precipitation. I Encontro Luso-Galaico de Estatística em Ambiente e Ecologia (EES2014), Vila Real, 6-8 November 2014.
5. **Dora Prata Gomes**: Prata Gomes, D, Neves, M., Moreira, E. Statistical modeling of spatial extremes: an application to extreme precipitation. 3rd International Conference on Ecohydrology, Soil and Climate Change (EcoHCC'14), Tomar, 10-12 September 2014.
6. **Dora Prata Gomes**: Prata Gomes, D. and Neves, M. Computer intensive methods for improving the extremal index estimation, 12TH INTERNATIONAL CONFERENCE OF NUMERICAL ANALYSIS AND APPLIED MATHEMATICS (ICNAAM 2014), Rhodes, Greece, 22-28 September 2014.

7. **Dora Prata Gomes:** Prata Gomes, D. and Neves, D. Exploring R for modeling spatial extreme precipitation data, INTERNATIONAL CONFERENCE OF COMPUTATIONAL METHODS IN SCIENCES AND ENGINEERING 2014 (ICCMSE 2014), Athens, Greece, April G4-7 2014.
8. **Elsa Moreira:** Moreira Elsa, Pires C., Pereira L.S., SPI Drought class prediction driven by teleconnection indices using loglinear models, Eco-HCC'2014 - International Conference on Ecohydrology Soil and Climate Changes, Tomar, Portugal.
9. **Francisco Carvalho:** International Conference of Numerical Analysis and Applied Mathematics (ICNAAM2014), 22-28 September 2014 (Rhodes, Grécia). Influence of cancer location, sex and country on the death age.
10. **Francisco Carvalho:** Stochastic Modeling Techniques and Data Analysis International Conference, 11-14 June, 2014, Lisboa (Portugal). Estimable vectors and Orthogonal Block Structure.
11. **Francisco Carvalho:** Workshop on Statistics, Mathematics and Computation (WSMC8), 12-15 March, 2014 (Cidade da Praia, Cabo Verde). Inference for structured families of models with Commutative Orthogonal Block Structure.
12. **Francisco Carvalho:** Global Multidisciplinary Academic Meeting, March 27-30 2014 (Cidade da Praia, Cabo Verde). Variance Components Estimation in a k-Way Nested Random Effect Model.
13. **Frederico Caeiro:** Extreme Value Analysis of the Sea Levels in Venice. ICNAAM2014 - 12th International Conference on Numerical Analysis and Applied Mathematics, Rhodes, Greece. September 23rd, 2014.
14. **Frederico Caeiro:** Comparison of Asymptotically Unbiased Extreme Value Index estimators: a Monte Carlo Simulation Study. 10TH INTERNATIONAL CONFERENCE OF COMPUTATIONAL METHODS IN SCIENCES AND ENGINEERING. Athens, Greece, 5th April, 2014.
15. **Filipe Marques:** A Note on the Distribution of the Linear Combination of Independent Gamma Random Variables, ICCMSE 2014, April 4-7, 2014.

16. **Filipe Marques:** The sphericity versus equivariance-equicorrelation test, ICNAAM 2014, September 22-28, 2014 .
17. **Carlos Agra Coelho** On sharp and highly manageable asymptotic approximations for instances of the Meijer G function, ICNAAM 2014, September 22-28, 2014
18. **Gonçalo dos Reis:** International Conference on Advances in Interdisciplinary Statistics and Combinatorics, Greensboro (USA), 10-12 October/2014
19. **Gonçalo dos Reis:** Maxwell Institute Probability Day, December 2014, Edinburgh (Scotland/UK), 08 December 2014
20. **Gonçalo dos Reis:** 2nd young researchers meeting on BSDEs, Numerics and Finance, Bordeaux (FR), 7-9 July/2014
21. **Gonçalo dos Reis:** 11th German Probability and Statistics Days, Ulm (Germany), 4-7 March/2014.
22. **Luís Grilo:** Grilo, L. M., Henriques, R. S., Correia, P. C. and Grilo, H. L. Attention-deficit/hyperactivity disorder in children. A statistical approach. 12th International Conference of Numerical Analysis and Applied Mathematics (ICNAAM 2014), Rhodes, Greece, September 22-28.
23. **Luís Grilo:** Grilo, L. M. and Grilo, H. L. Individual and moving range control charts in the production of olive oil. 12th International Conference of Numerical Analysis and Applied Mathematics (ICNAAM 2014), Rhodes, Greece, September 22 28.
24. **Luís Grilo:** Grilo, L. M., Mateus, D. M. R., Alves, A. C. and Grilo, H. L. (2014). Robust control charts in industrial production of olive oil. 10th International Conference of Computational Methods in Sciences and Engineering (ICCMSE 2014), Athens, Greece, April 04-07.
25. **Luís Grilo:** Grilo, L. M., Mateus, D. M. R., Alves, A. C. and Grilo, H. L. (2014). Cartas de controlo estatístico de qualidade com o IBM SPSS: uma aplicação à produção industrial de azeite. I Workshop on Computational

Data Analysis and Numerical Methods, Escola Superior de Tecnologia de Tomar, Instituto Politécnico de Tomar, Tomar, Portugal, July 25.

26. **Luís Grilo:** Grilo, L. M., Mateus, D. M. R., Alves, A. C. and Grilo, H. L. (2014). Individual and moving range charts for olive oil acidity. 2<sup>as</sup> Jornadas de Estatística e Computação da Universidade Aberta, Porto de Mós, Portugal, June 07.
27. **Miguel de Carvalho:** Joint Statistical Meetings, Boston, EE UU, 2–7 August, 2014.
28. **Miguel de Carvalho:** Extreme Events in Finance, Royaumont Abbey, Francia, 15–17 December, 2014.
29. **Marta Faias:** XXIII European Workshop on General Equilibrium Theory - EWGET 2014. (Universit Paris 1 Panthéon-Sorbonne, Paris, France, 30 June- 1 July, 2014). "On neutrality with multiple private and public goods".
30. **Marta Faias:** 8th Annual Meeting of the Portuguese Economic Journal. (School of Economics and Management, Universidade do Minho, Braga, Portugal, 4-5 July, 2014). "Stability in price competition revisited".
31. **Maria de Lourdes Afonso:** "2nd European Actuarial Journal Conference" from 10 to 12 de September, Vienna, Austria. "Measuring the impact of a bonus malus system in finite and continuous time ruin probabilities, for large portfolios in motor insurance" Joint work with Rui M.R. Cardoso, Alfredo D. Egídio dos Reis and Gracinda R. Guerreiro.
32. **Miguel Fonseca:** Fonseca, Miguel; Roy, Anuradha. Inference in k-Exchangeable Multivariate Models. LinStat'14. Sweden. 2014.
33. **Ricardo Covas:** International Conference of Numerical Analysis and Applied Mathematics (ICNAAM2014), 22–28 September 2014 (Rhodes, Grécia). B-matrices and its applications to linear models.
34. **Rui Rodrigues Cardoso:** "The Cramér-Lundberg and the dual risk models: ruin, dividend problems and duality features" The 30th International Congress of Actuaries 2014, 30 March to 4 April, 2014, Washington DC,

USA. Joint work with Agnieszka I. Bergel, Eugenio V. Rodríguez, Rui M. R. Cardoso and Alfredo D. Egídio dos Reis.

35. **Vanda Lourenço:** 2 - 7 August 2014 Joint Statistical Meeting (JSM2014), Boston, USA. Talk Title: 'A robust coefficient of determination for heritability estimation in genetic association studies'
36. **Vanda Lourenço:** 31 July - 2 August 2014 16th Meeting of New Researchers in Statistics and Probability (NRC), Harvard, USA. Flash Talk Title: 'Robust heritability estimation in plant candidate gene association studies'
37. **Vanda Lourenço:** 25 - 28 May 2014 41st Annual Meeting of the Statistical Society of Canada, Toronto, Canada. Talk title: 'A robust coefficient of determination for heritability estimation in genetic association studies'.
38. **Vanda Lourenço:** 10 - 12 April 2014 XXI Jornadas de Classificação e Análise de Dados, Lisboa, Portugal. Talk title: 'M-regression, false discovery rates and outlier detection in genetic association studies'

#### 4.7.3 Contributed talk (national)

1. **Carla Santos:** A vantagem da visualização das probabilidades condicionadas: o uso de diagramas de Venn e diagramas em árvore. Congresso Nacional de Práticas Pedagógicas no Ensino Superior, September,5, 2014 Lisboa.
2. **Luís Grilo:** Grilo, L. M. and Coelho, C. A. (2014). Near-exact distributions for the statistic used to test the reality of covariance matrix in a complex normal distribution. XXI Jornadas de Classificação e Análise de Dados (JOCLAD2014), Instituto Nacional de Estatística, Lisboa, Portugal, April 10-12 (pp. 141-144, Abstract book).

#### 4.7.4 Poster

1. **Luís Grilo:** Grilo, L. M. and Grilo H. L. (2014). Comparison of peroxide index of olive oil from different suppliers. Conferência Internacional da Amazônia em Estatística Experimental e Análise de Risco (I CIAEEAR),

Universidade Federal do Amazonas (UFAM), Manaus, AM Brasil, August 12-15 (p. 44, Abstract book).

2. **Vanda Lourenço**: 31 July – 2 August 2014 16th Meeting of New Researchers in Statistics and Probability (NRC), Harvard, USA. Poster Title: ‘Robust heritability estimation in plant candidate gene association studies’
3. **Vanda Lourenço**: 6 - 11 July 2014 27th International Biometric Conference (IBC), Florence, Italy. Poster Title: ‘Robust heritability estimation in plant candidate gene association studies’ Alves, A. C., Grilo, L. M. and Mateus, D. M. (2014). Técnicas Analíticas de Controlo de Qualidade de Azeites. Jornadas de Engenharia Química e do Ambiente: “produtos de fileira florestal”. Escola Superior de Tecnologia de Tomar, Instituto Politécnico de Tomar, Tomar, Portugal, May 09 10.

## 4.8 Other Important Information

### 4.8.1 Supervision of Ph.D. (2014)

1. **Miguel Fonseca** and **João Tiago Mexia**: Artur Pereira, Orthogonal Models, Structure, Crossing, Nesting and Inference, Ph.D. (Statistics and Risk Management), Universidade Nova de Lisboa (completed, awaiting viva).
2. **Miguel Brás de Carvalho**: Daniela Castro, Multivariate Extremes: Modeling, Smoothing, and Regression. (expected 2015).
3. **Marta Faias**, **Pedro Mota** and Joaquim Pina: Alberto Mulenga, VARs, ARCH models and Applications, Ph.D. (Statistics and Risk Management), Universidade Nova de Lisboa.
4. **Gracinda Rita Guerreiro** and **Manuel L. Esquível**: Cristina Nobre, Markov modeling for open populations. Ph.D. (Statistics and Risk Management), Universidade Nova de Lisboa.

5. **Gracinda Rita Guerreiro** and **Manuel L. Esquível**: Rute Baião Carrujo, Markov Chain models for Long Term Care. Ph.D. (Statistics and Risk Management), Universidade Nova de Lisboa.
6. **Pedro Palhinhas Mota** e **Manuel L. Esquível**: Clarinda Nhangumbe, On some auto-induced regime switching models for coupled systems of diffusions. Ph.D. (Statistics and Risk Management), Universidade Nova de Lisboa.

#### 4.8.2 Pos-docs

**Miguel M. Fonseca**: 1 July 2014 – 20 March 2015: 8,5 Month post-doc grant under project PTDC/MAT-STA/0568/2012 (Principal Investigator: **Vanda Lourenço**.)

#### 4.8.3 Conference and seminar organization

**Carlos Agra Coelho** & **Filipe Marques**: 4th Symposium on Distribution Theory, Estimation and Inference inside ICNAAM 2014 (12th International Conference on Numerical Analysis and Applied Mathematics, Rhodes, Greece, 22-28 September 2014).

**Frederico Caeiro**: Organizador do “Symposium on computational statistical methods”. Atenas, 05 de Abril de 2014. Organizador.

**Frederico Caeiro**: Organizador (com M.I. Gomes) de “Group discussion: choice”, Royaumont Abbey - France - December 16, 2014.

**Francisco Carvalho**: Session Organizer of Statistical Inference in Linear Models at ICNAAM’2013 – International Conference on Numerical Analysis and Applied Mathematics, Rhodes (Greece), 22 – 28 September 2014.

**Francisco Carvalho**: Member do Organizing Committee da Conferência Internacional EcoHCC’2014, Tomar (Portugal), September 2014.

**Francisco Carvalho**: Member do Scientific Committee do Statistical and Mathematical Sciences workshop (SMSW’14), Covilhã (Portugal), July 2014.

**Francisco Carvalho**: Member of the Organizing Committee do International Conference on Trends and Perspectives in Linear Statistical Inference (LinStat 2014), Linköping (Sweden), August 2014.

**Luis Grilo:** I workshop on Computational Data Analysis and Numerical Methods, Instituto Politécnico de Tomar, Portugal, July 25, 2014 (Chairman).

**Luis Grilo:** 2<sup>a</sup>s Jornadas de Estatística e Computação da Universidade Aberta, Porto de Mós, Portugal, June 07, 2014 (Member of Organizing Committee).

**Luis Grilo:** 8th Workshop on Statistics, Mathematics and Computation (in Honour to Professor Christos Kitsos). Cidade da Praia, Ilha de Santiago, Cape Verde, March 12-15, 2014 (Member of Organizing Committee).

**Gonçalo dos Reis:** Maxwell Institute Probability Day, Edinburgh (Scotland/UK), 08 December 2014, Organizer and speaker.

**Gonçalo dos Reis:** New Trends in Computational Finance and Related Topics, Edinburgh (Scotland/UK), 24-25 Apr 2014, Organizer.

**Miguel de Carvalho:** CLATSE (Congreso Latinoamericano de Sociedades de Estadística) 2014] [La Serena, Chile] [20-23 Octubre, 2014]

**Miguel de Carvalho:** Member of the Scientific Committee; Organizer of Invited Session on Risk and Extremes.

**Miguel de Fonseca:** Special Session organizer: Statistics in Life Sciences. LinStat'14. Sweden. 2014.

**Carla Santos:** Special Session organizer: SMSW'14 - Statistics and Mathematical Sciences Workshop, UBI, Covilhã, Portugal, July 7, 2014 Exhibition Organizer

**Carla Santos:** Special Session organizer: "Explorística - Aventuras na Estatística" at ESTIG of Polytechnic Institute of Beja From 1 to 31 May. Promoting statistical literacy among students of the Polytechnic Institute of Beja and high school students in the region of Beja.

#### 4.8.4 Outreach activities

**Manuel Esquível:** Member of the Education Committee of the Portuguese Institute of Actuaries; Member of the Certifying Committee of the Portuguese Institute of Insurance in representation of the Portuguese Association of Insurers.

**Luis Grilo:** Member of the Board of CLAD (Associação Portuguesa de Classificação e Análise de Dados), since November 2014.



**Carla Santos:** Raising public awareness to Mathematics importance: Mathematical column on the digital newspaper “ Tribuna Alentejo”.

#### 4.8.5 Computer applications

**F. Caeiro** and **A. Mateus.** (2014). randtests: Testing randomness in R. R package version 1.0. URL: <http://CRAN.R-project.org/package=randtests>

#### 4.8.6 Peer-review activities

**Gracinda Guerreiro:** ASTIN Bulletin; Risks

**Luis Grilo:** 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); British Journal of Applied Science & Technology; British Journal of Mathematics and Computer Science.

**Miguel de Carvalho:** Annals of Applied Statistics; Biometrika; Journal of the Royal Statistical Society, Ser. C; Statistical Modeling; Statistics and Computing

**Rui Cardoso:** European Actuarial Journal

### 4.9 2015 research of IM

**Ayana Mateus:** The research in 2015 will be focused in the study of non-parametric randomness tests and in the comparison of their performance through a Monte Carlo simulation study.

**Carla Santos:** To increase my scientific research and productivity and to promote the interest in Mathematics and its Applications.

**Carlos Agra Coelho & Filipe Marques & Luis Grilo:** Development of likelihood ratio tests for elaborate covariance structures, with the study of the exact distribution of the test statistics and development of near-exact distributions with good asymptotic properties not only for increasing sample sizes but also for increasing numbers of variables and populations involved and simultaneously with good performances for small and very small samples. This work is intended to be done both for real and complex random variables.

Besides the work on tests for covariance structures, we intend to continue work on Computational Statistics and Applied Statistics.

**Carlos A. Coelho** expects to finish the work on the book entitled “Finite representations of certain special functions with applications in Multivariate Analysis”, accepted by Springer and with expected publication in 2015; this is a joint work with Professor Barry C. Arnold from the Statistics Department of The University of California, Riverside

**Filipe J. Marques** and **Carlos A. Coelho** will work on the book entitled “Near-exact distributions for likelihood ratio statistics used to test covariance structures”, accepted by Springer.

**Dora Gomes:** The main objective is to use bootstrap and jackknife methods in the context of dependence to obtain more stable estimators of a parameter that appears characterizing the degree of local dependence on extremes, the so-called extremal index. I also intend to improve the algorithms already presented in Neves et al. (2014a) and Prata Gomes and Neves (2014 b,c) for an adaptive selection of the number of upper order statistics and perform a large scale Monte Carlo simulation study for an adequate study of some criterions therein considered.

**Elsa Moreira:** Testing the performance of two state regime-switching Markov models in the prediction of droughts and heavy precipitation. A new approach that combine techniques of linear mixed models and autoregressive models will also tested in forecasting precipitation.

**Frederico Caeiro:** Improve the estimation of parameters of extreme events.

**Gonçalo dos Reis:** Carry research on numerical methods for McKean-Vlasov equations and their application in finance; research on improved methods for the computation of Incremental Risk charges for the banking industry; Apply for research grants.

**Gracinda Guerreiro:** To submit 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 (usual approach). Obtain the results for the model obtained in 2014 (open portfolio). Joint work with Rui M.R. Cardoso, Alfredo D. Egídio dos Reis and Maria de Lourdes Afonso. Continue to develop the studies about Long Term Care focusing on the Portuguese Market.

**Inês Sequeira:** Improve the estimation of parameters of Pareto type models.

**Isabel Natário:** For 2015 my planned work comprehends continuing the studies with Prof Lucília Carvalho e Doctor Ivone Figueiredo team on modeling the dynamics of the black scabbardfish in NE Atlantic through a space state model and application of stochastic frontier analysis to fisheries, in particular the black scabbardfish fishery. We are about to submit a 3 years FCT project (as participants, principal investigator is Raquel Menezes of University of Minho) about "Spatial inference under preferential sampling and survey design", to begin in February 2016, being NOVA.ID.FCT budget of about €20 000,00, including a grant of 1 year for a PhD student. We are also initiating the works of the PROMAR project, PROMAR UNDULATA - N° 31-03-01-FEP-0186 (funded through FFCUL, March 2014-August 2015), for dealing with the ray fishery in the Portuguese continental waters (evaluation of its exploration state, and the study of technical measures for its management). Additionally, studies on spatial econometrics, namely for developing spatial models to deal with Portuguese macro-economic and social time-series data, such as unemployment and poverty, are being initiated with the PhD student Paula Simões. Finally, it is my intention to work on an extended document about binomial regression, theory and applications, in health context.

**João Beleza Sousa:** Proceed the research presented in "Bonds Historical Simulation Value at Risk in order to: a) evaluate the possibility of proof that the proposed method also apply to the class of affine short rate models. b) apply statistical tests to real bonds portfolios to confirm the validity of the proposed method on real data.

**João Filipe Lita da Silva:** In 2015, the strong consistency of the least-squares estimates in stochastic regression models and the strong consistency of ridge estimates in ridge regression models will proceed, trying to extend the results already obtained in recent papers (see [Lita14a] and [Lita14b]); additionally, applications of the developed theory will be emphasized.

**Manuel Leote Esquível:** In the auto-induced regime switching diffusion models we intend to extend to coupled systems of diffusions, the results obtained for single diffusions, namely, existence of solutions for the coupled system of stochastic differential equations with crossed regime switching con-

ditions, conditions for arbitrage free and complete market models, existence of consistent estimators of the parameters, simulation adequacy studies and benchmark studies with real data against alternative models. In the open arkov population models, following the transition intensity approach, the transition densities must be calibrated - or estimated - from data concerning disabilities, recoveries and mortalities. We propose to use the embedded Markov chain together with the transition probabilities determined with a numerical procedure. The idea is to get a transition matrix with constant entries corresponding to a suitable reference age; then, with a given objective function - for instance defining a minimum square error criteria - starting with some well known and frequently used intensities, we optimize the parameters of the intensities with a systematic search algorithm. A second approach consists on postulating a given adequate functional form depending on parameters to the transition probabilities, and then fitting the this functional form to the data; then we have by the usual derivative definition the correspondent empirical intensities which we then use to fit the intensities of the model.

**Maria de Lourdes Afonso:** To submit 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 (usual approach). Obtain the results for the model obtained in 2014 (open portfolio). Joint work with Rui M.R. Cardoso, Alfredo D. Egídio dos Reis and Gracinda R. Guerreiro.

**Marta Faias:** Analyze the phenomenon of price dispersion and monopolistic competition in the model with incomplete information, stability in demand faced by firms and where firms compete in prices. State the general model of endogenous exchange formation, define the related equilibrium concept and discuss the conditions that allow to prove equilibrium existence by means of club theory.

**Miguel Brás de Carvalho:** In 2015 I intend to keep investing in some core projects I have been working in 2014; particularly I will keep working in the fields of extremes and on statistical modeling of medical diagnostic data. A major task will be on finishing a book on Bayesian modeling of diagnostic data which will be published by Chapman and Hall/CRC press.

**Miguel Fonseca:** Advances on the inference for multivariate mixed linear

models, including inference with constraints on fixed effects and (co)variance components. Forecast of drought periods at mid and long range. Construction of an active aging index for elderly health assessment.

**Pedro Palhinhas Mota:** Continue with the study of diffusions with regimes and parameter estimation for ergodic diffusions.

**Rui Rodrigues Cardoso:** To submit 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 (usual approach). Obtain the results for the model obtained in 2014 (open portfolio). Joint work with Maria de Lourdes Afonso, Alfredo D. Egídio dos Reis and Gracinda R. Guerreiro. To extend the results for ruin probabilities using the duality between the Classical and Dual risk models, for the time to ruin and for expected present dividend amounts for the dual risk model considering generalized Erlang(n) and Phase-Type(n). Joint work with Alfredo D. Egídio dos Reis, Agnieszka I. Bergel and Eugenio V. Rodríguez-Martínez.

**Sandra Dias Nunes:** In 2015 I intend to develop the work in extreme value analysis, an area in which I began to research in late 2013. I also intend to continue to work with teachers of business science that has allowed me to develop applications of statistics in the most several areas. I intend to further research in Item Response Theory.

**Vanda Lourenço:** As individual goals, (i) I am writing a project application, as a PI, to submit to the FCT before the end of January where now I am turning to human genetics applications; I am also part of two other applications as a team member; (ii) I intend to pursue the collaboration with the German team during my 6 month sabbatical leave initiating in the beginning February/March. A very interesting research project was written by me and approved by the foreign team and therefore I do expect that the collaborative research work may result in at least one publication between this year and the next; (iii) I have another ongoing paper, under the scope of the ROBSTATGEN project, that I intend to submit before the end of 2015; Another one within the same project should also be initiated; (iv) Dissemination of research results is to be continued and therefore a presentation at ENAR2015 is already scheduled; (v) Launching of a personal website, which is something I have been wanting to do for a long time.

## 4.10 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 accepter paper, the classical risk model was considered modified in two different ways by the inclusion of a dividend barrier: numerical algorithms were presented to approximate or bound the expected discounted value of dividends up to a finite time horizon. Also it was established a closed connection between the dual and the classical risk. In the following, we will extend the

results for ruin probabilities, time to ruin and expected present dividend amounts for the dual risk model considering inter-claim distributions Erlang(n), generalized Erlang(n) and Phase-Type(n). Calculate the ruin probability for an auto insurance policy portfolio with a bonus malus system.

FCaeiro will work on Second-order Parameters Estimation for reduced-bias parameter estimation of extreme events and in "adaptive selection of thresholds". We now intend to apply an idea of Gomes & Oliveira (2001) - bootstrap threshold selection - to adaptive selection of thresholds in reduced bias estimation procedures. DGomes: will work on the estimation of relevant parameters in statistics of extremes using an adaptive algorithm on "Probability Weighted Moment Estimator of Extreme Quantiles" and modeling spatial extremes in real cases studies.

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

MFaias: We used club theory for the first time to provide an equilibrium setting where traders sort into bourses to trade their securities. Our aim now is to show that trading complementarities and bourse formation costs explain market fragmentation and the emergence of bourses with an incomplete security structure. We will study a game with incomplete information and stable residual demand functions where firms compete in prices. The stability in the demand is provided by a new variable, the type of the firm, reflecting its ability to attract customers.