

Reunião do Conselho Científico do CIDMA

Data: 10-jan-2023; Início: 14h30m; Local: Anfiteatro 11.1.10

## **Relatório de atividades de 2022 das Linhas Temáticas do CIDMA**

Neste documento apresentamos o relatório de atividades de 2022 das Linhas Temáticas (LTs) do CIDMA. As LTs do CIDMA são:

- a) MATEAS — Matemática: Ensino e Avaliação no (Ensino) Superior (Responsável: Luís Descalço);
- b) GEOMETRIX — Investigação e Desenvolvimento de Software Educativo (Responsável: Ana Breda);
- c) PICS — Problemas Inversos e Aplicações em Ciências da Saúde (Responsável: Paula Cerejeiras);
- d) BIOMATH — Biomatemática (Responsável: Cristiana Silva / desde outubro de 2022 Vera Afreixo);
- e) TFC — Da Teoria às Ferramentas Computacionais (Responsável: Eugénio Rocha);
- f) MI — Matemática para a Indústria (Responsável: Rui Borges Lopes).

O Coordenador Científico do CIDMA  
Delfim Fernando Marado Torres



## CIDMA/MATEAS activities - 01/01/2022 - 31/12/2022

Line name: MATEAS - Mathematics: Teaching and Assessment on Higher Education

Coordinator: Luís Descalço

Several groups of CIDMA are represented in line MATEAS, with Luís Descalço, Dina Seabra, Jorge Neves, José Carlos Lopes, Nuno Bastos and Paula Oliveira from group HMMEG, Paula Carvalho and Rute Lemos from group OGTCG, Andreia Hall and Pedro Sá Couto from group PSG, António Caetano from group FAAG and Manuel Martins from group GAG.

*In the year 2022 several experiments with teaching and assessment have been done and the resulting publications and related MSc thesis are listed in this report. We had 4 students with introduction to research CIDMA grants this year. Two of these students worked on the creation of parameterized questions with detailed solution for learning and assessment in mathematics, in the subjects of numerical analysis, linear algebra, analytic geometry and number sequences, and the other two worked in the development of software for helping autonomous learning (SIACUA), and for parameterized question authoring (TAMAT).*

Summary of activities of the students with grants:

- Tiago Quintas, supervised by Paula Oliveira, Nuno Bastos and Luís Descalço, has developed and improved a new web application, TAMAT, for authoring parameterized questions with detailed solution of several kinds, for using in Moodle, SIACUA and other computer systems.
- Gustavo Noronha, supervised by Luís Descalço and Paula Carvalho, has implemented several improvements in web application SIACUA for autonomous learning, including functionalities to use in gamification and forms for searching within study materials and student activity.
- Clárisse Oliveira, supervised by Paula Carvalho, has created more than 30 question generation templates for multiple choice questions with detailed solutions, about numeric sequences, to be used in SIACUA and in the new web application for pre-calculus we are planning to develop next year. Moreover, 619 questions were selected for this purpose, from more than 2000 existing in SIACUA about this subject.
- Cláudia Azevedo, supervised by Jorge Neves, Dina Seabra and Rute Lemos, has created 35 questions generator templates for numerical analysis, linear algebra, and analytic geometry, to be used in the correspondent two new courses in SIACUA and in other systems.

### Publications

Breda, A., Carvalho, P. & Hall, A. (2022) Beautiful Geometry: a STEAM Experience in a Professional Development Course for Mathematics Teachers, Proceedings of Bridges 2022: Mathematics, Art, Music, Architecture, Education, Culture. Phoenix, Arizona: Tessellations Publishing, 151-158. <http://hdl.handle.net/10773/35400>

Rita, P., Bastos, N. & Hall, A. (2022) Interlacing Islamic Art with the teaching of Symmetry in Portuguese Schools, Em Viana, V., Nagy, D., Xavier, J., Neiva, A., Ginoulhiac, M., Mateus, L. & Varela, P. (Eds.), *Symmetry: Art and Science*, Journal of the International Society for the Interdisciplinary Study of Symmetry, 12th SIS-Symmetry Congress [Special Issue], 48-53. <https://doi.org/10.24840/1447-607x/2022/12-05-048>

Breda, A., Carvalho, P. & Hall, A. (2022) Using a STEAM approach in a professional development course for mathematics teachers, *Proceedings of EDULEARN22 Conference*, 4th-6th July 2022, Palma, Mallorca, Spain, 53-61. <https://doi.org/10.21125/edulearn.2022.0018> <http://hdl.handle.net/10773/35396>

Hall, A. & Pais, S. (2022) Using an artistic approach to the teaching of solid geometry in a professional development course for mathematics teachers, *Proceedings of EDULEARN22 Conference*, 4th-6th July 2022, Palma, Mallorca, Spain, 43-52. <https://doi.org/10.21125/edulearn.2022.0017> , <http://hdl.handle.net/10773/35394>

Pais, S., Hall, A. & Sousa, A. (2022) The Use of Digital Technologies in the Teaching of Mathematics during the COVID-19 Pandemic – A Case Study with Undergraduate Tourism Students, *Proceedings of EDULEARN22 Conference*, 4th-6th July 2022, Palma, Mallorca, Spain, 662-667. <https://doi.org/10.21125/edulearn.2022.0198> , <http://hdl.handle.net/10773/35395>

Santos, V., Hall, A., Bastos, N. & Caridade, C.M.R. (2022) Active learning during the COVID-19 Pandemic – A Triple Experiment, *Proceedings of EDULEARN22 Conference*, 4th-6th July 2022, Palma, Mallorca, Spain, 1302-1307. <https://doi.org/10.21125/edulearn.2022.0340> <http://hdl.handle.net/10773/35397>

P. Rita, N. R. O. Bastos and A. Hall, Interlacing Islamic Art with the Teaching of Symmetry in Portuguese Schools. Viana, V., Nagy, D., Xavier, J., Neiva, A., Ginoulhiac, M., Mateus, L. & Varela, P. (Eds.) *Symmetry: Art and Science | 12th SIS-Symmetry Congress [Special Issue]*. *Symmetry: Art and Science*. International Society for the Interdisciplinary Study of Symmetry. pp. 48-53, 2022. <https://doi.org/10.24840/1447-607x/2022/12-05-048>{<https://doi.org/10.24840/1447-607x/2022/12-05-048>}

N.R.O. Bastos, Breakout rooms: a collaborative space that works, *EDULEARN22 Proceedings*, pp.7749-7754, 2022. (<https://ria.ua.pt/handle/10773/35408>)

N.R.O. Bastos, Use of Desmos to engage students in calculus, *EDULEARN22 Proceedings*, pp.7766-7771, 2022.

V. Santos, N.R.O. Bastos, Activities with Desmos and GeoGebra for formative and automatic feedback, *EDULEARN22 Proceedings*, pp.7555-7559, 2022.

L. Dias, M.P. Oliveira, N.R.O. Bastos, An experience with Desmos in the study of the quadratic function, *EDULEARN22 Proceedings*, pp.4456-4464, 2022. ( <https://ria.ua.pt/handle/10773/35412> )

P. Rita, N. R. O. Bastos and A. Hall, Exploring Symmetry Through Portuguese Tiles in Historical Monuments, *Proceedings of Bridges 2022: Mathematics, Art, Music, Architecture, Culture*, pp. 395-398, 2022. (<https://ria.ua.pt/handle/10773/35419>)

M.P. Oliveira. Mathematics, Computers and Competitions: 30 years together. *Proceedings of Edulearn22 conference*. 4th-6th July, 2022, Palma Mallorca, Spain (<http://hdl.handle.net/10773/35411>)

L. Descalço, P. Carvalho. An experiment with serious games on mathematics in higher education. Proceedings of EDULEARN22 Conference, 4th - 6th July, Palma de Maiorca, Spain, International Academy of Technology, Education and Development (IATED), 3899-3903, Palma, Spain, 2022. (<http://hdl.handle.net/10773/35354>)

L. Descalço, P. Carvalho. Effective learning in mathematics. Proceedings of EDULEARN22 Conference, 4th - 6th July, Palma de Maiorca, Spain, International Academy of Technology, Education and Development (IATED), 3870-3876, Palma, Spain, 2022. (<http://hdl.handle.net/10773/35355>)

### **MSc thesis**

(Supervised by Andreia Hall and Nuno Bastos) Elsa Maria Godinho de Assunção, Aprendizagens ativas em matemática com recurso ao GeoGebra: a função exponencial, MSc thesis on Mathematics for Teachers, University of Aveiro, 16 de dezembro de 2022.

(Supervised by Andreia Hall and Sónia Pais) Helena Maria da Cruz Ambrósio, Percursos matemáticos na região de Leiria: a matemática está aí, MSc thesis on Mathematics for Teachers, University of Aveiro, 11 de julho de 2022. (<http://hdl.handle.net/10773/34595>)

(Supervised by Nuno Bastos and Paula Oliveira) Isabel Cristina Barbosa Ferreira, Aprendizagens ativas nos domínios da estatística e das probabilidades com recurso a ferramentas digitais, MSc thesis on Mathematics for Teachers, University of Aveiro, 2022

(Supervised by Paula Oliveira and Sandra Diogo Ramos) Maria Clarisse Ribeiro Soares, A Matemática do Ensino Básico numa abordagem STEAM, MSc thesis on Mathematics for Teachers, University of Aveiro, 2022.

(Supervised by Paula Oliveira and Nuno Bastos) Isabel Cristina Barbosa Ferreira, Aprendizagens ativas nos domínios da estatística e das probabilidades com recurso a ferramentas digitais, MSc thesis on Mathematics for Teachers, University of Aveiro, 2022.

(Supervised by Paula Oliveira) João Álvaro Cunha das Neves, Impacto de práticas de avaliação formativa na qualidade do sucesso dos alunos de matemática a no ensino secundário, MSc thesis on Mathematics for Teachers, University of Aveiro, 2022. (<http://hdl.handle.net/10773/34567>)

(Supervised by Paula Oliveira and Dina Seabra) Maria João da Silva Barroso, Estratégias dinâmicas de aprendizagem em Matemática no domínio da Trigonometria, MSc thesis on Mathematics for Teachers, University of Aveiro, 2022. (<http://hdl.handle.net/10773/34568>)

(Supervised by Paula Oliveira and Dina Seabra) Janilson de Jesus Semedo Pereira, Avaliação na disciplina de Matemática, MSc thesis on Mathematics and Applications, Universidade de Cabo Verde, 2022.

(Supervised by Paula Oliveira and Dina Seabra) José Manuel Fernandes Moreira, Estratégias dinâmicas de aprendizagem em Matemática no domínio da Trigonometria, MSc thesis on Mathematics and Applications, Universidade de Cabo Verde, 2022.

(Supervised by Paula Oliveira and Dina Seabra) Manuel de Jesus Pires Tavares, Estratégias dinâmicas de aprendizagem em Matemática no domínio da Geometria, MSc thesis on Mathematics and Applications, Universidade de Cabo Verde, 2022.

(Supervised by Luís Descalço and Paula Carvalho) Mercedes Maria Coutinho Soares Pinto,  
Aprendizagem ativa e gamificação no ensino da Matemática, MSc thesis on Mathematics for  
Teachers, University of Aveiro, 2022.

# Formulário Relatório de Progresso - Componente Científica

Relatório de Progresso nº 3, 01-01-2022 to 31-12-2022 do orçamento UIDP/04106/2020

## RESUMO DOS TRABALHOS

### Summary of the activities carried out by the thematic line GEOMETRIX, in 2022

1. Within the scope of the CNME serious game, developed by GEOMETRIX, it was:
  - designed and implemented an accompanying digital guide for teachers and game users;
  - reviewed its usability, legibility, and functionality.
2. Regarding the support resources for mathematics teachers, it was:
  - designed and implemented an algorithm (first attempt) to generate automatic feedback suitable for teaching and learning platforms.
  - developed an application, using augmented reality, to support Basic Education teachers and students in the characterization of geometric solids.
  - designed an inclusive board game for the general population.
3. With regard to the study and research of creative teaching methodologies aimed at developing students' hard and soft skills, several pedagogical experiments were carried out, giving rise to several publications. Geometrix also collaborated in the organization and dynamization of a professional development course "Creative Mathematics" (25 hours) for mathematics teachers.

*(máximo de 1000 caracteres por grupo, contando com espaços)*

### Desvios dos trabalhos face à proposta aprovada

No discrepancies to report

### Orçamento

Grant /Type	Tasks	Duration (months)	Valor
David Tinoco /BII	Augmented reality	6	2 916,72 €
João Loureiro /BII	Design component	5	2 430,60 €
Iara Monteiro /BII	Inclusive game	5	2 430,60 €
Luke Gubbins /BII	Intelligent algorithms	5	2 430,60 €
Carolina Alves /BII	Content producer	5	2 430,60 €
Mariana Leite /BII	Computational Thinking research	3	1 458,36 €
Diana Gomes/BII	Computational Thinking research	3	1 458,36 €

<b>TOTAL</b>	15 555,84 €
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## Indicadores

A - Publicações

Livros 0

**Artigos em revistas internacionais 2**

**Artigos em revistas nacionais 1**

B - Comunicações

**Comunicações em encontros científicos internacionais 11 (Proceeding papers)**

**(Das 11, 7 estão publicados como proceeding papers)**

**Comunicações em encontros científicos nacionais 1**

C - Relatórios 0

D - Organização de seminários e conferências 0

E - Formação avançada

Teses de Doutoramento 0

Teses de Mestrado 1

**Outras - See Extension Activities 5**

F - Modelos 0

G - Aplicações computacionais 0

H - Instalações piloto 0

I - Protótipos laboratoriais 0

J - Patentes 0

K - Publicações científicas em domínios científicos enquadráveis na RIS3 0

L - Patentes EPO 0

M - Outros 1 -

Creative explorations transversal to different areas of knowledge, based on excerpts from the book with perceived content “De for a para dentro e de dentro para fora”. (<https://livrodentroefora.wordpress.com/>)

**Websites gerados no contexto do projeto (opcional)**

Enumerar as URL/endereços dos sites web criados no âmbito do projeto ou com informação sobre o mesmo, separados por vírgulas



## **Publications in:**

### **A. International journals**

- [1] L. A. Bayzid, A. Breda, E. Rocha; J. Dos Santos, Feedback Systems for Students Solving Problems Related to Polynomials of Degree Two or Lower, Schloss Dagstuhl - Leibniz-Zentrum für Informatik, pp. 1-10, <https://doi.org/10.4230/OASICS.ICPEC.2022.5>
- [2] A. Encarnação; T. Neto; A. Breda, A formação de professores no âmbito de competências do raciocínio geométrico: uma revisão de literatura. INTERMATHS, 3(1), 279–293.  
<https://doi.org/10.22481/intermaths.v3i1.10477>

### **B. International Conferences**

- [1] A. Breda, C. Cruz: Children’s literature: a way for the development of math and soft skills, 14th International Conference on Education and New Learning Technologies, 2022.  
<https://doi.org/10.21125/edulearn.2022.0566>;
- [2] A. Breda, P. Carvalho, A. Hall, Using a STEAM approach in a professional development course for mathematics teachers, 14th International Conference on Education and New Learning Technologies, 2022. <https://doi.org/10.21125/edulearn.2022.0018>
- [3] A. Breda, P. Carvalho, A. Hall, Beautiful Geometry: a STEAM Experience in a Professional Development Course for Mathematics Teachers, Bridges 2022 Conference Proceedings, 15-158, 2022, <http://archive.bridgesmathart.org/2022/bridges2022-151.html>
- [4] C. Cruz, A. Breda Children’s literature: a pathway of scientific and didactical opportunities, 14th International Conference on Education and New Learning Technologies, 2022.  
<https://doi.org/10.21125/edulearn.2022.0566>
- [5] M. Lourenço, C. Costa, C. Cruz, A. Gonçalves, A students’ representations in a flowerbed construction: a window for mathematical thinking and learning, INTED2022 Proceedings, 4353-4363, 2022. <https://doi.org/10.21125/inted.2022.1171>
- [6] S. Ribeiro, A. Breda, E. Rocha, D. Tinoco, Augmented reality as an asset to 3D geometry: a digital resource for teachers, 16th International Technology, Education and Development Conference, INTED 2022. <https://doi.org/10.21125/inted.2022.0162>
- [7] S. Ribeiro, A. Breda, E. Rocha, Computational thinking in upper-secondary education: a systematic literature review, 16th International Technology, Education and Development Conference, INTED 2022. <https://doi.org/10.21125/inted.2022.0777>

### **C. National Chapter book**

- [1] F. Teixeira, S. Silveira, D. Vaz, A. Santiago, C. Cruz, O meio co(n)vida: Relato de uma prática integrada de Ciências Naturais e Matemática na formação docente. In F. Teixeira et al. (Eds.), Educação em Ciências: Interações e desafios, Escola Superior de Educação de Coimbra - Associação Portuguesa de Educação em Ciências, 2022  
(<https://owncloud.esec.pt/index.php/s/LMgQU9qrLYG4VRw>)

## **Professional development Courses and workshops**

### **A. Professional Development Courses**

[1] A. Breda, A. Hall, P. Carvalho (February and March, 25 hours), Creative Mathematics, Aveiro University, Aveiro, 2022.

### **B. Workshops**

[1] C. Cruz, A. Santiago, S. Ribeiro (March 28, 2 hours). Learning Scenarios using educational robotics in a nursery and kindergarten context, Coimbra Higher School of Education, Coimbra, 2022.

[2] S. Ribeiro, C. Cruz, A. Santiago. (May 6 – 7, 2 hours). Paths for the integration of educational robotics in contexts of nursery and preschool education, VI Research Meeting on Educational Practices - EIPE 2022, Coimbra Higher School of Education, Coimbra, 2022.

[3] C. Cruz, A. Santiago, S. Ribeiro (October 8, 4 hours). Educational robotics in STEAM education context, 20.º MatViseu, Superior School of Technology and Management of Viseu, Viseu, 2022.

### **C. Extension Activities**

[1] A. Breda, C. Cruz (April 24, 1 hour), Presentation of the book "De dentro para fora e de fora para dentro", by invitation of the Figueira de Castelo Rodrigo City Council, FCR Library, 2022.

[2] A. Breda (June 5, 1 hour), Panel member of the debate on "Text and Image in children's literature", by invitation of the Aveiro City Council, as part of the activities of the 46th Aveiro Book Fair, 2022.

[3] A. Breda, C. Cruz, (July 13, 1,5 hours), Insights of children' s soft skills using the book "De dentro para fora e de fora para dentro" as a resource, Aveiro Summer School, University of Aveiro 2022.

[4] A. Breda, C. Cruz, (November 19, 1 hour), Presentation of the book "De dentro para fora e de fora para dentro", by invitation of the Charity, Culture and Civic Association, Padre Manuel António Marques, in partnership with the Union of Parishes of Cantanhede and Pocariça, and the Cantanhede City Council, Cantanhede Library, Cantanhede, 2022.

[5] A. Breda, C. Cruz, Vanessa Rebelo (December 9, 3 hours) Interactive presentation, with (60) children, of the book "De dentro para fora e de fora para dentro", Escola de Verdemilho, Aveiro, 2022.

# Report on the activities of Lt PICS period 01-01-2022 to 31-12-2022

## Research topics and principal results:

4 grants were given:

BI\_Lt\_PICS\_2022A, duração 5m (Licenciado)

BI\_Lt\_PICS\_2022B, duração 4m (Master)

BII\_Lt\_PICS\_2022C, duração 6m (under-graduate)

BII\_Lt\_PICS\_2022D, duração 3m (under-graduate)

The thematic line focused on several inverse problems with high importance for medical and health sciences.

First and foremost, the thematic line focused on the topic of electric impedance tomography (EIT). A prototype was constructed and the necessary algorithms were implemented with the ability to obtain measurements at different frequencies of alternating current, and which is noise-robust. Furthermore, for (complex) conductivities a reconstruction method (Calderón problem) based on an adequate **Sim** (simulation) operator, and AAD methods for acceleration were developed and tested with this prototype. A corresponding PhD thesis is being finalized.

Additionally, discontinuous Galerkin methods were constructed, as well as similar methods and their corresponding SIMD-parallelization with focus on applications to Electric Impedance Tomography (EIT). This also led to the development of AAD (automatic adjoint differentiation)-based methods for parallelisation and acceleration of the implemented methods.

During this period the Mittag-Leffler function was studied in the context of special fractional differential operators, namely the Caputo and Riemann-Liouville. Solutions of the associated differential equations were obtained in terms of integral transforms. Particular attention was given to the time-fractional diffusion equation with space dimension equal to 1 and 2, and to the Cattaneo-Hristov diffusion equation. A graphical representation via Mathematica was developed to represent the solutions of these equations as well as applications in inverse problems under study in the thematic line.

Also, the study of the Quaternionic Fourier Transform and its main properties was undertaken. This initial study include the obtaining of correct formulae for its inversion, Plancherel and Parseval Theorems. The discrete version of this transform was also studied and a numerical implementations (in the context of image processing) was constructed using the software Python. This gave raise to several numerical simulations which were presented in a student presentation. Future work will include its application to higher-dimensional signals.

## **Presentations:**

- **Student presentations**

Cálculo Fracionário e Equações Fracionárias de Difusão, Tiago Araújo, UA (12/12/2022)

Quaterniões e Transformada de Fourier quaterniônica, Rodrigo Domingues, UA (28/09/2022)

- Several communications in international conferences.

## **Seminários (not mentioned on GACH report):**

- **ADGIS**

May 25, 2022, Steven Flynn, University of Bath, U.K.

Title: The Heisenberg X-ray transform: A first approximation Inverse Problems on sub-Riemannian manifolds

February 24, 2022, Victor Nistor, Université de Lorraine, France,

Title: Analysis on singular and non-compact spaces and Lie manifolds

- **International Intensive Courses dedicated to Dirac operators, Hypercomplex and Harmonic Analysis**

May 16 - 27, 2022, Alexander Strohmaier, School of Mathematics, University of Leeds, UK

Title: Dirac operators in Spectral Geometry and Mathematical Physics

## **Publicações:**

José Brito, Andrei Goloubentsev, Evgeny Goncharov; Automatic Adjoint Differentiation for special functions involving expectations

<https://arxiv.org/pdf/2204.05204.pdf>

N. Vieira, M.M. Rodrigues, and M. Ferreira, Time-fractional telegraph equation of distributed order in higher dimensions with Hilfer fractional derivative, Electronic Research Archive, 30-No.10 (2022), 3595--3631.

N. Vieira, M. Ferreira, and M.M. Rodrigues, Time-fractional telegraph equation with  $\Psi$ -Hilfer derivatives, Chaos, Solitons & Fractals, 162 (2022), Article ID: 112276, 26pp.

N. Vieira, M.M. Rodrigues, and M. Ferreira, Time-fractional diffusion equation with  $\Psi$ -Hilfer derivative, Computational and Applied Mathematics, 41-No.6 (2022), Article ID: 230, 26pp.

N. Vieira, M. Ferreira, and M.M. Rodrigues,  $\Psi$ -Hilfer fractional relaxation-oscillation equation, International Conference on Mathematical Analysis and Applications in Science and Engineering (ICMA2SC'22) - Book of Extended Abstracts, (2022), 163-166.

M.M. Rodrigues, M. Ferreira, and N. Vieira, Some representations for the eigenfunctions of the time-fractional wave operator, International Conference on Mathematical Analysis and Applications in Science and Engineering (ICMA2SC'22) - Book of Extended Abstracts, (2022), 245-248.

M. Ferreira, M.M. Rodrigues, and N. Vieira, On a regular  $\Psi$ -fractional Sturm-Liouville problem, International Conference on Mathematical Analysis and Applications in Science and Engineering (ICMA2SC'22) - Book of Extended Abstracts, (2022), 167-170.

D. Alpay, P. Cerejeiras, U. Kähler, Generalized white noise analysis and topological algebras, Stochastics, 94 (6), 926-958, (2022).  
<https://doi.org/10.1080/17442508.2021.2016766>

P. Cerejeiras, F. Colombo, U. Kähler, I. Sabadini, Quaternionic triangular linear operators, Math Meth Appl Sci. 2022;46:2093–2116.

D. Alpay, P. Cerejeiras, U. Kähler, Generalized Grassmann algebras and applications to stochastic processes, Math Meth Appl Sci., 45, 383-401, (2023).  
<https://doi.org/10.1002/mma.7781>

P. Cerejeiras, U. Kaehler, S. Lucas, Discrete pseudo-differential operators in hypercomplex analysis. Math Meth Appl Sci. (early view)  
<https://doi.org/10.1002/mma.7881>

M. Sc. Thesis - Automatic Adjoint Differentiation for Mean Squared Error Involving Expectations, José Nuno Catarino de Brito

**Projectos:**

Hypergeometric Functions and Machine Learning in the Diagnosis Process, FCT and Google, 2022-23

## **Thematic Line BioMathematic's report from 01-01-2022 until 31-12-2022**

The work developed in 2022 was aligned with the programs of the fellowships financed by the Thematic Line BioMathematics and connected different branches of mathematical areas applied to biology, medicine and epidemics. These works were supervised by members of different groups of CIDMA in collaboration with medical doctors and researchers from different scientific areas.

The following topics were studied:

- *Investigate possible interpretations of results when Principal Components Analysis is applied on compositional data ( /2022/BII/CIDMA )*

Selected candidate: Mariana Pinto

Advisors: Adelaide Freitas, Marco Costa

- *Mathematical modeling applied to agricultural irrigation using ordinary differential equation (2/2022/BII/BIOMATH)*

Selected candidate: António César

Advisors: Ana Pedro Paião, Daniel Oliveira Figueiredo, Sofia Lopes

- *Modeling Primary Health Care indicators (BII-BIOMATH-3-2022)*

Selected candidate: Catarina Cardoso

Advisors: Vera Afreixo, Cristiana Silva, Magda Monteiro, José Pedro Antunes

- *Analysis of COVID19 data from ACeS Baixo Vouga (4/2022/BI/BIOMATH )*

Selected candidate: Pedro Machado

Advisors: Sofia Pinheiro, Cristiana Silva, Vera Afreixo, Rui Pedro Leitão,

- *Statistical analysis in clinical trials (5/2022/BI/BIOMATH )*

Selected candidate: Filipa Rocha

Advisors: Pedro Sá Couto

- *Characterization of mental health issues in the region of Aveiro (1/2022/BI/Dmat)*

Selected candidate: Filipa Rocha

Advisors: Sofia Pinheiro, Cristiana Silva, Vera Afreixo, Miguel Felgueiras, Rui Pedro Leitão

## **Budget**

Executed budget: 3 BI fellowships (BII-BIOMATH-3-2022, 4/2022/BI/BIOMATH, 5/2022/BI/BIOMATH) and 2 BII fellowships (/2022/BII/CIDMA, 2/2022/BII/BIOMATH), each of them with 3 months duration, which gives a total budget of 10800,54 euros.

More 1 fellowships were open with own funding (Department of Mathematics) aligned with the objectives of the Thematic Line corresponding to a total of 2627,94 euros: 1 BI with duration of 3 months (1/2022/BI/Dmat)

The total budget was dedicated to BI and BII fellowships, with total amount of 13428,48 euros.

## **Indicators**

### **A - Publications**

#### **Articles in international journals**

1. Pedro Machado, Sofia J. Pinheiro, Vera Afreixo, Cristiana J. Silva, Rui Leitão. "Graph theory approach to COVID-19 transmission by municipalities and age groups" *Math. Comput. Appl.* 2022, Volume 27, Issue 5, 86 <https://www.mdpi.com/2297-8747/27/5/86/pdf>
2. Jorge Cabral, Cristiana Silva, Ana Helena Tavares, Alda Marques, Vera Afreixo Statistics, "A multiobjective optimization approach to pulmonary rehabilitation effectiveness in COPD" *Optimization & Information Computing* <https://doi.org/10.19139/soic-2310-5070-1505>

#### **Book Chapter**

1. Freitas, A., Escudeiro, S., Reis, J., & Silva, C. J. (2022). COVID-19's pandemic: a new way of thinking through linear combinations of proportions. In *Mathematical Analysis of Infectious Diseases* (pp. 41-59). Academic Press.

#### **Publications in Proceedings: 7**

1. Catarina Cardoso, Cristiana Silva, Magda Monteiro, José Pedro Antunes, Vera Afreixo (2022) "(Dis)similarities of primary health care indicators". Vol 4 No 1 (2022): Special Issue - Statistics on Health Decision Making: Real World Data, *Journal of Statistics on Health Decision*.
2. Pedro Machado, Sofia Pinheiro, Cristina Silva, Vera Afreixo, Rui Pedro Leitão (2022). "Graph Theory approach to COVID-19 transmission across adjacent municipals". Vol 4 No 1 (2022): Special Issue - Statistics on Health Decision Making: Real World Data, *Journal of Statistics on Health Decision*.
3. Leonor Rodrigues, Jorge Cabral, Ana Helena Tavares, Vera Enes, Miguel Pinheiro, Gabriela Moura, Vera Afreixo (2022) "Assessment of the stability of a procedure for variables selection in high dimensionality data: an application to genomic data - Alzheimer's Disease". Vol 4 No 1 (2022): Special Issue - Statistics on Health Decision Making: Real World Data, *Journal of Statistics on Health Decision*
4. Filipa Rocha, Cristiana Silva, Miguel Felgueiras, Rui Pedro Leitão, Sofia Pinheiro, Vera Afreixo "Characterization of mental health issues in the region of Aveiro — A retrospective analysis". Vol 4 No 1 (2022): Special Issue - Statistics on Health Decision Making: Real World Data, *Journal of Statistics on Health Decision*.
5. Cristiana Silva, Pedro Alexandre Machado, Rui Pedro Leitão, Sofia Pinheiro, Vera Afreixo. "Graph Theory approach to COVID-19 transmission across adjacent municipals" Vol 4 No 1

- (2022): Special Issue - Statistics on Health Decision Making: Real World Data, Journal of Statistics on Health Decision.
6. Leonor Carvalho Rodrigues, Vera Afreixo, Ana Helena Tavares, Marisa Caetano, Catarina Chaves, Luís Cabral “Bacterial multidrug resistance description in Coimbra Burns Unit, 2016-2020” Vol 3 No 1 (2021): Special Issue - Statistics on Health Decision Making: Public Health, Journal of Statistics on Health Decision.
  7. Mariana Pinto, Marco Costa, Adelaide Freitas (2022) Evolution of diet patterns over time in Europe from 1963 to 2013: an exploratory analysis using PCA for compositional data vectors. Special Issue - Statistics on Health Decision Making: Real World Data. Journal on Statistics in Health Making Decision, Vol 4 No 1, 42-4

## **B - Communications**

### **Communications in national scientific meetings: 10**

1. Leonor Rodrigues, Ana H. Tavares, Vera Enes, Miguel Pinheiro, Gabriela Moura, Vera Afreixo “Stable variable selection in penalized regression models: an application to high dimensional genomic data - Alzheimer’s Disease” Bioinformatics Open Days Communication 5
2. Filipa S. Rocha “Characterization of reported mental health issues in the region of Aveiro — A retrospective analysis” Research Summit 2022, University of Aveiro
3. Catarina Silva Cardoso “(Dis)similarities of primary health care indicators” Research Summit 2022, University of Aveiro
4. Márcia Lemos-Silva “A note on a prey-predator model with constant-effort harvesting” Research Summit 2022, University of Aveiro
5. Antonio C. Castro Iglesias “Optimal Control Problem for an Irrigation Mechanism” Research Summit 2022, University of Aveiro
6. Mariana Pinto “Diet patterns over time: an analysis using compositional data vectors” IV Workshop in BioMathematics 2022, University of Aveiro
7. António C. Iglésias “Optimal control problem for an irrigation mechanism” IV Workshop in BioMathematics 2022, University of Aveiro
8. Catarina Cardoso “Primary Health Care indicators: short and medium term forecasting model” IV Workshop in BioMathematics 2022, University of Aveiro
9. Pedro Machado “Graph theory approach to COVID-19 transmission by municipalities and age groups” IV Workshop in BioMathematics 2022, University of Aveiro
10. Filipa Rocha “Characterization of the mental health issues in the region of Aveiro” IV Workshop in BioMathematics 2022, University of Aveiro

### **Posters: 8**

1. Tedim, S., Afreixo, V., Felgueiras, Leitão, M., Pinheiro, S., Silva, C. (2022). “Fitting Covid-19 data with bootstrap methodology”. (Poster). 22th CMMSE, Spain.
2. Catarina Cardoso, Cristiana Silva, Magda Monteiro, José Pedro Antunes, Vera Afreixo (2022) “(Dis)similarities of primary health care indicators”. Statistics on Health Decision Making: Real World Data, University of Aveiro.
3. Pedro Machado, Sofia Pinheiro, Cristina Silva, Vera Afreixo, Rui Pedro Leitão (2022). "Graph Theory approach to COVID-19 transmission across adjacent municipals". Statistics on Health Decision Making: Real World Data, University of Aveiro.



4. Leonor Rodrigues, Jorge Cabral, Ana Helena Tavares, Vera Enes, Miguel Pinheiro, Gabriela Moura, Vera Afreixo (2022) "Assessment of the stability of a procedure for variables selection in high dimensionality data: an application to genomic data - Alzheimer's Disease Statistics on Health Decision Making: Real World Data, University of Aveiro.
5. Filipa Rocha, Cristiana Silva, Miguel Felgueiras, Rui Pedro Leitão, Sofia Pinheiro, Vera Afreixo "Characterization of mental health issues in the region of Aveiro — A retrospective analysis". Statistics on Health Decision Making: Real World Data, University of Aveiro.
6. Cristiana Silva, Pedro Alexandre Machado, Rui Pedro Leitão, Sofia Pinheiro, Vera Afreixo. "Graph Theory approach to COVID-19 transmission across adjacent municipals" Statistics on Health Decision Making: Real World Data, University of Aveiro.
7. Leonor Carvalho Rodrigues, Vera Afreixo, Ana Helena Tavares, Marisa Caetano, Catarina Chaves, Luís Cabral "Bacterial multidrug resistance description in Coimbra Burns Unit, 2016-2020" Vol 3 No 1 (2021): Statistics on Health Decision Making: Real World Data, University of Aveiro.
8. Mariana Pinto, Marco Costa, Adelaide Freitas (2022) Evolution of diet patterns over time in Europe from 1963 to 2013: an exploratory analysis using PCA for compositional data vectors. Special Issue - Statistics on Health Decision Making: Real World Data Statistics on Health Decision Making: Real World Data, University of Aveiro.

#### **D – Organization of workshops: 1**

Organization of the IV Workshop in BioMathematics, helded at Room Sousa Pinto of the Department of Mathematics of the University of Aveiro, Portugal, at 7th December 2022.

Invited speakers: 2

- Pedro Damião Rebelo, (MD), University of Aveiro

Title of the talk: Learning from nature

- Rui Fonseca-Pinto, (MD, Ph.D.), Polytechhnic of Leiria

Title of the talk: Adaptive Analysis in Medical Data Processing: The Hilbert-Huang Transform Challenges

Number of contributed talks: 5

Number of participants: 40

<https://sites.google.com/view/4wsbiomath2021/home>

#### **Websites criated in the context of the project**

<https://sites.google.com/view/4wsbiomath2021/home>

<https://sites.google.com/view/ltbiomath/activities-2022>

## Thematic Line TFC - From Theory to Computational Frameworks (Coordinated by the GAFA member Eugénio Rocha)

In the LT-TFC, the following mathematical computational frameworks were implemented in 2022:

- [F01] Variables influence analysis of gas leak testing using belief propagation over factor graphs (J.Martins<sup>1</sup>, D.Costa, **E.Rocha**) – use case at Bosch TT;
- [F02] Predictive system for stocks improvement in the ceramic industry (P.Lobo<sup>2</sup>, **E.Rocha**) – use case at Aleluia Cerâmicas;
- [F03] An IoT proposal for injection mold data retrieving (B.Mendes<sup>2</sup>, R.Antunes, **E.Rocha**, J.Santos) – use case at OLI;
- [F04] Recommendation system in PCBA repair (J. Cozinheiro, **E.Rocha**, J.Santos) – use case at Bosch BT;
- [F05] Convolutional neural networks for identification of moving combustion chambers entering a brazing process (R.Pereira, **E.Rocha**, D.Pinto, J.Santos) – use case at Bosch TT.
- [F06] Identificação de fatores relevantes em problemas de qualidade e manutenção numa empresa de porcelana (B.Rato, **E.Rocha**) – use case at Vista Alegre.
- [F07] Metodologias Bayesianas na Avaliação do Risco e Progressão da Degenerescência Macular da Idade (M.Inês Silva, **E.Rocha**) – study data of AIBILI.

The LT-TFC did not spend any CIDMA financial resources during 2022. All work was done by integrated students and/or LT-TFC members. The frameworks [F03] and [F04] are deployed in edge devices in the shopfloor of the industrial companies, being used every day. [F01] and [F02] have corresponding publications accepted in 2022. Works [F02]-[F07] produced 6 Master Theses, available at RIA/UA.

The following talks were given:

- E.Rocha. 4th International Conference on Industry 4.0 and Smart Manufacturing, Linz, Austria, 2022. Communication title: Convolutional neural networks for identification of moving combustion chambers entering a brazing process;
- E.Rocha was a tutor/scientific committee member in the VII Iberian Modelling Week, Coimbra, Portugal, 2022, for the problem 4.

The outputs present here are not included in GAFA outputs, although some are quite related.

## Thematic Line TFC - From Theory to Computational Frameworks (Coordinated by the GAFA member Eugénio Rocha)

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<sup>1</sup> PhD student (co)supervised by E.Rocha

<sup>2</sup> MSc student (co)supervised by E.Rocha

In 2023, the LT-TFC activities will focus mainly on the implementation of mathematical computational frameworks for the fish and agriculture industry with close collaboration with SEA8 company with the integration of sensors developed by members of I3N.

# Relatório Preliminar de Progresso - Componente Científica

Relatório Preliminar de Progresso nº : 2, 01-01-2022 to 31-12-2022 do orçamento  
UIDP/04106/2020

## Resumo dos trabalhos

Concerning scientific outputs in the scope of the thematic line Mathematics for Industry (MI), 2 articles in international journals and 5 communications in scientific events were done by the research team. Additionally, 1 PhD thesis and 6 master theses with industrial applications were supervised. In this period, the event XXVII EURO Working Group on Locational Analysis Meeting, EWGLA XXVII, was organized.

Of note in this period is also the participation in the corporate R&D co-promotion project titled “Scalable, efficient and abstract luggage mobility infrastructure (SCALUM)”.

## Indicadores

### Artigos em revistas internacionais

1. Costa, M., Madaleno, M. and Macedo, P. (2022). Generalized maximum entropy in electrical energy price modeling for households and non-households in Portugal. *Energy Reports*, 8, 448-453;
2. Zanjani, Z., Soares, I. and Macedo, P. (2022). The nexus between CO2 emissions from electricity generation, GDP and energy intensity using a complete maximum entropy approach: The case of Iran. *Energy Reports*, 8, 319-324.

### Comunicações em encontros científicos internacionais

1. Zanjani, Z., Soares, I. and Macedo, P. (2022). Investigating CO2 emissions from aviation in oil producing countries using a two-stage maximum entropy approach. *Proceedings of the ICEE 2022 – 5th International Conference on Energy and Environment*, June 02-03, Porto, Portugal.
2. Rita, R., Marques, V., Bárbara, D., Chaves, I., Pereira, M., Moutinho, V. and Macedo, P. (2022). Crossing Non-parametric and Parametric Techniques for Measuring the Efficiency: Evidence from 65 European DSO. *Proceedings of the ICEE 2022 – 5th International Conference on Energy and Environment*, June 02-03, Porto, Portugal.
3. Figueiredo, B. and Lopes, R.B. (2022). Considering resilience in a green location-routing problema. *13th International Conference on Computational Logistics, ICCL 2022*, September 21-23, Barcelona, Spain.
4. Figueiredo, B. and Lopes, R.B. (2022). Sustainability and resilience in a location-routing problem. *XXVII EURO Working Group on Locational Analysis Meeting, EWGLA XXVII*, September 14-16, Aveiro, Portugal.

## Comunicações em encontros científicos nacionais

1. Figueiredo, B. and Lopes, R.B. (2022). A multi-objective location-routing problem addressing resilience and sustainability. 22º Congresso da Associação Portuguesa de Investigação Operacional, IO 2022, November 6-8, Évora.

## Organização de seminários e conferências

1

1. XXVII EURO Working Group on Locational Analysis Meeting, EWGLA XXVII, University of Aveiro, Portugal, 14-16 September 2022. Event with the main goal of bringing together researchers and practitioners working in the wide area of location science through the proposal of models and methods to solve theoretical and practical problems.

## Teses de Doutoramento

1. PhD in Economics, Faculty of Economics, University of Porto  
Title: Carbon Emissions of Electricity Generation and Air Transport in Middle East Countries: A Maximum Entropy Approach  
Student: Zeinab Zanjani

## Teses de Mestrado

1. MSc in Industrial Engineering and Management, University of Aveiro  
Title: Sustentabilidade e resiliência num problema de localização-distribuição  
Student: Bruna Figueiredo
2. MSc in Industrial Engineering and Management, University of Aveiro  
Title: Conceptualização de um sistema de informação para a gestão de campanhas de desconto na Prio Energy  
Student: Diogo Martins
3. MSc in Industrial Engineering and Management, University of Aveiro  
Title: Desenvolvimento de dashboards e aplicação de técnicas lean para o aumento de produtividade numa indústria corticeira  
Student: Jorge Almeida
4. MSc in Industrial Engineering and Management, University of Aveiro  
Title: Desenvolvimento e estudo da usabilidade de um sistema de business intelligence na área de qualidade, segurança e ambiente da Prio  
Student: Jorge Pinho
5. MSc in Industrial Engineering and Management, University of Aveiro  
Title: Implementação de uma metodologia de gestão de projetos com ciclo PDCA na Schaeffler Portugal  
Student: Rita Antunes
6. MSc in Industrial Engineering and Management, University of Aveiro  
Title: Value stream mapping como ferramenta de melhoria do fluxo produtivo na Amorim Top Series  
Student: Vânia Martins