



Center for Mathematics and Applications

CMA/FCT/UNL

2016 Report

FCT Fundação
para a Ciência
e a Tecnologia

Funded by Project UID/MAT/00297/2013



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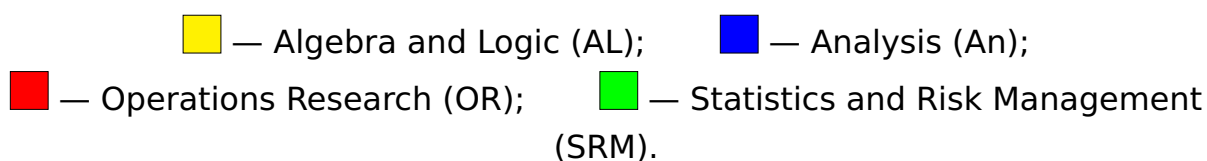
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Report structure

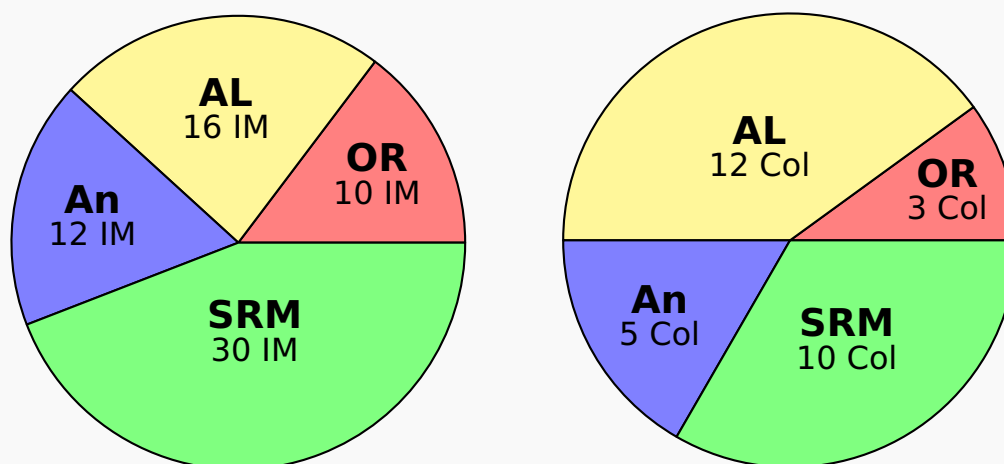
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Part I

Pictorial Report

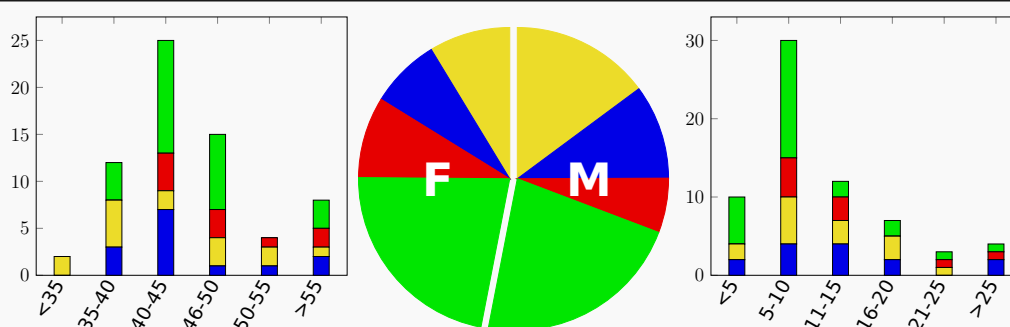


Composition 2016



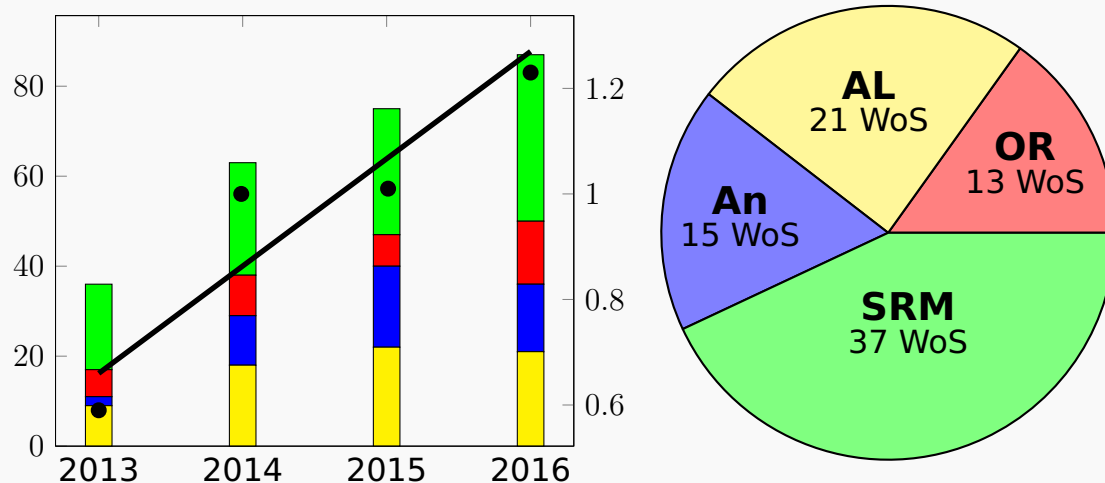
Number of members per group. Left: Integrated Members (IM), i.e., members who satisfy the productivity criterion; Right: Collaborators with Ph.D. (Col). Group budget is proportional to the number of IM.

Who are the IM?



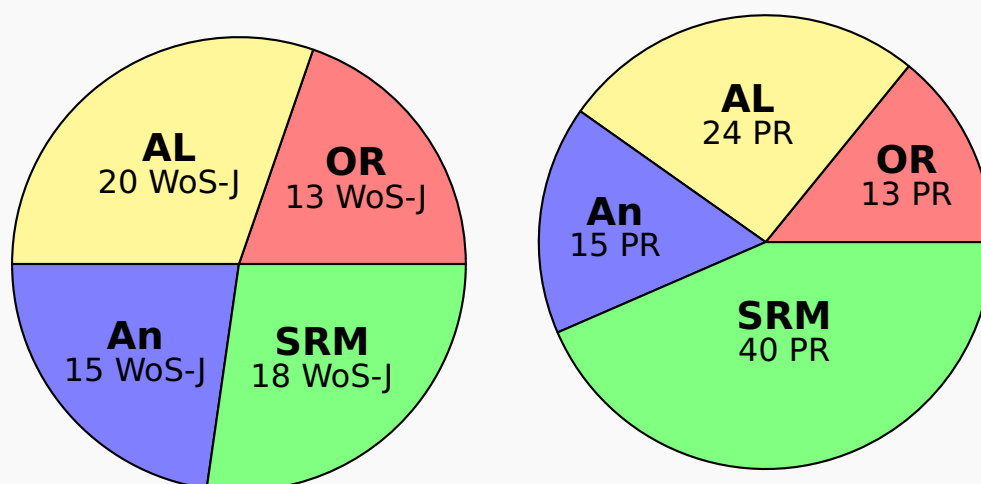
Left: Age distribution. Center: Gender distribution. Right: Post-doctoral experience (years). All data as of 1st January 2017.

Scientific Productivity — Web of Science



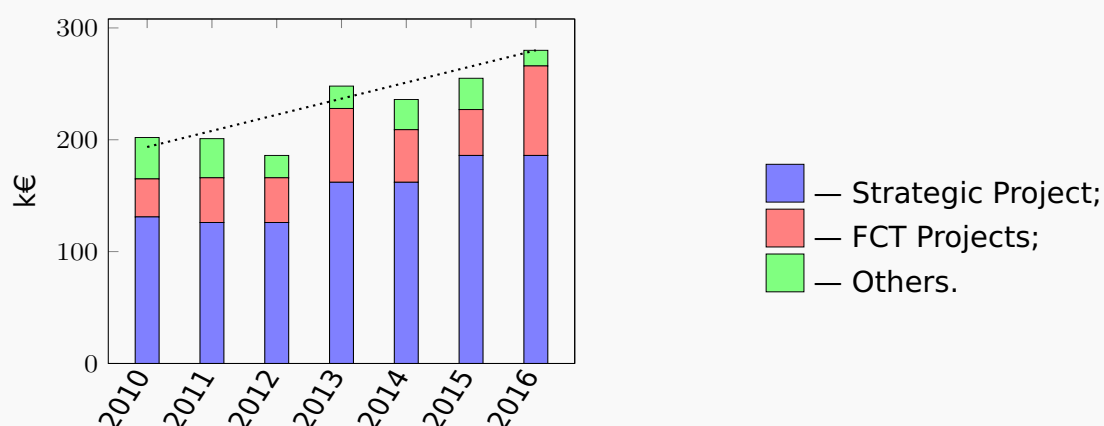
Web of Science (WoS) Publications. Left: Evolution 2013-2016. The solid line and dots indicate the evolution in the WoS publications per capita (right scale; in fact, the total number of publications (IM & Col) divided by the number of IM). Right: WoS publications in the year 2016.

Scientific Productivity — 2016



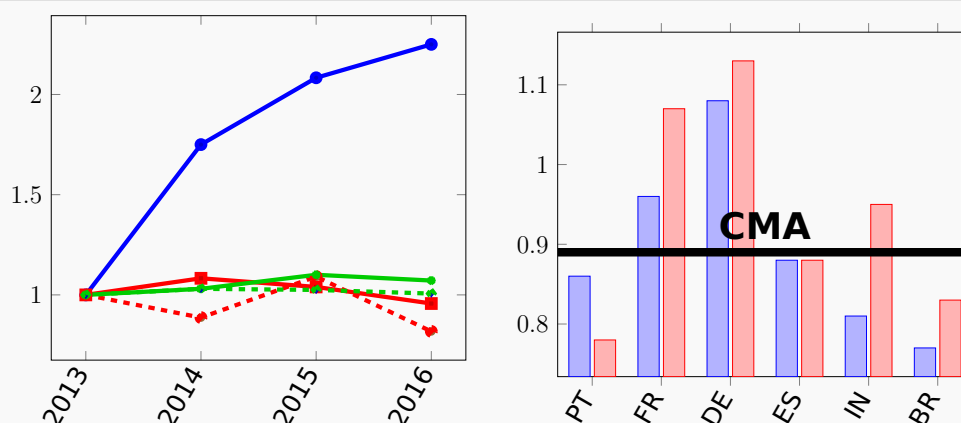
Left: Publications in Journals indexed at WoS. Right: Peer-reviewed publications.

Budget Evolution — 2010-16



Funding from different sources from 2010 to 2016.

CMA in Portugal & Beyond



Left: Evolution in the number of publications, normalized to the year 2013: CMA (solid blue line) vs “Mathematics” (continuous line) vs “Mathematics, Applied” (dashed), in accordance to the WoS categories, in Portugal (red) and in the World (green). Right: Citations in 2016 of the papers published in 2015, per paper (immediate impact): CMA, Portugal and selected countries (France, Germany, Spain, India, and Brazil) in “Mathematics” (blue) and “Mathematics, Applied” (red). These numbers of publications and citations are not directly comparable, as many publications of CMA are not classified in these WoS categories, but provide an indication of the quantity and quality of the CMA research nationally and internationally.

Conferences



CSA 2016

**INTERNATIONAL
CONFERENCE ON
SEMIGROUPS AND
AUTOMATA 2016**

DSYS in LOGIC 2016

**Seventh Workshop Dynamical Systems Applied to Biology and
Natural Sciences | DSABNS 2-5 Feb. 2016
Escola de Ciências e Tecnologia, Universidade de Évora,
Portugal**

[WORKSHOP VENUE](#) | [CONTACT US](#) | [PROGRAM](#) | [ABSTRACTS](#) | [REGISTRATION](#) | [FUNDING](#)



29.º Encontro

**Seminário Nacional de
HISTÓRIA DA MATEMÁTICA**



International Joint Conference on Automated Reasoning 2016

WOAT 2016

International Workshop on Operator Theory and Operator Algebras

Instituto Superior Técnico, Lisbon, Portugal. July 5-8, 2016.



Outreach



MatNova 2016

Escola de Verão de Matemática
Departamento de Matemática
Faculdade de Ciências e Tecnologia
Universidade Nova de Lisboa

mathINGENΦUS

faculdade de ciências e tecnologia | universidade nova de lisboa

6 a 8 de Julho de 2016

Jornada da Matemática

FCT FACULDADE DE
CIÊNCIAS E TECNOLOGIA
UNIVERSIDADE NOVA DE LISBOA

18 de março de 2016

Matemáticos da NOVA no Mundo



CIÊNCIA VIVA NO LABORATÓRIO

OCUPAÇÃO CIENTÍFICA DE JOVENS NAS FÉRIAS
JUNHO - SETEMBRO 2016

12 relevant outcomes

1. D. Alagador, **J. O. Cerdeira**, and M. B. Araujo. Climate change, species range shifts and dispersal corridors: an evaluation of spatial conservation models. *Methods Ecol. Evol.*, 7(7):853–866, JUL 2016.
2. R. A. Bailey, **S. S. Ferreira**, **D. Ferreira**, and **C. Nunes**. Estimability of variance components when all model matrices commute. *Linear Alg. Appl.*, 492:144–160, MAR 2016.
3. G. Bonfante, **R. Kahle**, J.-Y. Marion, and **I. Oitavem**. Two function algebras defining functions in NC^k boolean circuits. *Inf. Comput.*, 248:82–103, JUN 2016.
4. **C. Bras**, G. Eichfelder, and J. Judice. Copositivity tests based on the linear complementarity problem. *Comput. Optim. Appl.*, 63(2):461–493, MAR 2016.
5. **A. J. Cain**, and M. Pfeiffer. Decision problems for word-hyperbolic semigroups. *J. Algebra*, 465:287–321, NOV 1 2016.
6. **C. A. Coelho**, **F. J. Marques**, and **S. Oliveira**. Near-exact distributions for likelihood ratio statistics used in the simultaneous test of conditions on mean vectors and patterns of covariance matrices. *Math. Probl. Eng.*, Article ID 8975902, 2016.
7. **I. Correia**, and T. Melo. Multi-period capacitated facility location under delayed demand satisfaction. *Eur. J. Oper. Res.*, 255(3):729–746, DEC 2016.
8. S. Correia, **F. Oliveira**, and H. Tavares. Semitrivial vs. fully nontrivial ground states in cooperative cubic Schrödinger systems with $d \geq 3$ equations. *J. Funct. Anal.*, 271(8):2247–2273, OCT 2016.
9. **P. Doutor**, **P. Rodrigues**, **M. d. C. Soares**, and **F. A. C. C. Chalub**. Optimal vaccination strategies and rational behaviour in seasonal epidemics. *J. Math. Biol.*, 73(6-7):1437–1465, DEC 2016.
10. **M. L. Esquivel**, **P. P. Mota**, and **J. T. Mexia**. On some statistical models with a random number of observations. *J. Stat. Theory Pract.*, 10(4):805–823, 2016.
11. **A. Y. Karlovich**, Y. I. Karlovich, and A. B. Lebre. On a weighted singular integral operator with shifts and slowly oscillating data. *Complex Anal. Oper. Theory*, 10(6):1101–1131, AUG 2016.
12. M. Marcolli, and **G. Tabuada**. Noncommutative numerical motives, Tannakian structures, and motivic Galois groups. *J. Eur. Math. Soc.*, 18(3):623–655, 2016.

Part II

Activities at CMA

General Information

Highlights

1. CMA directly funded 5 conferences in 2016.
2. 3 post-docs work full time at CMA; 2 more are coming in 2017.
3. CMA members published 86 papers indexed by Web of Science.
4. Project “Hilbert’s 24th problem”, funded with 200 k€ and led by R. Kahle, started in 2016.
5. A prize of 12.5 k€ awarded by the Calouste Gulbenkian Foundation to the MSc student Diogo Pereira.
6. 2 CMA members were elected to the board of national scientific societies.

0.1. Objectives and Achievements

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0.1.1. Unit Description

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

FCT/UNL is the largest academic unit of the “Universidade Nova de Lisboa”, founded in 1977 and dedicated to research and higher education in Science, Technology, and Engineering. It has about 7500 students, of whom about 2500 are postgraduates. Its mission is the development of high-quality, international-level, research, which is being implemented as part of a fundamental policy of strengthening FCT/UNL as a research-oriented school. This is the essential basis for excellence in teaching, especially of postgraduates. As such, the Research Centers are fundamental components of FCT/UNL’s strategy, which is fully committed to their success.

The CMA has 68 active Ph.D. researchers and 34 internal collaborators. In the 2013 Evaluation of R&D Units by the Portuguese Science and Technology Foundation, CMA was ranked “very good”. Since then, the number of publications indexed by the Web of Science database has steadily increased, from 36 in the year 2013, to 63 in 2014, 75 in 2015 and 82 in 2016. Currently 13 Ph.D. students are members of CMA, and are supervised or co-supervised by CMA members.

The center is organized into four research groups: Algebra and Logic (AL), Analysis (An), Operations Research (OR), and Statistics and Risk Management (SRM) and along two thematic lines: “Mathematical Modelling for the Independent Living of Elderly, Disabled, and Chronic Patients” and “mathematical Modelling In Ecology, Evolution, and Genetics”.

An External Permanent Advising Scientific Committee including five internationally recognized high-level researchers assesses the scientific activities

of the center.

General administrative support is provided by a BGCT (*Bolsa de Gestão de Ciência e Tecnologia*, or, Science and Technology Management Fellowship), with the help of the secretariat of the Department of Mathematics. CMA bylaws and membership requirement regulations are available in a written document, reviewed every year in order to assess the classification of the researchers according to productivity indicators. Funding is allocated to each team, proportionally to the corresponding number of active Ph.D. researchers. For more information please visit the CMA/FCT/UNL web site:

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

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0.1.2. Productivity Criterion

Starting from 1 January, 2015, the criterion used to define integrated members (hereinafter, IM) is

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

A) One publication in one of the 10% WoS top journals in the following WoS^a 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. dissertation defended after 1 January of year X-3 and one publication in a peer reviewed journal.

C) Four scientific indicators, according to the FCT definition^b (see Registration Guide^c p. 25), two of them classified in WoS.

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

^aWeb of Science

^bInternational publication with referees, books, book chapters, patents.

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

Members who do not satisfy the criterion are invited to present a 3-year work plan, in the scope of the group project. The plan should present a credible strategy to recover scientific productivity (as measured by the Unit productivity criterion). If the plan is approved, they will be considered as “internal collaborators”. Internal collaborators are funded in the same way as integrated members. Integrated members and internal collaborators contribute together to the progress of the scientific program of the center. The designation “internal collaborators” also applies to Ph.D. candidates supervised by members of the Unit. As soon as an internal collaborator fulfills the criterion, he or she will be considered an integrated member.

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

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

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0.2. Indicators

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0.2.1. Scientific Productivity

CMA has experienced a steady increase in the ratio of publications (total number of publications in peer reviewed journals per integrated member). Since 2014 we also count the total and the per capita number of publications indexed by Web of Science (WoS), and since 2016 we divide the WoS count in “journals” and “others” (proceedings indexed at WoS).

Note that only WoS publications are considered in the definition of integrated members (IM).

Annual data for the total number of publications:

	2009	10	11	12	13	14	15	16
Publications in international peer reviewed journals	46	41	39	57	38	76	105	88
Publications in international peer reviewed journals per IM	0.96	0.84	0.80	1.03	0.62	1.25	1.42	1.29
WoS publications					36	63	75	86
WoS per IM					0.59	1.00	1.01	1.21
WoS journals							66	63
WoS journals per IM							0.89	0.93

Publication by each group in 2016:

Group	WoS Total	per IM	WoS Journals	per IM	Peer reviewed	per IM
AL	21	1.31	20	1.25	24	1.5
An	15	1.25	15	1.25	15	1.25
OR	13	1.30	13	1.30	13	1.30
SRM	37	1.23	17	0.57	40	1.33

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

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0.2.2. Funding

The table below presents CMA funding, on an annual basis, considering different sources.

	2011	2012	2013	2014	2015	2016
LA FCT	0	0	0	0	0	0
Units FCT	126348	126348	162438	162504	185787	185787
Projects FCT	39743	39743	65858	46625	41187	79604
Other (National)	2850	0	0	0	5740	13999
Other (International)	9500	19965	19965	27268	27993	0
National Industry	25000	0	0	0	0	0
International Industry	0	0	0	0	0	0
Total	203441	186056	248327	236397	260707	279390

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0.2.3. Team

In the table below we present the evolution, from 2007 to 2016, of the number of Integrated Members. Note that a productivity criterion was implemented in 2010, and modified in 2015 (implemented in 2016). In the second line we present the number of full time researchers in the CMA team with salary paid directly by the Ministry of Science, Technology and Higher Education (up to 2011 and after 2015) and the Ministry of Education and Science (from 2011 to 2015) — programs “Ciência”, “Investigador FCT,” and post-docs paid directly from CMA’s budget or long term post-docs (1 year or more) paid by projects hosted by CMA. Short term post-docs (less than 1 year) paid by projects are not included in this table.

	2007	08	09	10	11	12	13	14	15	16
Integrated Members	42	49	48	49	49	55	61	63	74	68
Full time researchers	0	2	2	0	0	0	1	2	4	5
Ph.D. dissertations completed	12	9	7	1	1	5	4	3	2	3

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0.2.4. Impact of 2015 research

In the table below we show the immediate impact (II) of CMA research per research group.

$$II = \frac{\text{\# citations in 2016 of papers published by CMA researchers in 2015}}{\text{\# papers published by CMA researchers in 2015}}.$$

	# papers in 2015	# citations in 2016 of these papers	II
AL	23	12	0.52
An	18	19	1.05
OR	7	21	3.00
SRM	32	19	0.59
CMA	80	71	0.89

Note that there are minor differences in the number of papers presented here and in the 2015 Report. This reflects inclusions in the WoS database after the production of report and correction of errors in the previous report.

One fact deserves notice:

1. The paper “Numerical approximation of distributed order reaction-diffusion equations” by Morgado, M. L. and **Rebello, M** (J. Comput. Appl. Math, 275, 216-227) is the paper published in 2015 with the largest number of citations in 2016 (11 citations), among all papers with at least one author with Portuguese affiliation, classified by the Web of Science as *Mathematics, Applied*.

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0.2.5. Teaching load

According to Portuguese law, Professors at public universities are expected to teach between 6 and 9 hours per week, while at Polytechnic Institutes, this number varies between 6 and 12 hours. However, except during sabbatical leaves, most of the IM are requested to teach the maximum legally possible.

In the table below we provide information only for the 42 IM with contracts as professors at the Universidade Nova de Lisboa. For future reports we plan to include IM with contracts in other universities and polytechnic institutes.

In the left table we present the number of different disciplines taught during civil year 2016 (1st semester plus 2nd semester), while in the right table we add the average number of effective hours in class per week for the 1st semester and 2nd semester during 2016. (0 hours and/or 0 disciplines indicate a “sabbatical leave”.)

Disciplines	# of IM at UNL	Hours	# of IM at UNL
0	3	0	3
1	0	1-7	2
2	15	8-10	3
3	10	11-13	9
4	11	14-16	7
5	2	17-19	9
		20-22	6
		23-	2

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0.2.6. Other relevant information

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

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0.3. Visitors

In 2015, CMA launched a program to attract researchers for stays of *circa* 1 month. Every 6 months CMA asks all members to invite a researcher for stays between 20 and 40 days, and pays all expenses, including travel and an allowance of 2650 euros per month before taxes. Visitors are expected to

interact with the CMA members and present a short course. In 2016, we had four visitors under this program:

1. Teresa Melo (Saarland Business School, Saarland, Germany; invited in the group of Operations Research) — 21/4/2016 to 11/5/2016.

<https://www.htwsaar.de/wiwi/fakultaet/personen/profile/melo-teresa>

2. Gabriele Fici (Palermo University, Italy; invited in the group of Algebra and Logic) — 19/5/2016 to 6/6/2016.

<http://math.unipa.it/fici/>

3. Marcos Raydan (Simon Bolivar University, Venezuela; invited in the group of Operations Research) — 6/6/2016 to 15/7/2016.

<http://kuainasi.ciencs.ucv.ve/mraydan/>

4. Yuriy Karlovych (Universidad Autónoma del Estado de Morelos, Mexico, invited in the group of Analysis) — 5/12/2016 to 6/1/2017.

<https://www.cinc.uaem.mx/init/investigadores/detalles?id=18>

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0.4. Post-doctoral program

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

After the term of CMA's fellowship, **Miguel Fonseca** started a 6 year fellowship directly funded by FCT, with CMA as host institution.

The contract of **Benjamín Alarcón Heredia** was renewed for one more year, until September 2017.

In the project led by Reinhard Kahle, **Gabriele Pulcini** was hired as a post-doc.

In October 2016 CMA opened a call for one post-doctoral fellowship, in all areas of Mathematics. Out of 17 applicants, Maíra Aguiar was selected to work in the group of Analysis, due to start in 1st January 2017. During the year 2017, we also expect Tara Brough to join CMA, as post-doc in the group of Algebra and Logic, following the results of the FCT 2016 call.

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0.5. Activities

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0.5.1. Organization of events

In 2015, for the first time, CMA launched a call to support conferences organized or co-organized by CMA members. Until then, support had been negotiated on a case by case basis. During the year 2016, CMA directly supported six conferences:

1. Days in Logic 2016, Monte de Caparica, Portugal, 28-30 January 2016.
<http://eventos.fct.unl.pt/dil2016>
2. WOAT 2016 - International Workshop on Operator Theory and Operator Algebras, Instituto Superior Técnico, Lisbon University, Portugal. 5-8 July 2016.
<https://woat2016.math.tecnico.ulisboa.pt/>
3. CSA 2016 - International Conference on Semigroups and Automata 2016. Lisbon University, 20-24 June 2016.
<https://ciencias.ulisboa.pt/pt/conferencia/csa-2016>
4. Seventh Workshop Dynamical Systems Applied to Biology and Natural Sciences | DSABNS 2-5 Feb. 2016, Évora University, Portugal
<http://dsabns2016.fc.ul.pt/>
5. 29º Encontro Nacional de História da Matemática, FCT/UNL, 18-19 November 2016.
<http://eventos.fct.unl.pt/snhm29>
6. International Joint Conference on Automated Reasoning. 27 June - 2 July, 2016. University of Coimbra, Portugal.
<https://www.uc.pt/en/congressos/ijcar2016>

Further details on these and other conferences supported directly by the group's budget, can be found in detail in the second part of the report.

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0.5.2. Seminars

During the year 2016, 54 seminars and short courses (from 56 in 2015) were organized by CMA. We do not count student seminars or seminars that were part of larger events (e.g., conferences, Jornadas da Matemática, Mat-Nova etc). 40 seminars (from 32 in 2015) were given by specialists outside CMA, including 18 from visitors from abroad (from 15 in 2015).

In the second part of this report we present a full list of seminars.

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0.5.3. Outreach

CMA continues to be involved in outreach activities. Many members write to general audiences, or are invited to participate in outreach events in schools, public libraries, etc.

During 2016, CMA directly partially funded three summer schools for high-school students:

1. **MatNova 2016**: <http://eventos.fct.unl.pt/matnova2016/>
2. **MathInGenious 2016**: <http://eventos.fct.unl.pt/mathingenious2016>
3. **Ciência Viva no Laboratório**: <http://www.cienciaviva.pt/cvlaboratorios/>
and <http://www.cma.fct.unl.pt/noticias/2016/05/ciencia-viva-no-laboratorio>

Furthermore, we also support the one-day event, locally organized, *Jornadas da Matemática*, normally around π -day (i.e, 14 March - 3/14).

Part III

Activities in the research groups

Research Group

Algebra and Logic

Highlights

1. Project “Hilbert’s 24th problem”, funded with €199.902 and led by R. Kahle, started in 2016.
2. One new post-doc and two collaborators joined the group.
3. The group has been involved in the organization of eight conferences and three special sessions at conferences.
4. 11 invited talks at international conferences and 21 research papers published in high-reputation journals in the area.
5. One book, *Advances in Proof Theory*, Birkhäuser, edited by R. Kahle and co-authors.

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1.1. Team

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1.1.1. Integrated Members

1. **Alan James Cain** – a.cain@fct.unl.pt
2. **Ana Cristina Malheiro Casimiro** – amc@fct.unl.pt
3. **António José Mesquita da Cunha Machado Malheiro** – ajm@fct.unl.pt
4. **Benjamín Alarcón Heredia** – baheredia@ugr.es
5. **Carlos Manuel Saiago** – cls@fct.unl.pt
6. **Gabriele Pulcini** – gab.pulcini@gmail.com
7. **Gonçalo Jorge Trigo Nery Tabuada** – tabuada@fct.unl.pt
8. **Isabel Maria Oitavem Fonseca da Rocha Kahle** – ifr@fct.unl.pt
9. **Joaquim Eurico Anes Duarte Nogueira** – jen@fct.unl.pt
10. **Manuel Almeida Silva** – mnas@fct.unl.pt
11. **Maria do Rosário Silva Franco Fernandes** – mrff@fct.unl.pt
12. **Maria Helena Coutinho Gomes de Almeida Santos** – mhas@fct.unl.pt
13. **Reinhard Josef Klaus Kahle** – kahle@fct.unl.pt
14. **Teresa Maria de Araújo Melo Quinteiro** – tmeloquinteiro@gmail.com
15. **Teresa Maria Jerónimo Sousa** – tmjs@fct.unl.pt
16. **Vítor Hugo Bento Dias Fernandes** – vhf@fct.unl.pt

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1.1.2. Other Researchers/Collaborators

1. **Herberto de Jesus da Silva** – hdjs@fct.unl.pt
2. **Jaime da Gama Gaspar** – mail@jaimegaspar.com
3. **Joana Mendonça Fonseca Marques de Matos** – jmf.matos@fct.unl.pt
4. **João Leitão Guerreiro** – jleitaoguerreiro@gmail.com
5. **João Nuno Gonçalves Faria Martins** – jn.martins@fct.unl.pt
6. **João Pedro Bizarro Cabral** – jpbc@fct.unl.pt

7. **Jorge Manuel Leocádio André** – jmla@fct.unl.pt
8. **Júlia Maria Nunes Loureiro Vaz de Carvalho** – jvc@fct.unl.pt
9. **Manuel Messias Rocha de Jesus** – mrj@fct.unl.pt
10. **Maria Cecília Perdigão Dias da Silva** – mcds@fct.unl.pt
11. **Maria de Fátima Vale de Gato Santos Rodrigues** – mfsr@fct.unl.pt
12. **Mirko Engler** – mir.engler@gmail.com

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1.1.3. Ph.D. Students

1. **João Rodrigo Pimenta Simões** – jrs12140@campus.fct.unl.pt
2. **Ricardo Jorge Pratas Guilherme** – rj.guilherme@campus.fct.unl.pt
3. **Serena Delli** – sere.rex@gmail.com

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1.2. Funding

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1.2.1. Projects led by CMA members

1. Hilbert's 24th Problem PTDC/MHC-FIL/2583/2014, (2016-2019)
 PI: **Reinhard Kahle**
 CMA members: **R. Kahle, A. J. Cain, A. Malheiro, I. Oitavem, M. Silva, G. Pulcini, S. Delli.**
 Funded by: FCT
 Total funding: €199.902.
2. IF/01622/2013/CP1161/CT0001, Investigador FCT Exploratory Project, led by **Alan Cain** (2014-2019).
 Total funding (CMA only) €50 000.00.
3. A correspondência de Hugo Baptista Ribeiro (2015-2017)
 PI: **Reinhard Kahle**
 CMA members: **R. Kahle, I. Oitavem**
 Funded by Gulbenkian Foundation.
 Total funding: €11.480.

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1.2.2. Others

1. Geometry and Mathematical-Physics EXCL/MAT- GEO/0222/2012
 PI: Miguel Tribolet Abreu (CGASMD/IST-U. Lisboa),
 Total funding: €326.000.00
 CMA members: **J. F. Martins** and **A. Casimiro** (2013-2016)

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1.3. Publications

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1.3.1. Publications in the Web of Science database

- [1] I. I. Akca, K. Emir, and **J. F. Martins**. Pointed homotopy of maps between 2-crossed modules of commutative algebras. *Homol. Homotopy Appl.*, 18(1):99–128, 2016.
<http://web.b.ebscohost.com/ehost/pdfviewer/pdfviewer?vid=0&sid=cda8774e-836f-4ea8-be09-c4e3e77a204c%40sessionmgr104>
- [2] **J. Andre**, J. Araujo, and P. J. Cameron. The classification of partition homogeneous groups with applications to semigroup theory. *J. Algebra*, 452:288–310, APR 15 2016.
<https://doi.org/10.1016/j.jalgebra.2015.12.025>
- [3] M. Bernardara and **G. Tabuada**. Chow groups of intersections of quadrics via homological projective duality and (Jacobians of) non-commutative motives. *Izv. Math.*, 80(3):463–480, 2016.
<http://iopscience.iop.org/article/10.1070/IM8409>
- [4] A. J. Blumberg, D. Gepner, and **G. Tabuada**. K -theory of endomorphisms via noncommutative motives. *Trans. Am. Math. Soc.*, 368(2):1435–1465, FEB 2016.
<http://www.ams.org/journals/tran/2016-368-02/S0002-9947-2015-06507-6/>
- [5] G. Bonfante, **R. Kahle**, J.-Y. Marion, and **I. Oitavem**. Two function algebras defining functions in NC^k boolean circuits. *Inf. Comput.*, 248:82–103, JUN 2016. 4th Workshop on Developments in Implicit Computational Complexity, Roma, ITALY, MAR 16-17, 2013.
<https://doi.org/10.1016/j.ic.2015.12.009>

- [6] S. P. Buckley, J. G. Corliss, C. R. Johnson, C. A. Lombardia, and **C. M. Saiago**. Questions, conjectures, and data about multiplicity lists for trees. *Linear Alg. Appl.*, 511:72–109, DEC 15 2016.
<https://doi.org/10.1016/j.laa.2016.08.002>
- [7] **A. J. Cain** and M. Pfeiffer. Decision problems for word-hyperbolic semigroups. *J. Algebra*, 465:287–321, NOV 1 2016.
<https://doi.org/10.1016/j.jalgebra.2016.07.007>
- [8] M. Calvo-Cervera, A. M. Cegarra, and **B. A. Heredia**. On the third cohomology group of commutative monoids. *Semigr. Forum*, 92(3):511–533, JUN 2016.
<https://link.springer.com/article/10.1007/s00233-015-9696-2>
- [9] **A. Casimiro**, C. Florentino, S. Lawton, and A. Oliveira. Topology of moduli spaces of free group representations in real reductive groups. *Forum Math.*, 28(2):275–294, MAR 2016.
<https://doi.org/10.1515/forum-2014-0049>
- [10] A. M. Cegarra and **B. A. Heredia**. Homotopy colimits of 2-functors. *J. Homotopy Relat. Struct.*, 11(4, SI):735–774, DEC 2016.
<https://link.springer.com/article/10.1007/s40062-016-0150-2>
- [11] **V. H. Fernandes**, P. Honyam, **T. M. Quinteiro**, and B. Singha. On semigroups of orientation-preserving transformations with restricted range. *Commun. Algebr.*, 44(1):253–264, 2016.
<http://dx.doi.org/10.1080/00927872.2014.975345>
- [12] **V. H. Fernandes** and **T. M. Quinteiro**. A note on bilateral semidirect product decompositions of some monoids of order-preserving partial permutations. *Bull. Korean. Math. Soc.*, 53(2):495–506, 2016.
http://www.mathnet.or.kr/mathnet/thesis_file/BKMS-53-2-495-506.pdf
- [13] **V. H. Fernandes** and **T. M. Quinteiro**. Presentations for monoids of finite partial isometries. *Semigr. Forum*, 93(1):97–110, AUG 2016.
<https://link.springer.com/article/10.1007/s00233-015-9759-4>
- [14] **J. Guerreiro**, I. Z. Ruzsa, and **M. Silva**. Monochromatic paths for the integers. *Eur. J. Comb.*, 58:283–288, NOV 2016.
<https://doi.org/10.1016/j.ejc.2016.06.002>

- [15] C. R. Johnson and **C. M. Saiago**. Diameter minimal trees. *Linear Multilinear Algebra*, 64(3):557–571, MAR 2016.
<http://dx.doi.org/10.1080/03081087.2015.1057097>
- [16] M. Marcolli and **G. Tabuada**. Noncommutative numerical motives, Tannakian structures, and motivic Galois groups. *J. Eur. Math. Soc.*, 18(3):623–655, 2016.
https://www.ems-ph.org/journals/show_abstract.php?issn=1435-9855&vol=18&iss=3&rank=4&srch=searchterm%7Ctabuada
- [17] **J. F. Martins**. Crossed modules of Hopf algebras and of associative algebras and two-dimensional holonomy. *J. Geom. Phys.*, 99:68–110, JAN 2016.
<https://doi.org/10.1016/j.geomphys.2015.09.012>
- [18] **G. Tabuada**. Algebraic K -theory with coefficients of cyclic quotient singularities. *C. R. Math.*, 354(5):449–452, MAY 2016.
<https://doi.org/10.1016/j.crma.2016.01.017>
- [19] **G. Tabuada**. Noncommutative mixed (ARTIN) motives and their motivic Hopf dg algebras. *Sel. Math.-New Ser.*, 22(2):735–764, APR 2016.
<https://link.springer.com/article/10.1007/s00029-015-0203-0>
- [20] **G. Tabuada**. A note on secondary K -theory. *Algebr. Number Theory*, 10(4):887–906, 2016.
<http://msp.org/ant/2016/10-4/ant-v10-n4-p07-p.pdf>
- [21] **G. Tabuada** and M. Van den Bergh. Noncommutative motives of separable algebras. *Adv. Math.*, 303:1122–1161, NOV 5 2016.
<http://www.sciencedirect.com/science/article/pii/S0001870816310891>

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1.3.2. Other publications in peer-reviewed journals

- [1] **A. Casimiro**, C. Florentino, S. Lawton, and A. Oliveira. Homotopy type of free group character varieties. In *Boletim da Sociedade Portuguesa de Matemática*, volume Special Issue, page 53–57. SPM, Portugal, SPM, Portugal, 2016.
- [2] A. H. Dediu, **J. M. Matos**, and C. Moraga. Query learning automata with helpful labels. *Journal of Machine Learning Research*, 57:1–15, 2016. Proceedings of the 13th International Conference on Grammatical Inference, ICGI2016, Delft, The Netherlands, October 5-7, 2016.

- [3] **B. A. Heredia** and J. Elgueta. On the representations of 2-groups in baez-crans 2-vector spaces. *Theory and Applications of Categories*, 31(32):907–927, 2016.

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1.3.3. Books

- [1] **R. Kahle**, T. Strahm, and T. Studer, editors. *Advances in Proof Theory*, volume 28. Birkhäuser, 2016.

<https://link.springer.com/book/10.1007%2F978-3-319-29198-7>

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1.3.4. Other (international) publications

- [1] S. Baptista, N. Chibeles-Martins, G. R. Guerreiro, **M. F. Rodrigues**, M. C. Soares, and E. Ughi. Mathematics in the making - a view over the portuguese activities. In A. Ludus, editor, *Proceedings of the Recreational Mathematics Colloquium IV (2015) · G4G Europe, Pavilhão do Conhecimento, Portugal, January 24-27, 2015*, 2016.
- [2] G. Fici, A. Restivo, **M. Silva**, and L. Q. Zamboni. Anti-powers in infinite words. In Y. R. Ioannis Chatzigiannakis, Michael Mitzenmacher and D. Sangiorgi, editors, *43rd International Colloquium on Automata, Languages, and Programming (ICALP 2016)*, volume 55 of *Leibniz International Proceedings in Informatics (LIPIcs)*, page 124:1–124:9, Dagstuhl, Germany, 2016. Schloss Dagstuhl-Leibniz-Zentrum fuer Informatik, Schloss Dagstuhl-Leibniz-Zentrum fuer Informatik.
- [3] **R. Kahle**. Is there a “Hilbert thesis”? In T. Piecha and P. Schroeder-Heister, editors, *General Proof Theory. Celebrating 50 Years of Dag Prawitz’s Natural Deduction. Proceedings of the Conference held in Tübingen, 27-29 November 2015*, pages 8, 181–190. University of Tübingen, Tübingen, 2016.
- [4] **R. Kahle**. Towards a proof-theoretic semantics of equalities. In T. Piecha and P. Schroeder-Heister, editors, *Advances in Proof-Theoretic Semantics*, volume 43 of *Trends in Logic*, pages 153–160. Springer, 2016.

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1.3.5. Other (national) publications

- [1] **R. Kahle**. O fim da *Grundlagenkrise*. In *Boletim da Sociedade Portuguesa de Matemática*, volume Número especial, page 87–90, 2016. Resumo alargado do Encontro Nacional da Sociedade Portuguesa de Matemática 2014.

- [2] **R. Kahle** and **I. Oitavem**. O computador enquanto tecnologia ao serviço da investigação matemática. *Educação e Matemática*, 139-140:70–72, 2016.
- [3] **R. Kahle** and **I. Oitavem**. Towards recursion schemata for the probabilistic class PP. In *Boletim da Sociedade Portuguesa de Matemática*, volume Número especial, page 91–94, 2016. Resumo alargado do Encontro Nacional da Sociedade Portuguesa de Matemática 2014.
- [4] **J. E. Nogueira**. Knight’s tours and its history. *Proceedings of the Recreational Mathematics Colloquium IV (2015) · G4G Europe, Pavilhão do Conhecimento, Portugal, January 24-27, 2015*, 2016.
- [5] **M. Silva** and P. J. Freitas. Coberturas distintas dos inteiros. *Gazeta de Matemática*, 2016.
- [6] **M. Silva** and P. J. Freitas. Os computadores aprendem a jogar go. *Gazeta de Matemática*, 2016.

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1.4. Activities

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1.4.1. Organization of conferences & sessions

1. Days in Logic 2016, Monte de Caparica, Portugal, 28-30 January, 2016. Organising Committee: **J. Gaspar** (University of Kent, New University of Lisbon), **I. Oitavem** (New University of Lisbon), J. Rasga (University of Lisbon).
2. Proof, Computation, Complexity (PCC2016), München, Germany, 5-6 May. Program Committee: **R. Kahle** (New University of Lisbon), L. Kristiansen (University of Oslo), R. Matthes (University of Toulouse), **I. Oitavem** (New University of Lisbon), A. Setzer (Swansea University).
3. International Joint Conference on Automated Reasoning, IJCAR 2016, Coimbra, Portugal, 27 June - 2 July 2016. Organizing Committee: Pedro Quaresma (University of Coimbra), Sandra Marques Pinto (University of Coimbra), **Reinhard Kahle** (Workshop-Chair - CMA & DM, FCT, UNL), Nuno Baeta, (Polytechnic Institute of Coimbra), Carlos Caleiro (IST - University of Lisbon), Nelma Moreira (University of Porto), João Rasga (CMAF-CIO - University of Lisbon), Vanda Santos (CISUC).

4. International Conference on Semigroups and Automata: Celebrating the 60th birthday of Jorge Almeida and Gracinda Gomes, Lisboa, Portugal, 20–24 June 2016. Organizing Committee: M. Branco (University of Lisbon), A. Costa (University of Coimbra), M. Delgado (University of Porto), **V. H. Fernandes** (New University of Lisbon), **A. Malheiro** (New University of Lisbon), A. Moura (Polytechnic Institute of Porto), C. Santa-Clara (University of Lisbon), P. V. Silva (University of Porto).
5. The 6th Combinatorics Day, FCT-UNL, 14 July 2016 Organising Committee: **M. Silva** (CMA, UNL), O. Azenhas (CMUC, UC), A. G. Oliveira (CMUP, FCUP). <http://www.mat.uc.pt/combdays/6thcombdays> Cryptography and Related Topics Special/Thematic Session in the 2016 National Meeting of the Portuguese Mathematical Society, Barreiro, Portugal, 12–13 July, 2016. Organising Committee: **J. Gaspar** (University of Kent, New University of Lisbon).
6. Categorification Special/Thematic Session in the 2016 National Meeting of the Portuguese Mathematical Society, Barreiro, Portugal, 12–13 July, 2016. Organizing Committee: **J. F. Martins** (New University of Lisbon).
7. Logic and Computational Complexity (LCC2016), Marseille, France, 2–3 September 2016. Heads of the Steering Committee: A. Dawar (University of Cambridge), **I. Oitavem** (New University of Lisbon). 29º Seminário Nacional de História da Matemática (SNHM2016), Caparica, Portugal, 18–19 November 2016. Organizing Committee: R. Kahle (New University of Lisbon), M. Engler (New University of Lisbon), Nuno Jerónimo, **I. Oitavem** (New University of Lisbon).
8. Simplicity of Proofs - The philosophical challenges of Hilbert's 24th Problem. Symposium at Third Lisbon International Conference on Philosophy of Science, Lisbon, Portugal, 14 December 2016. Organizing Committee: **R. Kahle** (CMA & DM, FCT, UNL), A. Cain (CMA, FCT, UNL), F. de Oliveira (CFCUL).
9. Modelling Topological Phases of Matter: TQFT, HQFT, premodular and higher categories, Yetter-Drinfeld and crossed modules in disguise Workshop, University of Leeds, 5–8 July 2016. Local Organising committee:

Zoltán Kádár (Leeds), **J. F. Martins** (Lisbon), Marcos Calçada (Leeds, partially supported by CNPq), Paul Martin (Leeds)

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1.4.2. Seminars & Short-courses

Organized by Alan Cain and Isabel Oitavem

19 Jan: *Grau de Emparelhamentos*, Rosário Fernandes, DM, FCT-UNL, Portugal.

23 Feb: *Is there a 'Hilbert thesis'?*, Reinhard Kahle, DM & CMA, FCT-UNL, Portugal.

08 Mar: *Markov Semigroups*, Alan J. Cain, CMA, FCT-UNL, Portugal.

15 Mar: *Extreme supercharacters of the infinite unitriangular group*, Carlos André, CEAFEL & DM, Universidade de Lisboa, Portugal.

22 Mar: *The Nonnegative Inverse Eigenvalue Problem*, Charles R. Johnson, Dept. of Mathematics, College of William and Mary, USA.

05 Apr: *Amenability and geometry of semigroups*, Robert Gray, School of Mathematics, University of East Anglia, UK.

12 Apr: *Rees quotients of numerical semigroups*, Vitor Hugo Fernandes, DM & CMA, FCT-UNL, Portugal.

19 Apr: *Turán numbers, Ramsey numbers and Graph Decomposition*, Teresa Sousa, Escola Naval & CMA, UNL, Portugal.

03 May: *Simplicial Cocommutative Hopf Algebras*, Kadir Emir, Department of Mathematics and Computer Science, Eskişehir Osmangazi University, .

17 May: *Some results on the Frobenius coin problem*, Manuel Branco, Universidade de Évora, Portugal.

20 May: *Combinatorics on Words*, Gabriele Fici, University of Palermo, Italy.

24 May: *Representations of surface groups, Higgs bundles and their moduli spaces*, André Oliveira, CMUP, Universidade do Porto, Portugal.

30 May: *Dedução Automática*, João Araújo, Universidade Aberta and CEMAT, Portugal.

07 Jun: *Nonnegative integral matrices*, Henrique Cruz, Universidade da Beira Interior, Portugal.

28 Jun: *Cayley-automatic semigroups*, Richard Thomas, Department of Computer Science, University of Leicester, UK.

19 Jul: *Backtrack searches in permutation groups*, Markus Pfeiffer, School of Computer Science, University of St Andrews, UK.

18 Oct: *Hilbert's 24th Problem*, Reinhard Kahle, DM & CMA, FCT-UNL, Portugal.

25 Oct: *Cuts and cut elimination for complementary classical logic*, Gabriele Pulcini, CMA, FCT-UNL, Portugal.

08 Nov: *Rewriting systems and the plactic monoid*, Alan Cain, CMA, FCT-UNL, Portugal.

15 Nov: *Minimal Ockham algebras*, Herberto Silva, DM & CMA, FCT-UNL, Portugal.

22 Nov: *Word problems of free inverse monoids*, Tara Brough, CEMAT, Universidade de Lisboa, Portugal.

06 Dec: *Special subgroups of regular semigroups*, Thomas S. Blyth, School of Mathematics & Statistics, University of St Andrews, UK.

13 Dec: *The Littlewood-Richardson commutativity symmetry and the many faces of its involutive nature*, Olga Azenhas, CMUC, Universidade de Coimbra, Portugal.

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1.4.3. Supervision of Ph.D. students

- **V. H. Fernandes:** supervises João Simões, New University of Lisbon.
- **R. Kahle:** supervises René Gazarri, University of Tübingen, co-supervision with Peter Schroeder-Heister. Topic: The Calculus of Natural Calculations. Ongoing.
- **R. Kahle:** supervises Serena Delli, New University of Lisbon, within the project "Hilbert's 24th Problem". Starting
- **R. Kahle:** supervises Mirko Engler, Humboldt-University, Berlin, co-supervision with Karl-Georg Niebergall, within the project "Hilbert's 24th Problem". Starting.

- **A. Malheiro**: supervises F. Silva, University of Lisbon, co-supervision with G. Gomes. Topic: Computations and combinatorics on Hopf algebras and monoids. Ongoing.
- **A.J. Cain** and **A. Malheiro**: supervise R. Guilherme, New University of Lisbon. Topic: Littelmann paths for hypoplactic, sylvester, and related monoids, and connections to computation, combinatorics, and crystals. Starting.
- **A. Malheiro**: supervises T. Ribeiro, Open University, co-supervision with J. Araújo. Topic: Exporting techniques from loops to semigroups. Starting.

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1.4.4. Talks in international and national conferences

G. Tabuada. “Noncommutative Artin Motives”, Conference Mid-Atlantic Topology, Johns Hopkins University, March 12-13.

A. Malheiro. “A complete rewriting system for the Plactic monoid using crystals”, 10th Workshop on Statistics, Mathematics and Computation, 26-28 May, Instituto Politécnico de Tomar, Portugal.

F. Rodrigues. “Specht modules and symmetry classes of tensors”, 10th Workshop on Statistics, Mathematics and Computation, 26-28 May, Instituto Politécnico de Tomar, Portugal.

I. Oitavem. “The polynomial hierarchy of time”, 10th Workshop on Statistics, Mathematics and Computation, 26-28 May, Instituto Politécnico de Tomar, Portugal.

I. Oitavem. “Applicative theories for the polynomial hierarchy of time and its levels”, Journées sur les Arithmétiques Faibles 35, 6-7 June, Universidade de Lisboa, Portugal.

R. Kahle. “Hilbert’s Programme and Georg Kreisel, Intuitionism, Computation, and Proof: Selected themes from the research of G. Kreisel”, Paris, 10 - 11 June.

G. Tabuada. “Noncommutative Artin Motives, Workshop Algebraic K-theory and motivic cohomology”, Oberwolfach, Germany, 26 Jun - 2 Jul.

G. Tabuada. “Negative K-theory of quotient singularities, Conference Interacting Algebraic Geometry”, Dijon, France, July 4-8.

G. Tabuada. “Around Voevodsky’s nilpotent conjecture”, Conference K-theory, Sydney, Australia, August 1-6.

G. Tabuada. “Around Voevodsky’s nilpotence conjecture”, Conference noncommutative, derived and homotopical methods in geometry, Antwerp, Belgium, September 19-24.

A.J. Cain. “Combinatorial and computational properties of the sylvester monoid”, 6th Iberian Mathematical Meeting, University of Santiago de Compostela, Spain, 6-8 October.

G. Tabuada. “Noncommutative Motives, Geometry, physics, and representation theory”. Seminar, Northeastern University.

A. J. Cain. “Combinatorics of cyclic shifts in the plactic, hypoplactic, sylvester, and related monoids”. International Conference on Semigroups and Automata 2016, Universidade de Lisboa, 20-24 June.

T. Quinteiro. “Bilateral decompositions of some monoids of transformations”. International Conference on Semigroups and Automata 2016, Universidade de Lisboa, 20-24 June.

B. A. Heredia. “Apéry sets and Feng-Rao numbers over telescopic numerical semigroups”. International meeting on numerical semigroups with applications. Levico Terme, July 5.

A. Malheiro. “Crystals, tableaux, and the (hypo)plactic monoid (Part I)”, Algebra Seminar, Faculty of Mathematics, Informatics and Mechanics, Warsaw University, October 27.

A.J. Cain. “Crystals, tableaux, and the (hypo)plactic monoid (Part II)”, Algebra Seminar, Faculty of Mathematics, Informatics and Mechanics, Warsaw University, 27 October.

M. Silva. “Anti-Powers in Infinite Words”, 16èmes Journées Montoises d’Informatique Théorique, Université de Liège, 5 - 9 September.

R. Kahle. “ From Dedekind to Zermelo vs. Peano to Gödel”. In Memoriam: Richard Dedekind (1831 - 1916), Braunschweig, Germany, 6 - 8 October.

M. Silva. “Coloring factors in infinite words”, Words and automata Seminar, Universidade de Palermo, 17 November 2016.

R. Kahle. “Hilberts 24. Problem”. Logik-Oberseminar, FB Informatik, Universität Tübingen, Germany, December 6.

R. Kahle. “Hilberts umfassendes Programm”. Logik-Oberseminar, FB In-

formatik, Universität Tübingen, Germany, December 7.

R. Kahle. “Hilbert’s 24th Problem”. Symposium: Simplicity of Proofs. Lisbon ICPOS 2016, Lisbon, Portugal, December 14.

R. Kahle. “Is there a “Hilbert thesis?” Days in Logic, Caparica, Portugal, January 28-30.

A. Malheiro. “Crystallizing the hypoplactic monoid”, 6th Combinatorics Day, UNL, Lisbon, Portugal, July 14.

C. Saiago. “Diameter, Seeds and Branch Duplication for Trees”, 6th Combinatorics Day, UNL, Lisbon, Portugal, July 14.

T. Sousa. “Os 40 anos do Teorema das 4 Cores”, Lição Prof. António St. Aubyn, Jornadas de Outono do Curso de Matemática Aplicada à Economia e Gestão, ISEG, November 28, 2016.

A. C. Casimiro. “Schottky principal bundles over Riemann surfaces”, Geometry Seminar, CMUP – Centro de Matemática da Universidade do Porto, February 12.

R. Kahle. “Is there a “Hilbert thesis?” Seminário de Álgebra e Lógica (CMA/FCT-UNL), Caparica, Portugal, February 23.

J. F. Martins. “Crossed modules and 2-dimensional homotopy invariants of knotted surfaces in the 4-sphere”. Leeds University, February 23.

A. Malheiro. “An overview over conjugacy in semigroups”, Joint seminar “Álgebra e Combinatória” and “Álgebra, Lógica e Topologia”, University of Coimbra, April 13.

R. Kahle. “Schwichtenberg’s Paradox in Dialogical Logic”. Seminário de Lógica Matemática (CMAFIO, FCUL), Lisbon, Portugal, April 21.

A. Malheiro. “On the decidability of conjugacy for homogeneous monoids”, Algebra Seminar, CEMAT – Centre for Computational and Stochastic Mathematics, University of Lisbon, April 29.

J. Gaspar. “Security of transformations in cryptography”, Three Minute Thesis competition, Canterbury, United Kingdom, 9 May 2016.

J. F. Martins. “Crossed modules and 2-dimensional homotopy invariants of knotted surfaces in the 4-sphere”, Seminário de Geometria (CMAF-CIO) University of Lisbon, 27 May 2016.

J. Gaspar. ““Taxonomy” of cryptography laws”, 4th Annual Kent Law School Graduate Student Conference: “Who Needs Law? - An Interdisciplinary Dis-

cussion of the Positioning of Law as Interconnected or Isolated", Canterbury, United Kingdom, 7 June, 2016.

J. Gaspar. "Transformation of cryptographically-secure pseudorandom generators into indistinguishable-from-random stream ciphers", University of Kent School of Computing Conference 2016, Canterbury, 10 June 2016.

B. A. Heredia. "Homotopy theory of 2-categories". Encontro Nacional da Sociedade Portuguesa de Matemática. Barreiro, July 12.

A. Malheiro. "On the complexity of the word problem for the Plactic monoid", Algebra session at the "Encontro Nacional da Sociedade Portuguesa de Matemática 2016", Barreiro, Portugal, July 11-13.

R. Kahle. "Erros Graves", Encontro Nacional da Sociedade Portuguesa de Matemática 2016, Barreiro, Portugal, July 11-13.

A. J. Cain. "Combinatorics of cyclic shifts in the plactic, hypoplactic, sylvester, and related monoids", Algebra session at the "Encontro Nacional da Sociedade Portuguesa de Matemática 2016", Barreiro, Portugal, July 11-13.

A. C. Casimiro. "Principal Schottky bundles over Riemann surfaces", Algebraic Geometry session at the "Encontro Nacional da Sociedade Portuguesa de Matemática 2016", Barreiro, Portugal, July 11-13.

J. Nogueira. "O problema do lobo, da cabra e da couve", Recreational Mathematics session at the "Encontro Nacional da Sociedade Portuguesa de Matemática 2016", Barreiro, Portugal, July 11-13.

F. Rodrigues. "Sobre os bastonetes do jogo Senet", Recreational Mathematics session at the "Encontro Nacional da Sociedade Portuguesa de Matemática 2016", Barreiro, Portugal, July 11-13.

R. Kahle. "Hilbert's 24th Problem". Seminário de Álgebra e Lógica (CMA/FCT-UNL), Caparica, Portugal, October 18.

R. Kahle. "Some historical considerations concerning Hilbert's 24th Problem". 29.º Encontro do Seminário Nacional de História da Matemática (SNHM), Caparica, Portugal, 18-19 November.

T. Sousa. "Os 40 anos do Teorema das 4 Cores", 29º Seminário Nacional de História da Matemática, UNL, Lisbon, Portugal, November 19, 2016.

M. Silva. "Ramsey Theory for infinite words", CEAFL Seminar, Universidade de Lisboa, 21 December 2016.

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1.4.5. Outreach

- **J. Gaspar** participated at the competition "Three Minute Thesis" at the University of Kent (Canterbury, UK).
- **V. H. Fernandes** and **A. Malheiro** organized the course "*αὐτόματον*: agindo por vontade própria", on Matnova 2016.
- **V. H. Fernandes** presented "Técnicas de Demonstração" at "Workshop do Núcleo de Matemática da FCT (alunos)".
- **A. Casimiro** co-organized the course "Matemática e Cosmos", on MathIngenious 2016.
- **F. Rodrigues** integrated the portuguese team of the International Commission on Mathematical Instruction/International Mathematical Union.
- **F. Rodrigues** coordinated "ClubeMath", a Club for basic and high school students, which aims to show a different side of Mathematics, through fun and recreational activities, in order to stimulate skills and interest in this science. <http://eventos.fct.unl.pt/clubemath>
- **A. Malheiro** presented the talk "Problemas de contagem: os números de Catalan" integrated in the series "Matemática na FCT - Investigação em matemática".
- **F. Rodrigues** co-organized the "Ciclo de Palestras Almada Negreiros e a Matemática".
- **F. Rodrigues** co-organized "Matemática na FCT".
- **F. Rodrigues** organized the program "Ciência Viva no Laboratório - 2016".
- **I. Oitavem** organized the course "Criptografia" integrated in the "Ciência Viva no Laboratório - 2016" program.

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1.4.6. Master thesis completed, supervised by CMA members

A. Malheiro and **J. F. Martins**: supervised R. Guilherme, MSc student at FCT-UNL, co-supervision with Luís Monteiro. Topic: A coalgebraic approach to fuzzy automata. Completed.

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1.4.7. Other

V. H. Fernandes is on the editorial board of: *Asian-European Journal of Mathematics* and *Journal of Semigroup Theory and Applications*.

Peer-review reports made by group members to *Journal of Graph Theory*, *Journal of Algebra and Its Applications*, *The American Mathematical Monthly*, *Periodica Mathematica Hungarica*, *Bulletin of the Malaysian Mathematical Sciences Society*, *Communications in Algebra*, *Proceedings of the Royal Society of Edinburgh Section A: Mathematics*, *Dialectica*, *Bulletin of Symbolic Logic*, *Acta Mathematica Hungarica*, *International Journal of Algebra and Computation*, *Royal Society of Edinburgh: Proceedings A*, *Semigroup Forum*, *Communications in Algebra*, *Open Mathematics*, *Semigroup Forum*, *Information and Computation*, several conferences and to *MathReviews* and *Zentralblatt MATH*.

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1.5. Achievements

I. Oitavem and **R. Kahle** refined their characterizations of probabilistic classes of computational complexity and the corresponding formal theories. **R. Kahle** studied extensively historico-philosophical aspects of “Hilbert’s Programme”, obtaining new insights in the proper understanding of fundamental concepts of this Programme, notably in response to criticisms from Georg Kreisel. **R. Kahle** and **I. Oitavem** (together with Nuno Jerónimo and others) finalized the scientific editing of the correspondence of Hugo Ribeiro.

J. Gaspar essentially finished the research part of his Ph.D. in cryptography. He also continued in part-time his research in mathematical logic.

G. Tabuada continued the development of the foundations and applications of the theory of noncommutative motives. Among other achievements, he computed the Picard group of several subcategories of noncommutative motives and embedded the Brauer group into secondary K-theory.

B. Heredia, in collaboration with J. Elgueta, studied the 2-representation theory of 2-groups in Baez-Crans 2-vector spaces. They described the 2-vector space of intertwiners between two representations, characterized the irreducible and indecomposable 2-representations, and they showed that for finite groups the 2-representation theory over a field of characteristic 0 is

described by the classic representation theory of the underlying group.

T. Sousa has continued her research studies in decompositions of graphs into copies of a fixed graph H and single edges. **T. Sousa** with Henry Liu have published the paper Fan Decompositions of Graphs to appear in Journal of Graph Theory.

M. Silva (with J. Guerreiro, I. Ruzsa) studied some variants of van der Waerden's theorem on monochromatic arithmetic sequences, describing properties of the set of differences of those sequences.

C. Saiago developed, with Charles R. Johnson (USA), a generalization of the Parter-Wiener, etc. theorem for combinatorially symmetric matrices whose graph is a tree. In a joint work with Charles R. Johnson (USA) and Kenji Toyonaga (JAPAN) we obtained a characterization of the changes in the multiplicity of the eigenvalues of a Hermitian matrix when two disjoint graphs (and the corresponding Hermitian matrices) are connected with an edge.

R. Fernandes (with A. Duffner (University of Lisbon)) characterized the semilinear preservers of the immanants in the set of doubly stochastic matrices.

A. J. Cain and **A. Malheiro** developed theories of quasi-crystals for "plactic-like" monoids connected with binary trees, such as the sylvester monoid and Baxter monoid.

A. J. Cain and **A. Malheiro** showed that several monoids connected with algebraic combinatorics, such as the hypoplactic, sylvester, taiga, and Baxter monoids, satisfy non-trivial identities. In collaboration with F. Silva, they showed that the left and right patience sorting monoids satisfy no such identity.

A. J. Cain and **A. Malheiro**, in collaboration with R. Gray, showed that there is a duality between the crystal structure for plactic monoids and its Squier complex.

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

As non-standard g -groups may be created lifting non-standard f -groups, when f is primitive of degree 2, **J.E. Nogueira** (with O. Brison, FC-UL) using

ratio-equivalence and other techniques characterized the polynomials g and the related g -sequences.

A. J. Cain (with T. Brough) proved that free inverse monoids, free ample, and free left and right ample monoids have one-counter cross-sections.

V. H. Fernandes (together with J. Koppitz and I. Dimitrova) obtained some results on the semigroup of endomorphisms of an infinite countable chain.

V. H. Fernandes and **T. Quinteiro** (together with R. Caneco) obtained some structural results, in particular ranks and presentations, for some relevant class of normally ordered inverse semigroups.

M. H. Santos (with T. S. Blyth) extended the notions of inverse transversal and associate subgroup investigate regular semigroups with *special subgroups*. In particular, they determined when the subset of perfect elements is a subsemigroup and describe its structure in naturally arising situations.

B. Heredia, in collaboration with J.I. Farrán, P.A. García-Sánchez, and M. Leamer, proved the conjecture stating that the second Feng-Rao number of a telescopic numerical semigroup is the multiplicity of the semigroup.

B. Heredia, in collaboration with P.A. García-Sánchez, H.I. Karakas, and J.C. Rosales, gave a new algorithm to compute all Arf numerical semigroups with a given Frobenius number, and a given genus.

J. M. Matos (together with A.-H. Dediu and C. Moraga) studied complexity aspects and properties of helpful learning algorithms based on label queries and correction queries.

J. M. Matos (together with A.-H. Dediu and C. Martín-Vide) reviewed several distributed, discrete time, and probabilistic models with interacting multi-agents and also studied the emergent behavior of a multi-agent system whose agents follow simple rules.

H. Silva considered, in the context of an Ockham algebra, ideals that are kernels of congruences. He describes the smallest and the biggest congruences having a given kernel ideal. The congruence kernels form a complete lattice which in general is not modular, and for which necessary and sufficient conditions for modularity and distributivity have been established.

A. Casimiro, S. Ferreira, and C. Florentino proved, based on the characterization of Ramanathan, that all Schottky G -bundles have trivial topological type, for G a connected reductive algebraic group. Strict Schottky representa-

tions are shown to be related to branes in the moduli space of G -Higgs bundles over a compact Riemann surface X . Finally, the Schottky map is shown to be surjective onto the space of flat bundles for two special classes: when G is an abelian group over a general surface X , and in the case of a general G -bundle over an elliptic curve.

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1.6. Plan: 2017

I. Oitavem and **R. Kahle** will continue their work on probabilistic classes of computational complexity.

R. Kahle (together with P. Santos) will study abstract formalizations of Gödel's Theorems and related results.

R. Kahle aims to clarify the rationale of "Hilbert's Programme" in a broader context and with respect to its merits for modern foundational developments.

J. Gaspar will continue writing and likely finish his Ph.D. dissertation in cryptography. He will also continue in parttime his research in mathematical logic.

G. Pulcini and **R. Kahle**, will address Hilbert's 24th problem about "simplicity" of proofs. We will consider both formalized and ordinary mathematical proofs. In particular, we will take Gentzen's sequential systems as the privileged formalism for turning ordinary mathematical proofs into their formal counterpart and then measure and compare them.

G. Tabuada will continue the development of the theory of noncommutative motives. In particular, he plans to compute the noncommutative motives of the global orbifolds associated to finite group actions on algebraic varieties using solely fixed-point-data.

B. Heredia, in collaboration with J. Elgueta, will study the 2-representation theory of 2-groups in the bicategory of algebras and bimodules. They aim to attain a reconstruction theorem, some weak form of Schur's lemma, and a categorification of the Peter-Weyl formula in classical representation theory.

T. Sousa will pursue her research in decompositions of graphs for the special case of the gem graph.

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

C. Saiago plans [with Charles R. Johnson (USA) and Kenji Toyonaga (JAPAN)]

to continue the investigation of the changes in the multiplicity of the eigenvalues of a Hermitian matrix with a graph G , when edges are inserted into G or removed from G ; He also plans [with Charles R. Johnson (USA)] to generalize, for combinatorially symmetric matrices, the current Parter-Wiener, etc. theory we have developed for Hermitian matrices whose graph is a tree.

R. Fernandes (with C. Silva, M. Freitas, and R. Del-Vecchio (Universities of Brazil)) will investigate some of the open problems concerning matrices and graphs.

R. Fernandes [with S. Furtado (University of Porto), and H. Cruz (University of Beira Interior)] will investigate the Bruhat order for symmetric matrices.

R. Fernandes [with G. Dolinar, B. Kuzma (Universities of Slovenia) and H. Cruz (University of Beira Interior)] aim to describe the doubly stochastic matrices with maximal centralizers.

A. J. Cain and **A. Malheiro** will continue their unifying program of finding crystal-type structures for monoids that are connected to combinatorics, and will seek further applications of these structures. In collaboration with F. Rodrigues they plan to investigate new classes of combinatorial monoids arising from the theory of quasi-crystals.

J. E. Nogueira intends to study standard and non-standard f -groups in the complex field, and (in finite fields) to generalize the concept of superprimitive polynomials.

A. J. Cain and **A. Malheiro**, in collaboration with Jan Okniński, Łukasz Kubat, and George Klein, will study whether the plactic monoid satisfies a non-trivial identity, and continue examining the combinatorics of cyclic shifts in the plactic monoid.

A. J. Cain, in collaboration with Ines Klimann and Matthieu Picantin, will study orbit trees for automaton semigroups generated by non-invertible automata, attempting to extend the tools these provide in the case of invertible automata, and applying these tools to new classification results.

V. H. Fernandes and **T. Quinteiro** (together with J. Koppitz and I. Dimitrova) aim to continue the study of the monoid of all partial automorphisms of a finite tournament. **V. H. Fernandes** (together with J. Koppitz and T. Musunthia) aims to obtain some structural results for the monoid of all endomorphisms of a finite fence.

V. H. Fernandes and **M. Jesus** (together with B. Singha) aim to study the semigroup of all orientation-preserving transformations of an infinite chain.

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

C. Fernandes, **V. H. Fernandes**, and **J. M. Matos** plan to prosecute the study of pseudovarieties of inverse semigroups generated by some classes of semigroups of partial permutations.

V. H. Fernandes (together with P. Santos) aims to describe the monoid of endomorphisms of some order-preserving transformation semigroups.

B. Heredia, in collaboration with J.I. Farrán and P.A. García-Sánchez, will develop new methods to compute the second Feng-Rao distance of numerical semigroups verifying the Arf property.

J. M. Matos (together with M. J. J. Branco) aims to improve the algorithms to compute the Malcev expansions determined by particular pseudovarieties of semigroups, presented in her Ph.D. dissertation, as well as to describe the congruence associated with the definition of the Malcev expansion determined by the trivial variety of semigroups.

J. M. Matos (together with A.-H. Dediu and C. Martín-Vide) will review actual computational models used in Linguistics to be published as an invited paper, entitled "Natural Language Processing, Moving from Rules to Data", in TAMC2017.

M. H. Santos will pursue ongoing research in regular and ordered semigroups investigating the situation in which S is an ordered regular semigroup and each x in S has a biggest associate.

J. Andre will carry on the investigation on some properties of transformation semigroups that preserve equivalence relations and their connection to variants of semigroups.

H. Silva will pursue ongoing research in the topic of congruences in Ockham algebras.

A. Casimiro plans to obtain a description of basic tools for a variational theory of discrete fields, and plans to generalize topological results concerned with the variety of representations of a free group in a real reductive algebraic group, to the case of reductive linear algebraic monoids.

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1.7. 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 developed 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 mo-

tives.

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 Group

Analysis

Highlights

1. A prize of 12.5 k€ awarded by the Calouste Gulbenkian Foundation to the MSc student Diogo Pereira, supervised by Fernanda Cipriano: project “Monte Carlo na Equação Hamilton-Jacobi-Bellman”.
2. Fabio Chalub was elected a Vice-President of the Portuguese Mathematical Society in July of 2016.
3. Several members of the group were involved in the organization of two international conferences: *Seventh Workshop Dynamical Systems Applied to Biology and Natural Sciences*, *International Workshop on Operator Theory and Operator Algebras*.

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2.1. Team

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2.1.1. Integrated Members

1. **Ana Margarida Fernandes Ribeiro** – amfr@fct.unl.pt
2. **Fabio Augusto da Costa Carvalho Chalub** – chalub@fct.unl.pt
3. **Filipe Serra de Oliveira** – fso@fct.unl.pt
4. **Gonçalo Nuno Rosado Moraes** – gnupost@gmail.com
5. **Luís Manuel Trabucho de Campos** – trabucho@fct.unl.pt
6. **Magda Stela de Jesus Rebelo** – msjr@fct.unl.pt
7. **Maria Fernanda Almeida Cipriano Salvador Marques** – mfsm@fct.unl.pt
8. **Maria Luísa Martins Macedo de Faria Mascarenhas** – mlfm@fct.unl.pt
9. **Nuno David de Jesus Lopes** – ndlopes@gmail.com
10. **Oleksiy Karlovych** – oyk@fct.unl.pt
11. **Paula Cristiana Costa Garcia Silva Patrício Rodrigues** – pcpr@fct.unl.pt
12. **Rogério Ferreira Martins** – roma@fct.unl.pt

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2.1.2. Other Researchers/Collaborators

1. **Bento José Carrilho Miguens Louro** – bjl@fct.unl.pt
2. **Cláudio António Rainha Aires Fernandes** – caf@fct.unl.pt
3. **Maria de Serpa Salema Reis de Orey** – msso@fct.unl.pt
4. **Maria do Céu Cerqueira Soares** – mcs@fct.unl.pt
5. **Paulo José Fernandes Louro Ribeiro Doutor** – pjd@fct.unl.pt

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2.2. Funding

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2.2.1. Projects led by CMA members

1. Dispersive Evolution Equations, Convénio FCT-CAPES (2016-2017).
PI Portugal: **Filipe Oliveira**, PI Brazil: Felipe Linares (IMPA, Brazil)

Total funding: €9.200,00. CMA funding: €2.300,00.

2. Prémio “Estímulo à Investigação 2016”, Fundação Calouste Gulbenkian (2016-2017).

Monte Carlo na Equação Hamilton-Jacobi-Bellman

MSc student: Diogo Pereira, Supervisor: **Fernanda Cipriano**.

Total funding: €12.500,00 CMA funding: €10.000,00

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2.3. Publications

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2.3.1. Publications in the Web of Science database

- [1] S. S. Allaei, T. Diogo, and **M. Rebelo**. The Jacobi collocation method for a class of nonlinear Volterra integral equations with weakly singular kernel. *J. Sci. Comput.*, 69(2):673–695, NOV 2016.

<https://link.springer.com/article/10.1007/s10915-016-0213-x>

- [2] **N. Arada**. On generalized Newtonian fluids in curved pipes. *SIAM J. Math. Anal.*, 48(2):1210–1249, 2016.

<http://epubs.siam.org/doi/abs/10.1137/140964709>

- [3] **N. Arada**. On the convergence of the two-dimensional second grade fluid model to the Navier-Stokes equation. *J. Differ. Equ.*, 260(3):2557–2586, FEB 5 2016.

<http://www.sciencedirect.com/science/article/pii/S0022039615005628>

- [4] **F. A. C. C. Chalub**. An asymptotic expression for the fixation probability of a mutant in star graphs. *J. Dyn. Games*, 3(3, SI):217–223, JUL 2016.

<http://dx.doi.org/10.3934/jdg.2016011>

- [5] **F. A. C. C. Chalub** and M. O. Souza. Fixation in large populations: a continuous view of a discrete problem. *J. Math. Biol.*, 72(1-2):283–330, JAN 2016.

<https://link.springer.com/article/10.1007/s00285-015-0889-9>

- [6] S. Correia, **F. Oliveira**, and H. Tavares. Semitrivial vs. fully nontrivial ground states in cooperative cubic Schrödinger systems with $d \geq 3$ equations. *J. Funct. Anal.*, 271(8):2247–2273, OCT 15 2016.

<https://doi.org/10.1016/j.jfa.2016.06.017>

- [7] J.-P. Dias, M. Figueira, and **F. Oliveira**. Existence and linearized stability of solitary waves for a quasilinear Benney system. *Proc. R. Soc. Edinb. Sect. A-Math.*, 146(3):547–564, JUN 2016.
<https://doi.org/10.1017/S0308210515000578>
- [8] **P. Doutor**, **P. Rodrigues**, **M. d. C. Soares**, and **F. A. C. C. Chalub**. Optimal vaccination strategies and rational behaviour in seasonal epidemics. *J. Math. Biol.*, 73(6-7):1437–1465, DEC 2016.
<https://link.springer.com/article/10.1007/s00285-016-0997-1>
- [9] **A. Y. Karlovich**, Y. I. Karlovich, and A. B. Lebre. The generalized Cauchy index of some semi-almost periodic functions. *Bol. Soc. Mat. Mex.*, 22(2, SI):473–485, OCT 2016.
<https://link.springer.com/article/10.1007/s40590-016-0119-5>
- [10] **A. Y. Karlovich**, Y. I. Karlovich, and A. B. Lebre. On a weighted singular integral operator with shifts and slowly oscillating data. *Complex Anal. Oper. Theory*, 10(6):1101–1131, AUG 2016.
<https://link.springer.com/article/10.1007/s11785-015-0452-0>
- [11] **A. Y. Karlovich**, Y. I. Karlovich, and A. B. Lebre. One-sided invertibility criteria for binomial functional operators with shift and slowly oscillating data. *Mediterr. J. Math.*, 13(6):4413–4435, DEC 2016.
<https://link.springer.com/article/10.1007/s00009-016-0753-1>
- [12] **R. Martins**. Why are we not able to see beyond three dimensions? *Math. Intell.*, 38(4):46–51, DEC 2016.
<https://link.springer.com/article/10.1007/s00283-016-9670-1>
- [13] M. L. Morgado and **M. Rebelo**. Introducing graded meshes in the numerical approximation of distributed-order diffusion equations. In F. D. Yaroslav D. Sergeev, Dmitri E. Kvasov and M. S. Mukhametzhanov, editors, *NUMERICAL COMPUTATIONS: THEORY AND ALGORITHMS (NUMTA-2016): Proceedings of the 2nd International Conference “Numerical Computations: Theory and Algorithms”*, volume 1776, 070002, 2016. AIP Conference Proceedings.
<http://dx.doi.org/10.1063/1.4965348>
- [14] **F. Oliveira**. A note on the existence of traveling-wave solutions to a Boussinesq system. *Differ. Integral Equ.*, 29(1-2):127–136, JAN-FEB 2016.

<https://projecteuclid.org/euclid.die/1448323255>

- [15] **F. Oliveira** and H. Tavares. Ground states for a nonlinear Schrödinger system with sublinear coupling terms. *Adv. Nonlinear Stud.*, 16(2):381–387, MAY 2016.

<https://doi.org/10.1515/ans-2015-5029>

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2.3.2. Other (international) publications

- [1] S. Baptista, N. Chibeles-Martins, G. R. Guerreiro, M. F. Rodrigues, **M. C. Soares**, and E. Ughi. Mathematics in the making - a view over the Portuguese activities. In A. Ludus, editor, *Proceedings of the Recreational Mathematics Colloquium IV (2015) · G4G Europe, Pavilhão do Conhecimento, Portugal, January 24-27, 2015*, 2016.
- [2] **R. Martins**. Math on TV? Yes, we can! In *Bridges 2016 Conference Proceedings*, pages 565–566, 2016.

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2.3.3. Other (national) publications

- [1] **F. Chalub**. Matéria atrai matéria... e a anti-matéria? *Gazeta de Matemática*, 180:11–13, 2016.
- [2] **F. Chalub**. Os quanta de Wallis. *Gazeta de Matemática*, 179:11–13, 2016.
- [3] **F. Chalub**. Razão áurea na idade da pedra. *Gazeta de Matemática*, 178:15–17, 2016.

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2.4. Activities

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2.4.1. Organization of conferences & sessions

F. Chalub and **P. Rodrigues** are members of the Scientific and Organizing Committees of the *Seventh Workshop Dynamical Systems Applied to Biology and Natural Sciences*, Escola de Ciências e Tecnologia, Colégio do Espírito Santo, Universidade de Évora, Portugal, February 2-5, 2016.

<http://dsabns2016.fc.ul.pt/>

C. Fernandes and **O. Karlovych** are members of the Scientific and Organizing Committees of the *International Workshop on Operator Theory and*

Operator Algebras, Instituto Superior Técnico, Universidade de Lisboa, Portugal, July 5-8, 2016.

<https://woat2016.math.tecnico.ulisboa.pt/>

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2.4.2. Seminars & Short-courses

Organized by Magda Rebelo and Paulo Doutor

09 Mar: *Existence of weak solutions to stationary mean-field games*, Rita Ferreira, Center for Uncertainty Quantification in Computational Science & Engineering, King Abdullah University of Science and Technology, Saudi Arabia.

13 Apr: *On the mathematics of medical imaging*, Pedro Serranho, Universidade Aberta and IBILI-Instituto para a Imagem Biomédica e Ciências da Vida, Portugal.

27 Apr: *Inverse Problems to Detect Contact Cracks*, Carlos Alves, Instituto Superior Técnico and CEMAT, Portugal.

11 May: *Numerical methods for distributed-order diffusion equations*, Maria Luísa Morgado, CMAT and Universidade de Trás-os-Montes e Alto Douro, Vila Real, Portugal.

08 Jun: *When does the norm of a Fourier multiplier dominate its L^∞ -norm?*, Oleksiy Karlovych, DM & CMA, FCT-UNL, Portugal.

12 Oct: *The theory of spatial plane waves*, Simão Correia, CMAF-CIO, Faculdade de Ciências, Universidade de Lisboa, Portugal.

26 Oct: *Pointwise products and multipliers- Calculus of function spaces*, Karol Leśnik, Poznan University of Technology, Poland.

09 Nov: *Slow-fast dynamics in interacting multi-strain pathogens*, Erida Gjini, Instituto Gulbenkian de Ciência, Portugal.

07 Dec: *About a Hybrid Nonautonomous SIR-model: stability, simulations and extensions*, Eugénio Rocha, Departamento de Matemática, Universidade de Aveiro, Portugal.

14 Dec: *Solutions of evolution equation in white noise distribution spaces*, Habib Ouerdiane, University of Tunis El Manar, Tunisia.

12-19 Dec: *Convolution Type Operators*, Yuri Karlovich, Universidad Autónoma del Estado de Morelos, Cuernavaca, Mexico.

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2.4.3. Talks in international and national conferences

F. Chalub: "Optimal Vaccination Strategies and Rational Behavior in Seasonal Epidemics". Seventh Workshop Dynamical Systems Applied to Biology and Natural Sciences, Évora, Portugal, February 2-5, 2016.

F. Cipriano: "Well-posedness and optimal control for stochastic second grade fluids". Fluids under Pressure, Summer School and Workshop, Praga, Czech Republic, August 29 - September 2, 2016.

O. Karlovych: "One-sided invertibility criteria for binomial functional operators with shift and slowly oscillating data". Workshop on Operator Theory and Complex Analysis, Coimbra, Portugal, June 21-24, 2016.

R. Martins: "Maths on TV? Yes, we can!". Bridges 2016, Jyväskylä, Finland, August 9-13, 2016.

R. Martins: "The (not so simple) chain fountain". MathsJam 2016, Stone, United Kingdom, November 12-13, 2016.

L. Mascarenhas: "Asymptotic spectral analysis in nanowires with axial heterogeneities". Workshop "New Challenges for the Calculus of Variations Stemming from Problems in the Materials Sciences and Image Processing" in honor of Professor Irene Fonseca, Montreal, Canada, May 16-20, 2016.

F. Oliveira: "Nontrivial ground states for cooperative cubic Schrödinger systems, Xth Workshop on Statistics, Mathematics and Computation, Instituto Politécnico de Tomar, Portugal, May 26-28, 2016.

M. Rebelo: "A numerical method for the space distributed order Riesz fractional diffusion equation". 6th Iberian Mathematical Meeting, Santiago de Compostela, Spain, October 6-8, 2016.

A.M. Ribeiro: "Characterization of Sobolev spaces through functionals without derivatives dependence". International Conference on Applied Mathematics and Numerical Methods, University of Craiova, Craiova, Romania, April 14-16, 2016.

P. Rodrigues: "Modelling tuberculosis transmission: the role of heterogeneity in susceptibility to infection". Seventh Workshop Dynamical Systems

Applied to Biology and Natural Sciences, Évora, Portugal, February 2-5, 2016.

F. Chalub: “Regularity and time-inhomogeneity in the Wright-Fisher dynamics”. Models in Population Dynamics and Ecology, MPDE-16, Marseille, France, September 5-9, 2016.

P. Doutor: “Vaccination in seasonal epidemics with temporary immunity: optimal strategy and rational behavior”. Conference on Mathematical Modeling and Control of Communicable Diseases, Rio de Janeiro, Brazil, January 10-16, 2016.

O. Karlovych: “When does the norm of a Fourier multiplier dominate its L-infinity norm?”. 10th International Conference on Harmonic Analysis and Partial Differential Equations, El Escorial, Spain, June 12-17, 2016.

M. Rebelo: “Introducing graded meshes in the numerical approximation of distributed-order diffusion equations”. 2nd International Conference “Numerical Computations: Theory and Algorithms”, Calabria, Italy, June 23-25, 2016.

M. Rebelo: “Numerical methods for the diffusion equation with distributed order in time”, COST/IEEE-CASS Seasonal Training School in Fractional-Order Systems, Brno University of Technology, Brno, Czech Republic, November 24-26, 2016.

F. Chalub: “Consanguinidade - um risco real?”. XXXIV Jornadas Internacionais de Estudos da Reprodução, Tróia, Portugal, October 7-8, 2016.

O. Karlovych: “Semi-Fredholmness of weighted singular integral operators with shifts and slowly oscillating data”. II Encontro do Centro de Análise Funcional, Estruturas Lineares e Aplicações, Lisboa, Portugal, September 15-16, 2016.

F. Cipriano: “Well-posedness and optimal control for stochastic second grade fluids”. Encontro Nacional da SPM 2016, Barreiro, Portugal, July 11-13, 2016.

R. Martins: “A minha bicicleta calcula áreas!”. Encontro Nacional da SPM 2016, Barreiro, Portugal, July 11-13, 2016. Contributed Talks at National Conferences

P. Rodrigues: “Estratégias de vacinação ótimas e comportamento racional em epidemias sazonais”. Encontro Nacional da SPM 2016, Barreiro, Portugal, July 11-13, 2016.

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2.4.4. Outreach

P. Doutor, N. Martins, A. M. Ribeiro were co-organizers of the Summer School MatNova 2016 aimed at bright secondary school students (10-11th years), Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, August 30 - September 3, 2016.

M. Rebelo was a co-organizer of the Summer School MathIngenious 2016 aimed at bright secondary school students (12th year), Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, July 6-8, 2016.

M. C. Soares is a co-organizer of ClubeMath, a Club for basic and secondary school students, which aims to show a different side of Mathematics, through fun and recreational activities, in order to stimulate skills and interest in this science (<http://eventos.fct.unl.pt/clubemath>)

R. Martins wrote and filmed 52 episodes (four seasons) of the TV Show “Isto é Matemática”, broadcasted in the TV channel SIC Notícias, SIC Internacional and SIC Radical, the sponsor is “Fundação Vodafone Portugal”.

R. Martins wrote 52 articles on mathematics for a general audience in “Journal Expresso”.

R. Martins, P. Rodrigues and **L. Trabucho** gave a series of lectures for general public.

G. Moraes was responsible for the interviews in the “Gazeta de Matemática”.

M. C. Soares taught the course “Códigos e Criptografia” for Ciência Viva students, July 4-8, 2016.

M. C. Soares participated in the European Researchers Night, in Museu Nacional de História Natural e da Ciência, Lisboa, September 30, 2016 and in the Portuguese Mathematical Society’s Fair, in Museu Nacional de História Natural e da Ciência, Lisboa, October 21-22, 2016.

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2.4.5. Other

F. Chalub is a Vice-President of the Portuguese Mathematical Society since September 2016.

P. Rodrigues is a “Vogal da Mesa da Assembleia Geral da Delegação Sul e Ilhas” of the Portuguese Mathematical Society.

Peer-review reports made by group members to “Fractals”, “Complex Variables and Elliptic Equations”, “Journal of Computational Mathematics, Numerical Methods for Partial Differential Equations”, “Numerical Algorithms”, “Applied Numerical Mathematics”, “SIAM Journal on Scientific Computing”, “Communications in Nonlinear Science and Numerical Simulation”, “Ecological Complexity”, “Journal of Mathematical Biology”, and to MathReviews and Zentralblatt MATH.

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2.5. Achievements

F. Chalub, P. Rodrigues, P. Doutor and **M. C. Soares** continued to study vaccination strategies in populations with age structure. Global asymptotic stability of both disease-free and endemic equilibrium is proved. The aim is to describe the best strategy from the population point of view and compare it to the Nash equilibria resulting from assuming voluntary vaccination.

F. Chalub, P. Rodrigues, and T. Costa (former grant holder from the project “Game theory and epidemiology”, EXPL/MAT-CAL/0794/2013 hosted by CMA) continued the study on ring vaccination, in particular on how to define a vaccination strategy taking into consideration population migration between regions with different epidemiological background and the willingness of the local populations to be vaccinated according to the balance between the vaccination and disease risks.

F. Cipriano studied some optimal control problems for stochastic non-Newtonian fluids.

M. d’Orey, J. Henry (Bordeaux, France) and **B. Louro** worked on the factorization of overdetermined boundary value problems, solved technical issues, and are writing a paper to be submitted.

P. Doutor, J. M. Gomes, A. Patrício (NOVA University of Lisbon) and P. Pimenta (NOVA University of Lisbon) established some results for the existence and characterization of solutions of time independent nonlinear Schrödinger equation in the presence of an obstacle.

C. Fernandes, jointly with M. A. Bastos (University of Lisbon) and Yu. Karlovich (Cuernavaca, Mexico), studied C^* -algebras of Cauchy singular integral operators with piecewise quasicontinuous coefficients and shifts.

O. Karlovych, jointly with Yu. Karlovich (Cuernavaca, Mexico) and A. Le-

bre (University of Lisbon), found criteria for one-sided invertibility of binomial functional operators with slowly oscillating shifts and slowly oscillating coefficients on the Lebesgue space L_p . Further, they established a formula for the Fredholm index of weighted singular integral operators with coefficients being binomial functional operators as above.

N. Lopes and **L. Trabuco**, jointly with P.J.J. Pereira (ISEL, Lisbon), studied the Boussinesq type equation models for surface water waves using a continuous/discontinuous Galerkin finite element method. N. Lopes worked on the development of the software: DOLFWAVE - "A library for surface water waves". (<https://launchpad.net/dolfwave>).

B. Louro and **M. C. Soares**, jointly with J. Henry (Bordeaux, France), applied the method of invariant embedding to the Poisson problem in a quasi-cylindrical domain, using a Neumann-to-Dirichlet operator. They have solved some technical issues and are writing a paper to be submitted.

L. Mascarenhas, in collaboration with R. Ferreira (KAUST, Saudi Arabia) and I. Fonseca (CMU, USA), proposed a variational model for imaging segmentation and denoising color images. The model combines Meyer's "u+v" decomposition with a chromaticity-brightness framework, and is expressed by a minimization of energy integral functionals depending on a small parameter $\epsilon > 0$. The asymptotic behavior as ϵ tends to zero was characterized, and convergence of infima, almost minimizers, and energies were established. In particular, an integral representation of the lower semicontinuous envelope, with respect to the L^1 -norm, of functionals with linear growth and defined for maps taking values on a certain compact manifold was provided. This study escapes the realm of previous results since the underlying manifold has boundary, and the integrand and its recession function fail to satisfy hypotheses commonly assumed in the literature. The main tools are Γ -convergence and relaxation techniques.

N. Martins developed and implemented a numerical method for elastic wave propagation. Furthermore, he has studied an inverse source problem for Helmholtz type of equations.

R. Martins found a new approach to the dynamics of the chain fountain phenomenon.

G. Moraes finished the academic part of the PhD in Economics (ISCTE-

IUL, Lisbon) and started to develop research in the area of Econometrics of Financial Markets in order to deliver a Ph.D. dissertation under the supervision of José Dias Curto (ISCTE-IUL, Lisbon) and Marc Paoletta (University of Zurich, Switzerland). He also continued to work in collaboration with C. Johnson (Williamsburg, USA).

F. Oliveira and colleagues studied several dispersive models, more precisely Boussinesq and Schrödinger related systems, such as quasilinear Benney systems and couplings with the Ginzburg-Landau equation. These models were studied from the perspective of local and global well-posedness and existence/stability of solitary waves. Furthermore, a sharp study of ground states to (stationary) Schrödinger systems was carried out.

M. Rebelo proceeded with the study and development of numerical methods for the diffusion equations with distributed order in time and also studied a class of nonlinear Volterra integral equations. For the class of nonlinear Volterra integral equations, smoothness properties of the solution were analyzed and high-order methods were developed to obtain an approximate solution of the problem.

A. M. Ribeiro, in collaboration with R. Ferreira (KAUST, Saudi Arabia) and P. Hästö (Turku, Finland), obtained a new characterization of Musielak-Orlicz spaces through an averaging functional operator. The characterizations obtained generalize previous results with P. Hästö in several directions requiring methods completely different from those used before and involve a new bootstrapping scheme. This work has recently been submitted for publication.

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2.6. Plan: 2017

F. Chalub, P. Rodrigues, P. Doutor, and **M. C. Soares**, with the new post-doc M. Aguiar, will study the effects of voluntary vaccination in the dengue fever epidemiology.

F. Chalub, P. Rodrigues, P. Doutor, and **M. C. Soares** will submit the work on the study of vaccination strategies in populations with age structure.

F. Chalub, and **A. M. Ribeiro**, in collaboration with M. Souza (Niteroi, Brazil), L. Monsaignon (Nancy, France), and A. Blanchet (Toulouse, France), are studying a reformulation of discrete (Moran) and continuous (Kimura) description of evolutionary process using a variational formalism.

F. Chalub and M. Souza (Niteroi, Brazil) will continue the study of discrete evolutionary process without weak selection assumption. In particular, they show that any fixation pattern can be obtained with arbitrary precision as a result of a Wright-Fisher process in a finite population evolving according to a d-player game for sufficiently large d.

F. Chalub, P. Rodrigues, and T. Costa (Champalimaud Foundation, Lisbon) plan to submit a paper on ring vaccination. They are studying barrier vaccination, i.e., vaccination strategies aiming to insulate an outbreak spot, in particular for risky vaccines when human willingness to be vaccinated is also considered. Further, they will collaborate with M. Souza (Niteroi, Brazil) in expanding the work on ring vaccination to a continuous domain using a diffusion model with an increasing transmission function.

F. Cipriano will study optimal control problems for some non-linear stochastic and deterministic PDEs.

M. d'Orey, J. Henry (Bordeaux, France), and **B. Louro** plan to work on the factorization of over-determined boundary value problems.

P. Doutor, J. M. Gomes, A. Patrício (NOVA University of Lisbon), and P. Pimenta (NOVA University of Lisbon) will continue the study of obstacle problems for the Schrödinger equation.

C. Fernandes, O. Karlovych, and Yu. Karlovich (Cuernavaca, Mexico) are going to construct a Fredholm symbol calculus for the Banach algebra of convolution type operators with piecewise quasicontinuous coefficients and presymbols on weighted Lebesgue spaces with Muckenhoupt weights.

M. A. Bastos (University of Lisbon), **C. Fernandes**, and Yu. Karlovich (Cuernavaca, Mexico) plan to establish a Fredholm symbol calculus for the C^* -algebra of singular integral operators with piecewise quasicontinuous coefficients and shifts admitting a finite number of fixed points.

O. Karlovych, Yu. Karlovich (Cuernavaca, Mexico) and A. Lebre (University of Lisbon) are going to find criteria for the $n(d)$ -normality of weighted singular integral operators with coefficients in the Wiener algebras of functional operators with shifts and slowly oscillating data.

O. Karlovych and K. Lesnik (Poznan, Poland) plan to study properties of Toeplitz and Hankel operators acting between different abstract Hardy spaces built upon rearrangement invariant Banach function spaces.

O. Karlovych and E. Shargorodsky (London, United Kingdom) plan to find conditions guaranteeing that the norm of a Fourier multiplier on a Banach function space dominates its L-infinity norm.

N. Lopes, L. Trabucho, and P. J. J. Pereira (ISEL, Lisbon) will continue the study of the Boussinesq type equation models for surface water waves using a continuous/discontinuous Galerkin finite element method. This study will include the analytical and numerical points of view along with the development of the software DOLFWAVE.

J. Henry (Bordeaux, France), **B. Louro**, and **M. C. Soares** plan to improve the method of invariant embedding applied to the Poisson problem in a quasi-cylindrical domain, using the Neumann-to-Dirichlet operator, in order to obtain results in stronger topologies.

R. Martins will continue the study of dynamical properties of the chain fountain phenomenon and the dynamics of quadrilaterals.

G. Morais plans to develop links between the area of Mathematics and Computation, applied to the Econometrics of Financial Markets. The area witnessed a huge boost in the last decade due to the necessity to develop new technologies that may function in proper accordance to the extreme phenomena saw during the last Financial Crisis. Among this new tool set, one can emphasize the role of Information Theory and Statistical Mechanics in the current research of the area.

F. Oliveira will study the dispersive Schrödinger-Debye system, more precisely the blow-up phenomena in the critical case, still very poorly understood. Furthermore, a full study of the hyperbolic Schrödinger system will be carried out.

M. Rebelo will work on partial differential equations with derivatives of fractional order, and will start to analyze some properties of the solution that will be crucial in order to develop appropriate numerical methods. Another goal of the investigation is to obtain an approximate solution to the problem. Some of the problems can be related to industrial applications.

A. M. Ribeiro intends to collaborate with M. M. Boureau (University of Craiova, Romania) on the study of some classes of elliptical systems of PDEs involving new generalized operators with variable exponents. Their interest is in how classical techniques of critical points theory apply to this setting.

A. M. Ribeiro intends to establish existence results in the Calculus of Variations for functionals defined in variable exponent Sobolev spaces. This work has been postponed due to the highly demanding work carried out on Musielak-Orlicz spaces.

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2.7. 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- Kuzntesov equation, which models the propagation of nonlinear ionic-sonic waves in a magnetized plasma. FO also plans to research on singularity formation of solutions and is interested in adapting these methods to Schrodinger-Debye and Davey-Stewartson systems.

OK, CF will study convolution type operators in more general spaces than Banach

spaces. Typical examples are Lebesgue spaces L_p and l_p for p less than one as well as more general Orlicz spaces generated by non-convex Orlicz functions. CF intend to investigate the Fredholm property in C^* algebras of nonlocal type operators generated by partial isometries. OK will prove boundedness conditions and Fredholm criteria for pseudodifferential operators with certain symbols of limited smoothness on variable exponent Lebesgue spaces over \mathbb{R}^n . LT will study Boussinesq-like wave models and, in collaboration with chemists, diffusion of chemical substances through membranes. Both studies will include the analytical and the numerical points of view. MR intends to develop a robust, efficient and stable method with a reasonable order of convergence for the numerical solution of the time-fractional diffusion equations. NM will use mesh-free inverse numerical methods to identify thermal and acoustic sources and obstacles.

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

Research Group

Operations Research

Highlights

1. A paper by J. O. Cerdeira and collaborators was selected to be included in the Virtual Issue *Conservation Ecology*, by the Cambridge Conservation Initiative.
2. Isabel Correia is member of the Editorial Advisory Board of the journal *Computers & Operations Research* (IF 1.988), since January 2016.
3. Jorge Orestes Cerdeira is vice-President of APDIO, the Portuguese Society for Operations Research and Paula Amaral is a board member of the recently created Portuguese group of the European Network for Industry and Innovation.
4. In 2016, OR Group members successfully supervised six Master theses.

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3.1. Team

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3.1.1. Integrated Members

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

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3.1.2. Other Researchers/Collaborators

1. **Graça Maria Marques da Silva Gonçalves** – gmsg@fct.unl.pt
2. **Lídia Ludovina Lampreia Caeiro Pica Lourenço** – lll@fct.unl.pt
3. **Maria Paula da Costa Couto** – mpcc@fct.unl.pt

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3.1.3. Ph.D. Students

1. **Bernardo Pedro E. Ferreira de Almeida** – bernardo.almeida@alunos.fc.ul.pt
2. **Bruna Alexandra Elias Mota** – bruna.mota@gmail.com

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3.2. Funding

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3.2.1. Projects led by CMA members

1. Spatial conservation planning: reconciling biodiversity and human development in a dynamic world, SFRH/BPD/104077/2014 (2016-2018).

PI: Diogo André Alves Salgado Rodrigues Alagador

CMA member: **Jorge Orestes Cerdeira**

Total funding: €87358. CMA funding: €5460

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3.3. Publications

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3.3.1. Publications in the Web of Science database

- [1] D. Alagador, **J. O. Cerdeira**, and M. B. Araujo. Climate change, species range shifts and dispersal corridors: an evaluation of spatial conservation models. *Methods Ecol. Evol.*, 7(7):853–866, JUL 2016.

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

- [2] B. F. Almeida, **I. Correia**, and F. Saldanha-da Gama. Priority-based heuristics for the multi-skill resource constrained project scheduling problem. *Expert Syst. Appl.*, 57:91–103, SEP 15 2016.

<https://doi.org/10.1016/j.eswa.2016.03.017>

- [3] **P. Amaral** and T. C. Pais. Compromise ratio with weighting functions in a tabu search multi-criteria approach to examination timetabling. *Comput. Oper. Res.*, 72:160–174, AUG 2016.

<https://doi.org/10.1016/j.cor.2016.02.012>

- [4] M. F. Anjos and **M. V. C. Vieira**. An improved two-stage optimization-based framework for unequal-areas facility layout. *Optim. Lett.*, 10(7):1379–1392, OCT 2016.

<https://link.springer.com/article/10.1007/s11590-016-1008-6>

- [5] **C. Bras**, G. Eichfelder, and J. Judice. Copositivity tests based on the linear complementarity problem. *Comput. Optim. Appl.*, 63(2):461–493, MAR 2016.

<https://link.springer.com/article/10.1007/s10589-015-9772-2>

- [6] **C. P. Bras**, A. N. Iusem, and J. J. Judice. On the quadratic eigenvalue complementarity problem. *J. Glob. Optim.*, 66(2, SI):153–171, OCT 2016.

<https://link.springer.com/article/10.1007/s10898-014-0260-5>

- [7] M. N. Bugalho, F. S. Dias, B. Brinas, and **J. O. Cerdeira**. Using the high conservation value forest concept and Pareto optimization to identify areas maximizing biodiversity and ecosystem services in cork oak landscapes. *Agrofor. Syst.*, 90(1, SI):35–44, FEB 2016.
- <https://link.springer.com/article/10.1007%2Fs10457-015-9814-x>
- [8] L. Calvet, A. Ferrer, **M. Isabel Gomes**, A. A. Juan, and D. Masip. Combining statistical learning with metaheuristics for the multi-depot vehicle routing problem with market segmentation. *Comput. Ind. Eng.*, 94:93–104, APR 2016.
- <https://doi.org/10.1016/j.cie.2016.01.016>
- [9] **N. Chibeles-Martins**, T. Pinto-Varela, A. P. Barbosa-Povoa, and A. Q. Novais. A multi-objective meta-heuristic approach for the design and planning of green supply chains – MBSA. *Expert Syst. Appl.*, 47:71–84, APR 1 2016.
- <https://doi.org/10.1016/j.eswa.2015.10.036>
- [10] **I. Correia** and T. Melo. Multi-period capacitated facility location under delayed demand satisfaction. *Eur. J. Oper. Res.*, 255(3):729–746, DEC 16 2016.
- <https://doi.org/10.1016/j.ejor.2016.06.039>
- [11] F. S. Dias, D. L. Miller, T. A. Marques, J. Marcelino, M. C. Caldeira, **J. Orestes Cerdeira**, and M. N. Bugalho. Conservation zones promote oak regeneration and shrub diversity in certified mediterranean oak woodlands. *Biol. Conserv.*, 195:226–234, MAR 2016.
- <https://doi.org/10.1016/j.biocon.2016.01.009>
- [12] T. Monteiro-Henriques, M. J. Martins, **J. O. Cerdeira**, P. Silva, P. Arsenio, A. Silva, A. Bellu, and J. C. Costa. Bioclimatological mapping tackling uncertainty propagation: application to mainland Portugal. *Int. J. Climatol.*, 36(1):400–411, JAN 2016.
- <http://onlinelibrary.wiley.com/doi/10.1002/joc.4357/abstract>
- [13] **R. Rodrigues** and **P. Couto**. Detection of false arrhythmia alarms with emphasis on ventricular tachycardia. *Physiol. Meas.*, 37(8):1326–1339, AUG 2016.
- <http://iopscience.iop.org/article/10.1088/0967-3334/37/8/1326>

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3.3.2. Other (international) publications

- [1] **S. Baptista, N. Chibeles-Martins**, G. R. Guerreiro, M. F. Rodrigues, M. C. Soares, and E. Ughi. Mathematics in the making - a view over the Portuguese activities. In A. Ludus, editor, *Proceedings of the Recreational Mathematics Colloquium IV (2015) · G4G Europe, Pavilhão do Conhecimento, Portugal, January 24-27, 2015*, 2016.
- [2] **I. Correia**, S. Nickel, and F. Saldanha-da Gama. A modeling framework for stochastic multi-period capacitated multiple allocation hub location. In *ILS2016 – 6th International Conference on Information Systems, Logistics and Supply Chain*, pages 1-8, 2016.
- [3] **I. Correia** and T. Melo. A computational comparison of formulations for a multi-period facility location problem with modular capacity adjustments and flexible demand fulfillment. Technical report, Saarland Business School, Saarland, Germany, 2016.
- [4] J. Salmerón, **P. Amaral**, L. Casado, E. Hendrix, and J. Žilinskas. On regular simplex refinement in copositivity detection. In C. M. Rocha, A.M.A.C. and E. Fernandes, editors, *Proceedings of the XIII Global Optimization Workshop*, pages 163-166, 2016.

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3.3.3. Computational Applications

- 1. **Paula Amaral**: A software for: i) Linear discriminant analysis for interval and histogram data in Matlab; ii) Lower bounds for minmax fractional quadratic problems in Matlab.
- 2. **Jorge Orestes Cerdeira**: New version (0.12.6, 2016-07-28) of CRAN package subselect: Selecting Variable Subsets A collection of functions which (i) assesses the quality of variable subsets as surrogates for a full data set, in either an exploratory data analysis or in the context of a multivariate linear model, and (ii) searches for subsets which are optimal under various criteria.
<https://cran.r-project.org/web/packages/subselect/index.html>
- 3. **Ana Luísa Custódio** and J. F. A. Madeira, MultiGLODS: Global and Local Multi-objective Optimization using Direct Search (MATLAB), Version 0.1
<http://ferrari.dmat.fct.unl.pt/personal/alcustodio/multiglods>
 Actual number of requests: 1 (first release)

4. **A. L. Custódio** and J. F. A. Madeira, GLODS: Global and Local Optimization using Direct Search (MATLAB), Version 0.3

<http://ferrari.dmat.fct.unl.pt/personal/alcustodio/GLODS> Actual number of requests: 24 (new release).

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3.4. Activites

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3.4.1. Organization of conferences & sessions

Special section: Area Prioritization for Biodiversity Conservation, Ecosummit2016, Ecological Sustainability: Engineering Change, Montpellier, 29 August – 1 September 2016 (organizer **Jorge Orestes Cerdeira**).

Workshop for Ageing and Independent Living: Quantitative methods, FCT-UNL, February 2016 (co-organizer **Isabel Gomes**)

III Iberian Modelling Week, Porto, April 11-15, 2016 (member of the program committee **Jorge Orestes Cerdeira**)

EngOpt 2016, 5th International Conference on Engineering Optimization, 19 to 23 June 2016, Federal University of Rio de Janeiro, Brazil (member of the program committee **Ana Luísa Custódio**)

ANTS 2016, Tenth International Conference on Swarm Intelligence, 7 to 9 September 2016, Université Libre de Bruxelles, Belgium (member of the program committee **Ana Luísa Custódio**)

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3.4.2. Seminars & Short-courses at CMA

Organized by Jorge O. Cerdeira

23 Mar: *Topics on Energy Optimization*, João Murta Pina, DEE, UNINOVA/CTS, Portugal.

23 Mar: *Smart Grids and Network Management*, Manuel Matos, INESC TEC & FEUP, Portugal.

23 Mar: *Otimização Multiobjectivo Para o Aumento da Fiabilidade em Redes de Distribuição Radiais com Incorporação de Geração Distribuída e Sistemas de Armazenamento*, António Pombo, DEE, UNINOVA/CTS, Portugal.

4 May: *Operations Research in Health Care Logistics*, Teresa Melo, Saarland University of Applied Sciences, Business School, Saarbrücken, Germany.

07 Jun: *Separable cubic modeling with impact in global optimization*, Marcos Raydan, Simon Bolivar University, Venezuela.

07 Jun: *Spectral simplex gradient method for unconstrained optimization*, Milagros Loreto, University of Washington Bothell, USA.

07 Jun: *Surfaces of minimal energy Applications*, Miguel Ángel Fortes, University of Granada, Spain.

14 Jun: *Low-cost methods for large-scale optimization*, Marcos Raydan, Department of Scientific Computing and Statistics, Simon Bolivar University, Venezuela.

21 Sep: *Dynamic energy budgets parameter estimation: helping biologists model their species*, Gonçalo Marques, MARETEC - Marine, Environment and Technology Center, Instituto Superior Técnico, Universidade de Lisboa, Portugal.

16 Nov: *Ecological concerns in forest management*, an integer programming approach, Isabel Martins, ISA, ULisboa and CMAF-CIO.

16 Nov: *A climate change adaptive dynamic programming approach to optimize eucalypt stand management scheduling: A Portuguese application*, Liliana Ferreira, Escola Superior de Tecnologia e Gestão and CMAF-CIO, Portugal.

16 Nov: *A model to minimize costs and promote species persistence under climate change*, Jorge Orestes Cerdeira, CMA/FCT/UNL, Portugal.

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3.4.3. Supervision of Ph.D. students

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

Bruna Alexandra Elias Mota, working on the topic “Integrated sustainable supply chain design and planning”, Ph.D. Program MIT Portugal Leaders for Technical Industries – EDAM, co-supervised by **Isabel Gomes**.

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3.4.4. Talks in international and national conferences

“Warehouse storing and collecting of parts: a challenge addressed on the 65th European Study Group with Industry”, the 19th European Conference on Mathematics for Industry, Santiago de Compostela, Spain, 13-17 June 2016 (**Jorge Orestes Cerdeira**)

“A model to minimize costs and promote species persistence under climate change”, Ecosummit2016, Ecological Sustainability: Engineering Change, Montpellier, 29 August - 1 September 2016 (**Jorge Orestes Cerdeira**).

“A modeling framework for stochastic multi-period capacitated multiple allocation hub location”, **Correia, I.**, Nickel, S., and Saldanha da Gama, F., ILS 2016, Bordeaux, France, June 1-4, 2016.

“A parallel matheuristic for the strategic planning of a closed loop supply chain with a time stochastic dominance risk averse functional measure”, **Baptista, S.**, Barbosa-Póvoa, A. P., Escudero, L., Gomes, M.I. and Pizarro, C. Presented by S. Baptista at OR2016-Annual International Conference of the German Operations Research Society, Hamburg, Germany, August 30 to September 2, 2016.

“Multi-period facility location with dynamic capacity planning and delayed demand satisfaction”, **Correia, I.** and Melo, T., OR2016-Annual International Conference of the German Operations Research Society, Hamburg, Germany, August 30 to September 2, 2016.

“An enhanced MILP model for stochastic multi-period multiple allocation hub location”, **Correia, I.**, Nickel, S., and Saldanha da Gama, F., INFORMS 2016, Nashville, USA, November 13-16, 2016.

“On risk management for a two-stage stochastic mixed 0-1 model for the design and operation planning of a closed-loop supply chain”, **Gomes, I.**, XXIII EURO Working Group on Locational Analysis Meeting (EWGLA), Malaga, Spain, 2016.

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3.4.5. Outreach

ClubeMath, FCT-UNL, during 2016 (**Susana Baptista** and **Nelson Chibeles Martins** were members of the Organizing Committee).

Pangea - the International Mathematics Competition, in 2016 edition enrolling 17126 Portuguese students (**Susana Baptista** was member of the Scientific Committee).

6th Journey of Mathematics of FCT-UNL, FCT-UNL, 18th March 2016 (**Ana Luísa Custódio** was member of the Organizing Committee).

“E se, por absurdo, não houvesse Investigação Operacional (IO)...”, talk at Nuc(M)- Nucleus of Mathematics of FCT-UNL, April 2016 (**Ana Luísa Custódio**).

Ciência Viva no Laboratório – traineeship “A matemática na logística das empresas”, 4th to 8th July 2016 (**Isabel Gomes**).

MathIngenious 2016, Summer School in Mathematics for merit senior high school students, FCT-UNL, 6th to 8th July 2016 (**Ana Luísa Custódio** was chair of the Organizing Committee).

“Calculando a Idade das Estrelas: Uma breve introdução à Optimização”, talk at MathIngenious 2016, FCT-UNL, 8th July 2016 (**Ana Luísa Custódio**).

“A Matemática no estudo e preservação da biodiversidade”, talk at MathIngenious 2016, FCT-UNL, 8th July 2016 (**Jorge Orestes Cerdeira**).

MatNova2016, FCT-UNL, 30 August - 3 September 2016 (**Maria do Carmo Brás** was member of the Organizing Committee).

“Noite dos Investigadores”, National Museum of Natural History and Science, Lisbon, September 2016 (**Nelson Chibeles Martins**).

Portuguese Mathematical Society’s Fair, National Museum of Natural History and Science, Lisbon, October 2016 (**Nelson Chibeles Martins**).

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3.4.6. Master theses completed, supervised by CMA members

1. Samuel Pacheco Marques Vaz Marcos, "Uma abordagem baseada em procura directa direcional a problemas com ruído", Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 30 November 2016. Supervised by **Ana Luísa Custódio**.
2. Ricardo Jorge da Conceição Silva, "Modelos em redes de fluxos para o problema de afetação de veículos ferroviários", Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 29 November 2016. Supervised by **Maria Isabel Gomes**.

3. Carla Patrícia Bento Simões, "Modelação e Otimização de Escalas de Pessoal: um Caso de Estudo", Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 25 November 2016. Supervised by **Paula Amaral**.

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3.4.7. Other

Jorge Orestes Cerdeira was member of the Mathematics Panel of the Portuguese Foundation for Science and Technology, responsible by evaluating the funding proposals for Ph.D. studentships and Post-doctoral fellowships in 2016.

Ana Luísa Custódio was member of the proposal evaluation panel of the 2016 call for research proposals of the National Research Council of Romania.

Isabel Gomes was responsible for project evaluation within the "City of Vienna-BOKU Research Funding" program.

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

Ana Luísa Custódio was jury member of the European BEST Engineering Competition (Case Study Category), Almada, February 2016.

Paula Amaral is member of the board of PT-MATHS-IN, the Portuguese group of the European Network for Industry and Innovation.

Jorge Orestes Cerdeira is vice-President of APDIO, the Portuguese Society for Operations Research.

Paula Amaral was group coordinator at the III Iberian Modeling Week, April 11-18, Porto where she supervised a study group on workforce timetabling optimization.

Manuel Vieira was group coordinator at ESGI-119 (European Study Group for Industry). The container loading problem "Time Reduction of the Packing Process" was proposed for solution by a shoes manufacturer. The group presented concrete actions to be implemented in the packing process.

Peer-review reports made by group members to Annals of Operations Research, Applied Mathematical Modeling, Applied Mathematics and Computation, Computational and Applied Mathematics, Computational Optimization and Applications, Computers & Operations Research, Computers and Industrial Engineering, Ecography, European Journal of Operational Research, International Transactions in Operational Research, Journal of Mathematical Extension

sion, Landscape and Urban Planning, Landscape Ecology, Mathematical Problems in Engineering, Modeling, Dynamics, Optimization and Bioeconomics II, Series Springer Proceedings in Mathematics and Statistics, Open Mathematics, Operations Research, Operations Research for Health Care, Optimization and Engineering, Optimization Letters, Pacific Journal on Optimization, SIAM Journal on Optimization, SIAM Journal on Scientific Computing, Transactions of Tianjin University, five chapters of a book to be published by Springer, conference Proceedings, and to Mathematical Reviews.

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3.5. Achievements

During 2016 the research conducted by the OR Group continued to be focused on its core areas, namely combinatorial optimization and nonlinear optimization. In nonlinear optimization, min-max fractional quadratic problems with quadratic and linear constraints were analyzed. Fractional problems were also used to obtain the solution of the symmetric eigenvalue complementarity problem and in linear discriminant analysis for interval and histogram data. Large and sparse symmetric eigenvalue complementarity problems were addressed by combining elements from the spectral projected-gradient method and the block active set method. Regarding derivative-free optimization, the work focused on the convergence of nonmonotone variants of directional direct search, to be used in noisy optimization, and in the efficiency improvement of the spectral simplex gradient method.

The work on combinatorial optimization included an analysis of the p-median problem on disconnected graphs, two combinatorial optimization problems in the areas of project scheduling and facility location, the problem of K clusters with fixed cardinality constraints, and the development of models and algorithms for facility layout problems. Applications were also the subject of research of some group members. In derivative-free optimization, the reconstruction of surfaces, considering nonlinear geometric constraints, was addressed. On supply chains, the main sources of uncertainty or divergence in an environmental analysis were identified and their impact was assessed on strategic and tactical supply chain decisions. An application to a pulp and paper producer was considered. The design and planning of supply chains in the context of risk averse decision making was also a subject of

research. Maps of bioclimatological indices were computed for Portugal as a consequence of developing a method to assess error propagation. Applications related to health and ageing were also addressed, namely the detection of false arrhythmia alarms, the characterization of the risk of sexual transmitted infections among sub-Saharan migrants' population living in Portugal, the identification of subgroups of individuals with similar behavior and with higher risk of exposure to HIV, the development of a selfie ageing index, and a new heuristic for the home care problem (based on the Clark and Wright Savings heuristic combined with biased randomization). Additionally, several researchers actively participated in initiatives for society and in particular for schools (enrolling in graduate training networks, organizing scientific courses, conducting seminars and special sessions in conferences, ClubeMath, Summer Schools MatNova and MathIngenious, Pangea competition).

As result, during 2016 the OR Group published 14 papers in international journals, 3 proceedings in international conferences, and released 4 computational implementations.

Paula Amaral: In 2016 PA initiated the study of min-max fractional quadratic problems with quadratic and linear constraints. This is a nonconvex problem, relevant in many applications, especially in economic models in which one wishes to consider robustness under different economic scenarios. PA developed a reformulation technique based on completely positive programs and studied the quality of the lower bounds obtained by a relaxation of this completely positive formulation. PA pursued a collaboration work on fractional quadratic optimization used in linear discriminant analysis for interval and histogram data, started the study on regular simplices applied to copositive detection, and prepared and lectured a 3-hour course on Conic Optimization.

Susana Baptista: SB pursued her work in the development of solution strategies for the design and planning of supply chains in the context of risk averse decision making, in particular, extended the parallel implementation of the risk neutral solution algorithm to a risk averse context.

Maria do Carmo Brás: The solution of the symmetric eigenvalue complementarity problem was addressed by treating an equivalent reformulation of finding a stationary point of a fractional quadratic program on the unit simplex. A new algorithm that combines elements from the spectral projected-

gradient method and the block active set method was developed. In this algorithm the projection onto the unit simplex in the spectral projected-gradient method is replaced by the more economical projection onto a box, with particular advantage for large and sparse symmetric eigenvalue complementarity problems.

Jorge Orestes Cerdeira: A method to assess error propagation was developed and used to produce maps of bioclimatological indices for Portugal [T. Monteiro-Henriques, M.J. Martins, J.O. Cerdeira, P.C. Silva, P. Arsénio, A. Silva, A. Bellu, and J.C. Costa, Bioclimatological mapping tackling uncertainty propagation: application to mainland Portugal, *International Journal of Climatology*, 36 (2016) 400-411 (DOI: 10.1002/joc.4357)]. The work on the p-median problem on disconnected graphs was pursued (a paper is currently under review).

Isabel Correia: The research in 2016 focused on two combinatorial optimization problems in the areas of project scheduling and facility location. In the area of project scheduling we studied a biased random-key genetic algorithm (BRKGA) for a multi-skill resource constrained project scheduling problem that uses as decoders a parallel scheduling scheme and a serial scheduling scheme. In the area of facility location we studied a multi-period capacitated facility location problem under delayed demand satisfaction, in which new facilities can be established at pre-specified potential locations and initially existing facilities can be closed over a planning horizon. Additionally, facilities operate with modular capacities that can also be dynamically adjusted over time. For this problem, two different mixed-integer linear programming models were proposed as well as a set of additional inequalities with the aim of strengthening the models.

Ana Luísa Custódio: The research work focused on four different topics of Derivative-free Optimization (DFO): global multiobjective DFO, nonmonotone directional direct search applied to noisy optimization, the spectral simplex gradient method and one application problem. ALC have launched a first release of MultiGLODS, a Matlab solver suited for global and local multiobjective DFO. The corresponding technical report was submitted for publication. ALC have established the convergence of some nonmonotone variants of directional direct search, previously identified as numerically suited for noisy optimization. The corresponding work led to a Masters thesis, successfully

defended in 2016. ALC have initiated the study of strategies to improve the numerical efficiency of the spectral simplex gradient method (SpecSimplex). This algorithm is suited for nonsmooth derivative-free unconstrained optimization problems and it is generally very efficient in terms of the total number of function evaluations required. Nevertheless, there are cases in which the associated computational cost is prohibitive, given the target problem class. ALC achieved a significant reduction in the total number of functions evaluations required by reusing previously computed simplex gradients, maintaining the quality of the final computed solution. Preliminary results will be presented on the DFO stream at IFORS 2017. ALC have also initiated some application work in the DFO reconstruction of surfaces, by considering nonlinear geometric constraints (like patches with a prescribed area or curvatures) when filling “holes”.

Paula Couto and **Rui Rodrigues**: As a consequence of the research undertaken on the detection of false arrhythmia alarms in intensive care units, namely the detection of ventricular tachycardia, we published an article in the *Physiological Measurement* journal.

Isabel Gomes: The objectives set for 2016 were achieved concerning: *Supply Chain sustainability* – in collaboration with **Bruna Mota**, Ana Carvalho, and Ana Póvoa (IST, Universidade de Lisboa), investigated the main sources of uncertainty or divergence in an environmental analysis and assessed their impact on strategic and tactical Supply Chain decisions. The generic modelling framework for the design and planning of sustainable supply chains previously developed was used to study the extent to which these points and sources of uncertainty influence managerial decisions within a real case study regarding a Portuguese-based pulp and paper producer. *Supply Chain uncertainty* – in collaboration with **Susana Baptista** (CMA, FCT-UNL), Laureano Escudeiro, and Celeste Pizzaro (University Rey Juan Carlos, Madrid), investigated the parallelization of the Fix-and-Relax matheuristic algorithm, as planned, conducted some computational experiments on randomly-generated networks, and were able to demonstrate the quality of the approach. *Home healthcare problems* – in collaboration with Manuel Eliseu (Masters student, FCT-UNL) and Angel Juan (UOC, Barcelona), developed a matheuristic approach based on the Clark and Wright Savings matheuristic combined with

biased randomization to solve a home care problem (HCP), which can be modelled as a rich Vehicle Routing Problem with Time Windows (VRPTW). The algorithm was tested in small instances based on a real case and achieved promising results. *Home healthcare problems* – in collaboration with **Miguel Fonseca** (CMA, FCT-UNL), Patrícia Abrantes, and Sónia Dias (IHMT, UNL), studied the characterization of the sexual behavior regarding exposure to HIV infection among a population of sub-Saharan migrants living in Portugal, and the identification of subgroups of individuals with similar behavior and higher risk of exposure to HIV. Hierarchical clusters analysis was carried out to identify different behavioral profiles. The results indicated five profiles of sexual behavior among the study's participants, and identified the profiles and individuals most vulnerable to HIV infection. *Home healthcare problems* – in collaboration with **Miguel Fonseca** (CMA, FCT-UNL), Judite Gonçalves and Pedro Pita Barros (SBE, UNL), and Amália Botelho (NMS, UNL), worked on a selfie ageing index using an ordered probit model applied to the SHARE data pertaining to the Portuguese population in order to determine which variables best explain the self-assessed health variable. The model revealed five ageing profiles.

Graça Gonçalves and **Lídia Lourenço** investigated the problem of the K clusters with fixed cardinality constraints.

Nelson Chibeles Martins: The paper version of the study “A Multi-Objective Meta-Heuristic Approach for the Design and Planning of Green Supply Chains – MBSA” was published in Expert Systems with Applications in April, 2016.

Manuel Vieira during 2016 developed new models and algorithms for facility layout problems and their specialized forms for the variants multirow facility layout and multi-floor facility layout. This research is ongoing.

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3.6. Plan: 2017

In 2017 the research work will continue on the topics mentioned above and will begin in some new areas. In nonlinear optimization, min-max fractional quadratic problems will continue to be analyzed. Separable cubic models will be used for solving smooth large-scale unconstrained minimization problems and for developing new derivative-free trust-region methods for solving smooth unconstrained minimization problems. Combinatorial optimization will include the development of new models for project scheduling problems

with flexible resources, the study of new capacitated hub location problems, the development of mixed integer linear optimization models for facility layout problems, the combination of clustering and decomposition techniques for the p-median problem on disconnected graphs, and different formulations for the problem of K clusters with fixed cardinality. Heuristics for production planning will also be developed, considering multi-product and multipurpose plants. In terms of applications, new research will be initiated in Big Data applied to political campaigns and the design of maximum persistence climate corridors for species on a bounded area for very large real data will be addressed. Additionally, the derivative-free reconstruction of surfaces will continue, and an application related to the derivative-free estimation of parameters in the Dynamic Energy Budget theory will be analyzed. In health and ageing, “Deep learning” will be applied to ECG, the selfie ageing index will be validated and be made publically available, and more complex home-care planning services will be analyzed. The design of supply chains will continue to be a subject of research, namely by measuring the impact of social objectives and by applying the models that consider uncertainty to a real case study.

As a result, the group expects to submit 15 papers and publish 14 in international journals.

Paula Amaral: We intend to continue the study of min-max fractional quadratic problems with quadratic and linear constraints, to finish the computational tests in linear discriminant analysis for interval and histogram data and to continue the study on regular simplices applied to copositive detection. We plan to initiate research in Big Data applied to political campaigns.

Susana Baptista: We plan to finish the report on the impacts of the developed risk averse procedure.

Maria do Carmo Brás: A separable cubic model for solving smooth large-scale unconstrained minimization problems will be studied. A specialized trust-region strategy to minimize the cubic model on a properly chosen low dimensional subspace will be analyzed.

Jorge Orestes Cerdeira: I plan to develop work on solving very large p-median problems by combining clustering and decomposition techniques for the p-median problem on disconnected graphs. In the scope of project REC-

ONCILE (PTDC/AAG-GLO/3979/2014), we intend to develop algorithms and computer programs for the design of maximum persistence climate corridors for species on a bounded area, for very large real data.

Isabel Correia: The research plans for 2017 include the following topics: (i) development of new models for project scheduling problems with flexible resources; (ii) study of new capacitated hub location problems.

Ana Luísa Custódio: We intend to report the work related to the use of nonmonotone directional direct search in noisy optimization. We will continue the work related to the performance improvement of the spectral simplex gradient method. In a different topic, as result of some discussions with Professor Marcos Raydan during his visit to CMA, we intend to develop a derivative-free separable cubic model for solving smooth unconstrained minimization problems in a trust-region framework. In terms of applications, we will continue the work related with the reconstruction of surfaces based on nonlinear geometric constraints, and we will work on an application related to the DFO estimation of parameters in the Dynamic Energy Budget theory.

Paula Couto and Rui Rodrigues: We are developing research related to the application of “Deep Learning” to ECG: 1- Biometrics using ECG, 2- Classification of short (10-90 seconds) ECG segments rhythm as “Normal”, “Atrial Fibrillation” or “other”. This target is related to the “Computing in Cardiology/Physionet Challenge 2017”.

Graça Gonçalves and Lúcia Lourenço: We will continue to study different formulations for the problem of K clusters with fixed cardinality.

Isabel Gomes: Next year we are planning to get the validation of the ageing profiles by a group of experts and to develop a web application to make the index publically available. We aim to collect new data to further test the index; to further investigate the impact of social objectives on a supply chain structure; to apply the developed model and solution approach to a real case study; and to extend the model previously developed and apply it to a new case study with more complex features.

Nelson Chibeles Martins: During 2016 a bi-objective simulated annealing based algorithm for production planning was explored. For 2017 the objectives will be: i) adapting the mentioned algorithm scheduling on multi-product and multipurpose plants; ii) adapting the methodology explored during 2015,

with supply chains, to scheduling on multi-product and multipurpose plants; iii) expanding one or both methodologies to alternative meta-heuristics.

Manuel Vieira: Our work will be focused on the development of mixed integer linear optimization models for facility layout problems. As facility layout is NP-hard, we will investigate algorithms to obtain good solutions. Furthermore, specialized variants deserve attention: Multirow facility layout: in some type of production facilities, layouts are arranged in rows. This type of specialized layouts allows specialized models and approaches. Multi-floor facility layout: services facilities such as hospitals, airports, etc. are services in which the “departments” are arranged within several floors. We aim to develop efficient two-stage algorithms to obtain good layouts.

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3.7. Strategic Plan: 2015-2020

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

The group develops research in two main areas: Non-Linear Optimization (NLO) and Combinatorial Optimization (CO). The topics addressed in NLO include: Derivative-free Optimization (DFO), Complementarity Problems (CP), Semi-definite Programming (SDP); in CO include: Networks Design Models (NDM), Hub Location Problems (HL), Vehicle Routing Problems (VRP), Resource Constraint Project Scheduling Problem (RPS). Besides theoretical results, part of the work has been directed to real applications (as retail distribution [SBN10], electric and electronic equipment [FGB11]), reports in the scope of European Study Groups in Industry (<http://www.maths-in-industry.org>), and to the development of free available software, e.g DMS (<http://www.mat.uc.pt/dms>), SID-PSM (<http://www.mat.uc.pt/sid-psm/>), GLODS (<http://ferrari.dmat.fct.unl.pt/personal/alcustodio>) MulTyLink (<http://pascal.iseg.utl.pt/rbras/MulTyLink/>), subselect (<http://cran.r-project.org/web/packages/subselect/index.html>). Brief description of specific work to be carried out on the topics above follows.

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

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

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

The group addresses a number of different problems in the scope of NDM: (1) previous work has focus on supply chain design with cost minimization [SBN10]; the work will now continue into a multiobjective approach to model sustainability by considering economic, environmental and social objectives; (2) the development of single and multiobjective metaheuristics to tackle computational complexity when the modelling of supply chain following previous work [CPBN12], (3) the modelling of sources of supply chain uncertainty by stochastic formulation with the development of decomposition based solution strategies as previous work follow up [BGB12], (4) work will continue on water network design problem considering piecewise-linear relaxations and applying principles of bilinear relaxation, (5) development of new quantitative models for variants of the classical hub location problems; (6) Past work on a generalization of the (node version of the) minimum Steiner tree and the minimum Steiner forest focused on the development of heuristics to handle very large instances (ENVIRON MODELL SOFTW, 40:336-339). The work will now be directed to the study of the polyhedra associated to a cut-covering formulation. The problem has applications in the design of ecological corridors linking habitats for multiple species. VRP will continue its study on the modelling of multi-compartment vehicles and periodic issues intrinsic to collection problems, and on the dial-a-ride problem arising within the context of medical services. RPS will, in particular, focus on (1) the formulation of new variants for the resource constrained project scheduling problem with flexible resources following the previous work, (2) the tailoring of solution procedures to improve the quality of obtained feasible solutions.

The group will develop a PhD program on Operations Research or integrate Operations Research as a discipline in the PhD program on Mathematics already in place at the Department of Mathematics of FCT/UNL

Research Group

Statistics and Risk Management

Highlights

1. Participation in two national and two international projects.
2. Increase by more than 30% the number of publications indexed by WoS compared to 2015.
3. Three Ph.D. theses defenses in 2016, and nine more Ph.D. dissertations currently supervised by CMA members.

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4.1. Team

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4.1.1. Integrated Members

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4.1.2. Other Researchers/Collaborators

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4.1.3. Ph.D. Students

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3. **Ivanilda Maria dos Santos Cabral Semedo** – ivanilda.cabral@docente.unicv.edu.
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6. **Sandra Maria Simões de Oliveira** – sandra.oliveira@esce.ips.pt
7. **Sheyla Ratan Rodrigues Cassy** – sheylaratan@hotmail.com

4.2. Funding

1. Improving Drought and Flood Early Warning, Forecasting and Mitigation using real-time hydroclimatic indicators (IMDROFLOOD), WATER JOINT PROGRAMMING INITIATIVE/0004/2014 (2014-18).
Principal investigator: Ricardo Machado Trigo (Instituto Dom Luiz, IDL/FC/UL).
Total Funding: 149.400 euros.
CMA member: Elsa Moreira.
2. Statistical Distribution Theory- Impact and Reach, COMPETITIVE PROGRAMME FOR RATED RESEARCHERS (CPRR) 160403161466, Grant No: 105840 (2017-19).
Principal investigator: Andriëtte Bekker.
Total funding: 600 kRands (circa 40 k€).
CMA member: Filipe Marques.
3. EPSRC Impact Acceleration grant: New algorithms for Efficient risk estimation, EPSRC P078 (2015/Sep - 2016/Jul).
Principal investigator: Goncalo dos Reis.
Total Funding: 20.000 pounds (circa 22 k€).
CMA member: Gonalo dos Reis.
4. SealTall - Sistema para Gesto Integrada de Pescas, CENTRO-01-0247-FEDER-017693 (2016-19).
Principal Investigator: Joo Carlos Amaro Ferreira (ISCTE-IUL).
CMA member: Iola Pinto.

4.3. Publications

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4.3.1. Publications in the Web of Science database

- [1] **L. B. Afonso** and P. C. Real. Using weighted distributions to model operational risk. *Astin Bull.*, 46(2):469–485, MAY 2016.

<https://doi.org/10.1017/asb.2016.4>

- [2] A. Areia and **J. T. Mexia**. ANOVA like analysis of cancer death age. In T. Simos and C. Tsitouras, editors, *Proceedings of the International Conference on Numerical Analysis and Applied Mathematics 2015 (ICNAAM-2015)*, volume 1738 of *AIP Conference Proceedings*, 2016. International Conference on Numerical Analysis and Applied Mathematics (ICNAAM), Rhodes, GREECE, SEP 23-29, 2015.

<http://dx.doi.org/10.1063/1.4951825>

- [3] R. A. Bailey, **S. S. Ferreira**, **D. Ferreira**, and **C. Nunes**. Estimability of variance components when all model matrices commute. *Linear Alg. Appl.*, 492:144–160, MAR 1 2016.

<https://doi.org/10.1016/j.laa.2015.11.002>

- [4] **I. Cabral**, **F. Caeiro**, and M. I. Gomes. Reduced bias Hill estimators. In T. Simos, Z. Kalogiratou, and T. Monovasilis, editors, *Proceedings of the International Conference of Computational Methods in Sciences and Engineering 2016 (ICCMSE-2016)*, volume 1790 of *AIP Conference Proceedings*, 2016. International Conference of Computational Methods in Sciences and Engineering (ICCMSE), Athens, GREECE, MAR 17-20, 2016.

<http://dx.doi.org/10.1063/1.4968687>

- [5] **F. Caeiro**, M. Ivette Gomes, J. Beirlant, and T. de Wet. Mean-of-order p reduced-bias extreme value index estimation under a third-order framework. *Extremes*, 19(4):561–589, DEC 2016.

<https://link.springer.com/article/10.1007/s10687-016-0261-5>

- [6] **F. Caeiro**, M. Ivette Gomes, and L. Henriques-Rodrigues. A location-invariant probability weighted moment estimation of the extreme value index. *Int. J. Comput. Math.*, 93(4, SI):676–695, APR 2 2016.

<http://dx.doi.org/10.1080/00207160.2014.975217>

- [7] **F. Caeiro**, **F. J. Marques**, **A. Mateus**, and S. Atal. A note on the Jackson exponentiality test. In T. Simos, Z. Kalogiratou, and T. Monovasilis, editors, *Proceedings of the International Conference of Computational Methods in Sciences and Engineering 2016 (ICCMSE-2016)*, volume 1790 of *AIP Conference Proceedings*, 2016. International Conference of Computational Methods in Sciences and Engineering (ICCMSE), Athens, GREECE, MAR 17-20, 2016.

<http://dx.doi.org/10.1063/1.4968686>

- [8] F. Carapau, P. Correia, and **L. M. Grilo**. Specific shear-dependent viscoelastic third-grade fluid model. In T. Simos, Z. Kalogiratou, and T. Monovasilis, editors, *Proceedings of the International Conference of Computational Methods in Sciences and Engineering 2016 (ICCMSE-2016)*, volume 1790 of *AIP Conference Proceedings*, 2016. International Conference of Computational Methods in Sciences and Engineering (ICCMSE), Athens, GREECE, MAR 17-20, 2016.
- <http://dx.doi.org/10.1063/1.4968737>
- [9] **F. Carvalho** and **R. Covas**. Mixed additive models. In T. Simos and C. Tsitouras, editors, *Proceedings of the International Conference on Numerical Analysis and Applied Mathematics 2015 (ICNAAM-2015)*, volume 1738 of *AIP Conference Proceedings*, 2016. International Conference on Numerical Analysis and Applied Mathematics (ICNAAM), Rhodes, GREECE, SEP 23-29, 2015.
- https://www.researchgate.net/profile/Francisco_Carvalho/publication/303912504_Mixed_additive_models/links/575e9cd108aed884621b53d0/Mixed-additive-models.pdf
- [10] **C. A. Coelho**, **F. J. Marques**, and **S. Oliveira**. Near-exact distributions for likelihood ratio statistics used in the simultaneous test of conditions on mean vectors and patterns of covariance matrices. *Math. Probl. Eng.*, 2016.
- <http://dx.doi.org/10.1155/2016/8975902>
- [11] **R. Covas** and **F. Carvalho**. Construction of linear models: a framework based on commutative Jordan algebras. In T. Simos and C. Tsitouras, editors, *Proceedings of the International Conference on Numerical Analysis and Applied Mathematics 2015 (ICNAAM-2015)*, volume 1738 of *AIP Conference Proceedings*, 2016. International Conference on Numerical Analysis and Applied Mathematics (ICNAAM), Rhodes, GREECE, SEP 23-29, 2015.
- https://www.researchgate.net/publication/303897855_Construction_of_linear_models_A_framework_based_on_commutative_Jordan_algebras
- [12] **C. Dias**, **C. Santos**, M. Varadinov, and **J. T. Mexia**. ANOVA like analysis for structured families of stochastic matrices. In T. Simos, Z. Kalogiratou, and T. Monovasilis, editors, *Proceedings of the International Conference of Computational Methods in Sciences and Engineering 2016 (ICCMSE-2016)*, volume 1790 of *AIP Conference Proceedings*, 2016. International Conference of Computational Methods in Sciences and Engineering (ICCMSE), Athens, GREECE, MAR 17-20, 2016.

<http://dx.doi.org/10.1063/1.4968735>

- [13] **M. L. Esquivel, J. M. Fernandes, and G. R. Guerreiro.** An open Markov chain scheme model for a credit consumption portfolio fed by ARIMA and SARMA processes. In T. Simos and C. Tsitouras, editors, *Proceedings of the International Conference on Numerical Analysis and Applied Mathematics 2015 (ICNAAM-2015)*, volume 1738 of *AIP Conference Proceedings*, 2016. International Conference on Numerical Analysis and Applied Mathematics (ICNAAM), Rhodes, GREECE, SEP 23-29, 2015.

<http://dx.doi.org/10.1063/1.4951970>

- [14] **M. L. Esquivel, P. P. Mota, and J. T. Mexia.** On some statistical models with a random number of observations. *J. Stat. Theory Pract.*, 10(4):805–823, 2016.

<http://dx.doi.org/10.1080/15598608.2016.1227735>

- [15] **M. Faias, P. Mota, A. Mulenga, and J. P. Pina.** Asymmetry of arch effects and natural resources disease or virtue: Mozambique experience. In T. Simos and C. Tsitouras, editors, *Proceedings of the International Conference on Numerical Analysis and Applied Mathematics 2015 (ICNAAM-2015)*, volume 1738 of *AIP Conference Proceedings*, 2016. International Conference on Numerical Analysis and Applied Mathematics (ICNAAM), Rhodes, GREECE, SEP 23-29, 2015.

<http://dx.doi.org/10.1063/1.4951971>

- [16] **C. Fernandes, P. Ramos, and J. T. Mexia.** Conditions to have umvue for the stair nested designs. *JP Journal of Biostatistics*, 13(2):165–175, 2016.

<http://www.pphmj.com/abstract/10366.htm>

- [17] **D. P. Gomes, I. J. Sequeira, C. Figueiredo, J. Rueff, and A. Bras.** The human chromosomal fragile sites more often involved in constitutional deletions and duplications - a genetic and statistical assessment. In T. Simos, Z. Kalogiratos, and T. Monovasilis, editors, *Proceedings of the International Conference of Computational Methods in Sciences and Engineering 2016 (ICCMSE-2016)*, volume 1790 of *AIP Conference Proceedings*, 2016. International Conference of Computational Methods in Sciences and Engineering (ICCMSE), Athens, GREECE, MAR 17-20, 2016.

<http://dx.doi.org/10.1063/1.4968684>

- [18] J. Goncalves, **E. Moreira**, **I. J. Sequeira**, A. S. Rodrigues, J. Rueff, and A. Bras. Integration of HIV in the human genome: Which sites are preferential? A genetic and statistical assessment. *Int. J. Genomics*, 2016.
<http://dx.doi.org/10.1155/2016/2168590>
- [19] **L. M. Grilo** and H. L. Grilo. Robust statistical approaches to assess the degree of agreement of clinical data. In T. Simos and C. Tsitouras, editors, *PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON NUMERICAL ANALYSIS AND APPLIED MATHEMATICS 2015 (ICNAAM-2015)*, volume 1738 of *AIP Conference Proceedings*, 2016. International Conference on Numerical Analysis and Applied Mathematics (ICNAAM), Rhodes, GREECE, SEP 23-29, 2015.
<http://dx.doi.org/10.1063/1.4952235>
- [20] **L. M. Grilo**, D. S. Silva, I. M. Nogueira, H. L. Grilo, and T. A. Oliveira. Individual control charts in paperboard industry. In T. Simos, Z. Kalogiratou, and T. Monovasilis, editors, *Proceedings of the International Conference of Computational Methods in Sciences and Engineering 2016 (ICCMSE-2016)*, volume 1790 of *AIP Conference Proceedings*, 2016. International Conference of Computational Methods in Sciences and Engineering (ICCMSE), Athens, GREECE, MAR 17-20, 2016.
<http://aip.scitation.org/doi/pdf/10.1063/1.4968738>
- [21] S. Gupta, J. Shabbir, **R. Sousa**, and P. Corte-Real. Improved exponential type estimators of the mean of a sensitive variable in the presence of nonsensitive auxiliary information. *Commun. Stat.-Simul. Comput.*, 45(9):3317–3328, 2016.
<http://dx.doi.org/10.1080/03610918.2014.941487>
- [22] **S. Inacio**, **J. Mexia**, **M. Fonseca**, and **F. Carvalho**. Estimation for large non-centrality parameters. In T. Simos and C. Tsitouras, editors, *Proceedings of the International Conference on Numerical Analysis and Applied Mathematics 2015 (ICNAAM-2015)*, volume 1738 of *AIP Conference Proceedings*, 2016. International Conference on Numerical Analysis and Applied Mathematics (ICNAAM), Rhodes, GREECE, SEP 23-29, 2015.
<http://dx.doi.org/10.1063/1.4951827>
- [23] B. Kedem, L. Pan, W. Zhou, and **C. A. Coelho**. Interval estimation of small tail probabilities - applications in food safety. *Stat. Med.*, 35(18):3229–3240, AUG 15 2016.

<http://onlinelibrary.wiley.com/doi/10.1002/sim.6921/full>

- [24] **F. J. Marques** and **C. A. Coelho**. Near-exact distributions for positive linear combinations of independent non-central Gamma random variables. In T. Simos and C. Tsitouras, editors, *Proceedings of the International Conference on Numerical Analysis and Applied Mathematics 2015 (ICNAAM-2015)*, volume 1738 of *AIP Conference Proceedings*, 2016. International Conference on Numerical Analysis and Applied Mathematics (ICNAAM), Rhodes, GREECE, SEP 23-29, 2015.

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- [25] **F. J. Marques** and F. Loingeville. Improved near-exact distributions for the product of independent Generalized Gamma random variables. *Comput. Stat. Data Anal.*, 102:55–66, OCT 2016.

<https://doi.org/10.1016/j.csda.2016.04.004>

- [26] **A. Mateus**, **F. Caeiro**, **D. P. Gomes**, and **I. J. Sequeira**. Statistical analysis of extreme river flows. In T. Simos, Z. Kalogiratou, and T. Monovasilis, editors, *Proceedings of the International Conference of Computational Methods in Sciences and Engineering 2016 (ICCMSE-2016)*, volume 1790 of *AIP Conference Proceedings*, 2016. International Conference of Computational Methods in Sciences and Engineering (ICCMSE), Athens, GREECE, MAR 17-20, 2016.

<http://dx.doi.org/10.1063/1.4968685>

- [27] **S. Monteiro**, **M. Fonseca**, and **F. Carvalho**. Estimators for variance components in structured stair nesting models. In T. Simos and C. Tsitouras, editors, *Proceedings of the International Conference on Numerical Analysis and Applied Mathematics 2015 (ICNAAM-2015)*, volume 1738 of *AIP Conference Proceedings*, 2016. International Conference on Numerical Analysis and Applied Mathematics (ICNAAM), Rhodes, GREECE, SEP 23-29, 2015.

<http://dx.doi.org/10.1063/1.4951830>

- [28] **E. E. Moreira**. SPI drought class prediction using log-linear models applied to wet and dry seasons. *Phys. Chem. Earth*, 94:136–145, AUG 2016.

<https://doi.org/10.1016/j.pce.2015.10.019>

- [29] **E. E. Moreira**, C. L. Pires, and L. S. Pereira. SPI drought class predictions driven by the north atlantic oscillation index using log-linear modeling. *Water*, 8(2), FEB 2016.

- <https://www.google.pt/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=0ahUKEwjHx4z816nVAhVCXR0KHfGzCW4QFggyMAE&url=http%3A%2F%2Fwww.mdpi.com%2F2073-4441%2F8%2F2%2F43%2Fpdf&usg=AFQjCNE7YGpBs8yf9jMtk1StVAem4AXe6Q>
- [30] **P. P. Mota** and **M. L. Esquivel**. Model selection for stock prices data. *J. Appl. Stat.*, 43(16):2977–2987, DEC 2016.
- <http://dx.doi.org/10.1080/02664763.2016.1155205>
- [31] **S. Nunes**. Perspectives and realities of teaching statistics at a superior school of business administration. In T. Simos and C. Tsitouras, editors, *Proceedings of the International Conference on Numerical Analysis and Applied Mathematics 2015 (ICNAAM-2015)*, volume 1738 of *AIP Conference Proceedings*, 2016. International Conference on Numerical Analysis and Applied Mathematics (ICNAAM), Rhodes, GREECE, SEP 23-29, 2015.
- <http://dx.doi.org/10.1063/1.4952234>
- [32] **D. Prata Gomes**, M. M. Neves, and **E. Moreira**. An exploratory study of spatial annual maximum of monthly precipitation in the northern region of Portugal. *Phys. Chem. Earth*, 94:77–84, AUG 2016.
- <https://doi.org/10.1016/j.pce.2015.12.001>
- [33] P. C. Rodrigues, A. Monteiro, and **V. M. Lourenco**. A robust AMMI model for the analysis of genotype-by-environment data. *Bioinformatics*, 32(1):58–66, JAN 1 2016.
- https://oup.silverchair-cdn.com/oup/backfile/Content_public/Journal/bioinformatics/32/1/10.1093_bioinformatics_btv533/3/btv533.pdf?Expires=1501259937&Signature=NkjS0UgXnbt~4tPJ4bSrtkGBRQJd-bwS0GS0n6ZEDurhDc920RExxWNMsMxcxdEnVdp_&Key-Pair-Id=APKAIUCZBIA4LVPVW3Q
- [34] A. Roy, R. Zmyslony, **M. Fonseca**, and R. Leiva. Optimal estimation for doubly multivariate data in blocked compound symmetric covariance structure. *J. Multivar. Anal.*, 144:81–90, FEB 2016.
- <https://doi.org/10.1016/j.jmva.2015.11.001>
- [35] **C. Santos**, **C. Nunes**, **C. Dias**, M. Varadinov, and **J. T. Mexia**. Imbedding linear regressions in models for factor crossing. In T. Simos, Z. Kalogiratou, and T. Monovasilis, editors, *Proceedings of the International Conference of Computational Methods in Sciences and Engineering 2016 (ICCMSE-2016)*, volume

1790 of *AIP Conference Proceedings*, 2016. International Conference of Computational Methods in Sciences and Engineering (ICCMSE), Athens, GREECE, MAR 17-20, 2016.

<http://dx.doi.org/10.1063/1.4968734>

- [36] K. Soto, P. Campos, **I. Pinto**, B. Rodrigues, F. Frade, A. L. Papoila, and P. Devarajan. The risk of chronic kidney disease and mortality are increased after community-acquired acute kidney injury. *Kidney Int.*, 90(5):1090–1099, NOV 2016.

[http://www.kidney-international.org/article/S0085-2538\(16\)30356-8/fulltext](http://www.kidney-international.org/article/S0085-2538(16)30356-8/fulltext)

- [37] R. Zmyslony, **J. T. Mexia**, **F. Carvalho**, and **I. J. Sequeira**. Mean driven balance and uniformly best linear unbiased estimators. *Stat. Pap.*, 57(1):43–53, MAR 2016.

<https://link.springer.com/article/10.1007%2Fs00362-014-0638-y>

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4.3.2. Other publications in peer-reviewed journals

- [1] **Sandra S. Ferreira**, **Célia Nunes**, **Dário Ferreira**, **Elsa Moreira** and **João Tiago Mexia**. Estimation and orthogonal block structure. *Hacettepe Journal of Mathematics and Statistics*, 45(2):541 – 548, 2016.
- [2] **M. Faías**, J. Hervés-Estévez, and E. Moreno-García. Stability in price competition revisited. *Economic Theory Bulletin*, 4(2):151–166, 2016.
- [3] P. Campos, **I. Pinto**, N. Datia, A. Papoila, and K. Soto. Kidney disease progression and associated factors in hiv+ patients. In J. A. S. Nephrol, editor, *J Am Soc Nephrol*, volume 27 of *Abstract Supplemment*, page 805A, 2016. (SA-PO760).

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4.3.3. Other (international) publications

- [1] S. Baptista, N. Chibeles-Martins, **G. R. Guerreiro**, M. F. Rodrigues, M. C. Soares, and E. Ughi. Mathematics in the making - a view over the Portuguese activities. In A. Ludus, editor, *Proceedings of the Recreational Mathematics Colloquium IV (2015) · G4G Europe, Pavilhão do Conhecimento, Portugal, January 24-27, 2015*, 2016.

- [2] **F. Caeiro** and M. I. Gomes. *Extreme Value Modeling and Risk Analysis Methods and Applications*, chapter Threshold selection in extreme value analysis, pages 69–86. John Wiley & Sons, 2016.
- [3] M. I. Gomes, **F. Caeiro**, L. Henriques-Rodrigues, and B. Manjunath. *Extreme Events in Finance: A Handbook of Extreme Value Theory and Its Applications*, chapter Bootstrap methods in statistics of extremes, pages 117–138. John Wiley & Sons, 2016.
- [4] A. Alves, A. M. Gonçalves, **J. M. Fernandes**, I. Vaz, S. Teixeira, I. Sousa, J. Pereira, and S. Dória-Nóbrega. Combined tools for surgical case packages contents and cost optimization: a preliminary study. volume 100 of *S1877-0509(16)32342-0*, page 393 – 398, 2016.
- [5] **S. Ferreira**, **D. Ferreira**, **C. Nunes**, and **J. Mexia**. Estimation in models with commutative orthogonal block structure, imbedded orthogonality. In C. H. S. Lidia Filus, Teresa Oliveira, editor, *Stochastic Modeling, Data Analysis and Statistical Applications*, pages 315–323, 2016.
- [6] M. Gomes, H. Penalva, **F. Caeiro**, and M. Neves. Non-reduced versus reduced-bias estimators of the extreme value index – efficiency and robustness. In *Proceedings of COMPSTAT 2016: 22th International Conference on Computational Statistics*, pages 279–290, 2016.
- [7] **L. M. Grilo** and H. L. Grilo. Robust statistical approaches to assess the degree of agreement of clinical data. In I. J. Ruda, editor, *Proceedings in Advances in Mathematics and Computer Science and their Applications*, volume 57 of *Mathematics and Computer in Science and Engineering Series*, pages 272–275, 2016.

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4.4. Activities

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4.4.1. Organization of conferences & sessions

1. **[CMAC]**: Xth Workshop on Statistics, Mathematics and Computation, and Vth Portuguese-Polish Workshop on Biometry, Tomar, Portugal, May 26-28, 2016, Member of the Scientific Committee.
2. **[CMAC]**: Special Invited Session "Likelihood-based Inference: Methods and Applications" at the upcoming 2nd International Conference on Sta-

- tistical Distributions and Applications, October 14-16, 2016, organizer and chair.
3. **[CMAC]**: 2nd International Conference on Statistical Distributions and Applications, October 14-16, 2016, Member of the Scientific Program Committee.
 4. **[CAS]**: III Workshop on Computational Data Analysis and Numerical Methods, Instituto Politécnico de Portalegre, UÉvora, IPBeja, IPTomar, Instituto Politécnico de Portalegre, November 18, Member of the Organizing and Scientific Committees.
 5. **[CAS]**: Encontros com a Matemática, Instituto Politécnico de Beja, September 26, Member of the Organizing Committee.
 6. **[CAS]**: A verdade por trás dos números, Instituto Politécnico de Portalegre, 22 Abril 2016, Member of the Organizing Committee.
 7. **[CAS]**: Seminário Dia do Pi, Instituto Politécnico de Beja, 14 Março 2016, Member of the Organizing Committee.
 8. **[CNU]**: 10th Workshop on Statistics, Mathematics and Computation (WSMC10) and 5th Portuguese-Polish Workshop in Biometry (PPWB5), Polytechnic Institute of Tomar, 26-28 may, 2016, Scientific Committee and Organizing Committee.
 9. **[DFe]**: 10th Workshop on Statistics, Mathematics and Computation (WSMC10) and 5th Portuguese-Polish Workshop in Biometry (PPWB5), Polytechnic Institute of Tomar, 26-28 may, 2016, Scientific Committee and Organizing Committee.
 10. **[DPG]**: Organizing Committee of II Galician-Portuguese Meeting of Biometry, with applications to Health Sciences, Ecology and Environmental Sciences (BIOAPP2016).
 11. **[FJM]**: Invited session "Statistical Distributions and Applications" in the X Workshop on Statistics, Mathematics and Computation (WSMC10) and in the V Portuguese-Polish Workshop on Biometry (PPWB5), 2016.

12. **[GdR]**: Organizer of Workshop: MCMC and particle methods: sampling, inference and stochastic approximation, Edinburgh (Scotland/UK), 5-9 Sep 2016.
13. **[GdR]**: Organizer of Summer-School: MIGSAA graduate course on stochastic pathwise integration and stochastic particle systems, Edinburgh (Scotland/UK), 18-21 April 2016.
14. **[LGr]**: III Workshop on Computational Data Analysis and Numerical Methods (WCDANM 2016), Instituto Politécnico de Portalegre, Portalegre, Portugal, November 18, 2016, Member of the Organizing Committee.
15. **[LGr]**: Xth Workshop on Statistics, Mathematics and Computation (WSMC10) and Vth Portuguese-Polish Workshop on Biometry (PPWB5), Instituto Politécnico de Tomar, Tomar, Portugal, May 26-28, 2016, Local Chairman.
16. **[MSF]**: XI Management Week. Tomar, Portugal. Scientific Committee.
17. **[MSF]**: I Workshop Ageing and Independent Living – Quantitative Methods. Lisbon, Portugal. Organizing Committee.
18. **[RRC]**: Scientific Committee of the 2016 ASTIN Colloquium, Lisbon, from 31 May to 3 June 2016, Member.
19. **[RRC]**: Scientific Committee of the V Iberian Congress of Actuaries, Lisbon, from 6th to 7th June 2016, President.
20. **[SSF]**: 10th Workshop on Statistics, Mathematics and Computation (WSMC10) and 5th Portuguese-Polish Workshop in Biometry (PPWB5), Polytechnic Institute of Tomar, 26-28 May, 2016, Scientific Committee and Organizing Committee.

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4.4.2. Seminars & Short-courses

Organized by Inês Sequeira and Dora P. Gomes

20 Jan: *CoPlot e CoStat: programas estatístico para elaboração de gráficos científicos que facilitam a sua vida*, Carlos Costa, Faculdade Meridional, IMED Business School, Passo Fundo, RS, Brazil.

04 May: *The Correlation Risk Premium Term Structure*, Gonçalo Faria, Business School and CEGE, Universidade Católica do Porto, Portugal.

04 May: *Dynamic Programming for Modulated Jump-Diffusion*, Nuno Azevedo, Financial Stability Department - Banco de Portugal, Portugal.

04 May: *The value of a firm with exit and suspension options*, Cláudia Nunes Phillipart, Instituto Superior Técnico, Universidade de Lisboa, Portugal.

04 May: *Bonds Historical Simulation Value at Risk*, João Beleza, CMA/FCT/UNL & Instituto Superior de Engenharia de Lisboa, Instituto Politécnico de Lisboa, Portugal.

12 Oct: *Estimation for the growth curve model with orthogonal covariance structure*, Miguel Fonseca, CMA/FCT/UNL, Portugal.

05 Dec: *Consequences of model misspecifications in synthetic data analysis*, Bimal Sinha, UMBC & Center for Statistical Research and Methodology (CSRM), US Census Bureau, USA.

14 Dec: *Linear Sufficiency in Models with Orthogonal Block Structure*, João Tiago Mexia, CMA/FCT/UNL, Portugal.

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4.4.3. Supervision of Ph.D. students

Theses presented in the year 2016.

1. Ricardo Moura, Ph.D. student of the Ph.D. Program in Statistics and Risk Management, finished Ph.D. degree with a Thesis entitled “Likelihood-based Inference for Multivariate Regression Models using Synthetic Data”. Supervised by **Carlos Agra Coelho**.
2. Sónia Inácio. “Não centralidade: estimabilidade e relevância”. Nova University of Lisbon, Faculty of Sciences and Technology, Department of Mathematics. 2016. Supervised by **Miguel Fonseca**.

3. Sandra Monteiro. “Modelos com cruzamento de aninhamentos em esca-
cada estruturados”. Nova University of Lisbon, Faculty of Sciences and
Technology, Department of Mathematics. 2016. Supervised by **Miguel
Fonseca**.

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4.4.4. Talks in international and national conferences

Ayana Mateus: Invited speaker of the organized session Algebra, Mathematics and Computation in the X Workshop on Statistics, Mathematics and Computation (WSMC10) with the talk “Comparing Several Tests of Randomness Based on the Difference of Observations”.

Carlos A. Coelho was Invited speaker at the Scientific Session of the Jubilee Celebration of Professor Roman Zmyslony, which took place on March 13, 2016, at the Department of Mathematics, Computer Science and Econometrics of the University of Zielona-Gora, Poland, with the talk entitled “Testing block-compound symmetry vs. block-matrix sphericity”.

Carlos A. Coelho was Invited speaker at the 10th Probability and Statistics Day at UMBC (University of Maryland Baltimore County), in celebration of Professor Bimal Sinha 70th birthday, which took place on May 20-21, 2016, with the talk entitled “Likelihood based inference methods for Statistical Disclosure Control - joint work with Professor Bimal Sinha”.

Carlos A. Coelho was Invited speaker at the Xth Workshop on Statistics, Mathematics and Computation, and Vth Portuguese-Polish Workshop on Biometry, Instituto Politécnico de Tomar on May 26-28, 2016, with the presentation of the oral communication entitled “Tests for equality of mean vectors with structured covariance matrices”.

Carlos A. Coelho was Invited Speaker at the International Conference on Statistical Distributions and Applications, which took place in Niagara Falls, Canada, October 14-16, 2016, with the presentation of the oral communication entitled “Likelihood ratio test for the equality of mean vectors when the joint covariance matrix is Block-circulant”.

Dora Gomes: Revisiting the choice of block size and the threshold in the extremal index estimation, PPWB5 & WSMC10, 27 de Maio, Tomar.

Gonçalo dos Reis: Topics in SDEs and their link to (S)PDEs, Leeds (UK), 19 Sep 2016.

Gonalo dos Reis: Crossroads: Workshop on Stochastic Analysis and Related Fields, Berlin (DE), 28 - 30 July 2016.

Joo Tiago Mexia, A. Markiewicz, F. Carvalho, S. Ferreira, C. Nunes and D. Ferreira. Linear Sufficiency in Models with Orthogonal Block Structure. Workshop on Statistics, Mathematics and Computation (WSMC10) and 5th Portuguese-Polish Workshop in Biometry (PPWB5), Polytechnic Institute of Tomar, 26-28 may, 2016.

Luis Grilo. (2016). Exploratory factor analysis in burnout state. III Workshop on Computational Data Analysis and Numerical Methods, Instituto Politcnico de Portalegre, Portalegre, Portugal, November 18 (p. 03, book of abstracts).

Luis Grilo. (2016). Statistical Analysis of Burnout State. 5th International Conference on Health Science and Biomedical Systems (HSBS '16). Ischia, Italy, June 17-19.

Luis Grilo. (2016). Parametric and Nonparametric approaches to evaluate the agreement of medical measurements. 4th International Conference on Mathematical, Computational and Statistical Sciences (MCSS '16). Barcelona, Spain, February 13-15.

Marta Faias Mateus: Manchester Economic Theory workshop 2016, (School of Social Sciences (Economics), University of Manchester, Manchester, United Kingdom, 15 June 2016. "Credit market segmentation, Essentiality of commodities, and supermodularity".

Marta Faias Mateus: 17th Annual Conference of the Public Economic Theory Association (PET16). (Fundaco Getlio Vargas, Rio de Janeiro, Brasil, 11-13 July, 2016). "Credit market segmentation, Essentiality of commodities, and supermodularity".

Marta Faias Mateus: 16th SAET Conference on Current Trends in Economics. (IMPA, Rio de Janeiro, Brasil, 6-9 July, 2016). "Credit market segmentation, Essentiality of commodities, and supermodularity".

Marta Faias Mateus: UECE Lisbon Meetings 2016: Game Theory and Applications. (Lisboa, Portugal, 3-5, November, 2016). "Credit market segmentation, Essentiality of commodities, and supermodularity".

Miguel Fonseca: Singull, Martin. Inference for the Growth Curve Model with Orthogonal Covariance Structure. 9th International Conference of the

ERCIM WG on Computational and Methodological Statistics. Spain. 2016.

Miguel Fonseca: Singull, Martin. Estimation for the Growth Curve Model with Orthogonal Covariance Structure. International Workshop on Matrices and Statistics. Portugal. 2016.

Miguel Fonseca: Przystalski, Marcin. Optimal Estimation for Doubly Multivariate Data in Blocked Compound Symmetric Covariance Structure. Seminar in Mathematical Statistics, Institute of Technology, Linköping University. Sweden. 2016.

Vanda Lourenço: 9 - 11 December 2016, 9th International Conference of the ERCIM WG on Computational and Methodological Statistics (CMStatistics2016), Seville, Spain. Invited session title: R and robustness and official statistics, Talk title: Robust SNP-based estimation of heritability with R.

Vanda Lourenço: 23 - 25 May 2016, 61ª Reunião Anual da Região Brasileira da Sociedade Internacional de Biometria (RBras2016), Salvador da Bahia, Brazil, Talk title: 'On the robust estimation of trait heritability. "Contributed talk".

Ayana Mateus: Statistical Analysis of Extreme River Flows in the 12th International Conference of Computational Methods in Sciences and Engineering. (Ayana Mateus, Frederico Caeiro, Dora Prata Gomes, and Inês J. Sequeira.)

Carla Santos, Célia Nunes, Cristina Dias e João Tiago Mexia, Obtaining COBS from the extension of a balanced mixed model, Instituto Politécnico de Portalegre, Instituto Politécnico de Tomar, Instituto Politécnico de Beja e Universidade de Évora, III Workshop on Computational Data Analysis and Numerical Methods, Instituto Politécnico de Portalegre, November 18.

Carla Santos, Célia Nunes, Cristina Dias e João Tiago Mexia, Models with orthogonal block structure, Commutativity and B-Matrices, Instituto Politécnico de Tomar, Universidade Aberta e Universidade da Beira Interior, X Workshop on Statistics, Mathematics and Computation (WSMC10), Instituto Politécnico de Tomar, 26-28 May.

Filipe Marques: "The simultaneous test of equality and circularity of q covariance matrices", in the International Conference on Advances in Interdisciplinary Statistics and Combinatorics (AISC), 2016.

Filipe Marques: "Gamma-series representations for the sum of indepen-

dent gamma random variables and for the product of independent beta random variables", in the X Workshop on Statistics, Mathematics and Computation (WSMC10) e no V Portuguese-Polish Workshop on Biometry (PPWB5), 2016.

Gonalo dos Reis: Stochastic analysis of dynamical systems, stochastic control and games, Leeds (UK), 24 to 26 Oct 2016.

Gonalo dos Reis: At the Frontiers of Quantitative Finance, Edinburgh (UK), 27 30 June 2016.

Inês Sequeira: The human chromosomal fragile sites more involved in constitutional deletions and duplications - a statistical assessment, ICCMSE 2016, March 17, Athens.

Inês Sequeira: Statistical Analysis of Extreme River Flows, ICCMSE 2016, March 17, Athens.

Iola Pinto: " Campos, P.P., Pinto, I., Datia, N., Papoila, A.L. and Soto, K. (2016). kidney disease progression and associated factors in hiv+ patients. Kidney-Week, Chicago, USA, PA November 14-19, 2016."

Iola Pinto: "Ferreira, J.C., Lage, S., Pinto, I., Antunes, I. Fishing Monitor System Data: A Naïve Bayes Approach. 16th International Conference on Intelligent Systems Design and Applications (ISDA 2016) Porto, Portugal, December 16-18, 2016."

João Beleza Sousa, Manuel Esquível, Raquel Gaspar, Pedro Corte Real "Bonds historical simulation Value at Risk" International Conference - Mathematical and Statistical Methods for Actuarial Sciences and Finance - MAF 2016 Paris Dauphine University Paris, March 31 - April 1, 2016.

Luis Grilo, Santos, M. A. and Grilo, H. L. (2016). Non-parametric Individual Control Charts for Silica in Water. Xth Workshop on Statistics, Mathematics and Computation (WSMC10) and Vth Portuguese-Polish Workshop on Biometry (PPWB5), Instituto Politécnico de Tomar, Portugal, May 26-28.

Luis Grilo, Silva, D. S., Nogueira, I. M., Grilo, H. L. and Oliveira, T. A. (2016). Individual Control Charts in Paperboard Industry. 12th International Conference of Computational Methods in Sciences and Engineering (ICCMSE 2016), Athens, Greece, March 17-20.

Dora Gomes: The human chromosomal fragile sites more involved in constitutional deletions and duplications - a statistical assessment, ICCMSE 2016,

March 17, Athens. Statistical Analysis of Extreme River Flows, ICCMSE 2016, March 17, Athens.

Natário, I., Cassy, S.. "Modelos de Regressão Logística sob Delineamentos Amostrais Complexos". II Encontro Galaico-Português de Biometria, con aplicación ás Ciencias da Saúde, á Ecoloxía e ás Ciencias do Medio Ambiente, Santiago de Compostela, June 30 - July 2.

S. Ferreira, D. Ferreira, C. Nunes, J.T. Mexia. Optimal Estimation in Models with Positive Orthogonal Block Structure. 20th Conference of the International Linear Algebra Society (ILAS), Leuven, 7-15 July, 2016.

C. Nunes, S. S. Ferreira, D. Ferreira, M. M. Oliveira and **J. T. Mexia**. Normal approximations to noncentral Wishart matrices. 25th International Workshop on Matrices and Statistics (IWMS'2016), University of Madeira, Funchal, 6-9 June, 2016.

C. Santos, C. Nunes, C. Dias, J. T. Mexia. Models with orthogonal block structure, commutativity and B-Matrices. Workshop on Statistics, Mathematics and Computation (WSMC10) and 5th Portuguese-Polish Workshop in Biometry (PPWB5), Polytechnic Institute of Tomar, 26-28 May, 2016.

C. Nunes, D. Ferreira, S. S. Ferreira and J. T. Mexia. Comparing for one-way fixed effects models the usual and the random sample sizes ANOVA. 25th International Workshop on Matrices and Statistics (IWMS'2016), University of Madeira, Funchal, 6-9 June, 2016.

C. Santos, C. Nunes, C. Dias and J. T. Mexia. On the extension of a balanced mixed model.. 25th International Workshop on Matrices and Statistics (IWMS'2016), University of Madeira, Funchal, 6-9 June, 2016.

Marta Faia Mateus: XXV European Workshop on General Equilibrium Theory - EWGET 2016. (Adam Smith Business School, University of Glasgow, Glasgow, United Kingdom, 16-18 June, 2016). "Credit market segmentation, Essentiality of commodities, and supermodularity".

Lourdes Afonso, R. Cardoso, A. Egidio dos Reis, G. Guerreiro: The impact of Bonus malus systems in finite and continuous time ruin probabilities in motor insurance considering an open versus a closed portfolio. ASTIN Colloquium, Lisboa 31 May-3 June, 2016.

Vanda Lourenço: 30 July - 4 August 2016, Joint Statistical Meetings (JSM 2016), Chicago, USA. Talk title: 'Robust heritability and predictive accuracy

estimation in plant breeding’.

Vanda Lourenço: 28 - 30 July 2016, 18h Meeting of New Researchers in Statistics and Probability (NRC), University of Wisconsin, Madison USA, Flash Talk Title: ‘Robust heritability and predictive accuracy estimation in plant breeding’.

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4.4.5. Outreach

[CAS]: Ocupação Científica de Jovens nas Férias: Olha à tua volta! Onde está a Estatística? 4 Julho a 8 de Julho de 2016, Centro de Matemática e Aplicações - FCT - Universidade Nova de Lisboa, Instituto Politécnico de Beja, 18h.

[CAS]: Divulgação da Matemática - Artigos no jornal digital “Tribuna Alentejo” : Os primos sabem guardar segredo; Desafio das compras de natal; Ainda nos resta um tempinho até ao fim do mundo; Desafio das 3 pilhas; A lenda de Gauss; Desafio dos triângulos; Tem que ser igual a 1; Mais rápido que a calculadora; Igual podia não ser = e = podia não ser igual; Quanto é... Abc?; Campanha eleitoral de Hillary Clinton apresenta ... o pior diagrama de Venn de sempre!; Desafio mãe e filha; A falácia de Monte Carlo; Desafio dos números perfeitos; O erro de Pitágoras; 14 de Março: dia do famoso número pi; Desafio: o dodecágono misterioso; Por que é 2016 um ano bissexto?

[ICN]: Natário, I. "Matemática e Vida, Compreendendo as Doenças Infecciosas pela Via Matemática". Estágio FCT-UNL Ciência Viva 2016. 11-15 de Julho de 2016.

[ICN]: Matemática e Vida, Compreendendo as Doenças Infecciosas pela Via Matemática. Mini-course (4 out of 10 hours) of the Summer School MathIngenious 2016, for final student of the secondary level. 6-8 July de 2016.

[MFM]: Responsible researcher in the project “Mathematical in Financial Markets” for high school students - Ciência Viva 2016.

[MFM]: Mini-Course at MathNova 2016 (Summer School for high school students at Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa). Title: “Mathematical Finance”.

[MFM]: Collaboration in the activities for high school students promoted by the project “Clube Math”.

[MFM]: Seminar in a high school, Colégio Valssassina, title: Game Theory and Applications to Economics.

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4.4.6. Master thesis completed, supervised by CMA members

[CAS]: Riscos Associados à Actividade Operacional dos Bombeiros, Carla Rianço, Mestrado em segurança e higiene no trabalho, I.P.Beja, 09-12-2016.

[CAS]: Risco Toxicológicos de Contaminantes Químicos e Biológicos em Cuidados de Saúde, Claudia Santos, Mestrado em segurança e higiene no trabalho, I.P.Beja, 14-12-2016.

[FJM]: Masters in Mathematics and Applications - Actuarial, Statistics and Operational Research, Faculty of Sciences and Technology, Universidade Nova de Lisboa. Aluna: Mariana Baptista Title of the thesis: "Determining Factors in Fixing Interest Rates in New Loan Operations to Non-Financial Companies." Completed in (2016) with the final mark: 17 points

[FJM]: Master in Mathematics and Applications - Actuarial, Statistics and Operational Research, Faculty of Sciences and Technology, Universidade Nova de Lisboa. Aluna: Sara Igreijas. Title of thesis: "Contribution to the development of a credit risk assessment model for companies with credit obtained from the Portuguese financial system.". Completed in (2016) with the final mark: 19 values

[GdR]: MSc thesis: Qiliang Chen, Multilevel Monte Carlo Methods and Fourier analysis, MSc Computational Mathematical Finance, University of Edinburgh (UK) **[GdR]:** MSc thesis: Yangsi Shangguan, BSDEs and stochastic Nash games under performance concerns, MSc Computational Mathematical Finance, University of Edinburgh (UK)

[GdR]: MSc thesis: Jianan Liu, BSDEs, Wiener Chaos expansions and CVA calculation, MSc Financial Modelling and Optimization, University of Edinburgh (UK)

[GdR]: MSc thesis: Georgios Samartzis, Large Deviations Principles and Fourier analysis, MSc Computational Mathematical Finance, University of Edinburgh (UK)

[GdR]: MSc thesis: Nataliia Savina, Mean Variance Optimization to test portfolios, MSc Financial Modelling and Optimization, University of Edinburgh (UK)

[GdR]: MMath thesis: Claire Stacey, MCMC Methods with Applications to Credit Risk, Masters in Mathematics, University of Edinburgh (UK)

[GRG]: Ana Daniela Santos, Seguro de Long Term Care, FCT NOVA, Dezembro de 2016.

[GRG]: Andreia Filipa Bártolo, Sistemas de Bonus Malus: Simulação de uma carteira aberta, Novembro de 2016 - joint supervision with Maria Isabel Gomes

[MLA]: Cláudia Isabel Moura Mateus, "Estudo da Metodologia Definida e Melhoramentos para a Compilação dos Valores Iniciais e Finais do Quadro Relativo a Direitos Associados a Pensões", Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 7 July 2016.

[MFM]: Master thesis co-adviser of João Gonçalo Vargem da Costa Neto. Title: Managing Osteoarthritis Through Nutrition Solutions: A Business Case Study. Location: Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa. Date: December 19.

[MSF]: Gisela Matos. "Análise multivariada para a funcionalidade dos idosos na Região do Alentejo". Nova University of Lisbon, Faculty of Sciences and Technology, Department of Mathematics. 2016.

[RRC]: Natacha Francisco Amaro, "A atividade seguradora e o estilo de vida em Portugal – O estímulo como incentivo para a mudança: uma abordagem atuarial", FCT UNL, December 14.

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4.4.7. Other

[ICN]: Coordinator and member of the Scientific Committee of the e-learning joint program of the Universidade NOVA de Lisboa of the MsC in Estatística para a Saúde, Instituto de Higiene e Medicina Tropical and Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa. 2016/2017.

[MLE]: Selection Committee of Responsible Actuaries of the National Supervision Authority Of Insurers and Pension Funds; more than 20 actuaries certified.

[MLE]: Education Committee of the Portuguese Institute of Actuaries.

[RRC]: Member (treasurer) of the Board of IAP (Portuguese Institute of Actuaries); president of the Statutory Audit Committee of CIM (International Center for Mathematics); president of the Statutory Audit Committee of SPM

(Portuguese Society of Mathematics). Member in representation of the IAP (Portuguese Institute of Actuaries) in the General Assembly of the Actuarial Association of Europe.

15 posters presented in several national and international conferences by group members.

Nine Ph.D. and three M.Sc. candidates are currently being supervised by CMA members.

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4.5. Achievements

[CMAC]: Continuity was given to the research on likelihood ratio tests for structured covariance matrices and to research on likelihood ratio tests for equality of mean vectors with structured covariance matrices, together with the development of near-exact distributions for the likelihood ratio test statistics. Also, some good advances were made toward the publication of the book entitled “Finite form representations of instances of Meijer G and Fox H functions – Applications: implementing likelihood ratio tests in Multivariate Analysis” by Springer, where the book was accepted for the “Lecture Notes in Statistics” series.

[DPG]: A first contribution in assessing the new features that max-stable processes allow for modeling and predicting spatial extremes. A research paper that may contribute to explain the occurrence of human disease due to presence of constitutional deletions and duplications in the human genome. Some improvements for the empirical choice of the optimal block size for the block bootstrap estimation of some characteristics of an estimator, in accepted paper.

[EFM]: Several advances were made in modeling drought class transitions using loglinear models (two published papers). These allowed for improvements in the drought forecasting at a monthly scale. The loglinear modeling associated with Markov Chains was also used to evaluate drought for different agro-ecological regions of India. A contribution was made to the understanding of the HIV virus integration in the human genome.

[FJM]: Development of new procedures to test elaborate patterns on covariances matrices, and also of near-exact distributions for the corresponding associated test statistics. Innovative results in the area of the algebra of ran-

dom variables, more specifically on the product of independent generalized gamma random variables which allowed the development of near-exact distributions and of computational modules for their implementation.

[GdR]: Developed expertise in pathwise calculus; Article published in *Annals of Applied Probability*; Won organization of World colloquim BSDE 2017

[GRG]: Obtained the results for the extended model to calculate the ruin probability in a motor insurance portfolio with a bonus malus system now with an open portfolio using the model of Afonso et al. (2009) and the results achieved in 2015. Joint work with Rui M.R. Cardoso, Alfredo D. Egídio dos Reis and **Gracinda R. Guerreiro**. Published a conference paper on Open Markov Chain Model for Credit Consumption portfolio.

[ICN]: In 2016 Isabel Natário continued her studies with Prof. Lucília Carvalho and Doctor Ivone Figueiredo's team on modeling the dynamics of the black scabbardfish in the NE Atlantic through a space state model, and are about to submit a final paper on the subject. Further work has been done on evaluating the exploration state of the UNDULATA ray in the continental Portuguese waters, with a paper on the subject revised and improved. Additionally, she has worked along with the Ph.D. candidate Paula Simões on spatio-temporal econometrics models with applications to Portuguese Health Line Saúde²⁴. Finally, some investigation on spatial statistics based on survey data has been tackled with Ph.D. candidate Sheyla Cassy.

[IJS] A research paper that may help to explain the occurrence of human disease due to the presence of constitutional deletions and duplications in the human genome, [46]. A contribution to predict the conditions and constraints of HIV-1 insertion in the human genome, [47].

[IoP]: Completion of research project EXPL / DTP-FTOL 1792/2013. HivK-lomics. Participation in an international conference with the work carried out under the project: "Kidney disease progression and associated factors in HIV+ patients". Kidney-Week, Chicago, USA, PA November 14-19, 2016, whose statistical analysis was performed based on the generalized linear mixed models. Conclusion and publication of an article in an international Peer Reviewed journal. Submission of one article to the international journal which awaits response.

[MFM]: For incomplete market economies where agents are subject to

price-dependent trading constraints compatible with credit market segmentation we proved equilibrium existence either when commodities are essential, i.e, indifference curves through individuals' endowments do not intersect the boundary of the consumption set, or when utility functions are concave and supermodular. We characterized the efficient size of clubs for private provision of goods in a context where types of agents can generate external effects that confer different benefits to their club or organization.

[MLE]: Together with **Gracinda Guerreiro**, Ph.D. candidate **Cristina Nobre** and M.Sc. Matilde Oliveira we finished the ground work in the problem of calibrating - with real data - the intensities of the transition probabilities of a continuous time Markov chain model for Long Term Care. Together with **Raquel Gaspar** (ISEG/UL) and **João Beleza** (ISEL) we introduced a way of determining the implicit propensity of default in bon prices. Together with **Pedro Mota** and Joaquim Pina, we studied a model for a collective vault.

[MSF] Advances in the inference for mixed linear univariate and multivariate models outside the scope of model orthogonality.

[VML] A paper was published in a Top 10% international journal (Web of Science). A project was submitted to the Luso-German Integrated Actions, which was approved for funding in January 2017. Two research visiting missions were made to European Universities (Finland; Germany), both partially funded by the Erasmus+ Mobility program. Three invited seminars were presented, one at a Portuguese University and two at other European universities (Finland; Holland). An invited session was successfully organized and took place at the "61ª Reunião Anual da Região Brasileira da Sociedade Internacional de Biometria (RBras2016)", Salvador da Bahia, Brazil. A contribution serving as session chair at a JSM Topic Contributed Session was made. Less fortunate was a Ph.D. project submission to the FCT 2016 call, which was not approved. Still, this represented a great amount of work and therefore needs to be mentioned.

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4.6. Plan: 2017

[CMAC]: It is intended to conclude during 2017 the book "Finite form representations of instances of Meijer G and Fox H functions – Applications: implementing likelihood ratio tests in Multivariate Analysis" to be published by

Springer in the “Lecture Notes in Statistics” series, and which is being written together with Professor Barry C. Arnold of the University of California, U.S.A. It is also intended to pursue the research in the area of likelihood ratio tests for equality of mean vectors with multi-level block-structured covariance matrices and to explore the relationship of these tests with growth-curve models and mixed linear models.

[DPG]: I will analyze the statistical differences between occurrence of deletions and duplications in each chromosomal fragile site. (Joint work with **Inês Sequeira**, Aldina Brás and José Rueff da Nova Medical School/Faculdade de Ciências Médicas.) I will focus on the estimation of extremal index using sliding blocks estimators, which has proved to be more efficient than the disjoint version and has a smaller asymptotic bias. (Joint work with Manuela Neves da Universidade de Lisboa.) I will continue to study extremal dependence of monthly maximum values of daily precipitation at some rain stations on the island of Madeira in order to perform a more complete study for predicting the occurrence of potentially disastrous extreme precipitation in the area under study, (Joint work with Délia Gouveia-Reis of the Universidade da Madeira and Manuela Neves.)

[FJM]: We expect that in 2017, we will be able to intensify the development of asymptotic and near-exact approximations for the test statistics used to test elaborated structures in covariance matrices and also to deepen the study of problems related with the algebra of random variables. One has in prospective to begin the study of problems in the area of Distribution Theory with a strong impact on insurance and reinsurance. In 2017 we expected to publish three articles and to submit of at least two articles in international journals indexed in the Web of Science.

[ICN]: The work planned for 2017 includes continuing the studies with Prof. Lucília Carvalho and Doctor Ivone Figueiredo’s team on fisheries modeling. An FCT2017 project is about to be proposed on methods of preferential sampling for accounting for the way fishermen choose their fishing spots, which coincides with the sampling locations of the fishery data. Additionally, studies on developing spatio-temporal models for the Saude24 health line data, with the Ph.D. candidates **Paula Simões**, should proceed (one paper). Finally, it is planned to retrieve work on modeling the first cases of a contagious disease

in case of an epidemic outbreak.

[IJS]: I will analyze the statistical differences between occurrence of deletions and duplications in each chromosomal fragile site. (Joint work with Dora Gomes and others.)

[IoP]: For 2017 the researcher aims to continue research work on statistics applied to medicine, namely methodologies of statistical analysis of longitudinal data, with binary outcome, as well as to study the joint analysis of longitudinal data and time to event data (Joint Modeling). It is hoped to successfully complete the orientation of the two masters theses underway in the year 2016/2017. The researcher will continue to develop statistical work applied to Engineering sciences, namely in projects and orientation of masters theses of ISEL students. It is estimated to obtain two publications in peer reviewed journals and three participations in international conferences.

[GRG]: Submitted the paper with the results for the extended model to calculate the ruin probability in a motor insurance portfolio with a bonus malus system now with an open portfolio using the model of Afonso et al. (2009) and the results achieved in 2015. (Joint work with **Rui M.R. Cardoso** and Alfredo D. Egídio dos Reis.) Submitted the paper on Open Markov chain scheme model for consumption credit portfolio fed with ARIMA and SARMA processes.

[MSF]: Advances in inference for multivariate models with complex covariance structure and their applications. Publication of two papers.

[MFM]: We will study a two-stage general equilibrium model of commercial real estate (CRE) development in a multi-jurisdictions economy with segmented markets. Our aim is to endogenize the financial structure in the context in which strategic jurisdiction authorities choose their land use and fiscal policies to attract global REIT investors. We consider a model in which couples may form to benefit from reduction on consumption rivalry. Our aim is to guarantee the existence of a stable equilibrium with externalities where each agent is concerned not only about her/his own partner but also on the partners of the others.

[RRC]: To obtain results for the extended model to calculate the ruin probability in a motor insurance portfolio with a bonus malus system with an open portfolio and to write a paper containing these results. Joint work with M. Lourdes Afonso, Alfredo D. Egídio dos Reis, and **Gracinda R. Guerreiro**. To

extend some results obtained for higher moments for the discounted dividends and to compute the distribution of the amount of a single dividend considering the Renewal Dual Risk Model (joint work with Alfredo D. Egídio dos Reis and Eugenio V. Rodríguez-Martínez).

[VML]: Submit a research project for funding in the ongoing call, the deadline for which is in mid-May. Continue working in the field of statistical genetics and strengthen the research collaborations begun in 2015 during the sabbatical leave. Initiate new research collaborations to work in human health applications.

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4.7. Strategic Plan: 2015-2020

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

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

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

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

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

MFonseca, JTMexia: The main research activities will be in univariate models with constraints on fixed and random effects, regarding estimation, hypothesis testing and confidence regions. For multivariate models, inference will be developed for structured data in complex model, also incorporating time dependency. These methods will be applied in analysis and forecasting in long-term care services. Comfort Keepers, a personal assistance services provider, is involved in this research.

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

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

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

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

Part IV

Activities in the thematic lines

Thematic line

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

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5.1. Homecare planning problem

In the homecare planning problem, the daily scheduling of teams of caregivers has to be planned so that all patients' requests within a week are met. These requests vary from several times a day to twice a week and may comprise activities of daily life and/or transportation to/from the day care center. Each caregiver starts the day at the day care center, returns for the lunch break, and ends the working day at the center. We have decomposed this case into two smaller problems: weekly visiting schedule plan and caregiver allocation in a rolling horizon context. For each problem an MILP formulation is proposed. One is based on the vehicle routing problem with time windows, while the other is an extension of the allocation problem. Two objectives are optimized and compared for the weekly visiting plan: minimization of walking time and workload balance among caregivers (minmax problem). Given the computational burden of the weekly VRP, a heuristic approach is developed combining a well known heuristic, the Clark and Wright Savings (CWS) heuristic, with biased randomization. The approach developed uses the CWS heuristic as a constructive method adapted to solve a problem formulated as a Vehicle Routing Problem with Time Windows. In order to achieve better results, a biased randomized behavior is introduced to the original CWS heuristic. The heuristic approach is able to solve the HCP in fast computing time and provides feasible solutions to the problem. The algorithm is tested in relatively small instances with real data and the results show its adequacy to solving the problem.

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5.2. Selfie Ageing Index (SAI)

This research topic addresses the population aged 55 and over from the perspective of the individual and functionality. More precisely, we are developing in the form

of a statistically based indicator, what we call “desirable aging”. Data have been retrieved from two surveys (SHARE¹ and EPEPP²). We first estimate ordered probit models in the EPEPP and SHARE samples separately. This allows us to determine if the same indicators appear to be relevant for healthy ageing in both samples. For the most part, the surveys’ original coding of the answers is maintained, in order to take advantage of the information already coded. In a second stage the two datasets are combined, which requires recoding the variables to accommodate the different ways in which questions are posed in the two surveys. The model estimated in the combined dataset is refined by eliminating the indicators that do not contribute to improving the model fit, based on statistical significance of the variables and model selection criteria (Likelihood ratio test, Akaike’s and the Bayesian information criteria). Relating the answers to the questions with the self-reported health status, each individual is assigned a score. Comparing this individual score with the score for individuals of the same age group, the individual obtains her/his Selfie Aging Indicator, which allows for perceiving the ageing state in relation to peers. As illustrative example, Figure 5.1 shows that a 60-year-old married individual with no difficulty walking at home or symptoms at an emotional level has a score of 0.74 on the 0-1 scale, falling into the fifth quintile for all persons in the sample aged 58-62 years (characteristics detailed in the legend).

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5.3. Long Term Care

The growing concern over the issue of an ageing population and the increased probability of people to become dependent upon special care has motivated the search for solutions in terms of both public or private insurance coverage. Within this research topic we intend to estimate the population at risk of dependency and to make a financial and actuarial evaluation of a possible assistance product to dependence, a product of Long Term Care (LTC); we also aim to estimate its expected individual costs, evolution, and the number of users per degree of dependency. Using the model of stochastic vortices, we have study the evolution of an open population subject to inputs, outputs, and periodic reclassification of subpopulations. Under the

¹“The Survey of Health, Ageing and Retirement in Europe (SHARE) is a multidisciplinary and cross-national panel database of micro data on health, socio-economic status, and social and family networks of approximately 123,000 individuals aged 50 and older (more than 293,000 interviews). SHARE covers 27 European countries and Israel.” (from <http://www.share-project.org>, October 2017)

²Mota-Pinto A. et al. (2011) A socio-demographic study of aging in the Portuguese population: The EPEPP study, Archives of Gerontology and Geriatrics, Volume 52, Issue 3, 304-308.

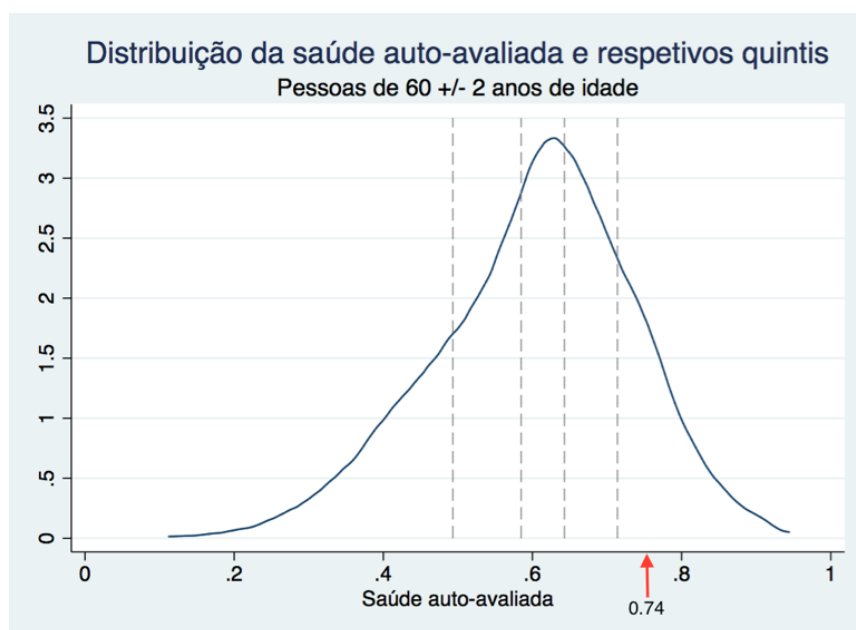


Figure 5.1: Self-ageing index for a 60-year-old man, married, confident, four years of schooling and a manual profession, of adequate weight, with no difficulty walking at home or in the basic activities of daily life, without emotional state symptoms, with good sense of temporal orientation, smoker, and who practices some physical activity.

model assumptions, it has been possible to obtain a detailed statistical study at any time and to know the distribution probability of number and proportion of elements in each subpopulation. These results provide valuable information so as to properly manage the resources required to meet the needs of individuals in long term care dependence, as well as to quantify over time the risk of dependency of the population. Real data from a Portuguese social-work institution has been used to validate the model.

5.4. Evaluation of the level of functioning in the elderly

Ageing with chronic noncommunicable diseases and with the decline of the level of functioning that is inherent to them, will be reflected in strong pressure on the health system, inevitably driving up spending on social care and health and financial sustainability of these systems. Identifying health indicators of the population may provide important information for health policy design and more socially equitable intervention. The health indicator analyzed in this study was the level of functioning. In the national context, the Alentejo has the highest ageing rate in the country. The study population consists of elderly people living in the Alentejo region. The main objective is to evaluate the elderly person's level of functioning based on the International Classification of Functionality by means of Factor analysis and multiple correspondence analysis (HOMALS).

5.5. Master Thesis

1. "Modeling and optimization of a Home Care Service", Manuel de Almeida Eliseu, Master of Science in Biomedical Engineering, supervised by **Maria Isabel Gomes**.
2. "Análise multivariada para a funcionalidade dos idosos na Região do Alentejo", Gisela Inge Ribeiro Matos, Master in Science in Mathematics and Applications, supervised by **Miguel Fonseca**.

5.6. Publication

Gomes, M. I. and Ramos, T. R. P. *Ajudando uma assistente social a planear o seu serviço de apoio domiciliário*. Boletim APDIO, **54**, 11–13, 2016.

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5.7. Events

I Workshop Ageing and Independent Living – Quantitative Methods. Lisbon, Portugal. Organizing Committee.

<http://docentes.fct.unl.pt/mirg/event/agil-workshop>

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5.8. Oral communications

1. “Long Term Care Model in discrete time”, Cristina Nobre, Faculdade de Ciências e Tecnologia, Univ. Nova de Lisboa, AgIL workshop, February 2016.
2. “Evaluation of the functionality in the elderly”, (joint work) Carla Pereira (ENSP, UNL) and Miguel Fonseca (FCT, UNL), AgIL workshop, February 2016.
3. “Modelling home social care services with non-loyalty features”, (joint work) Tania Ramos (IST, UL) and Maria Isabel Gomes (FCT, UNL), AgIL workshop, February 2016.
4. “Selfie Ageing Indicator”, Maria Amália Botelho, III Jornadas Científicas Nova Saúde, Nov. 2016.

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5.9. Invited Seminars at CMA

“Modelling human behavior in healthcare systems: is it possible, and why should we do it?”, Sally Brailsford, Southampton Business School, University of Southampton, UK

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5.10. Invited Seminars

“Modelling home social care services with non-loyalty features”, Maria Isabel Gomes, Universidad Oberta da Cataluna, Barcelona, feb. 2016.

Thematic line

Mathematical Modelling in Ecology, Evolution and Genetics

The thematic line Mathematical modelling in ecology, evolution and genetics gathers several members of the CMA working on the development of mathematical problems with strong biological motivation. The goal is to establish CMA as a competent partner for addressing mathematical issues arising in biology and to strengthen further collaborations with the biology community. In this direction we highlight during 2016, a paper by J. O. Cerdeira and collaborators that was selected to be included in the Virtual Issue Conservation Ecology created especially for the joint British Ecological Society and Cambridge Conservation Initiative Symposium.

<http://www.methodsinecologyandevolution.org/view/0/virtualIssues/ConservationVirtualIssue.html>

On the topics of the Thematic Line, during 2016 there was a funded project with CMA collaborators, three conferences or special sessions with CMA members on the organization, nine papers published, and six CMA seminars (see detailed list).

1. **F. Chalub, P. Rodrigues, P. Doutor, and M. C. Soares** continued working on epidemiological models with vaccination. A paper was published, and a generalization for age-structured populations is under preparation. Vaccination models with discrete spatial structure were studied by F. Chalub, P. Rodrigues and T. Costa (PhD candidate at the Champalimaud Foundation).
2. **F. Chalub** and **A. Ribeiro**, in collaboration with M. Souza (Brazil) and L. Monsagnion (France), started working on a variational (gradient flow) approach for modelling genetic evolution. F. Chalub and M. Souza, continued their work on models in population genetics.
3. **J.O. Cerdeira** continued working on deriving combinatorial optimization tools to address biodiversity conservation issues. In particular, network flow models to efficiently cope with climate change, while optimizing species persistence, were developed and tested. Improvements in the computational practicability were carried out to address large, real problems. Some of the material appeared in a published paper, and further developments were expounded in a submitted paper. An open source application (licensed under the GPL v3) has been developed.
4. As a result of collaboration with the Centre for Toxicogenomics and Human Health (ToxOmics), Genetics, Oncology and Human Toxicology, Nova Medical School, **Elsa Moreira** and **Inês Sequeira**, who had previously supervised a masters thesis, carried out a statistical analysis of data regarding the HIV virus

integration in the human genome. From this collaboration a paper was published in the International Journal of Genomics.

5. **Vanda Lourenço** continued working on the topic of robust methods for genetics in joint work with the Biostatistics Unit of the University of Hohenheim, Germany, and with Paulo C. Rodrigues of the Universidade Federal da Bahia, who was a former member of CMA. She applied successfully for a Luso-German Integrated Actions project in partnership with the Biostatistics Unit mentioned above. This two year project is scheduled for the years of 2017-2018.
6. **Isabel Natário** has continued her studies on modelling the dynamics of the black scabbardfish in the NE Atlantic through a space state model with Lucília Carvalho (CEAUL, Univ. Lisboa) and Ivone Figueiredo (IPMA).

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6.1. Projects with CMA members

1. Spatial conservation planning: reconciling biodiversity and human development in a dynamic world, SFRH/BPD/104077/2014 (2016-2018).

PI: Diogo André Alves Salgado Rodrigues Alagador

CMA member: **Jorge Orestes Cerdeira**

Total funding: €87358. CMA funding: €5460

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6.2. Organization of conferences & sessions

1. **F. Chalub** and **P. Rodrigues** are members of the Scientific and Organizing Committees of the Seventh Workshop Dynamical Systems Applied to Biology and Natural Sciences, Escola de Ciências e Tecnologia, Colégio do Espírito Santo, Universidade de Évora, Portugal, February 2-5, 2016.
2. Special section: Area Prioritization for Biodiversity Conservation, Ecosummit2016, Ecological Sustainability: Engineering Change, Montpellier, 29 August – 1 September 2016 (organizer **Jorge Orestes Cerdeira**).
3. Organizing Committee of II Galician-Portuguese Meeting of Biometry, with applications to Health Sciences, Ecology, and Environmental Sciences (BIOAPP2016). (organizer **Dora Prata Gomes**)

<http://biometria.sgapeio.es/index.php/es>

6.3. Selected Publications

1. D. Alagador, **J. O. Cerdeira**, and M. B. Araujo. Climate change, species range shifts and dispersal corridors: an evaluation of spatial conservation models. *Methods Ecol. Evol.*, 7(7):853–866, JUL 2016.
<http://onlinelibrary.wiley.com/doi/10.1111/2041-210X.12524/full>
2. M. N. Bugalho, F. S. Dias, B. Brinas, and **J. O. Cerdeira**. Using the high conservation value forest concept and Pareto optimization to identify areas maximizing biodiversity and ecosystem services in cork oak landscapes. *Agrofor. Syst.*, 90(1, SI):35–44, FEB 2016.
<https://link.springer.com/article/10.1007%2Fs10457-015-9814-x>
3. **F. A. C. C. Chalub**. An asymptotic expression for the fixation probability of a mutant in star graphs. *J. Dyn. Games*, 3(3, SI):217–223, JUL 2016.
<http://dx.doi.org/10.3934/jdg.2016011>
4. **F. A. C. C. Chalub** and **M. O. Souza**. Fixation in large populations: a continuous view of a discrete problem. *J. Math. Biol.*, 72(1-2):283–330, JAN 2016.
<https://link.springer.com/article/10.1007/s00285-015-0889-9>
5. F. S. Dias, D. L. Miller, T. A. Marques, J. Marcelino, M. C. Caldeira, **J. Orestes Cerdeira**, and M. N. Bugalho. Conservation zones promote oak regeneration and shrub diversity in certified Mediterranean oak woodlands. *Biol. Conserv.*, 195:226–234, MAR 2016.
<https://doi.org/10.1016/j.biocon.2016.01.009>
6. **P. Doutor**, **P. Rodrigues**, **M. d. C. Soares**, and **F. A. C. C. Chalub**. Optimal vaccination strategies and rational behaviour in seasonal epidemics. *J. Math. Biol.*, 73(6-7):1437–1465, DEC 2016.
<https://link.springer.com/article/10.1007/s00285-016-0997-1>
7. J. Goncalves, **E. Moreira**, **I. J. Sequeira**, A. S. Rodrigues, J. Rueff, and A. Bras. Integration of HIV in the human genome: Which sites are preferential? A genetic and statistical assessment. *Int. J. Genomics*, 2016.
<http://dx.doi.org/10.1155/2016/2168590>
8. T. Monteiro-Henriques, M. J. Martins, **J. O. Cerdeira**, P. Silva, P. Arsenio, A. Silva, A. Bellu, and J. C. Costa. Bioclimatological mapping tackling uncertainty propagation: application to mainland Portugal. *Int. J. Climatol.*, 36(1):400–411, JAN

2016.

<http://onlinelibrary.wiley.com/doi/10.1002/joc.4357/abstract>

9. P. C. Rodrigues, A. Monteiro, and **V. M. Lourenco**. A robust AMMI model for the analysis of genotype-by-environment data. *Bioinformatics*, 32(1):58-66, JAN 1 2016. <https://doi.org/10.1093/bioinformatics/btx457>