

From Theory to Computational Frameworks

“Da Teoria às Ferramentas Computacionais (TFC)”

Thematic Line of the Center for Research & Development in Mathematics and Applications (CIDMA)

Coordinators



Eugénio Rocha



Manuel A. Martins

CIDMA members (Theoretical Works)



Domingos Cardoso



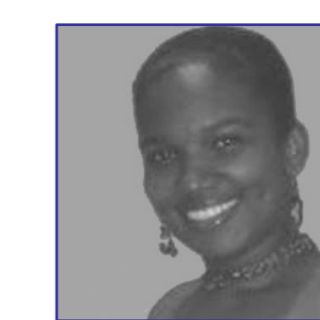
Paula Carvalho



Manuel Martins



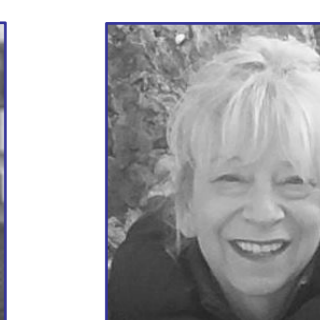
Daniel Figueiredo



Kelly Murillo



Eugénio Rocha



Ana Breda

Fellow(s) (FCT/BIC grant of 3 months)



Miguel Araújo
(Student)

External Collaborators



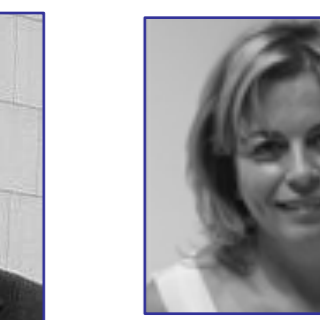
Pablo Benitez
(Paraguay)



Sudip Talukdar
(Canada)



Humberto Varum
(Porto)



Fernanda Rodrigues
(Aveiro)

AIMS

The thematic line LT-TFC intends to join together CIDMA members that want to reduce the time gap between the publication of recognized theoretical results and their application to different scientific fields, target communities, or society problems; mainly by researching and developing new Computational Frameworks, supported by their research work.

SCOPE AND HISTORY

LT-TFC is a research and development thematic line of the Center for Research and Development in Mathematics and Applications (CIDMA) of the University of Aveiro; created on 9/Jan/2018 at the “Reunião do Conselho Científico do CIDMA”, which was appointed to formally start in 1/Jan/2019.

EXPECTED OUTCOMES

The LT-TFC expected outcomes are:

- Implementation of computational frameworks (CF) of specific and recognized theoretical results co-authored by CIDMA members;
- Publication of tool papers explaining the innovation and use of the developed CF;
- Challenge CIDMA members for further theoretical problems generated from the interaction with real applications or other scientific areas.

PREVIOUS RESOURCES

During 2018, the LT-TFC had one “Bolsa de Iniciação à Investigação da FCT (BIC/FCT)”, for 3 months, with the purpose of CF development.

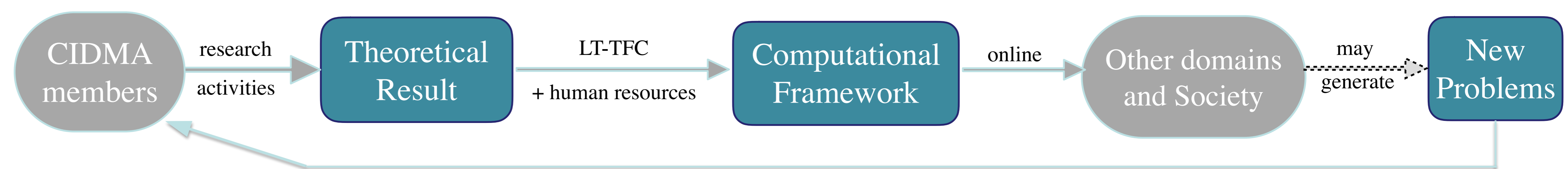
EXTERNAL USES

PhD Thesis in Civil Engineering, Pablo Mongelos Benitez: Maintenance support strategies for reinforced concrete structures under corrosion risk, Univ. of Aveiro, November, 2018, 220 pp (2 chapter are about the topic).
[Supervisors: M. Rodrigues and H.Varum]
[LT-TFC packages: W3 and W4]

Health Institutions Benchmarking, Maria Madaleno França (Conselho de Administração do CHBV) and Ana Rita Martins (MSc student in Public Administration), ongoing work.
[LT-TFC packages: W5]

Higher Education Institutions Benchmarking, Clara I. Pardo (Administration of the Observatory of Science and Technology OCyT, Bogotá, Colombia), ongoing a benchmarking of 146 public and private higher education institutions in Colombia.
[LT-TFC packages: W5]

General Schematic Approach



Achieved Goals and Outputs in 2018

W1. Invariants Calculation and Image Representation of Lexicographic Polynomials of Graphs

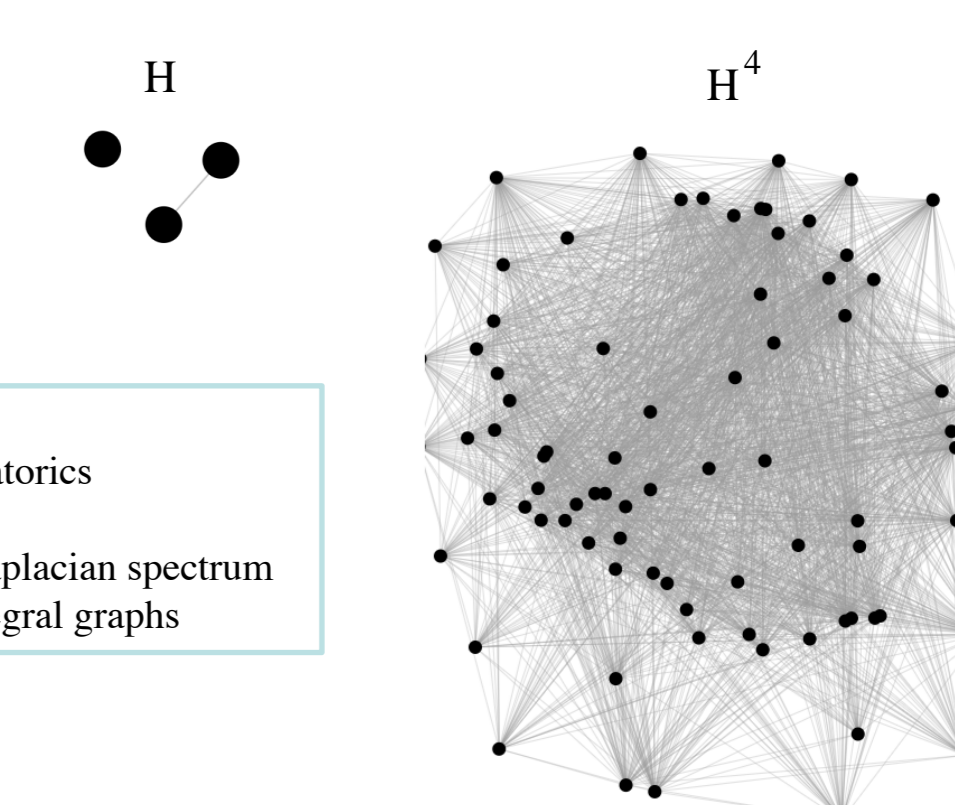
ABSTRACT: For a (simple) graph H and non-negative integers c_0, c_1, \dots, c_d ($c_d \neq 0$), $p(H) = \sum_{k=0}^d c_k \cdot H^k$ is the lexicographic polynomial in H of degree d , where the sum of two graphs is their join and $c_k \cdot H^k$ is the join of c_k copies of H^k . H^k is the k th power of H with respect to the lexicographic product ($H^0 = K_1$). The spectrum (if H is regular) and the Laplacian spectrum (in general case) of $p(H)$ are determined in terms of the spectrum of H and c_k 's.

Publication: D. M. Cardoso, P. Carvalho, P. Rama, S. K. Simic, Z. Stanic, "Lexicographic polynomials of graphs and their spectra." *Applicable Analysis and Discrete Mathematics* 11 (2017): 258-272

Implementation: Coordinated by D. Cardoso and P. Carvalho; Developed in Python by Miguel Araújo (BIC/FCT grant; 1.5 months)

Available: sDL package at <http://sdl-vm2.mathdir.org/docs/packages/PGLnv1.0/package.html>

TOPICS:
• Graph theory and combinatorics
• Linear algebra
• Lexicographic product, Laplacian spectrum
• Cospectral graphs and integral graphs



W2. Real Object Identification and Tracking as an Innovative Computer Input Device

ABSTRACT: This is the first step for the production of an Innovative Computer Input Device (CID). We propose the use recent real-time object identification and tracking algorithms in order to produce the CID, allowing the manipulation of multiple object simultaneously and largely extending the functionalities of the traditional mouse device. The possible applications are wide (e.g. in education software or as input devices for persons with motor impairment) but still need further research.

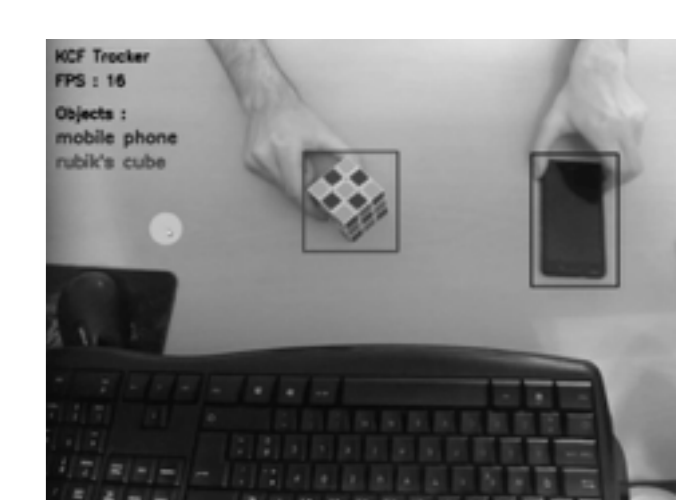
Collaboration: LT-Geometrix (Ana Breda), which allowed to use their NVIDIA GPU hardware needed for development purposes

Publication: E. Rocha, M. Araújo, "Real Object Identification and Tracking as an Innovative Computer Input Device" (will be prepared). The submission of a patent may be considered, under some requirements.

Implementation: Coordinated by E. Rocha and A. Breda; Developed in C++ by Miguel Araújo (BIC/FCT grant; 1.5 months)

Available: Source code at https://github.com/sDLsystem/TFC_3DObj_Tracking (*)

TOPICS:
• Mathematics of data mining
• Deep learning
• Object segmentation and tracking
• Vision algorithms and cloud computing



W3. Optimal Inspection Management for Reinforced Concrete Structures under Corrosion Risk

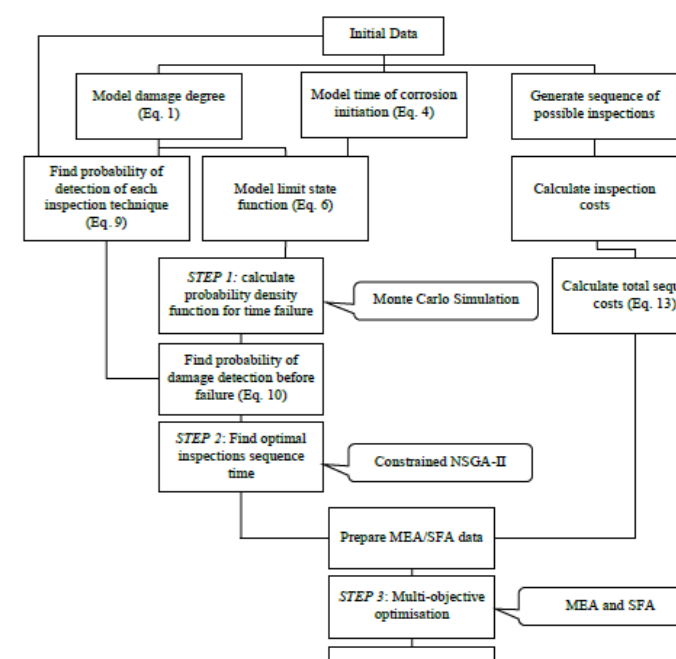
ABSTRACT: Reinforced concrete is one of the most predominant materials used in constructed structures and infrastructures throughout the world. We developed a CF of decision-making model for the optimal inspection planning for concrete structures subject to carbonation-induced corrosion, counting for the trade-off between inspection costs and the structure serviceability, it provides an inspection strategy that establishes the optimal solution for both the inspection times and the most suitable inspection technique to be applied considering the efficiency of the solution. Failure times and degrees are stochastically predicted.

Publication: P. Benitez, E. Rocha, S. Talukdar, H. Varum, F. Rodrigues, "Efficiency Analysis of Optimal Inspection Management for Reinforced Concrete Structures under Corrosion Risk", 21 pg (submitted).

Implementation: Coordinated by E. Rocha, F. Rodrigues and P. Benitez; Developed in R + MatLab by Eugénio Rocha and Pablo Benitez

Available: Source code at <https://github.com/sDLsystem/sDL-PACKAGE-corrosionOIM> (*)

TOPICS:
• Differential equations
• Non-convex and non-smooth optimization
• Numerical analysis
• Monte Carlo simulations



W4. Dynamic Multi-Criteria Decision-Making Model for the Maintenance Planning of Reinforced Concrete Structures

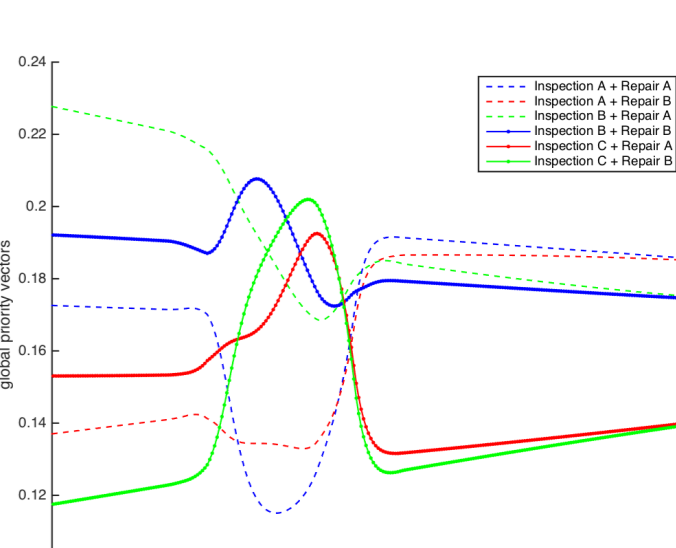
ABSTRACT: This methodology provides the best maintenance alternative (inspection/repair) to be performed in these structures for a given intervention time. The best solution for the intervention is chosen regarding the Global Priority Vector of the final pairwise comparison matrix. After an illustrative application, the new dynamic decision model developed proven be a helpful tool for decisions-making regarding the most suitable intervention alternative within the maintenance planning of these structures.

Publication: P. Benitez, E. Rocha, H. Varum, F. Rodrigues, "A dynamic multi-criteria decision-making model for the maintenance planning of reinforced concrete structures, 25 pg (submitted).

Implementation: Coordinated by E. Rocha, F. Rodrigues and P. Benitez; Developed in MatLab by Eugénio Rocha and Pablo Benitez

Available: Source code at <https://github.com/sDLsystem/sDL-PACKAGE-corrosionDMDM> (*)

TOPICS:
• Multi-criteria decision making
• Analytic hierarchy processes
• Linear algebra
• Probability and statistics



Ongoing Projects and Potential Future Work

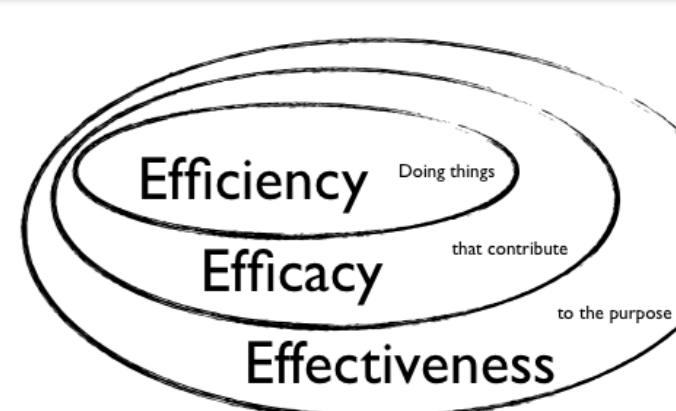
Considering the aims of LT-TFC, the amount of human resources in the form of grants for implementation issues is a key point which may invalidate the development of future work.

W5. Efficiency and Efficacy Toolbox with Real-Time Data Monitoring

ABSTRACT: Efficiency and efficacy are relevant measures of business activities, resource allocation, and process flows. A framework is under development to implement both approaches with the extra ability to monitoring real-data, generating semi-automatically management support tools (e.g. SWOT analysis). The first intended application uses data of the National Hospitals Benchmarking (ACSS) and will be a testbed for generating reports to support planning and management activities.

Collaboration: "Conselho de administração do Centro Hospitalar do Baixo Vouga (CHBV)"

Implementation: Coordinated by M.M. França, E. Rocha and G. Santinha; Developed in R by Eugénio Rocha



W6. Continuous-time Markov Chains on Reactive Networks

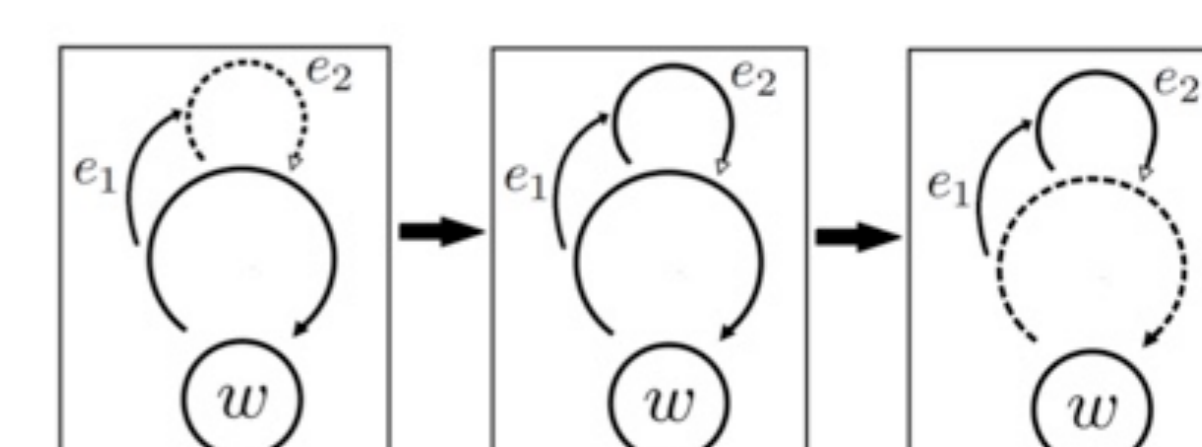
ABSTRACT: Efficiency and efficacy are relevant measures of business activities, resource allocation, and processes flow. It is under development a framework to implement both approaches with the ability to monitoring real-data. Using the first version of the package, we have produced a

Publication: E. Rocha, D. Figueiredo, M.A. Martins, M. Chaves, "rPrism – A software for reactive weighted state transition models", tool paper (submitted)

Implementation: Coordinated by M.A. Martins and E. Rocha; Developed in Python + C++ by Eugénio Rocha and Daniel Figueiredo

Available: sDL package at <http://sdl-vm2.mathdir.org/docs/packages/rPrism1.0/package.html>

Online Demo: Beta version available at <http://sdl-vm2.mathdir.org/demos/sDL-pck-run?pck=rPrism1.0>



Future (Potential) Work

Any CIDMA member may propose projects to be implemented by the LT-TFC, if the resource requirements turn out to be available for its implementation.

A brief list of (potential) future work to be implemented:

- Post-Quantum cryptography based on codes (research of Diego Napp, Paulo Almeida and Raquel Pinto)
- Atlas of highly symmetric hypertopes of a given type (research of M. Elisa Fernandes)
- Prover for hybrid(ised) logics (research of Alexandre Madeira, Manuel A. Martins)
- Efficient choice of parameters for delta-reachability of bounded hybrid systems (research of Eugénio Rocha and Kelly Murillo)

(*) After the paper is published, public access to part/total of the source code or demo will be available.

At the moment, to access the private repository, please contact eugenio@ua.pt