

RESEARCH CATALOG



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Instituto de Ciências Matemáticas e de Computação
Universidade de São Paulo

ONE INSTITUTION, INFINITE POSSIBILITIES

In Brazil, about 230 kilometers north of Sao Paulo, there is a special place: one of the main national institutions training qualified human resources in mathematics, computer science and statistics. It is called Instituto de Ciências Matemáticas e de Computação (ICMC) of the University of São Paulo.

In this pleasant atmosphere located in Sao Carlos city, 30 groups are performing research and innovation in all aspects of fundamental and applied science related to math, statistics and Information and Communications Technologies (ICT). Recognized worldwide because of publications in high-qualified specialized journals and participation in scientific events, ICMC scientists are making contributions to the development of new technologies, allowing us to answer even more challenging questions.

ICMC researchers are also working in cooperation with other universities, companies, research centers, agencies and other organizations, establishing joint projects with a lot of national and international institutions.

As part of USP, a leading institution for education and research in Brazil, ICMC offers eight undergraduate courses and five graduate programs, being responsible for educating a large part of Brazilian Masters and Ph.D's in its fields of knowledge. These programs are among the best evaluated by CAPES, the agency from the Brazilian Ministry of Education.

With over 150 faculty members, all of them holding a PhD degree, ICMC also has the support of a high-qualified technical and administrative staff and a modern infrastructure: multimedia classrooms, auditoriums, a high-performance computer park and one of the largest academic libraries in Brazil in maths and computing.

ICMC's community is prepared to help you find the best partnership opportunities. This catalog shows an overview of 30 research groups established in this special place. ICMC invites you to be part of this community, helping us to promote initiatives with positive impact in the world.

UNDERGRADUATE COURSES

- » Computer Science (BSc)
- » Computer Engineering
- » Information Systems (BSc)
- » Mathematics (BSc and Licenciante)
- » Applied Mathematics and Scientific Computing (BSc)
- » Statistics (BSc)
- » Exact Sciences (Licenciante)

GRADUATE PROGRAMS

- » Computer Science and Computational Mathematics (MSc and PhD degrees)
- » Mathematics (MSc and PhD degrees)
- » Statistics (MSc and PhD degrees)
- » Mathematics (Professional Master's degree)
- » Applied Mathematics, Statistics and Computing Applied to Industry (Professional Master's degree)

SOME THEMATIC RESEARCH NETWORKS COORDINATED BY ICMC

- » Center for Mathematics and Statistics Applied to Industry (CeMEAI)
- » Critical Embedded Systems (INCT-SEC)
- » Free Software (NAPSoL)
- » Machine Learning and Data Analysis (NAP-AMDA)



Index

Algebra	6
Applied and Geometrical Analysis.....	8
Applied Functional Analysis.....	10
Artificial Intelligence (Bio-inspired Computation)	12
Artificial Intelligence (Computational Linguistics)	14
Artificial Intelligence (Machine Learning and Data Mining)	16
Complex Systems, Particles and Control	18
Computational Fluid Mechanics.....	20
Data Bases and Images.....	22
Data Pattern Analysis.....	24
Data Science and Statistics	26
Differential Geometry.....	28
Distributed Systems and Concurrent Programming	30
Dynamical Systems and Ergodic Theory	32
Embedded and Evolutionary Systems	34
Functional Differential Equations	36
Linear Partial Differential Equations	38
Mathematics Education.....	40
Mobile Robotics.....	42
Nonlinear Dynamical Systems	44
Optimization.....	46
Risk Assessment	48
Singularities	50
Smart Networks.....	52
Software Engineering	54
Statistics	56
Topology	58
Visual and Geometry Processing.....	60
Visualization, Imaging and Computer Graphics.....	62
Web and Multimedia Interactive Systems.....	64

ALGEBRA

Mathematics Laboratory

Research lines

- » The Weyl algebra and its ideals
- » Brauer group
- » Algebraic curves over finite fields
- » Calogero-Moser spaces
- » Multiplicities (Equisingularities)

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Algebra is one of the largest areas of mathematics, so when you say “I want to study algebra” is almost the same as saying “I want to study mathematics”.


$$ax = b$$

APPLIED AND GEOMETRICAL ANALYSIS

Mathematics Laboratory

Research lines

- » Non-linear differential equations and dynamical systems
- » Mathematical physics
- » Singularity theory

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The group has worked on diverse subjects in the field of applied and geometrical analysis, and it has produced results involving Differential equations, Mathematical physics, Singularity theory, Non-linear differential equations and Dynamical systems.

APPLIED FUNCTIONAL ANALYSIS

Mathematics Laboratory - aproximacao.icmc.usp.br

Research lines

- » Approximation theory
- » Analysis on the sphere
- » The theory of positive definite and related kernels
- » Integral operators
- » Mercer's theory

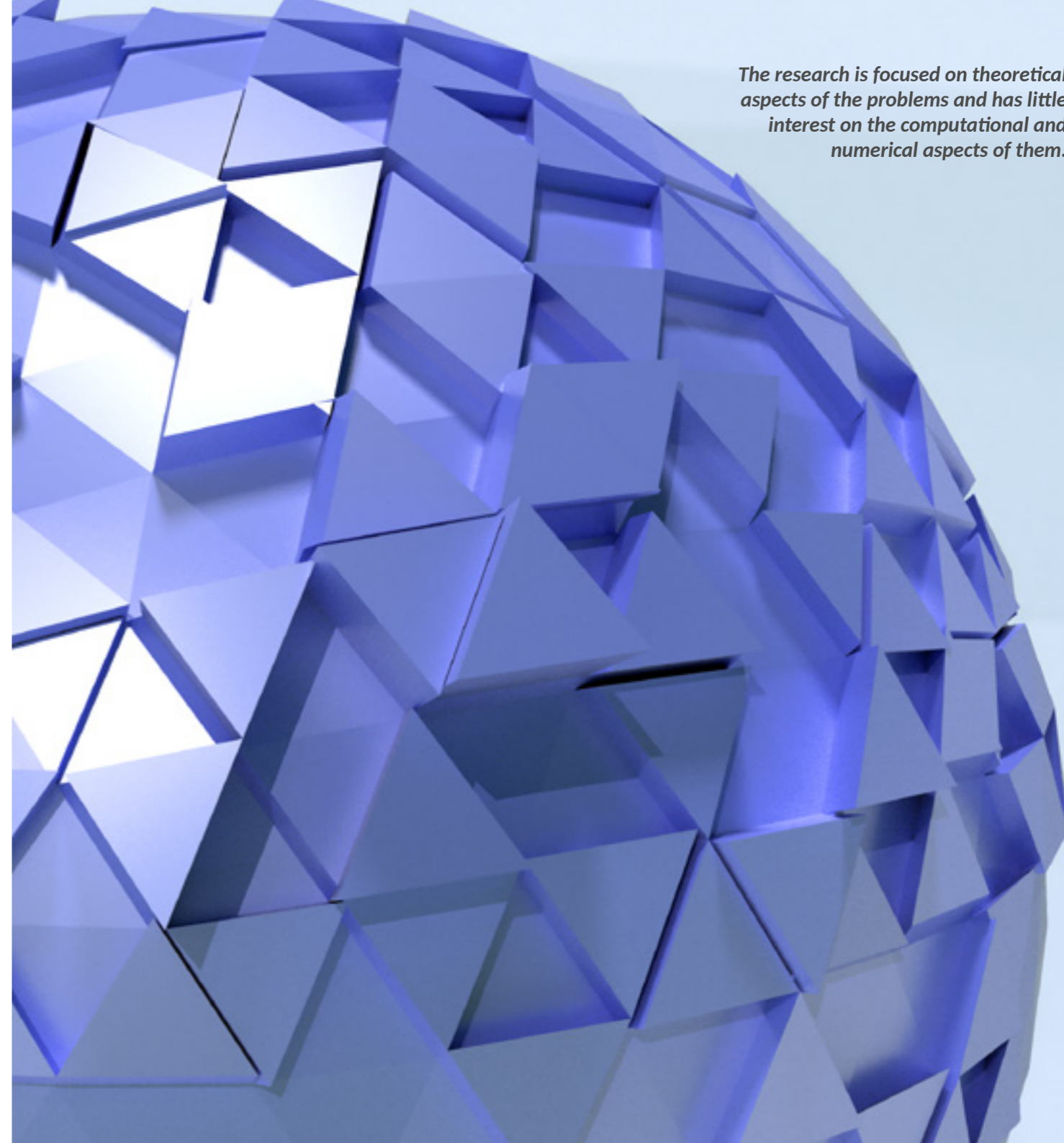
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The research is focused on theoretical aspects of the problems and has little interest on the computational and numerical aspects of them.



ARTIFICIAL INTELLIGENCE BIO-INSPIRED COMPUTATION

Bio-inspired Computation Laboratory - www.biocom.icmc.usp.br

Robots' Learning Laboratory - lar.icmc.usp.br

Massive Data Volume Analysis Laboratory - www.analytics.icmc.usp.br

Research lines

- » Artificial neural networks
- » Data clustering
- » Machine learning
- » Bioinformatics and biomedical informatics
- » Biological databases
- » Evolutionary computation
- » Data streams
- » Meta-learning
- » Data mining
- » Data warehousing
- » Complex networks
- » Social Robotics
- » Cooperative robotics
- » Human-robot interaction
- » Applied dynamical systems
- » Hybrid intelligent systems
- » Computational neurodynamics
- » Times series modeling and prediction

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Bio-inspired Computation consists of development of computational techniques inspired by biology, that can be applied to solve practical problems.



ARTIFICIAL INTELLIGENCE MACHINE LEARNING AND DATA MINING

Computational Intelligence Laboratory - labic.icmc.usp.br

Bio-inspired Computation Laboratory - www.biocom.icmc.usp.br

Massive Data Volume Analysis Laboratory - www.analytics.icmc.usp.br

Research lines

- » Data Clustering
- » Machine Learning
- » Distributed computing
- » Knowledge discovery and data mining
- » Knowledge acquisition
- » Intelligent hybrid systems
- » Time series processing

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New techniques are applied to solve real problems that usually require some form of automatic acquisition of knowledge from the application domain and cannot be solved by conventional computational techniques.

COMPLEX SYSTEMS, PARTICLES AND CONTROL

Complex Systems, Particles and Control Laboratory - scpc.icmc.usp.br

Research lines

- » Complex networks
- » Structure and dynamics of social networks
- » Internet modeling
- » Automatic identification of authorship
- » Image segmentation by networks
- » Synchronization of coupled oscillators
- » Dynamical process on spatial networks
- » Models of epidemic and rumor spreading
- » Probability and interacting particle systems
- » Mathematical physics
- » Classical statistical mechanics and quantum field theory
- » Stochastic differential equations
- » Particle systems modeling
- » Control and filtering
- » Control for minimizing fuel in vehicles
- » Control for hydrothermal operation
- » Structure of dynamical systems
- » Analysis and control of switched systems
- » Stability of control for nonlinear systems

Faculty

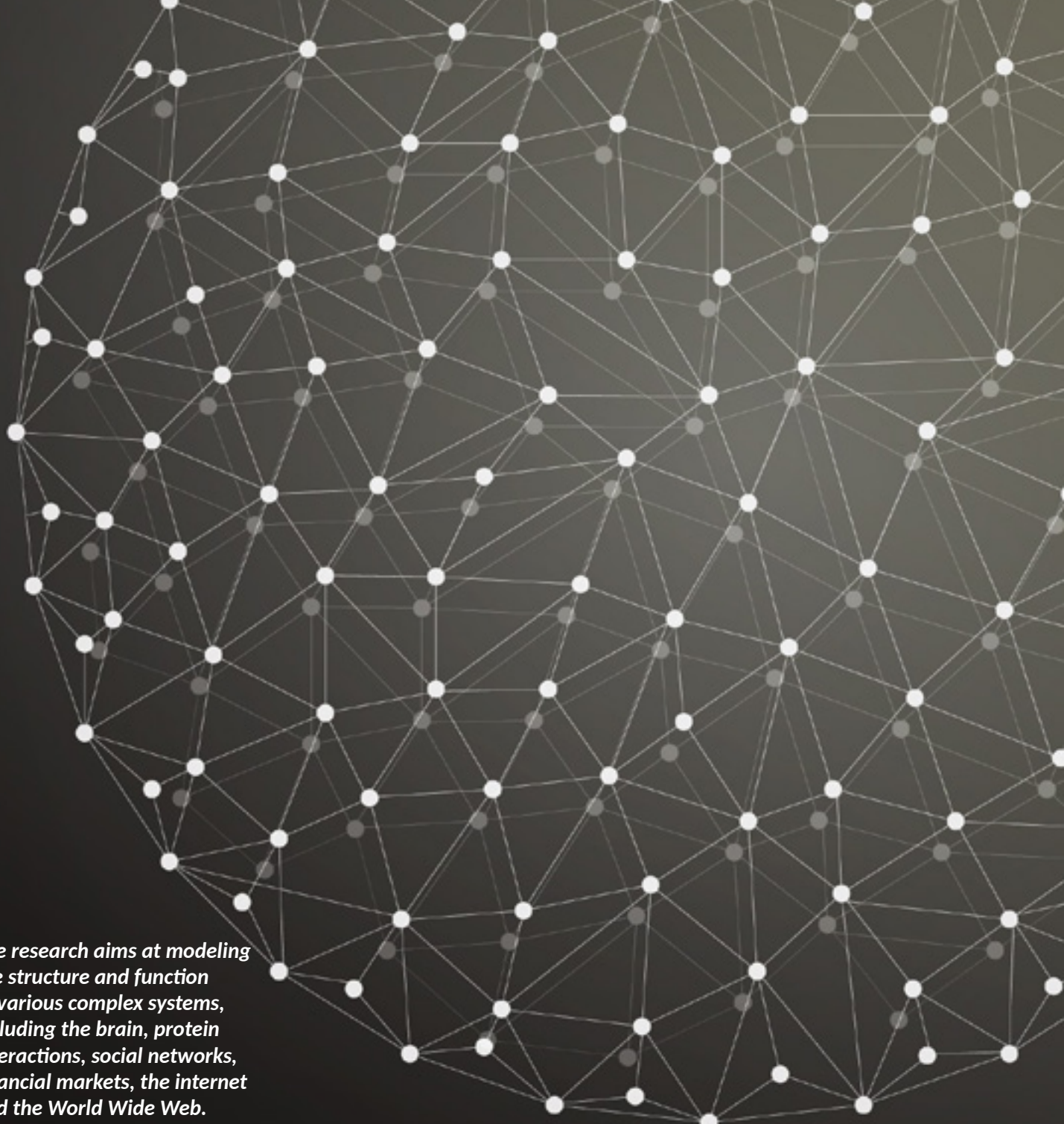
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The research aims at modeling the structure and function of various complex systems, including the brain, protein interactions, social networks, financial markets, the internet and the World Wide Web.

COMPUTATIONAL FLUID MECHANICS

High Performance Computing Laboratory - www.lcad.icmc.usp.br

Visualization, Imaging and Computer Graphics Laboratory - vicg.icmc.usp.br

Applied Mathematics and Scientific Computing Laboratory

Research lines

- » Numerical simulation of moving surfaces flows
- » Computational rheology
- » Modeling and numerical simulation in lubrication
- » Scientific computation applied in biology and medicine
- » Mesh generation and scientific visualization
- » Laminar-turbulent transition flows
- » Computational aeroacoustics

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The research focuses on developing methods for numerical simulation of moving free surface flows, using mainly finite differences and finite elements techniques.



DATA BASES AND IMAGES

Data Bases and Images Laboratory - www.gbdi.icmc.usp.br

Research lines

- » Image and data base management systems
- » Content-based image storage and retrieval
- » Indexing and query optimization for similarity retrieval
- » Picture archiving and communication systems
- » Health and medical information systems
- » Mining complex data
- » Visual data mining and visual analytics
- » Complex data integration
- » Data provenance
- » Data warehousing
- » Big data

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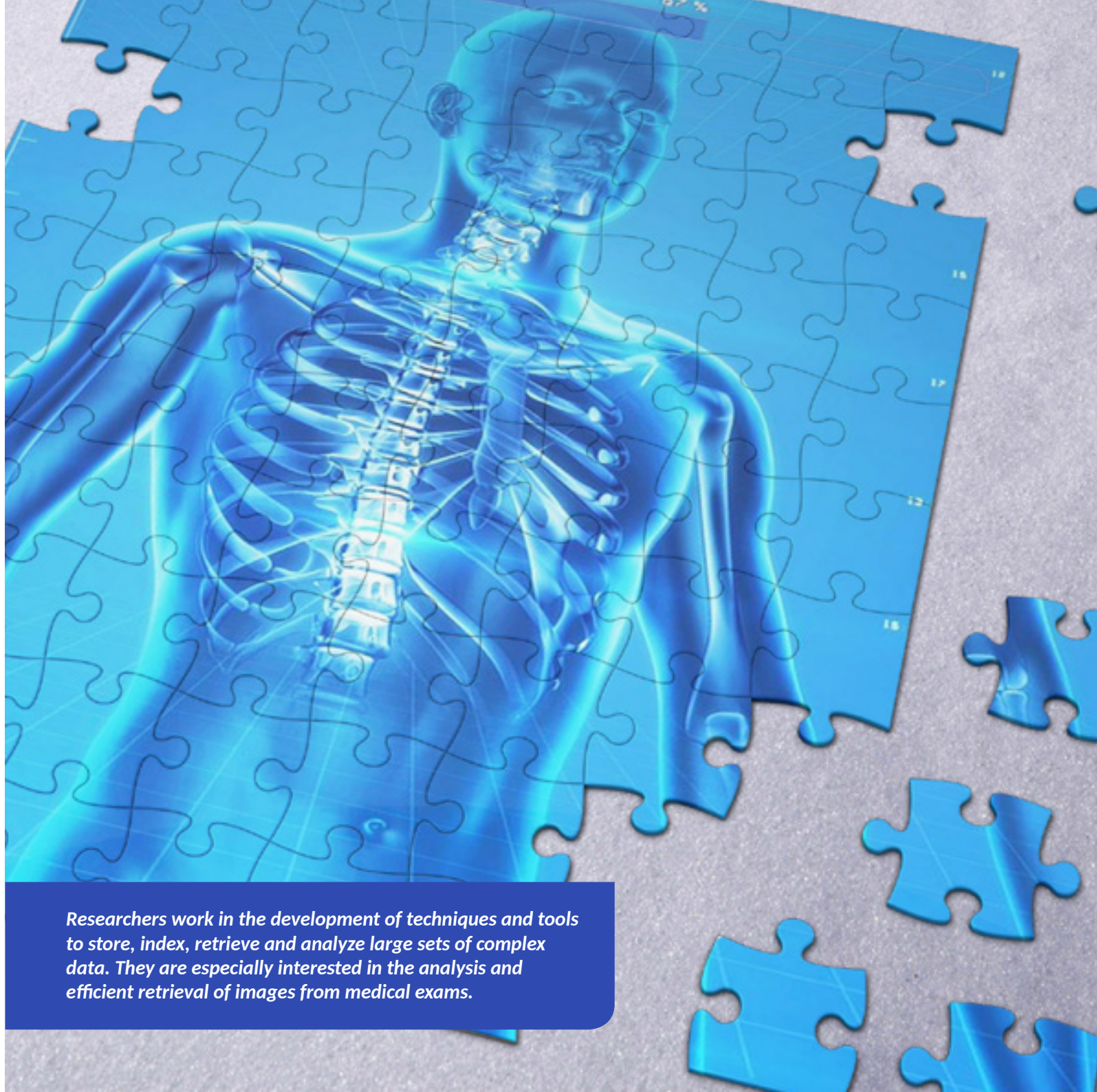
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Researchers work in the development of techniques and tools to store, index, retrieve and analyze large sets of complex data. They are especially interested in the analysis and efficient retrieval of images from medical exams.

DATA PATTERN ANALYSIS

Data Pattern Analysis Laboratory - lapad-web.icmc.usp.br

Research lines

- » Anomaly / outlier detection
- » Active, inductive and transductive learning
- » Bioinformatics
- » Complex networks
- » Data cluster analysis (clustering)
- » Data mining: unsupervised, semi-supervised and supervised
- » Data mining: structured, unstructured and mixed data
- » Data streams mining
- » Data preparation: imputation, feature selection, dimensionality reduction, etc.
- » Ensembles: classifiers, clusterings and outlier detectors
- » Graph and text mining
- » Machine learning: unsupervised, semi-supervised and supervised
- » Nonlinear regression
- » One class learning
- » Parallel and distributed data mining
- » Pattern classification
- » Recommender systems
- » Social network analysis
- » Statistical learning: Bayesian methods
- » Transfer learning

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Understanding patterns in complex high-dimensional data, often totally unlabeled or only partially labeled, has been a key ingredient for knowledge discovery in different domains.

DATA SCIENCE AND STATISTICS

Statistics Laboratory

Massive Data Volume Analysis Laboratory - www.analytics.icmc.usp.br

Visualization, Imaging and Computer Graphics Laboratory - www.vicg.icmc.usp.br

Risk Assessment Laboratory - www.cer.ufscar.br

Research lines

- » Data visualization
- » Machine learning
- » Data mining
- » Risk modelling for big data bases

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The group aims to investigate issues related to the training of human resources in Data Science and Statistics, create teaching material, establish national and international partnerships and develop joint research.

DIFFERENTIAL GEOMETRY

Topology Laboratory

Research lines

- » Geometry of minimal surfaces and constant mean curvature in homogeneous three-dimensional spaces
- » Quantization and symplectomorphism into symmetric spaces
- » Symplectic geometry
- » Mathematical physics
- » Quantum algebra
- » Submanifolds theory
- » Geometric analysis
- » Lie groups
- » Complex geometry

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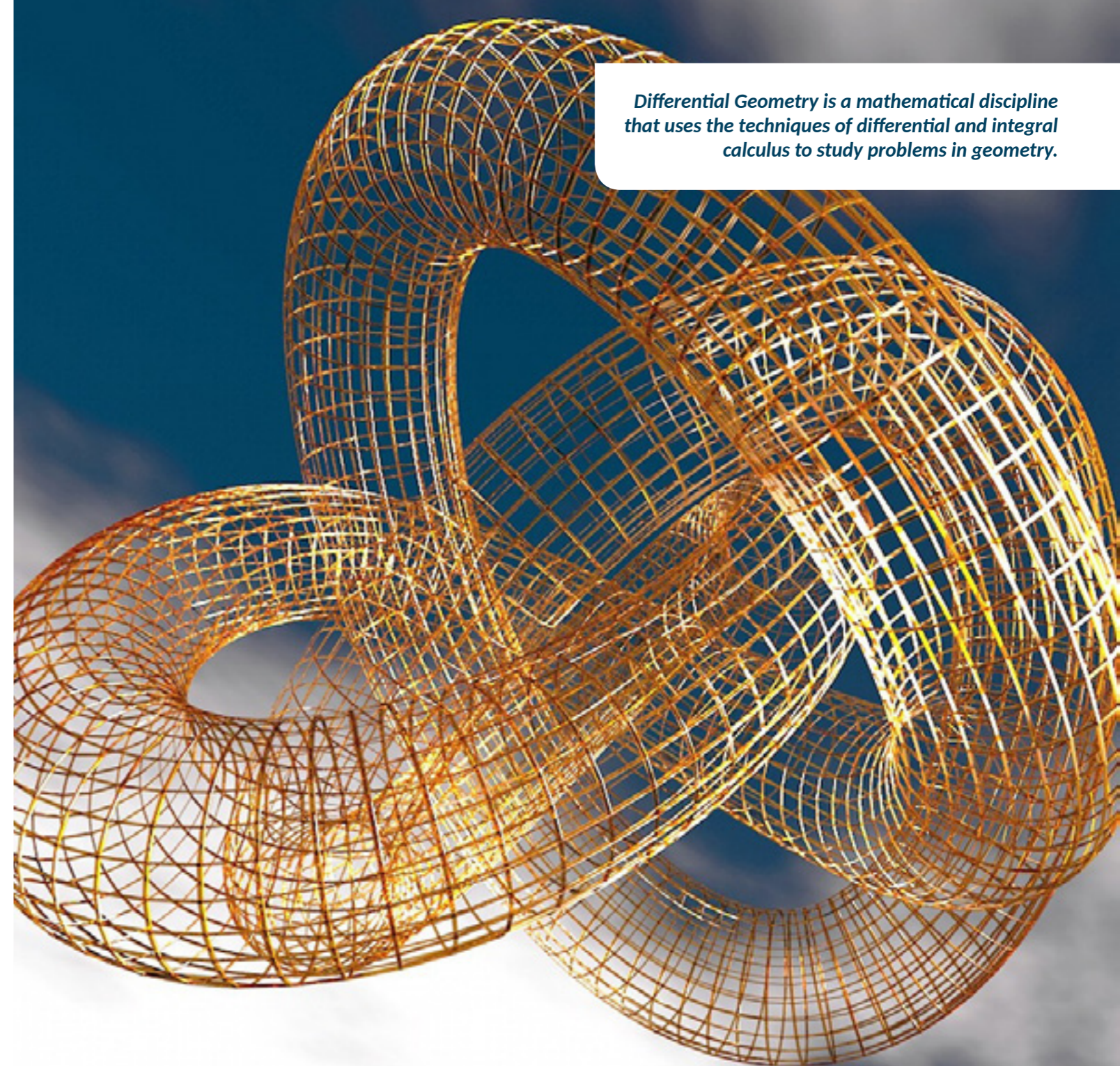
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Differential Geometry is a mathematical discipline that uses the techniques of differential and integral calculus to study problems in geometry.



DISTRIBUTED SYSTEMS AND CONCURRENT PROGRAMMING

Distributed Systems and Concurrent Programming Laboratory - www.lasdpic.icmc.usp.br

Research lines

- » Adaptive systems and real-time
- » Distributed computing: service-oriented architectures, validation and verification of parallel and distributed applications; high performance computing; grid computing; cloud computing; fog computing; green computing.
- » Operating systems
- » Internet of Things: architectures and middlewares
- » Performance evaluation: simulation and distributed simulation; prototyping; benchmark
- » Tools and methodologies for teaching computing

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The group researches problems and technological solutions for building computational systems formed by the interaction of various subsystems across a network.



DYNAMICAL SYSTEMS AND ERGODIC THEORY

Dynamical Systems Laboratory - sisdin.icmc.usp.br

Research lines

- » Renormalization theory
- » One-dimensional dynamics
- » Ergodic theory
- » Dynamics on manifolds
- » Group actions
- » Partially hyperbolic dynamics
- » Regularity of invariant foliations and rigidity

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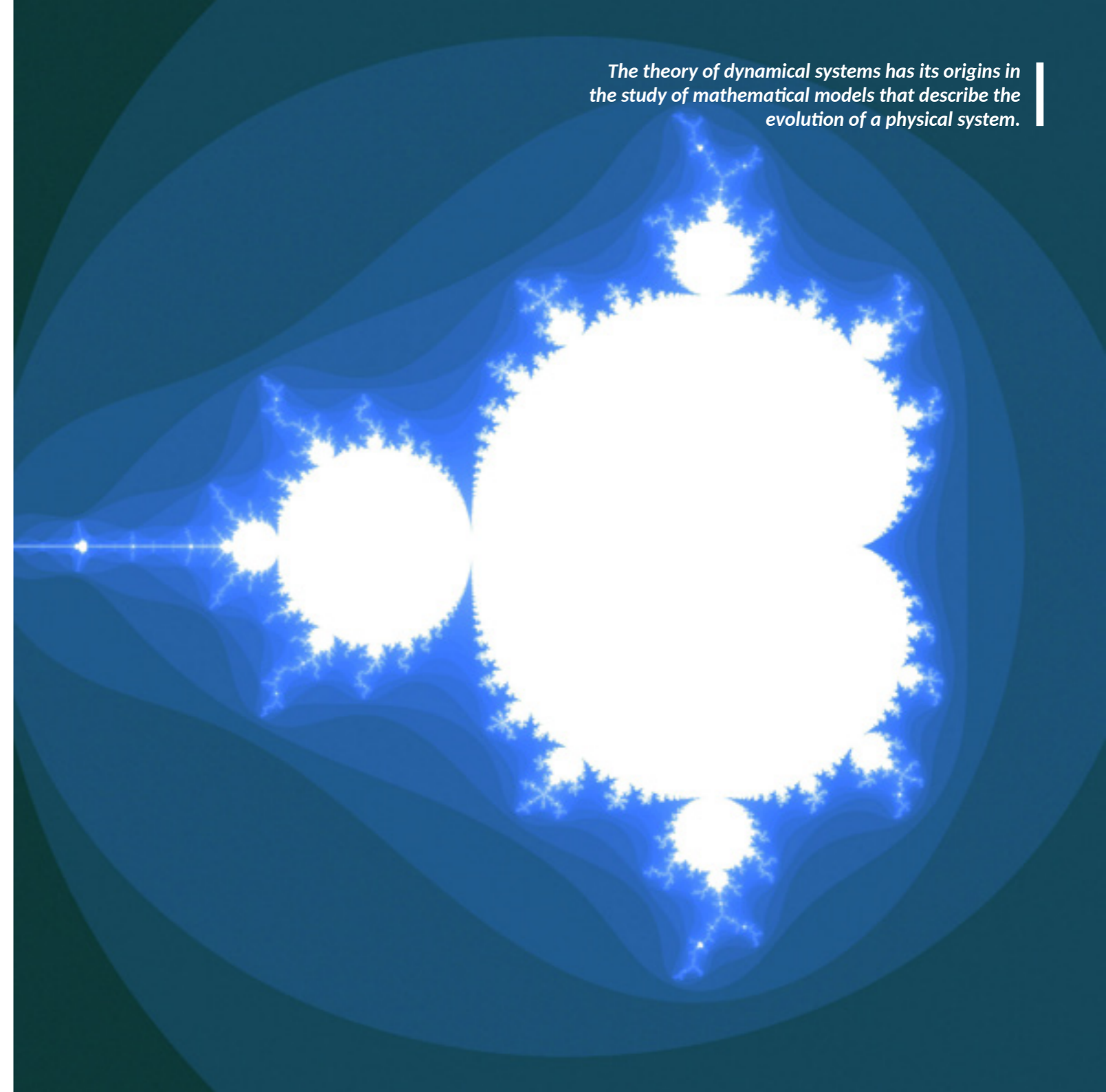
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The theory of dynamical systems has its origins in the study of mathematical models that describe the evolution of a physical system.



EMBEDDED AND EVOLUTIONARY SYSTEMS

Reconfigurable Computing Laboratory - lcr.icmc.usp.br

Research lines

- » Automatic hardware generation tool
- » Embedded multiprocessors
- » Power estimation
- » Embedded operating system
- » Image processing
- » Navigation and mapping algorithms for mobile robots
- » Reconfiguration of electrical networks
- » Frequency and phase estimations
- » "Ab initio" molecular modelling
- » Data mining of repositories of codes and spectra

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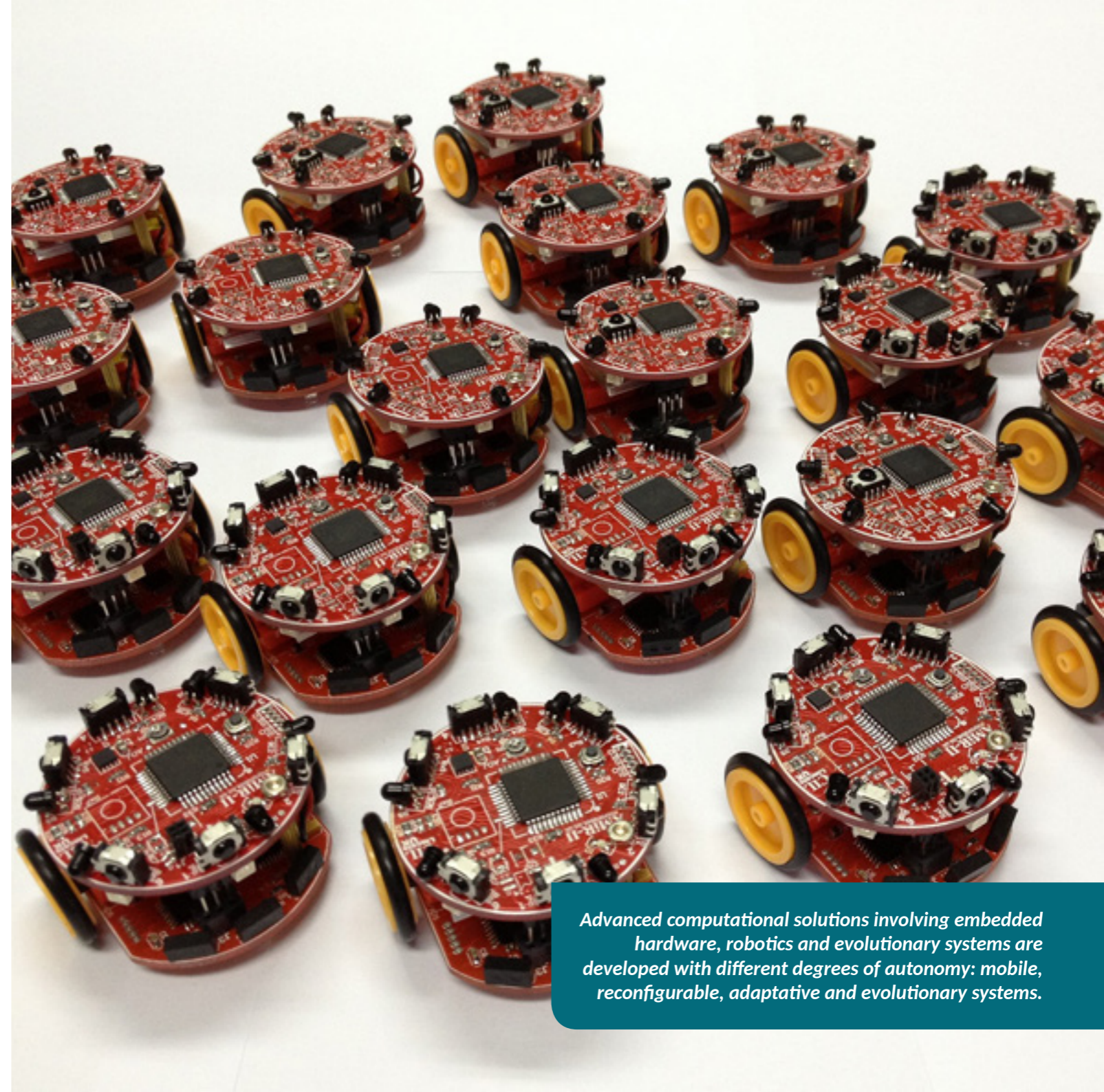
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Advanced computational solutions involving embedded hardware, robotics and evolutionary systems are developed with different degrees of autonomy: mobile, reconfigurable, adaptative and evolutionary systems.

FUNCTIONAL DIFFERENTIAL EQUATIONS

Functional Differential Equations Laboratory

Models described by Functional Differential Equations with temporal delays consider periods of latency or gestation and are more realistic, like some natural phenomena involving a lapse of time between cause and effect.

Research lines

- » Retarded functional differential equations
- » Neutral functional differential equations
- » Measure functional differential equations
- » Differential equations subject to impulse conditions

Faculty

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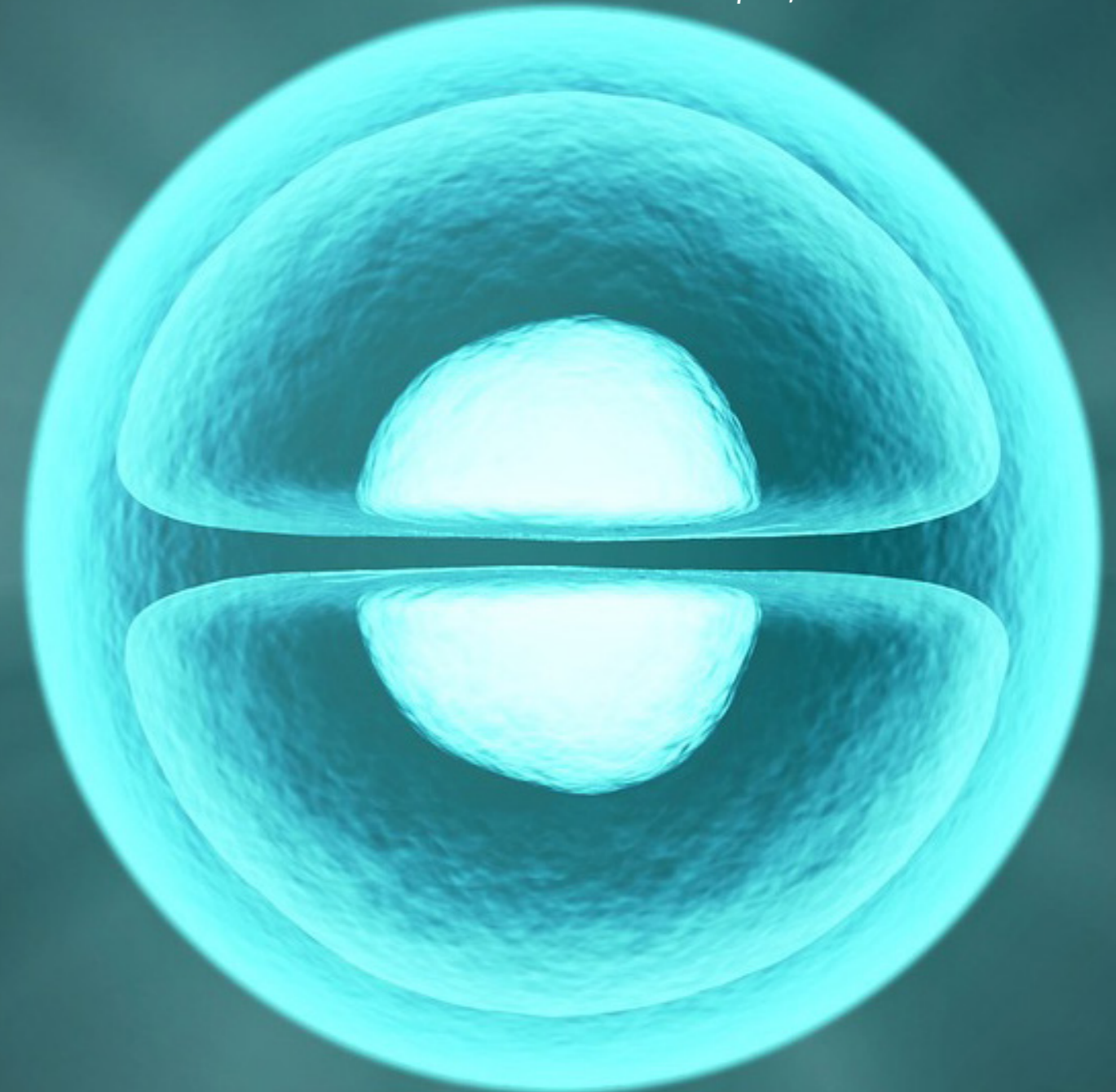
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LINEAR PARTIAL DIFFERENTIAL EQUATIONS

Mathematics Laboratory

Research lines

- » Global solvability
- » Semi-global solvability
- » Local solvability
- » Global hypoellipticity

Faculty

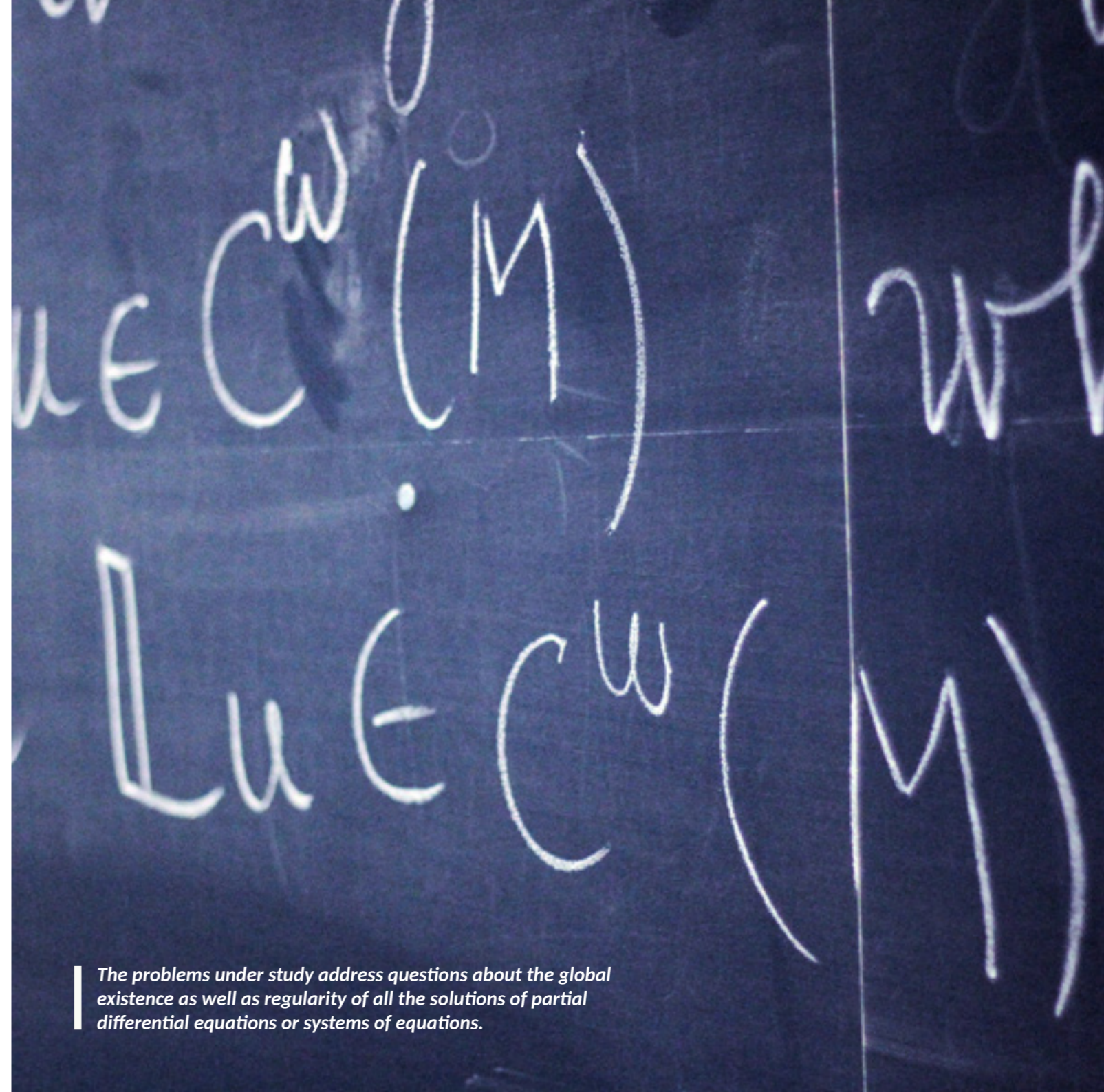
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The problems under study address questions about the global existence as well as regularity of all the solutions of partial differential equations or systems of equations.

MATHEMATICS EDUCATION

Mathematics Teaching Lab

Research lines

- » Cognitive and linguistic aspects in mathematics education
- » Conceptions of mathematical knowledge and their its relations to the teaching-learning processes
- » Ethnomathematics
- » Philosophy of mathematics education
- » Mathematics teachers' education
- » History of mathematics
- » Teaching methodologies for mathematics
- » Information technology applied to math education

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The main aim of the group is to investigate questions concerned to mathematics teaching-learning processes and teacher education.

MOBILE ROBOTICS

Mobile Robotics Laboratory - www.lrm.icmc.usp.br

Research lines

- » Mobile robotics
- » Intelligent vehicles
- » Machine learning
- » Computer vision
- » Embedded systems

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One of the main projects is CARINA, an intelligent vehicle able to navigate in urban environments without the need of a human driver.



NONLINEAR DYNAMICAL SYSTEMS

Nonlinear Dynamical Systems Laboratory - sdnl.icmc.usp.br

Research lines

- » Evolution equations, bifurcation, symmetry and synchronization
- » Linear and nonlinear partial differential equations
- » Semilinear parabolic problems
- » Asymptotic behavior
- » Existence, uniqueness, continuity and continuation of solutions: critical case
- » System of elliptic equations with jumping nonlinearities
- » Quasilinear problems
- » Smooth linearization
- » Conley index theory

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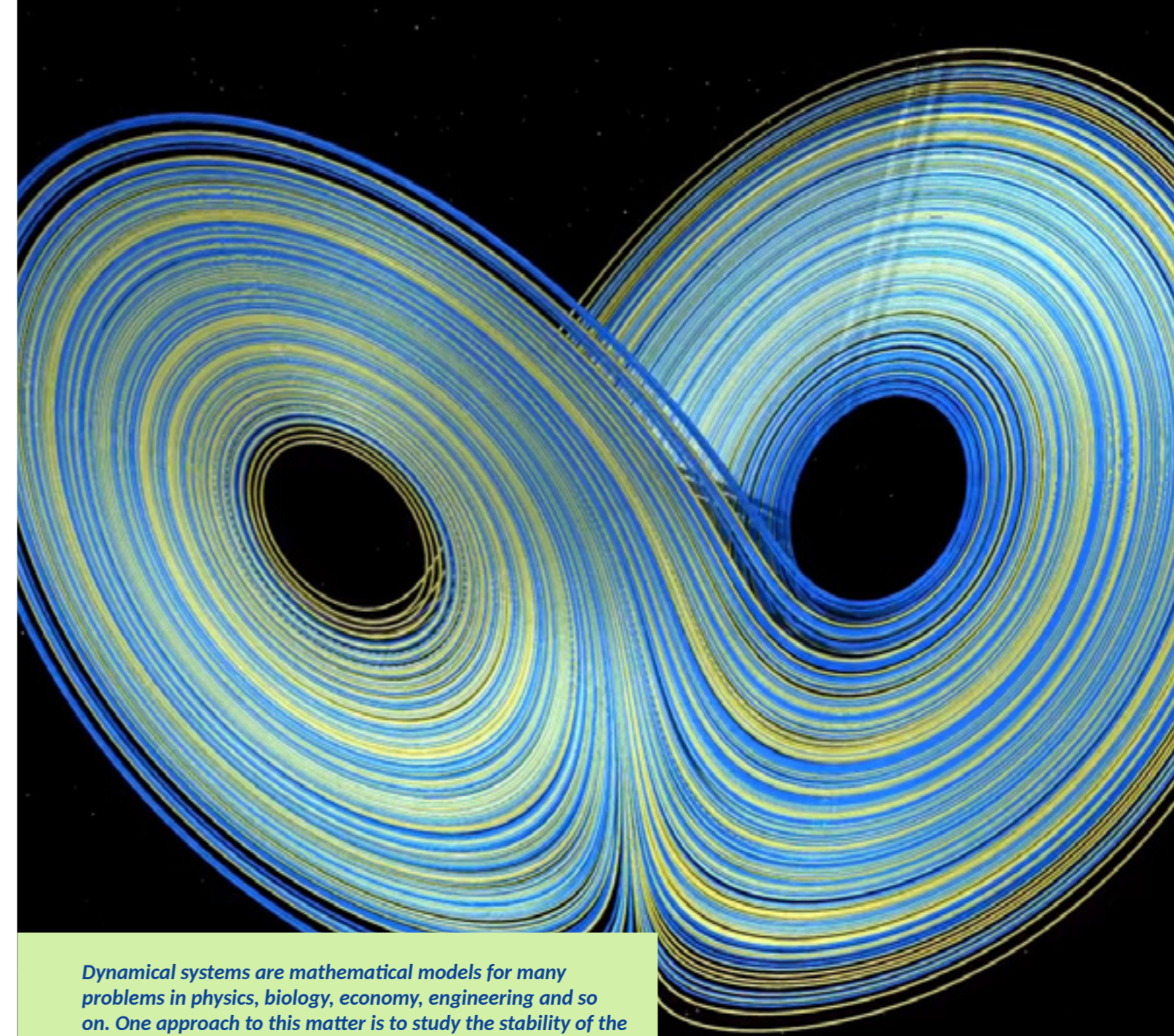
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Dynamical systems are mathematical models for many problems in physics, biology, economy, engineering and so on. One approach to this matter is to study the stability of the asymptotic dynamics (attractors) under perturbations.

OPTIMIZATION

Optimization Laboratory - www.otm.icmc.usp.br

Research lines

- » Integer linear programming models and methods
- » Nonlinear programming algorithms and theory
- » Control and filtering problems
- » Optimization in inverse problems

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Optimization research at ICMC addresses practical problems including production planning, vehicle fuel consumption optimization, cutting stock problems, agriculture production using ecological and sustainable criteria, and tomographic image reconstruction.

RISK ASSESSMENT

Risk Assessment Laboratory - www.cer.ufscar.br

Research lines

- » Management and statistical quality control
- » Statistical data mining
- » Statistical modeling for credit scoring, behavior and attrition data
- » Statistical modeling for dependence
- » Statistical modeling for fraud data
- » Statistical modeling for finance and insurance data
- » Statistical modeling for sport data
- » Statistical modeling for medical and biological data
- » Statistical modeling for survival and reliability data

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The risk assessment can be understood as a set of statistical and computational procedures for data analysis in order to study and determine the risk exposure to a certain event of interest, which can have undesirable consequences, the possibility of danger and or loss of control.

SINGULARITIES

Singularities Laboratory – sing.icmc.usp.br

Research lines

- » Topology and classification of singularities
- » Multiplicity, integral closure and equisingularity
- » Singularities in differential geometry and implicit equations
- » Applications of singularity theory to bifurcation problems
- » Singularities in dynamical systems

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Singularity theory has a wide range of applications to various areas of science and interacts with several lines of mathematics. It also contributes to the development of knot theory, optics, robotics and computer vision.

SOFTWARE ENGINEERING

Software Engineering Laboratory - www.labes.icmc.usp.br

Applied Computing in Education and Advanced Social Technology Laboratory - caed-lab.com

Research lines

- » Architectures for developing of educational software
- » Business process generation
- » Collaborative systems
- » Component-based development
- » Critical embedded systems
- » Geographical information systems
- » Model-based testing
- » Design and evaluation of educational software interfaces
- » Development, evaluation and analysis of educational games
- » Distance learning
- » Educational data mining
- » Educational ontologies and applications
- » Experimental software engineering
- » Software engineering tools and environments
- » Frameworks and software patterns
- » Application generators
- » Intelligent tutoring systems
- » Mobile learning
- » Modeling and development of educational modules
- » Multi-agent systems in education
- » Open educational resources
- » Personalization and recommender systems
- » Product lines for developing educational software
- » Semantic web and social semantic web in education
- » Social networking in education
- » Software architecture and reference architecture

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Research focuses on processes, methods and tools for software design and development, including the use of computational techniques in the development of educational resources.



STATISTICS

Statistics Laboratory

Research lines

- » Survival analysis and reliability
- » Quality management
- » Bayesian methods
- » Linear and nonlinear models
- » Probability and stochastic processes
- » Errors-in-variables models
- » Time series
- » Risk modeling
- » Item response theory
- » System of interacting particles

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The research is developed in a wide range of areas in probability and statistics, focusing on theoretical development with applications in practice.



TOPOLOGY

Topology Laboratory

Research lines

- » Classification of group actions on manifolds and associated dynamical systems
- » Applications of game theory to general topology
- » Bordism, equivariant bordism and cobordism of manifolds
- » Cellular decomposition and group resolutions
- » Fibrations, vector bundles and gauge theory
- » Foliations
- » Geometry and topology of submanifolds in euclidean spaces and of surfaces in homogeneous manifolds
- » Homotopy and topology of mapping spaces
- » Immersions and embeddings between manifolds
- » Algebraic invariants for homotopy and concordance of links
- » Properties of coverings; techniques to obtain weaker topologies; theory of games
- » Borsuk-Ulam type theorems
- » Homotopy and simple homotopy theory
- » Knots, links and braid theories
- » Root, fixed point, coincidence and G-coincidence theories
- » Topology of manifolds
- » Analytic, Whitehead and Reidemeister torsions for manifolds and for singular manifolds

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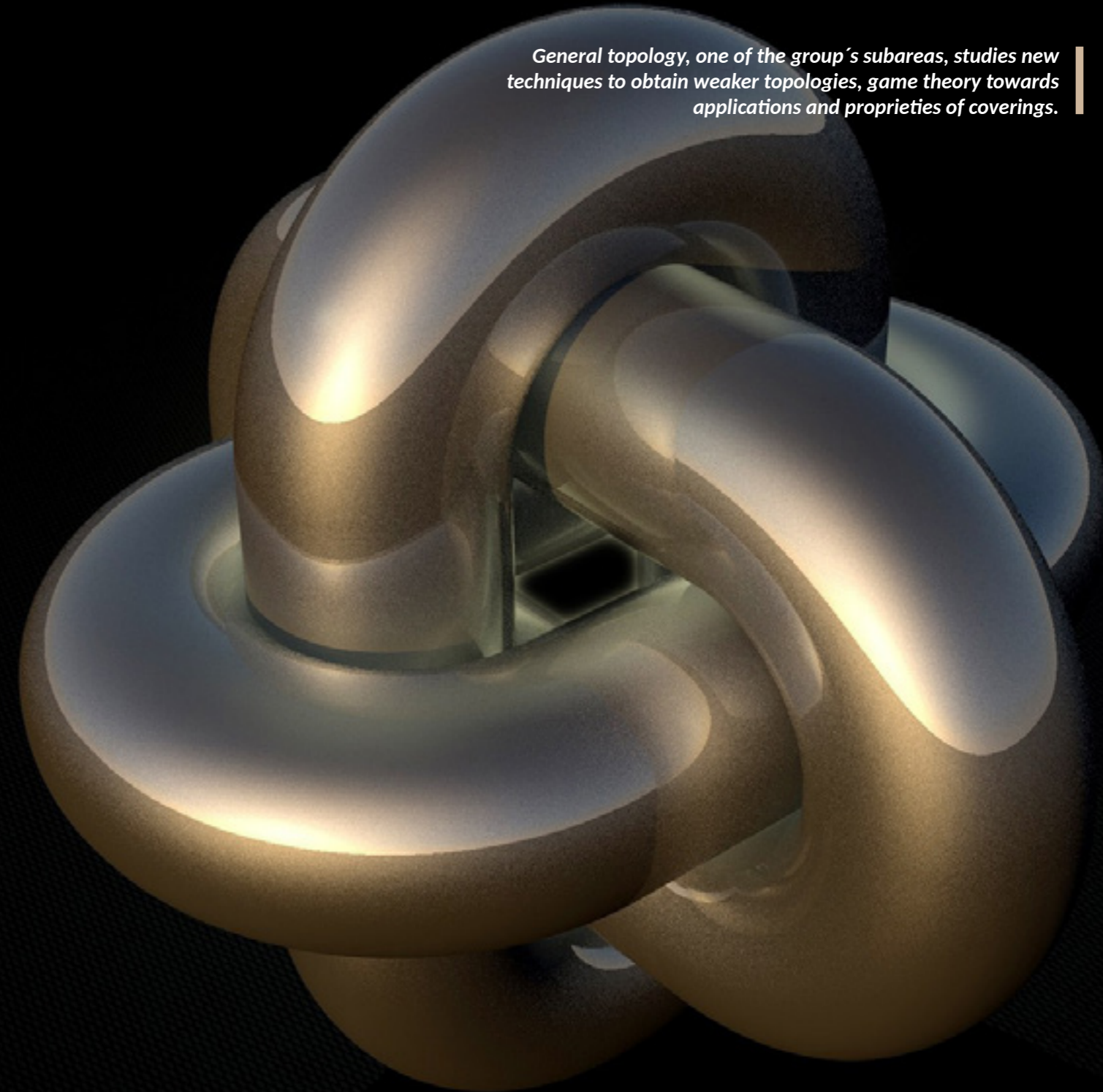
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General topology, one of the group's subareas, studies new techniques to obtain weaker topologies, game theory towards applications and proprieties of coverings.



VISUAL AND GEOMETRY PROCESSING

Visualization, Imaging and Computer Graphics Laboratory - vicg.icmc.usp.br
Applied Mathematics and Scientific Computing Laboratory

Research lines

- » Computational geometry
- » Geometric processing
- » Visualization and visual data analysis
- » Geometric modeling and mesh generation
- » Numerical and topological analysis of dynamical systems

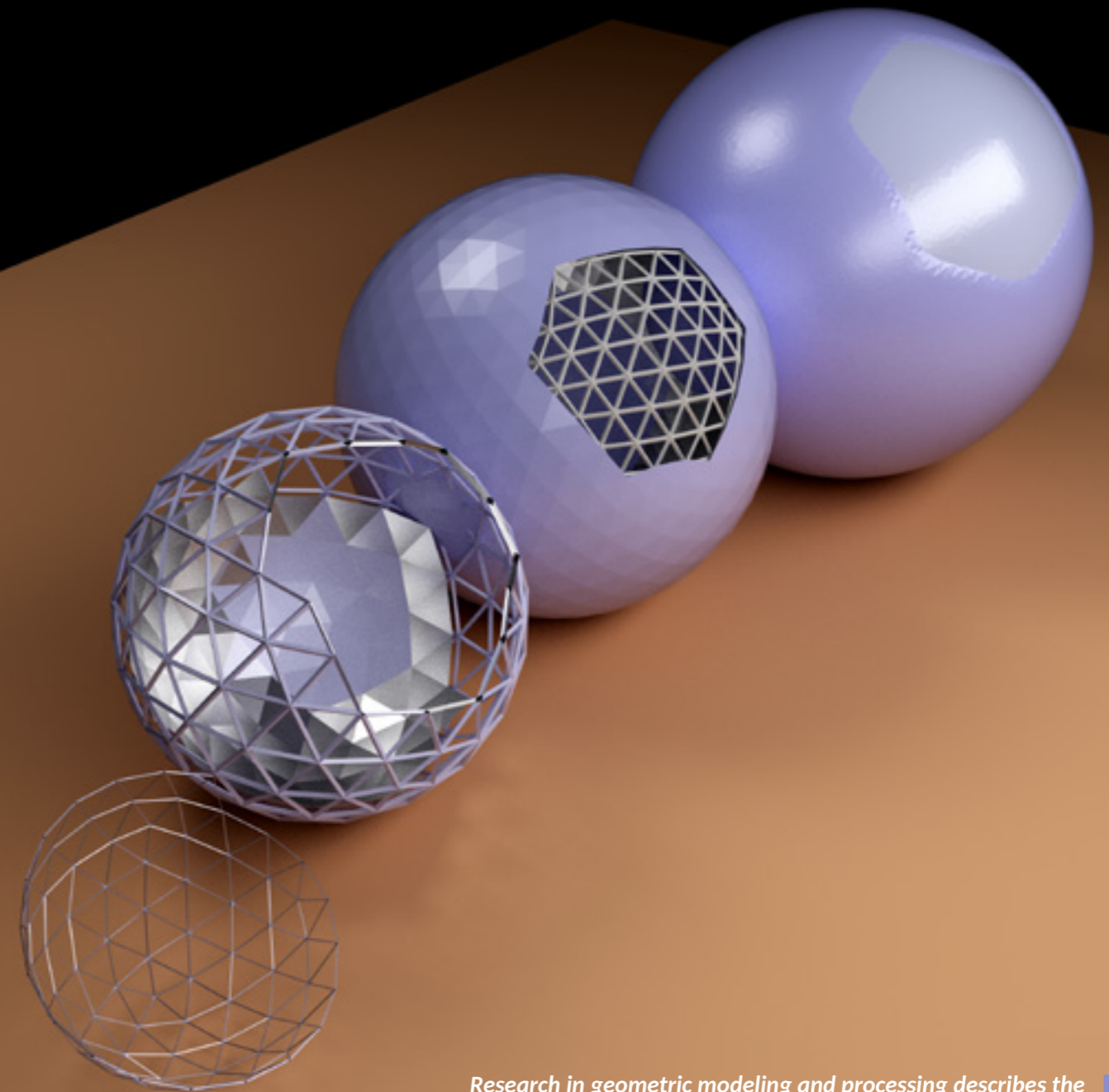
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Research in geometric modeling and processing describes the study of numerical methods and algorithms for manipulation, analysis and representation of geometric data.

VISUALIZATION, IMAGING AND COMPUTER GRAPHICS

Visualization, Imaging and Computer Graphics Laboratory - vicg.icmc.usp.br

Research lines

- » Computational geometry and geometric processing
- » Image processing and pattern recognition
- » Visualization and visual data mining
- » Validation and evaluation of visualization techniques
- » Visualization in data science and big data
- » Visualization applications in data analysis: image, document and music collections, social networks, biosensor measurements, bioinformatics, acoustic landscapes, crime data, volumes from computational simulations and multidimensional data sets

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The techniques and algorithms have potential applications in a wide range of real-world problems that require the analysis of complex high-dimensional data assisted by interactive visual representations.



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