Umberto Biccari

Curriculum Vitae

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Personal data

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ResearchGate: `https://www.researchgate.net/profile/Umberto_Biccari`

Actual position

From Mar 2017 **Associated researcher**, *DeustoTech - University of Deusto*, Bilbao, Spain, ERC grant DyCon - Dynamic Control.

Previous positions

Jan-Mar 2017 **Postdoctoral fellow**, *BCAM - Basque Center for Applied Mathematics*, Bilbao, Spain.

Education

Sep 2013 - Dec 2016 **International Ph.D *Summa Cum Laude* in Mathematics**, *University of the Basque Country and BCAM - Basque Center for Applied Mathematics*, Bilbao, Spain.

Mar - Aug 2013 **Internship**, *BCAM - Basque Center for Applied Mathematics*, Bilbao, Spain, ERC Advanced Grant FP7-246775 NUMERIWAVES.

2010 - 2012 **Master degree in Mathematics**, *University of Florence*, Italy.

2007 - 2010 **Bachelor's Degree in Mathematics**, *University of Florence*, Italy.

Ph.D Thesis

Title *On the controllability of Partial Differential Equations involving non-local terms and singular potentials (**link**)*

Institution *University of the Basque Country*

Advisor *Prof. Enrique Zuazua*

Description In this thesis, we study controllability properties of certain types of Partial Differential Equations that describe several phenomena arising in many fields of the applied sciences, such as elasticity theory, ecology, anomalous transport and diffusion, material science, filtration in porous media, and quantum mechanics. In particular, the first part of the thesis is devoted to the analysis of non-local PDEs involving the fractional Laplace operator. In the second part of the work, instead, we focus on PDEs with singular potentials of Hardy type.

Master's Thesis

Title *A free boundary problem for the $CaCO_3$ neutralization of acid waters*

Institution *University of Florence*

Advisors *Prof. Riccardo Ricci* and *Prof. Angiolo Farina*

Description In this thesis, we analyze a parabolic free boundary model arising from a problem of neutralization of acid waters via the filtration through calcium carbonate. After having developed the model according to the Physics, we computed an approximate but reliable solution, investigating its properties and its asymptotic behavior. This analysis has been repeated also in cylindrical and spherical geometry, both configurations being relevant in the description of the physical phenomena at the basis of our model.

Bachelor's Thesis

Title *Some facts about the existence of periodic solutions for the generalized Liénard Equation*

Institution *University of Florence*

Advisor *Prof. Gabriele Villari*

Description This thesis concerns the qualitative analysis of a generalized Liénard-type equation, which is a well-known model for oscillating circuits. In particular, we show some results that guarantee the existence of periodic solutions.

Research interests

My primary field of expertise is the analysis of Partial Differential Equations, both from the theoretical and from the numerical point of view, with a particular emphasis on non-local models and control theory. My contributions to the topic spread among different areas of PDE analysis, including:

- the study of controllability properties of hyperbolic, parabolic and dispersive PDE, involving the fractional Laplacian, integral kernels, singular inverse-square potentials and/or variable degenerate coefficients, memory terms;

- numerical controllability for non-local parabolic PDE involving the fractional Laplacian;
- regularity results for non-local elliptic and parabolic PDE involving the fractional Laplacian;
- mathematical and numerical asymptotic analysis for the propagation of solutions of wave-like processes in a local and non-local setting;
- analysis and control of collecting behavior models and their micro-macro limit.

Besides, in the last period, I started working on the development of mathematical and computational tools for the model, stability analysis, and control of hybrid AC/DC power grids. This is the core topic of two shared research project between our team, the University of Mondragón (Basque Country), and three industrial partners strongly committed with the topics of control and energy management.

Publications and preprints

Papers published or accepted

1. U. B. and V. Hernández-Santamaría, **Null controllability for a nonlocal heat equation with integral kernel**. SIAM J. Control Optim., Vol. 57, Nr. 4 (2019), pp. 2924-2938 (**link**).
2. U. B. and M. Warma, **Null-controllability properties of a fractional wave equation with a memory term**. Evol. Equ. Control The., to appear (**link**).
3. U. B. and S. Micu, **Null-controllability properties of the wave equation with a second order memory term**. J. Differential Equations, Vol. 267, Nr. 2 (2019), pp. 1376-1422 (**link**).
4. U. B., D. Ko and E. Zuazua, **Dynamics and control for multi-agent networked systems: a finite difference approach**. Math. Models Methods Appl. Sci., Vol. 29, Nr. 4 (2019), pp. 755-790 (**link**).
5. U. B., **Boundary controllability for a one-dimensional heat equation with a singular inverse-square potential**. Math. Control Relat. F., Vol. 9, Nr. 1 (2019), pp. 191-219 (**link**).
6. U. B. and V. Hernández-Santamaría, **The Poisson equation from non-local to local**. Electron. J. Differential Equations, Vol. 2018, Nr. 145 (2018), pp. 1-13 (**link**).
7. U. B. and V. Hernández-Santamaría, **Controllability of a one-dimensional fractional heat equation: theoretical and numerical aspects**. IMA J. Math. Control Inf., to appear (**link**).
8. U. B., M. Warma and E. Zuazua, **Local elliptic regularity for the Dirichlet fractional Laplacian**. Adv. Nonlinear Stud., Vol. 17, Nr. 2 (2017), pp. 387-409 (**link**).
   - U. B., M. Warma and E. Zuazua, **Addendum: Local elliptic regularity for the Dirichlet fractional Laplacian**. Adv. Nonlinear Stud., Vol. 17, Nr. 4 (2017), pp. 837 - 839 (**link**).
9. U. B. and E. Zuazua, **Null controllability for a heat equation with a singular inverse-square potential involving the distance to the boundary function**. J. Differential Equations, Vol. 261, Nr. 5 (2016), pp. 2809 - 2853 (**link**).

Papers submitted

10. U. B., M. Warma and E. Zuazua, Zuazua, **Controllability of the one-dimensional fractional heat equation under positivity constraints** (**link**).
11. U. B., A. Marica and E. Zuazua, **Propagation of one and two-dimensional discrete waves under finite difference approximation** (**link**).
12. U. B. and A.B. Aceves, **WKB expansion for a fractional Schrödinger equation with applications to controllability** (**link**).
13. U. B., **Internal control for non-local Schrödinger and wave equations involving the fractional Laplace operator** (**link**).

Books chapters

1. U. B., M. Warma and E. Zuazua, **Local regularity for fractional heat equations**. In *Recent Advances in PDEs: Analysis, Numerics and Control*. SEMA SIMAI Springer Series, Volume 17 (2018), Springer International Publishing (**link**).

Certifications

IKERTRAMOS call 2019: positive evaluation of the Agencia de Calidad del Sistema Universitario Vasco (UNIBASQ) for the research activity in the 6 years period 2013-2018.

Teaching

U. B. **Control problems for nonlocal PDE**, *University of Naples, Italy*, June 24 - 28, 2019.

Description This is an intensive course of ten hours held within the semester on *Shape optimization, control and inverse problems for PDEs* (**link**), organized by the University of Naples, Italy, with the collaboration of INDAM. The topic of the course is control of non-local PDE. The course is addressed to Ph.D. students in analysis and PDE theory.

U. B. **Mathematical methods for control theory**, *DeustoTech, University of Deusto, Bilbao, Spain*, September 2018 - April 2019.

Description This course is an extension of the 2017-2018 one (see below), in which we aim to cover the same spectrum of topics with the integration of several previously unaddressed relevant issues. The course is addressed to master and Ph.D. students with a basic knowledge of PDE theory.

U. B. and V. Hernández-Santamaría **Mathematical methods for control theory**, *DeustoTech, University of Deusto, Bilbao, Spain*, September 2017 - April 2018.

Description This course covered some fundamental aspects of the analysis of Partial Differential Equations. Our principal aim was to discuss control properties, although other relevant issues such as existence, uniqueness, and regularity of solutions, and numerics were considered. In particular, we addressed the following topics:

- Controllability and stabilizability of finite dimensional systems.
- Elliptic PDEs:
  - existence, uniqueness, and regularity of solutions through variational methods;
  - optimal control problems;
  - computation of optimal controls through the conjugate gradient method.
- Hyperbolic PDEs:
  - existence, uniqueness, and regularity of solutions through Galerkin approximation;
  - controllability properties through the Hilbert Uniqueness Method (HUM);
  - most common techniques for the observability (multiplier method, sidewise energy estimates, Ingham inequalities).
- Parabolic PDEs:
  - existence, uniqueness, and regularity of solutions through semi-group theory;
  - controllability properties;
  - most common techniques for the observability (Carleman estimates, moment method);
  - computation of optimal controls through the Penalized HUM approach.
- Well-posedness, regularity, and control of non-local PDEs.

The course was addressed to master and Ph.D. students with a basic knowledge of PDE theory, and its total duration has been of 57 hours.

Computational codes

Contribution to the computational blog of DyCon research project:

- Development of a Matlab code for the FE discretization of the one-dimensional fractional Laplacian, with applications to:
  - the numerical controllability of a non-local parabolic equation through the Penalized Hilbert Uniqueness Method (**link**).
  - the propagation of localized solutions of a fractional Scrhödinger equation (**link**).
  - the LQR stabilization of a fractional reaction-diffusion equation (**link**).

Other scientific contributions

- **Reviewer for the following indexed journals**:
  - Systems and Control Letters.
  - Journal de Mathématiques Pures et Appliquées.
  - SIAM Journal on Control and Optimization.
  - IEEE Transactions on automatic control.
  - Applied Mathematics and Optimization.

- ESAIM: Control, Optimization and Calculus of Variations.
- Mathematical Control and Related Fields.
- Advances in Difference Equations.
- Journal of Mathematical Analysis and Applications.

- **Organization of conferences**:
  - Organizer of the thematic session *Young researchers* within the *8th workshop on Partial Differential Equations, optimal design and numerics*, Benasque, Spain, August 18 - 30, 2019 (**link**)
  - Organizer of the thematic session *Nonlocal PDE and control* within the *8th workshop on Partial Differential Equations, optimal design and numerics*, Benasque, Spain, August 18 - 30, 2019 (**link**)
  - Organizer of the symposium on *Control of Partial Differential Equations* within the *International Conference on Elliptic and Parabolic Problems*, Gaeta, Italy, May 20 - 24, 2019 (**link**)

Talks

Aug 21, 2019 **Controllability of a 1d fractional heat equation under positivity constraints**, *8th workshop on Partial Differential Equations, optimal design and numerics*, Benasque, Spain.

Apr 3, 2019 **Dynamics and control for multi-agent networked systems: a finite difference approach**, *Universidad de Cantabria*, Santander, Spain.

Mar 14, 2019 **Dynamics and control for multi-agent networked systems: a finite difference approach**, *Friedrich-Alexander Universität*, Erlangen, Germany.

Dec 5, 2018 **Controllability of a one-dimensional fractional heat equation: theoretical and numerical aspects**, *1st workshop on dynamics, control and numerics for fractional PDE's*, San Juan, Puerto Rico, U.S..

Aug 30, 2018 **Propagation of one and two-dimensional discrete waves under finite difference approximation**, *14th French-Romanian conference in applied mathematics*, Bordeaux, France.

Jul 6, 2018 **Propagation of one and two-dimensional discrete waves under finite difference approximation**, *University of Craiova*, Craiova, Rumania.

Mar 1, 2018 **Controllability of Partial Differential Equations with integral kernels**, *MINAKE 2018 - Microlocal and Numerical Analysis, Kinetic Equations Control Conference*, Madrid, Spain.

Aug 29, 2017 **A Finite Element approximation of the one-dimensional fractional Poisson equation with applications to numerical control**, *7th workshop on Partial Differential Equations, optimal design and numerics*, Benasque, Spain.

Aug 25, 2017 **Control of partial differential equations involving the fractional Laplacian**, *7th workshop on Partial Differential Equations, optimal design and numerics*, Benasque, Spain.

Mar 8, 2017 **Null controllability for a heat equation with a singular inverse-square potential involving the distance to the boundary function**, *Universidad Autónoma de Madrid*, Madrid, Spain.

Nov 3, 2015 **Boundary controllability for a one-dimensional heat equation with two singular inverse-square potentials**, *Workshop on Recent Developments on Approximation Methods for Controlled Evolution Equations*, Mathematisches Forschunginstitut of Oberwolfach, Germany.

Sep 1, 2015 **Boundary controllability for a one-dimensional heat equation with two singular inverse-square potentials**, *6^{th} workshop on Partial Differential Equations, optimal design and numerics*, Benasque, Spain.

Nov 14, 2014 **Internal control for non-local Schrödinger and wave equations involving the fractional Laplace operator**, *FCPNLO 2014*, BCAM-Bilbao, Spain.

May 20, 2014 **Internal control of evolution problems involving the fractional Laplace operator**, *CIMI - Centre International de Mathématiques et d'Informatique*, Toulouse, France.

Nov 8, 2013 **Internal control for a fractional Schrödinger equation via the Hilbert Uniqueness Method**, *FCPNLO 2013*, BCAM-Bilbao, Spain.

Attended workshops and conferences

Aug 18 - 30, 2019 **Speaker at the 8^{th} workshop on PARTIAL DIFFERENTIAL EQUATIONS, OPTIMAL DESIGN AND NUMERICS**, *Centro de Ciencia Pedro Pascual*, Benasque, Spain.

May 20 - 24, 2019 **INTERNATIONAL CONFERENCE ON ELLIPTIC AND PARABOLIC PROBLEMS**, *Gaeta*, Italy.

Dec 5 - 7, 2018 **Invited speaker at the workshop on DYNAMICS, CONTROL AND NUMERICS FOR FRACTIONAL PDE's**, *San Juan*, Puerto Rico, U.S.

Aug 26 - 31, 2018 **Speaker at the 14^{th} FRENCH-ROMANIAN CONFERENCE IN APPLIED MATHEMATICS**, *University of Bordeaux*, France.

Feb 26 - Mar 2, 2018 **Invited speaker at the 1^{st} MICROLOCAL AND NUMERICAL ANALYSIS, KINETIC EQUATIONS CONTROL CONFERENCE**, *Real Academia de Ciencias*, Madrid, Spain.

Aug 20 - Sep 1, 2017 **Plenary speaker at the 7^{th} workshop on PARTIAL DIFFERENTIAL EQUATIONS, OPTIMAL DESIGN AND NUMERICS**, *Centro de Ciencia Pedro Pascual*, Benasque, Spain.

Jul 3 - 7, 2017 **CONTROL OF DISTRIBUTED PARAMETER SYSTEMS**, *Bordeaux*, France.

May 23 - 26, 2017 **NEW TRENDS IN PARTIAL DIFFERENTIAL EQUATIONS, un homenaje a Ireneo Peral**, *Granada*, Spain.

Jun 21 - 24, 2016 **CORON60 - Conference in honour of the 60^{th} birthday of Prof. Jean-Michel Coron**, *Institut Henri-Poincaré*, Paris, France.

Apr 4 - 6, 2016 **GEOMETRICAL ASPECTS OF SPECTRAL THEORY**, *BCAM - Basque Center for Applied Mathematics*, Bilbao, Spain.

Nov 1 - 7, 2015 **Invited speaker at the Workshop on RECENT DEVELOPMENTS ON APPROXIMATION METHODS FOR CONTROLLED EVOLUTION EQUATIONS**, *Mathematisches Forschunginstitut of Oberwolfach*, Germany.

Aug 24 - Sep 4, 2015 **Speaker at the 6th workshop on PARTIAL DIFFERENTIAL EQUATIONS, OPTIMAL DESIGN AND NUMERICS**, *Centro de Ciencia Pedro Pascual*, Benasque, Spain.

Apr 22 - 24, 2015 **Workshop on CONTROL OF PARTIAL DIFFERENTIAL EQUATIONS**, *GSSI - Gran Sasso Science Institute*, L'Aquila, Italy.

Nov 13 - 14, 2014 **Speaker at the 2nd Workshop on FRACTIONAL CALCULUS, PROBABILITY AND NON-LOCAL OPERATORS: APPLICATIONS AND RECENT DEVELOPMENTS**, *BCAM - Basque Center for Applied Mathematics*, Bilbao, Spain.

Feb 20 - 21, 2014 **Workshop on PARTIAL DIFFERENTIAL EQUATIONS AND APPLICATIONS**, *Pisa*, Italy.

Dec 12 - 13, 2014 **CONCA60 - Conference in honour of the $60^{\mathbf{th}}$ birthday of Prof. Carlos Conca**, *Paris*, France.

Nov 6 - 8, 2013 **Speaker at the 1st Workshop on FRACTIONAL CALCULUS, PROBABILITY AND NON-LOCAL OPERATORS: APPLICATIONS AND RECENT DEVELOPMENTS**, *BCAM - Basque Center for Applied Mathematics*, Bilbao, Spain.

Aug 25 - Sep 5, 2013 **5th workshop on PARTIAL DIFFERENTIAL EQUATIONS, OPTIMAL DESIGN AND NUMERICS**, *Centro de Ciencia Pedro Pascual*, Benasque, Spain.

Attended courses and schools

Jan 14 - 15, 2019 **CONTROL OF PDEs UNDER UNCERTAINTY**, *Intensive course held by Prof. Jesús Martínez-Frutos and Francisco Periago (Politecnic University of Cartagena, Spain)*, Bilbao, Spain.

Jan 10 - 15, 2016 **GEOMETRIC PDEs AND THEIR APPROXIMATION**, *Winter school*, Texas A&M University, College Station, U.S.A..

Oct 2014 - Jun 2015 **Topics on PDEs, control and numerics**, *Advanced course held by Prof. Enrique Zuazua*, Bilbao, Spain.

Jun 24 - 28, 2013 **NONLINEAR WATER WAVES**, *2013 C.I.M.E. summer school*, Cetraro (CS), Italy.

May 27 - 31, 2013 **An introduction to finite elements methods**, *BCAM advanced course held by Prof. Sergey Korotov (BCAM)*, Bilbao, Spain.

May 6 - 10, 2013 **An introduction to viscosity solutions for fully non-linear PDEs and applications to calculus of variations in L^{∞}**, *BCAM advanced course held by Prof. Nikolaos Katzourakis (University of Reading)*, Bilbao, Spain.

Apr 29 - May 3, 2013 **Numerical methods for SPDE**, *BCAM advanced course held by Prof. Max. Gunzburger (Florida State University)*, Bilbao, Spain.

Apr 8 - 12, 2013 **An introduction to domain decomposition methods for PDEs**, *BCAM advanced course held by Dr. Luca Gerardo-Giorda (BCAM)*, Bilbao, Spain.

Jun 11 - 15, 2012 **6th edition of the MODELLING WEEK**, *Universidad Complutense de Madrid - Faculty of Mathematics*, Madrid, Spain.

Research visits

Mar 11 - 15, 2019 **Friedrich-Alexander Universität**, *Erlangen*, Germany, Invited by Prof. Günter Leugering.

Nov 19 - Dec 14, 2018 **University of Puerto Rico**, *San Juan*, Puerto Rico, U.S.
Invited by Prof. Mahamadi Warma

July 3 - 10, 2018 **University of Craiova**, *Craiova*, Rumania.
Invited by Prof. Sorin Micu

Mar 6 - 10, 2017 **Universidad Autónoma de Madrid**, *Madrid*, Spain.
Invited by Prof. Ireneo Peral

Feb - Mar, 2016 **University of Puerto Rico**, *San Juan*, Puerto Rico, U.S.
Invited by Prof. Mahamadi Warma

May, 2014 **CIMI - Centre International de Mathématiques et d'Informatique**, *University Paul Sabatier*, Toulouse, France.
Within Enrique Zuazua's CIMI Chair in Control, PDEs, Numerics and Applications

Mar, 2014 **CIMI - Centre International de Mathématiques et d'Informatique**, *University Paul Sabatier*, Toulouse, France.
Within Enrique Zuazua's CIMI Chair in Control, PDEs, Numerics and Applications

Participation in research projects

- **ELKARTEK 2018 - Road2DC- Nuevas herramientas para el diseño y control de redes de distribución híbridas ac/dc**, led by Mondragón University and with partners Ingeteam, Tecnalia, DeustoTech, and IK4-Ikerlan.
- **MTM2017-92996-C2-1-R - COSNET - Control y estabilidad de redes híbridas AC/DC: Ecuaciones Diferenciales y Ecuaciones en Derivadas Parciales para el análisis de estabilidad de redes** of MINECO, in collaboration between DeustoTech and Mondragón University.
- **FA9550-18-1-0242. Nonlocal PDEs: Analysis, Control and Beyond** of EOARD-AFOSR, with P.I. Prof. M. J. Warma.
- **MTM2017-82996-C2-1-R - Control y estabilidad de redes híbridas AC/DC: Ecuaciones Diferenciales y Ecuaciones en Derivadas Parciales para el análisis de estabilidad de redes** of MINECO, with P.I. Prof. Enrique Zuazua.
- **ERC Grant 694126 DYCON - Dynamic Control** of the European Research Council, with P.I. Prof. Enrique Zuazua.
- **FA9550-14-1-0214** of EOARD-AFOSR, with P.I. Prof. M. J. Warma.
- **MTM2014-52347 - Methods for platforms of numerical simulations and control of environmental fluxes** of MINECO, with P.I. Prof. Miguel Escobedo.
- **ERC Grant FP7-246775 NUMERIWAVES** of the European Research Council, with P.I. Prof. Enrique Zuazua.
- **MTM2011-29306 - Partial Differential Equations: Analysis, Control, Numerics and Applications** of MICINN, with P.I. Prof. Enrique Zuazua.

Computer skills

Operating systems **Ubuntu and Windows**.

Computational software **Matlab, `IpOpt`, LaTeX, Microsoft Office**.

Certificates **European Computer Driving License (ECDL)**, *2004*.

Languages

Italian **Mother tongue**

English **Level C1, certificate of *Cambridge Assessment English* (2018)**

Spanish **Level C1, certificate of *Escuela de idiomas de Bilbao* (2016)**

French **Level B2, certificate of the *Institut Français de Florence* (2006)**

	Written comprehension	**Writing**	**Listening**	**Speaking**
Italian	Mother tongue	Mother tongue	Mother tongue	Mother tongue
English	Professional	Professional	Professional	Professional
Spanish	Professional	Professional	Professional	Professional
French	High level	Medium level	Medium level	Medium level