Centro de Investigação em Matemática e Aplicações

SELFIE IIFA

10 de abril de 2015

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Centro de Investigação em Matemática e Aplicações

Objectivos principais:

- contribuir para o desenvolvimento do conhecimento matemático e consciência cultural

- criar os novos conceitos, teorias e ferramentas matemáticos

- contribuir para desenvolvimento regional

Equipa:

42 Membros Integrados
19 Alunos de Doutoramento
22 Colaboradores Doutorados

- Universidade de Évora
- Universidade de Madeira
- Instituto Superior de Engenharia de Lisboa
- Institutos Politécnicos de Setúbal, Leiria, Tomar e Beja
- Outras instituições nacionais e internacionais

Grupos de investigação (2015-2020):

- Estatistica, Processos Estocásticos e Aplicações
- Sistemas Dinâmicos
- Equações Diferenciais e Otimização
- Lógica, Álgebra, Geometria

Linhas de investigação (2015-2020):

- Modelação Matemática em Ciências da Vida e Aplicações Industriais
- Sistemas Complexos

Indicadores (2010-2014):

- Artigos em revistas internacionais com referee – 168 (+15 aceites)
- Livros e capítulos de circulação internacional – 61
- Artigos em Proceedings dos congressos internacionais – 52
- Comunicações em Congressos internacionais – 327
- Teses de Doutoramento concluídos – 29
- Teses de Mestrado concluídos – 44

40% das publicações em Q1 de Scopus
75% das publicações em Q1+Q2 de Scopus

Grupos de investigação

Statistics, Stochastic Processes and Applications

***PhD Members*:** **(17) José Silva, Anabela Afonso, Carlos Braumann, Clara Carlos, Dulce Gomes, Dulce Pereira, Gonçalo Jacinto, Joaquim Azevedo, João Alves e Sousa, Jorge Santos, Ludwig Streit, Manuela Oliveira, Manuel Carmo, Md. Abdus Salam Akanda, Patrícia Filipe , Paulo Infante, Russell Alpizar-Jara.**

***PhD Students*:** **(12) Ana Galantino, Ana Jorge, Filipe Santos, Fernando Ceia, Luísa Carvalho, Maria João Inácio, Mafalda Lira, Maria Larguinho, Nuno Brites, Palmira Caseiro, Sónia Barbosa.**

***PhD Collaborators*:** **(13) Ana Cantarinha, Ana Abreu, Custodia Drumond, Georgy Bobashev, José Borges, João Monteiro, Manuel Minhoto, Maribel Gordon, Nuno Ribeiro, Salvador Abreu, Margarida Faria.**

***Coordinators* : José Luís Silva, Manuela Oliveira**

Main Research Lines

A) Stochastic Processes and Applications

A1. Population and individual modelling in random environments
A2. Stochastic Processes, Time Series Analysis and Space-time Modelling

B) Statistical Modeling and Data Analysis

B1. Sampling elusive populations and parameter estimation
B2. Multivariate Analysis and Experimental Designs
B3. Quality Control and Survival Analysis

C) Stochastic and Mathematical Physics

C1. Stochastic analysis associated to Fractional Processes and grey Brownian motion
C2. Infinite particle systems and Polymer Physics
C3. Measurement uncertainty phenomena and Wireless sensors networks

Life Science Applications: Forestry, Wildlife, Agriculture and Fisheries, Public Health, Medicine, Genetics, Epidemiology, Social and Demographic issues, etc.

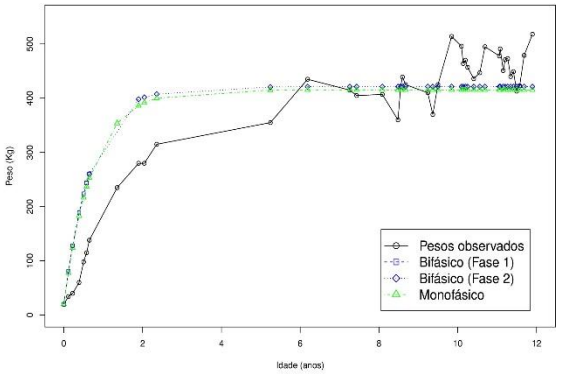
Industry and Telecommunications: Efficiency analysis, Finance, and wireless sensors networks, internet traffic, etc.

Mathematical-Physics: Fractional Processes and grey Brownian motion; Infinite particle systems and Polymer Physics and Measurement uncertainty phenomena, etc.

Main research areas

A1: Population and Individual modeling in random environments

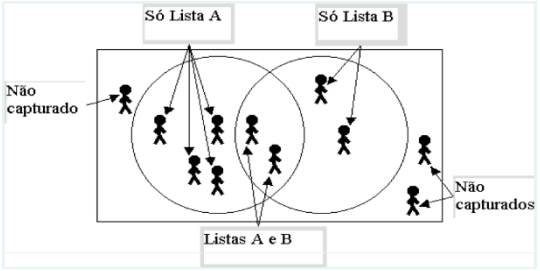
Life Science Applications: Agriculture, Fisheries, Social and Demographic issues, etc.



A2: Stochastic Processes, Time Series Analysis and Space-time Modeling

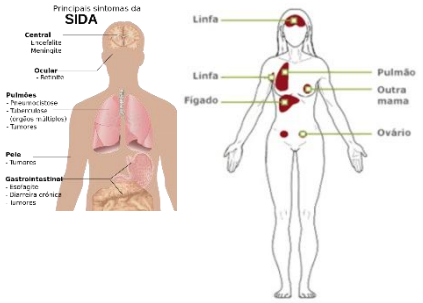
Industry and Telecommunications: Efficiency analysis, Finance, and wireless sensors networks, internet traffic, etc.

B1: Population and Individual modeling in random environments estimation



Life Science Applications: Agriculture, Fisheries, Social and Demographic issues, etc.

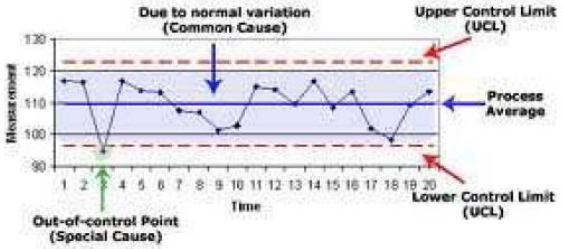
B2: Multivariate Data Analysis and Experimental Designs



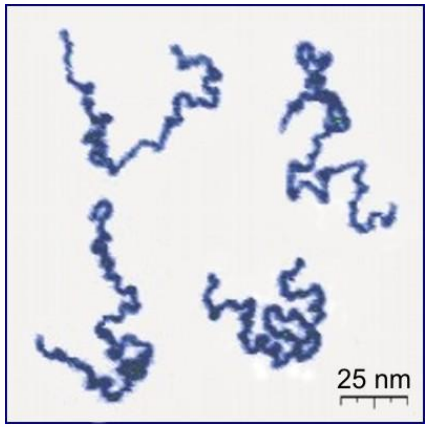
Life Science Applications : Forestry, Wildlife, Agriculture, Public Health, Medicine, Genetics, Epidemiology, Network, Cognitive maps, Education,etc,

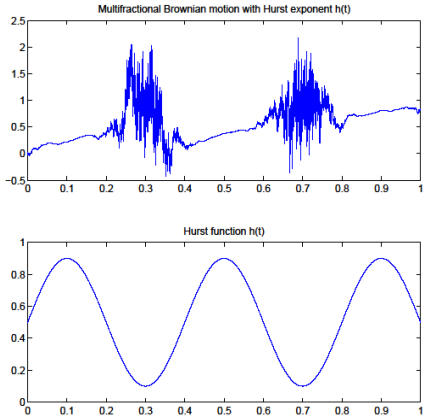
B3: Quality Control and Survival Analysis

Industry



C: Stochastic and Mathematical Physics





Fractional Processes and grey Brownian motion; Infinite particle systems and Polymer Physics and Measurement uncertainty phenomena, etc.

Internationalization

International research projects

- Marie Curie,
- SFB701 Germany,
- ERASMUS MUNDUS-EMMA-WEST,
- SOCRATES/ERASMUS,
- FP6,
- Methodology Center, Penn State University

Collaboration with research centers

- ICAM-UÉ,
- CMAF-UL,
- CMA-UN,
- CEF-ISA,
- CEFAG-UÉ,
- CGE-UÉ
- CEGF-UA

Sistemas Dinâmicos

Sistemas dinâmicos não lineares,
Teoria do Caos,
Complexidade

Coordenador - Carlos Ramos

1. Sistemas simples de comportamento complexo.

2. Sistemas complexos ideais *(a realidade como inspiração)*

3. Sistemas computacionais, processamento da informação e robótica

4. Sistemas reais complexos *(a teoria e a sua aplicação)*

5. Sistemas complexos e arte

6. Divulgação e ensino

Metodologia *Tipos de tarefas*

Investigação artística e especulação científica:

A prática artística, independente de fins e objectivos imediatos permite a liberdade necessária à definição de novos caminhos de investigação científica.

Metodologia *Tipos de tarefas*

Investigação teórica e formal:

(a) Técnicas e conceitos matemáticos.

(b) Fundamentação filosófica, discurso, linguagem, comunicação.
Interpretar e procurar as experiências e observações necessárias.

Metodologia *Tipos de tarefas*

Investigação aplicada:

Os resultados aqui obtidos permitem a passagem da investigação teórica e formal para a investigação tecnológica e a experimentação.

Metodologia *Tipos de tarefas*

Experimentação:

Fixadas hipóteses é necessário testá-las e para tal desenvolver equipamento adequado.

Metodologia *Tipos de tarefas*

Engenharia:

(a) Implementação e optimização dos processos. Passagem à tecnologia e ao *design*.

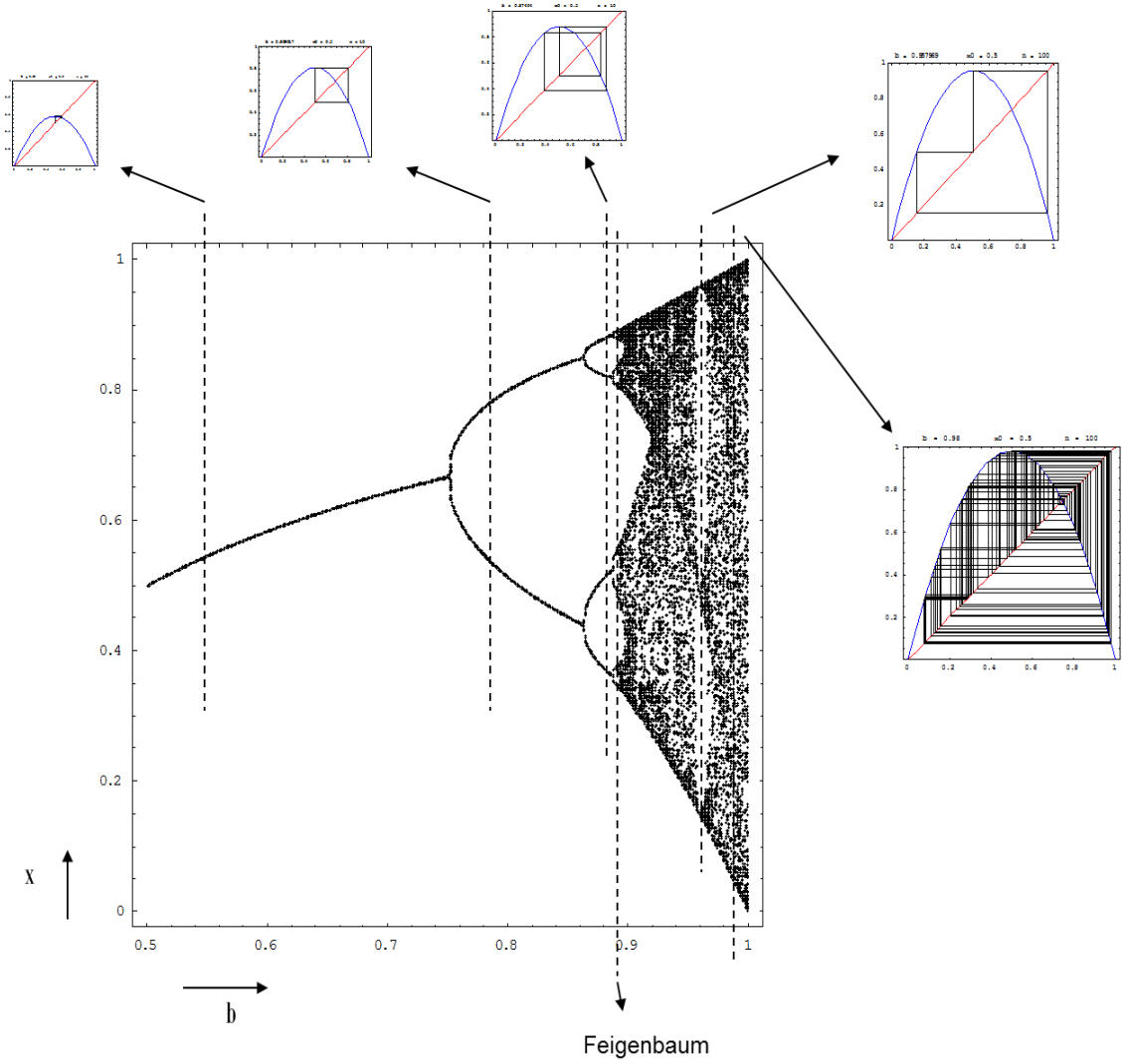
(b) Uso e amadurecimento. A passagem ao discurso comum. O ensino.

Metodologia *Tipos de tarefas*

Actividade crítica:

Desconstruir, perspectivar o trabalho desenvolvido e…

...recomeçar...


1
0.8
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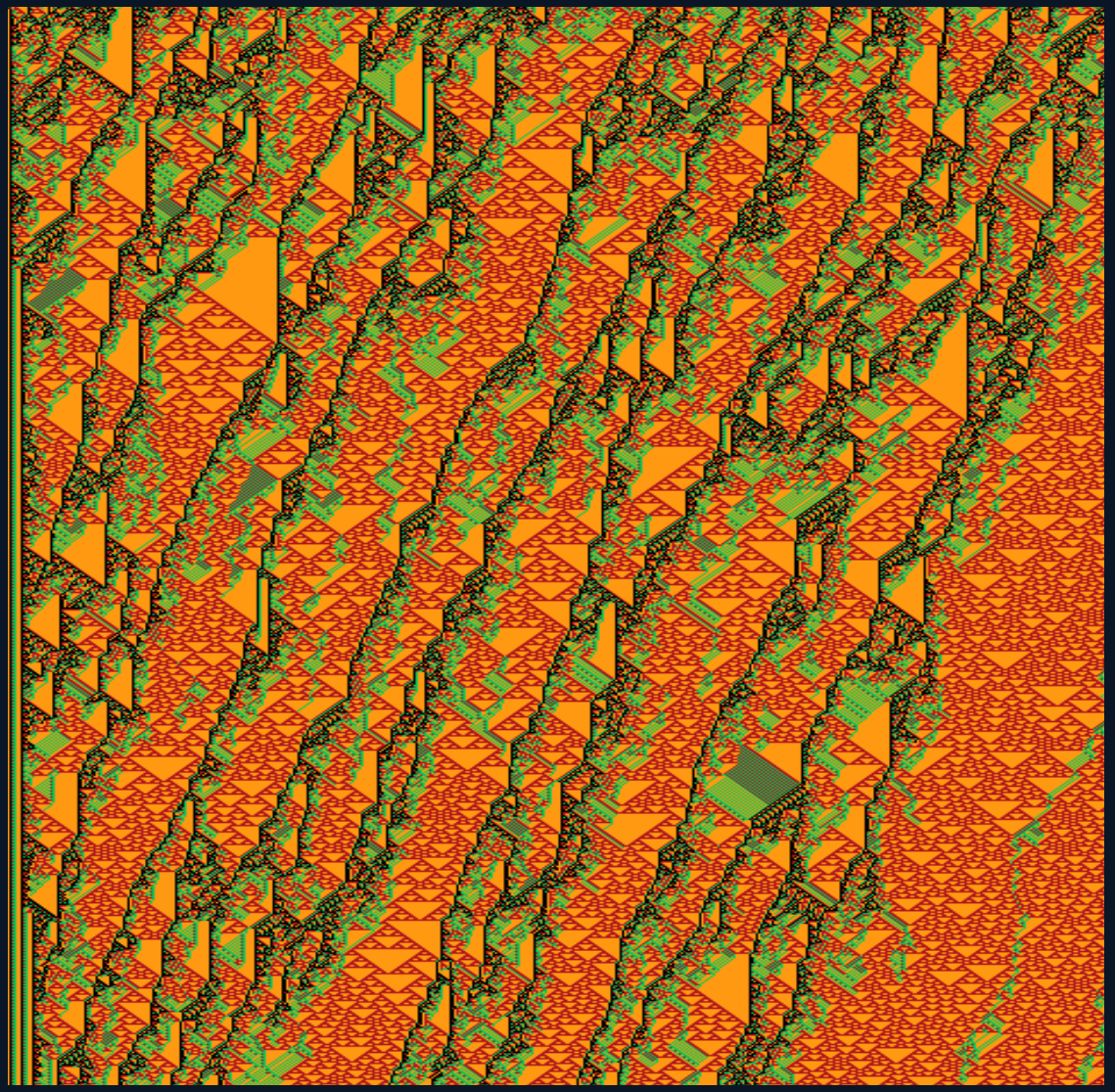
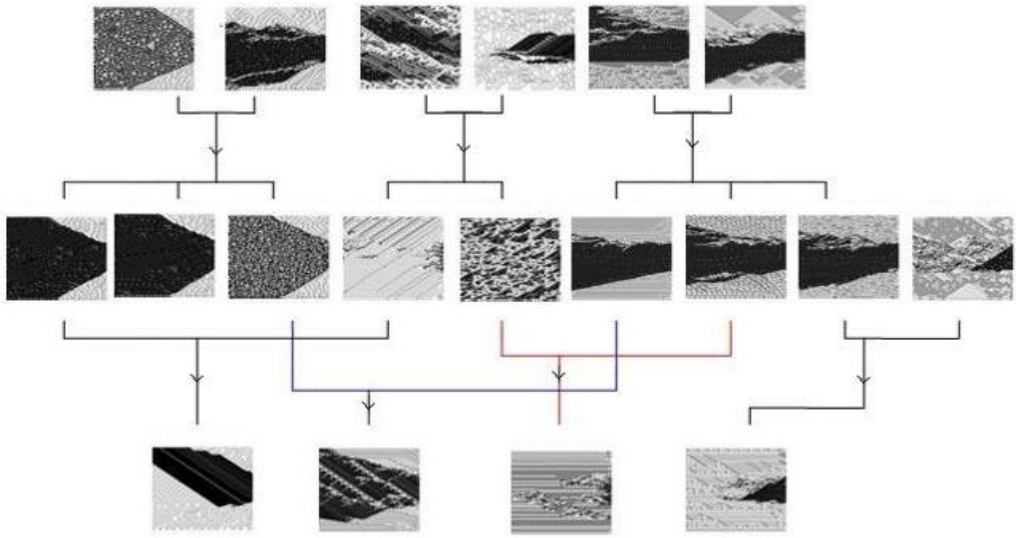
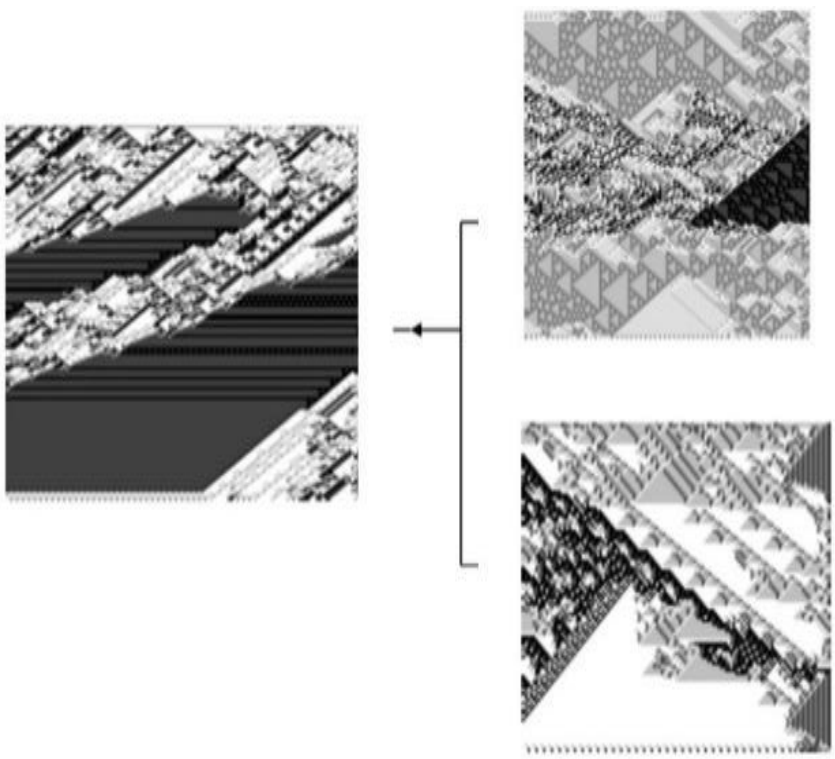
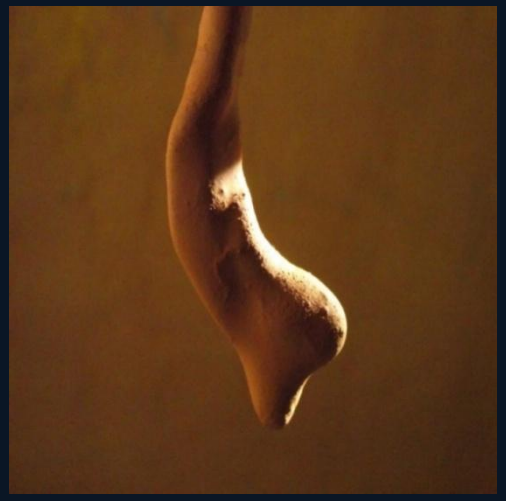




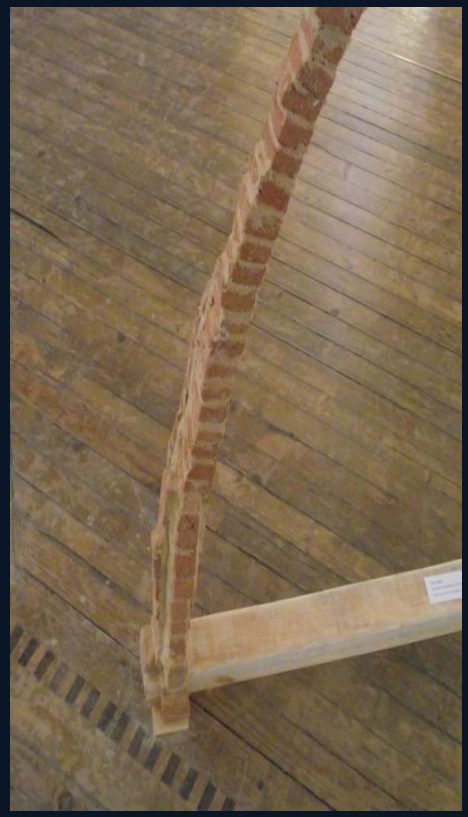




Matemática, artes e letras
Sistemas Complexos

Sistemas Complexos - Disciplina proposta em 2010, à Escola de Ciências e Tecnologias, Universidade de Évora

Matemática, artes e letras - Disciplina proposta em 2010, à Escola das artes, Universidade de Évora



Logic, Algebra, Geometry

Coordenador:

Imme van den Berg

Teoria dos Números

Manuel Branco

Aplicação: criptografia.

Quem faz pagamento na net aplica resultados sobre os números primos.

Geometria Diferencial

Rui Albuquerque

A teoria de Relatividade Geral de Einstein é impensável sem “retas curvadas”: geodésicos.

Álgebra, Geometria Algébrica

Nuno Franco, Pedro Marques

Resolve problemas na teoria dos números.

Um resultado celebro é a demonstração do
Último Teorema de Fermat (1638) por Wiles (1995).

Lógica Modal

José Carmo, Reitor da Universidade de Madeira

É a Lógica para quem existem níveis de verdades entre o verdadeiro absoluto e a falsidade absoluta.

Matemática Não Standard

Imme van den Berg, Bruno Dinis, Júlia Justino, Tran Van Nam

Robinson (1966) justificou, através da Lógica, o cálculo infinitesimal de Leibniz e Newton (~1670).

Aplicações:

Simplificação, estruturas infinitas substituídas por estruturas finitas infinitamente finas: ensino do Cálculo Financeiro Avançado nesta universidade.

Modelos com ordens de grandeza de números: números flexíveis, propagação de erros em cálculos, otimização com incertezas.

Grupo DEO
Differential Equations and Optimization

April 10, 2015

- 13 membros integrados
- 9 colaboradores
- 4 alunos de doutoramento

4 linhas de investigação

- Boundary Value Problems
- Calculus of Variations and Optimal Control
- Variational, Multialued and Functional Analysis
- Numerical Methods

Cooperação

- Cooperação internacional
  - University of Castilla-La Mancha (Spain)
  - University of Padua (Italy)
  - University of Napoles (Italy)
  - Carnegi Mellon University (USA)
  - Dorodnicym Computing Centre of RAS (Moscow, Russia)
  - Institute of Systems dynamics and Control Theory of RAS (Irkutsk, Russia)
- Cooperação nacional
  - CMAF
  - Universidade Nova de Lisboa
  - Universidade de Aveiro
  - Universidade de Porto
  - Universidade de Minho
- Cooperação local
  - Centro de Geofísica de Évora
  - Instituto de Ciências Agrárias Mediterráneas, UE

Boundary Value Problems

Equipa:

- Membros integrados
  - F. Minhos
  - A.I. Santos
- Colaboradores
  - J. Fialho
- Alunos de doutoramento
  - H. Carrasco
  - R. Carrapinho

BVP for high order differential, integro-differential and fractional differential equations with various applications in mechanics, engineering and medicine

Boundary Value Problems

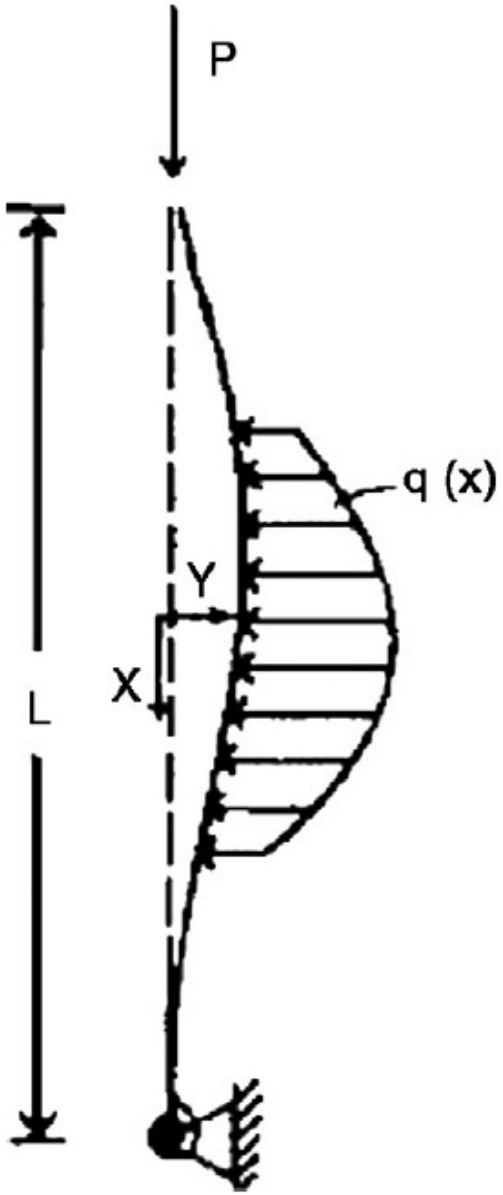
Example (beam-column deformations)

BV problems for high order ordinary differential equations permit to study the mechanical deformations of the human spine, which is under various loading conditions such as aircraft ejections or vehicle crush situations. One can take in consideration also some inicial deformations due, for instance, certain form of scoliosis. The displacement $y_1(x)$ of the beam-column is modelled with a fourth order nonlinear equation

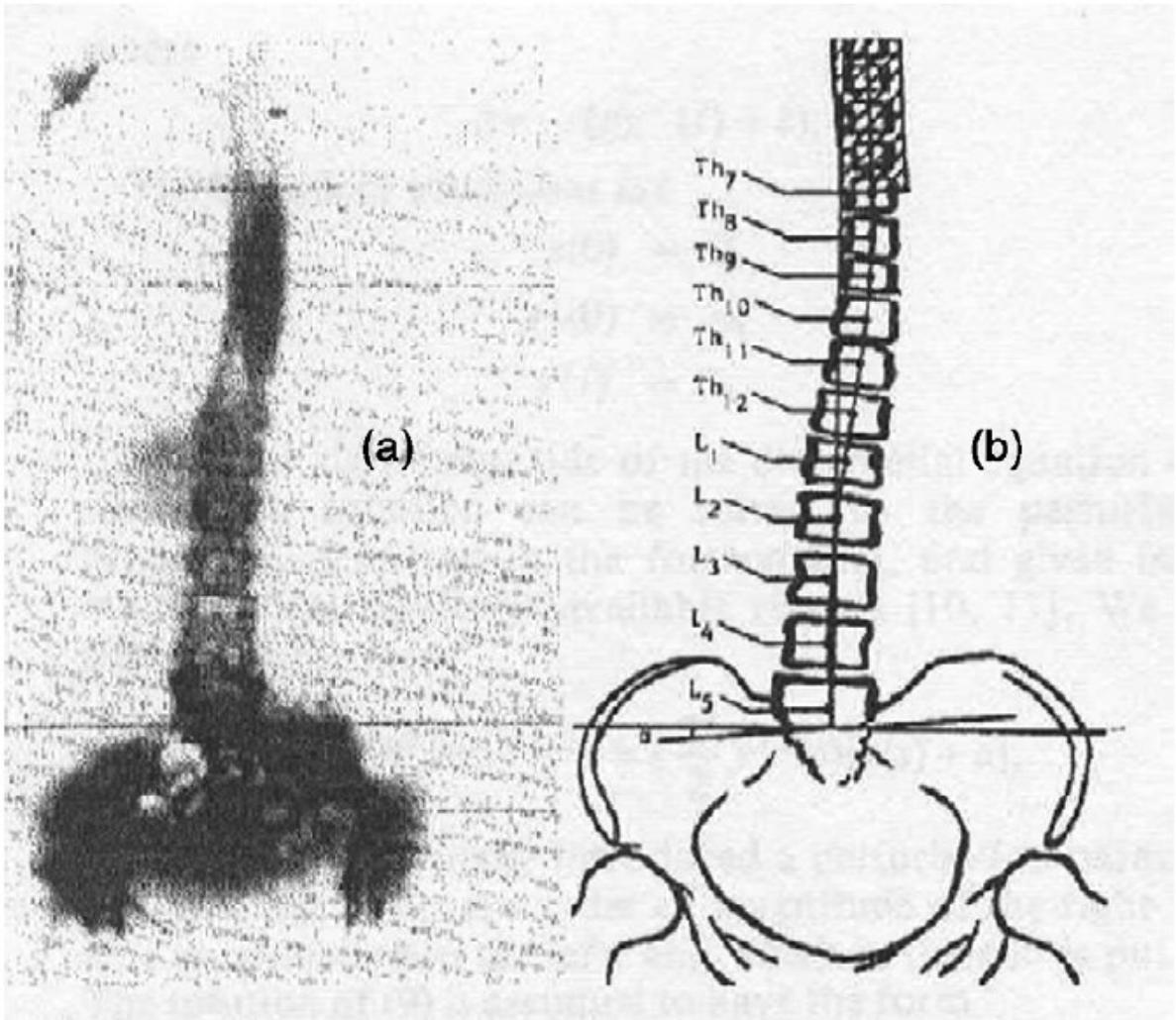
$$EIy_1^{(4)} + Py_1'' = q(y_1''') - Py_0''$$

where EI is the flexural rigidity of the beam-column, P is the axial load, $y_0(x)$ is the initial displacement and $q(\cdot)$ is some continuous function of the third derivative of the displacement meaning the tranverse forces. The boundary condition here includes the restriction on the maximal curvature (the second derivative) of the column, i.e., we have a functional BV problem

Boundary Value Problems



Boundary Value Problems



Calculus of Variations and Optimal Control

Equipa:

- Membros integrados
  - A. Ornelas
  - L. Bandeira
  - L. Bicho
- Colaboradores
  - C. Carlota
  - M Vornicescu
  - S. Chá

Direct methods of infinite dimensional optimization: in scalar as well as vector Variational and Optimal Control problems. Existence theorems and optimality conditions

Variational, Multivalued and Functional Analysis

Equipa:

- Membros integrados
  - V. Goncharov
  - G. Carita
  - F. Pereira
  - T. Santos
  - N. Freire
- Colaboradores
  - E. Zappale (Italy)
  - V. Roshchina (Australy)

Development of the methods of Nonlinear Functional Analysis and their applications to Calculus of Variations, Geometry of Banach spaces, Time Optimal Control, Differential Inclusions etc. Despite of the theoretical orientation of this group there are some interesting pracical applications, e.g., in the image segmentation and in the plastic surgery.

Example (plastic surgery)

We study a vector variational problem with non traditional boundary conditions, which appear in the plastic surgery, namely, in modelling of the woman's breast. We are interested in knighting of the breast tissues. Considering the breast as a superelastic body we should minimize the energy functional, which depends on the gradient of the tissue displacement:

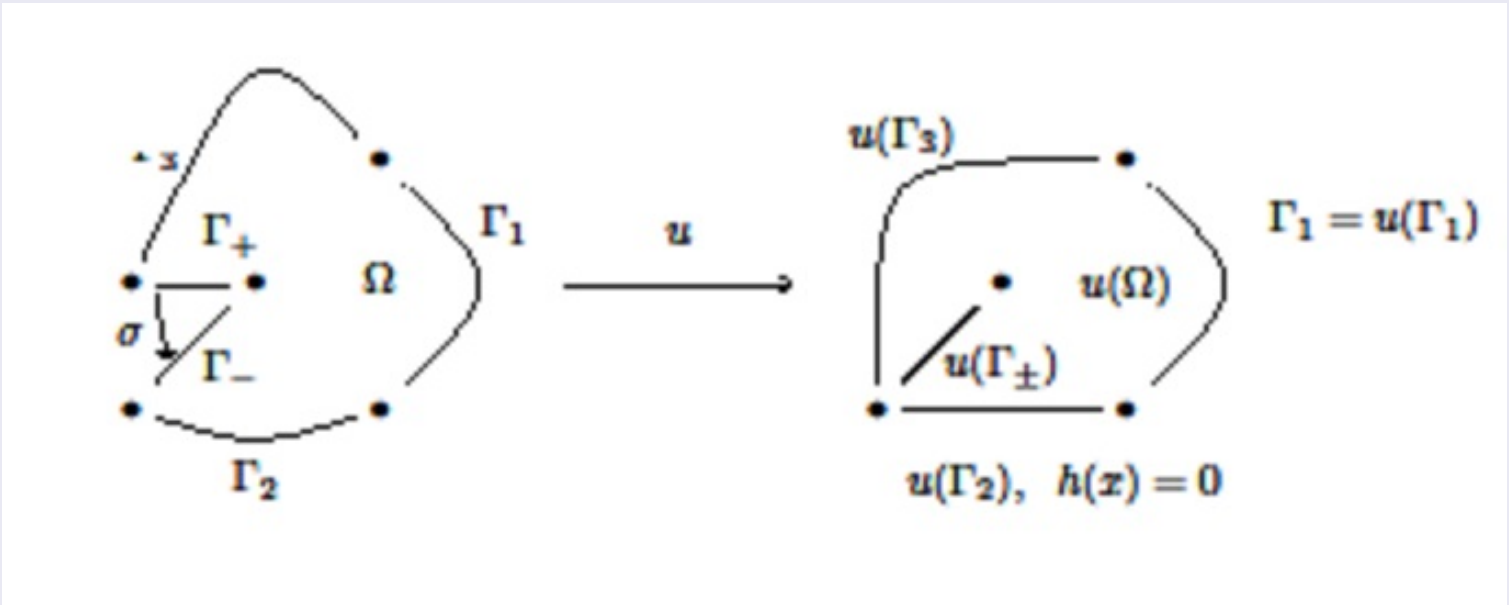
$$\int_{\Omega} W(\nabla u(x))\, dx$$

where W is a polyconvex integrand satisfying a natural growth assumption

Example (plastic surgery)

Furthermore, we should guarantee that the various parts of the breast surface were knighted carefully. Namely, one of the piece (Γ_1) coincides with a part of the woman's chest, which was not cut. So, the displacement here should verify $u(x) = x$. Another piece (let Γ_2) should be knighted with a fixed chest surface, so the boundary condition on Γ_2 is $h(u(x)) = 0$, while one more piece (Γ_3) is devided into two parts Γ^+ and Γ^-, which should be knighted one to other and the respective condition is $u(\sigma(x)) = u(x)$. Finally, one part of the breast surface (say Γ_4) is left free allowing a flexibility of the tissue during the knighting process.

Example(plastic surgery)



Numerical Methods

Equipa:

- Membros integrados
  - V. Bushenkov
  - F. Carapau
  - J. Santos
- Colaboradores
  - A. Lotov (Russia)
  - P. Correia
  - M Pires
- Alunos de doutoramento
  - C. Pimentel

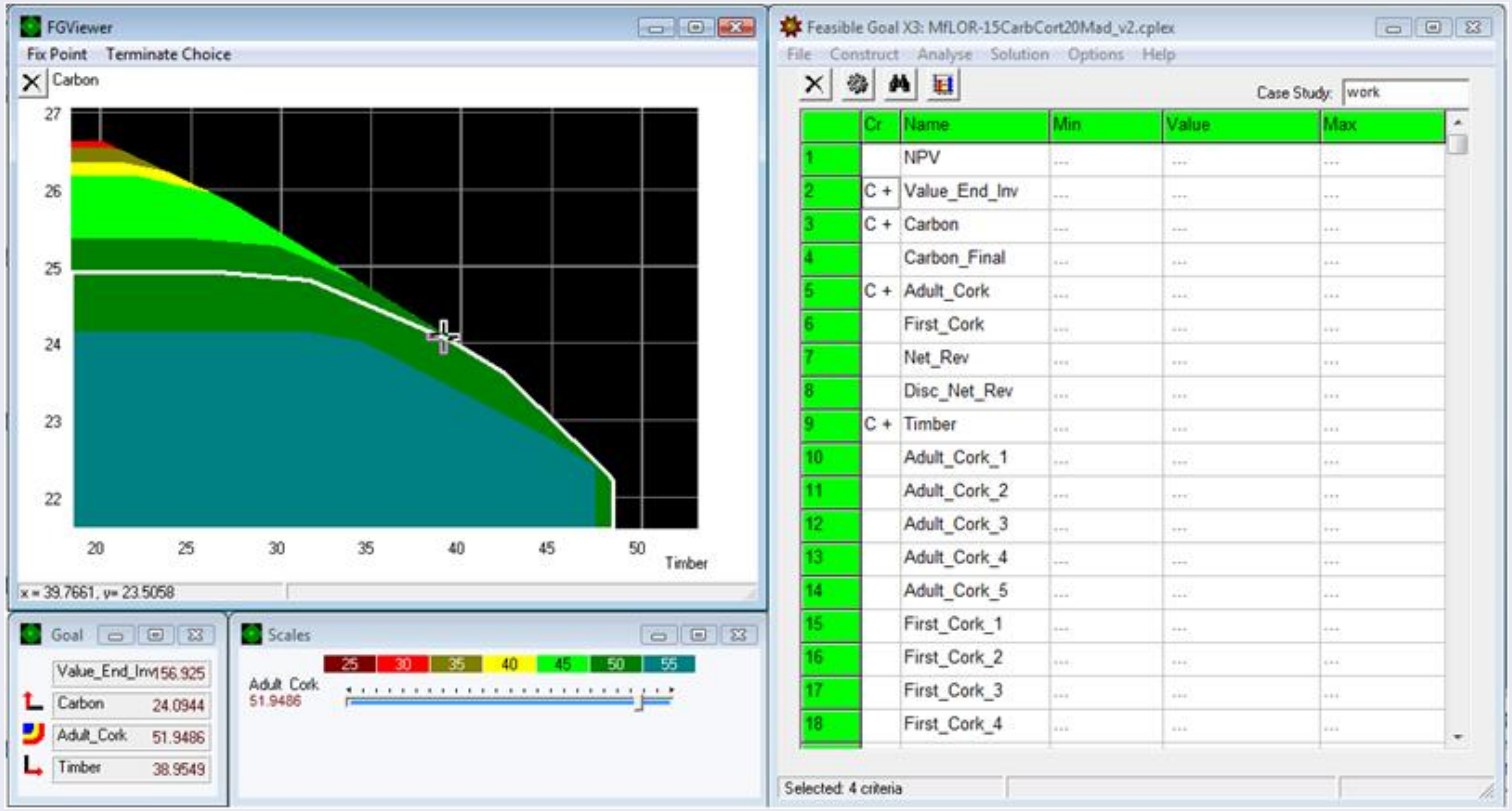
Development of the numerical methods in finite as well as infinite dimensional optimization, multiobjective optimization, mathematical modelling of real physical and chemical processes, computer realization of constructed numerical schemes

Numerical Methods

Example 1 (modelling of the forests management)

Based on a multicriterion optimization method a system of the decision suport for the forests management was created in collaboration with Instituto Superior de Agronoimia em Lisboa. This method can be afterwards successively applied in other situations, for instanse, for modelling of the management of the hidro-resourses (such as Alqueva)

Example 1 (modelling of the forest management)



Numerical Methods

Example 2 (modelling of the liquid flows interacted with the surrounding matter)

In particular, the team is working on the numerical analysis of the blood flow through the human tissues such as the filtration blood through the kidneys. The results can be applied in medicine, e.g., in the kidneys dialysiis. The bood flow in such a situation cane be described by the following hydrodynamical equations:

Example 2 (modelling of the liquid flows interacted with the surrounding matter)

Classical Johnson-Segalmann Model Summary

$$\begin{aligned}
\operatorname{div} \boldsymbol{u} &= 0 \\
\rho \frac{d\boldsymbol{u}}{dt} &= -\boldsymbol{\nabla} p + \operatorname{div} \mathbf{T} \\
\mathbf{T} &= \mathbf{T}_s + \mathbf{T}_e \\
\mathbf{T}_s &= 2\mu_s \mathbf{D} \\
\frac{\partial \mathbf{T}_e}{\partial t} + (\boldsymbol{u} \cdot \boldsymbol{\nabla})\, \mathbf{T}_e &= \frac{2\mu_e}{\lambda}\mathbf{D} - \frac{1}{\lambda}\mathbf{T}_e + (\mathbf{W}\mathbf{T}_e - \mathbf{T}_e\mathbf{W}) + a(\mathbf{D}\mathbf{T}_e + \mathbf{T}_e\mathbf{D}) \\
& \qquad a \in [-1; 1]
\end{aligned}$$

Example 2 (modelling of the liquid flows interacted with the surrounding matter)