MATH AmSud

2023 call for proposal approved projects

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CatHopf

Category theory and hopf algebras

The present project proposes the establishment of a network of collaboration between Argentina, Colombia and France, using the strength of 3 mathematics groups of 3 different institutions. The research topic of the proposal is Category Theory, an important and modern area of mathematics, and one of our goals is to show how results on this “macro” level produce results in a “micro” level, as are the Hopf algebras.

Moreover, the different goals listed above reflect the interdisciplinarity of our project, it involves tools from Category Theory, Hopf algebra and Non-commutative Rings, but also considers applications in Deformation Theory and Quantum Topology. The results of our research also have a high potential of applications in Quantum Physics like 2d Logarithmic Conformal Field Theories – one of the fields of expertise of the French coordinator.

The proposal is structured in such a way that the training of highly qualified human resources and research activities are intertwined, combining the complementary areas of expertise of the coordinators. This will ensure the generation of new knowledge in the relevant scientific areas and leave permanent ties of collaboration between Latin-America and Europe beyond the completion of the project.

Finally, this project has a special emphasis in involving and supporting young female researchers and female students. We propose three scientific activities: a 2-week meeting (research mission) the first year in France, and two meetings (workshop for students) the next year in Latin-America to produce spill-over of knowledge.

Project coordinators

Adriana Mejía Castaño, Universidad del Norte, Colombia
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CODICIS

COlors, DImension and Covers In graphS

This project aims at investigating three key topics within graph theory: graph coloring, metric dimension and edge-coverings.

A central problem in graph theory consists in guaranteeing dense substructures in graphs with a given chromatic number. We aim at tackling this problem for two types of substructures. For immersions, we will work towards a conjecture that states that every graph contains an immersion of a clique on as many vertices as the graph's chromatic number. For subgraphs, we aim at guaranteeing large clique subgraphs in graphs with certain excluded induced subgraphs.

Another question of much importance is: how do we store a graph in a compact way? The metric dimension of a graph is the minimum size of a vertex set S such that any vertex in the graph is uniquely defined by the vector of its distances to vertices of S. This notion has many applications even beyond mathematics to, for example, robotics and chemistry. We aim at better understanding the relations between the order of the graph, its metric dimension, and its diameter.

The last question of our project deals with partitioning the elements of a graph into subgraphs with strong properties. In particular, a recent conjecture aims at generalizing a classic result of Lovász: there is a constant C such that every properly edge-colored graph can be partitioned into C*n rainbow paths.Towards this conjecture we consider covering weakenings, for instance, the question of whether we can cover the edges of any n-vertex graph with O(n) rainbow paths.

Project coordinators

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EPPPT

Elliptic and Parabolic PDEs arising in Physics and Technology

This project contains a research plan in the main area of Partial Differential Equations (PDEs) to be carried out at the Universidade Federal da Paraíba in collaboration with other foreign and national research institutions. The project is divided into three main parts: Elliptic PDEs, Trudinger-Moser and Adams-type inequalities, Parabolic and Elliptic PDEs by means of probabilistic techniques. Apart from research activities, we aim to involve PhD students and postdocs into the advanced topics of this project. We are focused on PDEs that arise in quantum mechanics, physics, and technology; our choice of problems always takes into consideration the importance of these applications.

Project coordinators

João Marcos Bezerra do Ó, Universidade Federal da Paraíba, Brazil
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HAMDYN

Hamiltonian and symplectic dynamics

The final goal of this project is to develop and consolidate a regional collaboration network in the areas of interaction of symplectic geometry and symplectic topology with Hamiltonian or conservative dynamics. We are especially interested in carrying out this objective through the study of classical problems of mathematical physics, such as n-body problems and other models of classical mechanics, as well as the dynamics of generic Reeb flows.

Project coordinators

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HHMA

Homological and Homotopical Methods in Algebra

We aim to study various invariants of associative algebras. Homological invariants arise when one works with additive categories, while homotopical invariants arise from non-additive categories. These two contexts rely on different kind of intuition (coming from algebraic geometry and representation theory, and from algebraic topology respectively). The combined expertise of the project participants will allow us to combine those intuitions to progress in research directions.

Project coordinators

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MiLNE

Mixed local and nonlocal equations: analytic, numerical and probabilistic aspects

The importance of mathematical models in Science in Engineering is, by now, almost impossible to overshadow. Physics, Biology, Material Sciences, Social and Economic Sciences, or Data Science and Machine Learning are only a few of the many instances in which accurate mathematical models and efficient numerical methods to compute them are of prime importance to understand, predict and/or optimize the underlying phenomena. At the same time, questions from the applied sciences have long been a source of inspiration for deep questions within the realm of pure mathematics.

In this context, our project aims to contribute to the study of the interaction between local, or integer order, and nonlocal, or fractional order, equations. Both of these separately (since the 19th century the former and more recently the latter) have received much attention from the Partial Differential Equations, Probabilistic and Numerical Analysis Communities. However, it is only in the past five years or so that these communities have directed their interest to the interaction between them. Since they account for different types of interactions, namely infinitesimal and long-range respectively, their study is both of intrinsic mathematical interest and an important contribution to the understanding of phenomena occurring in the applied sciences.

We will approach the study from the analytic, probabilistic and computational/numerical points of view, as we consider that different aspects of the problem are complementary in the overall understanding of the models in question. The specific problems to be studied have connections to problems in material sciences and phase transitions, game theory, image processing, population dynamics and optimal control theory, among others..

Project coordinators

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MORA-DataS

Matrices, Optimization, and Randomness with Applications in Data Science

During the last decades, a lot of progress has been made in the optimization research field. New challenges in data science and operational research have not only motivated the development of new optimization tools, but also many (old) theoretical studies have become relevant in these areas. In this project, we propose to study diverse optimization models, deterministic and stochastic, and to investigate matrix inverse eigenvalue problems, some with potential applications in data science. More specifically, we propose to develop numerical methods for computing critical angles between cones, which are formulated as an optimization problem, and to apply them to the image set classification problem. To summarize the main features of an image set data, it will be necessary a matrix analysis and inverse eigenvalue problems will take part on it. In addition, we will address the Extremal EIP for symmetric and non-symmetric pentadiagonal matrices and some structured Hermitian matrices. We propose also to study a (nonsmooth) joint chance constrained optimization problem and to propose numerical methods to solve it based on a sequence of smooth chance constrained optimization problems. This problem has applications in resource management, electricity network expansion, telecommunications, etc. Another optimization model that we propose to study is the nonlinear second-order cone programming. For this, we propose to develop a numerical method for its resolution with the specific purpose of reducing the numerical cost compared to existing methods. In this way, we expect to obtain a tool to deal with large-scale classification problems. Last but not least, we propose to develop and use Euclidean Jordan algebra techniques to solve optimization problems under conic constraints, like the problem of computing the maximal angle between LISC cones (Linear Image of Symmetric Cones) and the problem of computing the conic intrinsic volumes of LISC cones. Finally, we propose to introduce new proximal algorithms to solve Separable Symmetric Cone Minimization and analyze their properties: convergence, rate of convergence, finite termination and complexity of the iterations. Then we give some applications of these algorithms to the above mentioned problems.

Project coordinators

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SMILE

Statistical Modeling, nonparametric Inference and modeL sElection for complex data

Statistical modelling for complex data is an important framework for analyzing data in fields such as ecology, meteorology, health, and telecommunications. These models are used to model population dynamics, animal movement, longitudinal data, spatial-temporal analysis, or Poisson processes. In this proposal, we are interested in to propose novel estimation procedures in this kind of complex data, considering restricted data (for instance, data on compact domain or longitudinal compositional data), spatial weighted regression, and model selection with weakly dependent observations and non-homogeneous Poisson processes. We will use parametric and nonparametric strategies.

Project coordinators

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SOGGA

Stochastic optimization, generalized games and applications

Chile, Peru and France, as well as many countries in South America and Europe, share a very similar systems to deal with their electricity markets. In parallel, all three countries (together with the rest of the world) are being affected by climate change in many aspects, such as scarcity of water, intense droughts, pollution and the greenhouse effect, the necessity of new energy sources, just to name a few.

To face these challenges, we need new technology coming from many fields of science. One of such fields is mathematics and in particular, stochastic optimization and game theory. These theoretical fields allow us to model economic interactions, management solutions, optimal design and operations, among many other relevant aspects of Natural Resources and Energy Management.

In the present project, we propose to develop new theoretical and numerical advances in four research lines, concerning Stochastic Optimization and Game Theory. Namely, we will work on: 1) Continuity-like properties in Equilibrium problems; 2) Regularity in Generalized Equilibrium problems; 3) Bilevel games with decision-dependent uncertainty; and 4) Algorithms and mechanism design in learning games. The four research lines are strongly motivated by the aforementioned applications.

Project coordinators

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VARLIE

The variety of lie algebras

The aim of this project is to form and establish a network of researchers from Argentina, Chile, Colombia and France to study the variety of Lie algebras.

This will be done by following different approaches in order to obtain results regarding the algebraic classification, geometric classification and rigid elements of the variety of Lie algebras or interesting subvarieties.

Project coordinators

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VIPS

Variational analysis in probability spaces with applications to optimal control theory

Starting with the pioneering formulation by Benamou and Brenier of the 2-Wasserstein distance in terms of a time-dependent convex variational problem, the optimal control of curves of probability measures has attracted increasing interest in the field of applied mathematics. Very recently, Cavagnari, Lisini, Orrieri, and Savaré, have justified this type of problem in terms of the asymptotic behavior of standard optimal control problems involving symmetric interactions between an increasing number of agents.

The limit optimal control problem described above, also called a mean-field optimal control problem, will be at the heart of our investigations. In this framework, the main research lines of our proposal are the following:

- The study of the existence of optimizers.
- Optimality conditions.
- Numerical optimization techniques.

Since, for the first two points, our analysis will go beyond the convex framework, the proof of the existence of optimizers will need the use of relaxation techniques and, hence, it will hold in functional spaces with low regularity. In particular, classical techniques of abstract optimization theory will not be applicable to obtain necessary optimality conditions, and a tailored study must be carried out. Regarding the numerical approximation, we will focus our study on the convergence analysis of standard space-time discretizations and numerical schemes that take advantage of the (weak) Riemannian structure of the space of probability measures. In a second step, the central theme will be the study of the three points above when considering controlled measure sweeping processes. Finally, applications of the problems above to crowd motion and traffic congestion models will be considered in detail.

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Project coordinators

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WAFFLE

Waters, atmosphere, fluids and friedman-lemaître evolutions

This proposal describes an emerging but genuinely cohesive collaborative network between researchers in France, Ecuador and Chile specialized in fluid dynamics from a mathematical point of view. What distinguishes us from other groups present in the region is our particular flavor involving i) deep harmonic analysis of Navier-Stokes and Euler models, ii) the comprehensive understanding of the dynamics in water wave models, and iii) a profound work on 2D fluid dispersive models such as KP, ZK, and more recently, studies in Fluids appearing in Climatology and General Relativity. We are a forming group with broad interests and high synergy looking for the advance of Science and Mathematics in Latin America through the French connection and Amarun and Alphanumeria outreach initiatives. We also propose here the formation of 3 graduate students and junior researchers, and forthcoming MathAmSud focused research events

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Project coordinators

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