

# Franco Coltraro, PhD.

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## Summary

I am a mathematician who has always been fascinated by the application of mathematical tools and the creation of models to solve real world problems with the aid of computers. During my career I have used and developed tools from very diverse disciplines such as Differential Geometry, Optimization and Computational Topology to solve and model problems arising from fields such as Robotics, Telecommunications and Neuroscience. I am a person full with curiosity and enthusiasm for new things with very good communication and personal skills.

## Work experience

- **Post-doctoral researcher**

Consejo Superior de Investigaciones Científicas (CSIC).

From: *April 2023 - current.*

Project: physical simulation and modeling of inextensible textiles for their robotic control.

Development of predictive algorithms based on geometrical and topological methods.

- **Technology transference**

Real Federación Española de Fútbol (Spanish Football Federation).

From: *May, 2023 - September 2023.*

Project: computation of a valid double round-robin tournament for LaLiga first division.

Solution of mixed-integer optimization problems with Gurobi using *fix-and-relax* techniques.

Supervised by Toni Susin and Carles Bonet.

- **PhD student in Applied Mathematics, FME**

Universitat Politècnica de Catalunya (UPC).

From: *April, 2018 - April 2023.*

Project: set a mathematical framework useful for cloth representation and manipulation using techniques from Differential Geometry, ODEs and Computational Topology.

Supervised by Jaume Amorós and Maria Alberich.

- **Data science analyst**

Minsait (by Indra).

From: *Sept., 2017 - April, 2018.*

Project: development of Machine Learning algorithms, Graph Theory models and Text Mining procedures for fraud detection in public administrations.

- **Research intern**

Grupo de Comunicaciones Ópticas y Arquitectura Computadores (UPC).

From: *Sept. 2016 - July 2017.*

Project: Development of mathematical models (based on Differential Equations) for the simulation of big scale Telecommunication Networks (Queuing theory).

Supervised by Marc Ruiz and Luis Velasco.

- **Research internship (JAE Intro 2016 at CSIC)**

Institut de Robòtica i Informàtica Industrial, CSIC-UPC.

From: *Oct. 2016 - Dec. 2016.*

Project: application of Computer Vision techniques to Computational Neuroscience, for the identification of synaptic partners in brain images.

Supervised by Jan Funke and Francesc Moreno.

## Education

- **PhD in Applied Mathematics** at Universitat Politècnica de Catalunya (UPC).  
*Started:* April, 2018. *Defended:* 30th March, 2023.  
Doctoral thesis: *Robotic Manipulation of Cloth: Mechanical Modeling and Perception*.  
Grade: Excellent with *Cum Laude* distinction.  
Awarded with *Premi IEC de la Secció de Ciències i Tecnologia de Ciències de l'Enginyeria*.  
<http://hdl.handle.net/10803/688226>
- **Master in Advanced Mathematics and Mathematical Engineering (MAMME)**, 2017.  
Universitat Politècnica de Catalunya (UPC).  
Fields: Modelling and Analysis in Science, Engineering and Statistics.  
Average grade: 8.9/10.  
Master thesis: *A logistic queue model for network traffic modelling and simulation*.  
<https://upcommons.upc.edu/handle/2117/106777>
- **Bachelor degree in Pure Mathematics** (2016) at Universidad Complutense de Madrid (UCM).  
Focus: Differential Geometry, Differential equations.  
Average grade: 9.40/10.  
Bachelor thesis: *Teorema de Poincaré-Hopf*.  
<https://docta.ucm.es/entities/publication/1471f359-a937-452c-ac13-caf0bb387cce>

## Publications

**Note:** All the following publications are derived from my PhD thesis except the article: *CURSA-SQ: A methodology for service-centric traffic flow analysis* and the pre-print *The logistic queue model: theoretical properties and performance evaluation* which are derived from my final master project (TFM).

### Journal articles

- Franco Coltraro, Jaume Amorós, Maria Alberich-Carramiñana and Carme Torras: **A novel collision model for inextensible textiles and its experimental validation**. *Applied Mathematical Modelling*, Vol. 128 (2024); pp 287-308, ISSN 0307-904X. DOI: <https://doi.org/10.1016/j.apm.2024.01.030>.
- Franco Coltraro, Josep Fontana, Jaume Amorós, Maria Alberich-Carramiñana, Júlia Borràs and Carme Torras: **A Representation of Cloth States based on a Derivative of the Gauss Linking Integral**. *Applied Mathematics and Computation*, Vol. 457 (2023), 128165. DOI: <https://doi.org/10.1016/j.amc.2023.128165>.
- Franco Coltraro, Jaume Amorós, Maria Alberich-Carramiñana and Carme Torras: **An inextensible model for the robotic manipulation of textiles**. *Applied Mathematical Modelling*, Vol. 101 (2022), pp 832-858. DOI: <https://doi.org/10.1016/j.apm.2021.09.013>.
- Marc Ruiz, Franco Coltraro and Luis Velasco: **CURSA-SQ: A methodology for service-centric traffic flow analysis** *Journal of Optical Communications and Networking (IEEE/OSA)*, vol. 10, no. 9, pp. 773-784, Sept. 2018. DOI: <https://doi.org/10.1364/JOCN.10.000773>

### Book chapters

- Maria Alberich-Carramiñana, Jaume Amorós and Franco Coltraro. **Developable surfaces with prescribed boundary**. *Trends in Mathematics*, vol 15, pp. 127-132. Springer-Birkhäuser, 2021. DOI: [https://doi.org/10.1007/978-3-030-84800-2\\_21](https://doi.org/10.1007/978-3-030-84800-2_21)

## Proceedings

- Franco Coltraro, Jaume Amorós, Maria Alberich-Carramiñana and Carme Torras: **Reconstruction of sampled surfaces with boundary via Morse theory**. *Proceedings of CEIG'23 - Spanish Computer Graphics Conference (2023)*. The Eurographics Association, ISBN 978-3-03868-230-1. DOI: <https://doi.org/10.2312/ceig.20231146>
- Maria Alberich-Carramiñana, Jaume Amorós, Franco Coltraro, Carme Torras, and Miquel Verdaguer: **Morse cell decomposition and parametrization of surfaces from point-clouds**. *Proceedings of XVII EACA 2022 (Encuentro Álgebra Computacional y Aplicaciones)*, pp 35-38. DOI: <http://dx.doi.org/10.6035/INFiTEC.51>

## Pre-prints

- Franco Coltraro, Jaume Amorós, Maria Alberich-Carramiñana and Carme Torras: **Surface reconstruction of sampled textiles via Morse theory**. *arXiv pre-print*: <https://arxiv.org/abs/2405.17257>
- Franco Coltraro, Marc Ruiz, Luis Velasco: **The logistic queue model: theoretical properties and performance evaluation**. *arXiv pre-print*: <https://arxiv.org/abs/2405.17528>

## Selected conferences and talks

- **Modelling inextensible textiles by geometrical constraints tailored to robotic manipulation**. *Special Semester on Rigidity and Flexibility: Kinematic Aspects of Robotics*. Linz, Austria. May 2nd, 2024 (joint talk with Maria Alberich).
- **Constrained dynamics: methods, numerics and examples**. *Learning Week II: Industrial skills and advanced topics in ML (Doctoral Network: GRAPES Learning, processing and optimising shapes)*. Barcelona, Spain. September 8th, 2023.
- **Reconstruction of sampled surfaces with boundary via Morse theory**. *Spanish Computer Graphics Conference CEIG'23*. Palma de Mallorca, Spain. July 5th, 2023.
- **Experimental validation of an inextensible cloth model**. *AICA 2022 (Applications to Industry of Computational Algebra)*. Barcelona, Spain. November 10th, 2022.
- **Contacts, friction and self-collisions for inextensible cloth**. *XXVII CEDYA 2022 (Congreso de Ecuaciones Diferenciales y Aplicaciones)*. Zaragoza, Spain. July 21th, 2022.
- **Morse cell decomposition and parametrization of surfaces from point-clouds**. *XVII EACA 2022 (Encuentro Álgebra Computacional y Aplicaciones)*. Castellón, Spain. June 21th, 2022.
- **Collisions and friction for inextensible cloth simulation**. *Conference Women in Geometry and Topology (organized by GEOMVAP)*. Barcelona, Spain. September 26th, 2019.

## Languages and skills

- Spanish (native), English (C1-C2), German (B2), Catalan (B1) and Italian (oral).
- Python, MATLAB, R, SQL, Apache Spark, Neo4j and L<sup>A</sup>T<sub>E</sub>X.

## Participation in financed research projects

- **ClothIRI: Robotic Cloth Manipulation at IRI**. *Financing*: Consejo Superior de Investigaciones Científicas (CSIC). *Grant number*: 202350E080. *Duration*: 17/03/2023 until 16/03/2026. *P.I.*: Carme Torras. <https://www.iri.upc.edu/project/show/305>. *Members*: 4. *Endowment*: 200 000 euros.

- **SGR RobIRI: Grup consolidat de Percepció i Manipulació Robotitzada de l'IRI.** *Financing:* Generalitat de Catalunya. *Grant number:* 2021-SGR-00514. *Duration:* 01/01/2022 until 31/12/2024. *P.I.:* Carme Torras. <https://www.iri.upc.edu/project/show/306>. *Members:* 27. *Endowment:* 60 000 euros.
- **CLOTH manIpulation Learning from DEmonstrations.** *Financing:* European Research Council (ERC). *Grant number:* H2020-741930- CLOTHILDE. *Duration:* 01/01/2018 until 31/12/2023. *P.I.:* Maria Alberich. <https://clothilde.iri.upc.edu/> *Members:* 3. *Endowment:* 305 125 euros.

## Awards and Scholarships

- **Premi IEC de la Secció de Ciències i Tecnologia de Ciències de l'Enginyeria** (en honor d'Isabel de P. Trabal i Tallada).  
Triennial award given by the Institut d'Estudis Catalans to the best PhD thesis on Science applied to Engineering done in Catalan territory during the last 5 years prior to 2023, April 2024.
- **Beca de Excelencia de la Comunidad de Madrid**  
Monetary Award for great university grades.  
2012/2013, 2013/2014 and 2015/2016.
- **Beca NILS Ciencia y Sostenibilidad**  
Financial aid received in the framework of a one-year Erasmus+ stay at the University of Oslo in Norway during the academic year 2014/2015.
- **Beca de Iniciación a la Investigación de la UCM**  
Study of multivariate complex analysis techniques. Supervised by María del Socorro Ponte Miramonte in the academic year 2015/2016.
- **Severo Ochoa ICMAT: Introducción a la Investigación 2016**  
Development of computational techniques for the study of non-autonomous bi-dimensional dynamical systems. Supervised by Ana María Mancho.

## Teaching

- **Calculo II** en el Grau en Enginyeria en Tecnologies Industrials.  
Second semester of academic year 2023/2024, 6 ETCS.
- **Algebra and Geometry** in Bachelor's degree in Industrial Technologies and Economic Analysis (course coordinator).  
First semester of academic year 2023/2024, 6 ETCS.
- **Geometria** en el Grau en Enginyeria en Tecnologies Industrials.  
First and second semester of academic year 2022/2023, 6 ETCS each.

## Directed Bachelor/Master theses and students

- Julen Antonio Echevarria, April 2022. **Manipulació robòtica de tela: percepció i ajust de model.** *Bachelor Thesis.* UPC, Grau en Enginyeria en Tecnologies Industrials.
- José Maria Julià, February 2022. **Primeros pasos en el control de la tela por simulación isométrica.** *Master Thesis.* UPC, Màster Universitari en Enginyeria Industrial.
- Román Arañó Llach, July 2020. **Validación del modelo de tela del proyecto Clothlide mediante la simulación y el cálculo numérico.** *Bachelor Thesis.* UPC, Grau en Enginyeria en Tecnologies Industrials.
- Arnau Dols Férrez. **Towards a new paradigm for regression and classification problems using computational topology.** From January 2024 until *Current* at IRI (CSIC-UPC). Grant *JAE INTRO Artificial-Intelligence-HUB.* Co-directed with Maria Alberich.

- Roger Gómez López. **Creation of a virtual reality framework for simulation of realistic garments.** From May 2023 until *Current* at IRI (CSIC-UPC). Grant *INIREC-UPC*. Co-directed with Maria Alberich.
- Jordi Baroja Fernández. **Task-oriented classification of cloth configuration states using topological and geometrical indices.** From July 2022 until April 2023 at IRI (CSIC-UPC). Grant *JAIntroICU-2021-IRII-07*. Co-directed with Júlia Borràs and Maria Alberich.

## Research stays

- **Departamento Matemática Aplicada I, Universidad de Sevilla.** Mathematical problems related to the robotic manipulation of cloth. 15th to 18th of November, 2022. *Supervised by:* Rocío González Díaz.

## Selected courses and seminars

- *Midmat 2024. Jornada de metodologies i innovació docents per a joves matemàtics*, organised by the Centre de Recerca Matemàtica on the 6th of February, 2024.
- *Valuation Theory and the OM Algorithm*, organised by the Centre de Recerca Matemàtica from January 15th to 19th, 2024.
- *Máster Universitario en Profesorado de Enseñanza Secundaria Obligatoria y Bachillerato, Formación Profesional y Enseñanza de Idiomas* at Universidad Nacional de Educación a Distancia (UNED). *Focus:* Mathematics. 21 completed credits (ECTS). Year 2021/2022.
- *5th EACA International School on Computer Algebra and its Applications* at BCAM (Basque Center for Applied Mathematics) in Bilbao. 4 courses of 10 hours each. From 24th until 28th of February, 2020.
- *Escuela Jae de Matemáticas 2018 XI Edition* at ICMAT (Instituto de Ciencias Matemáticas) in Madrid. 3 courses of 10 hours each. From 18th until 29th of July, 2018.

## Technical expertise

- *Mathematical modeling:* solution of ODE's and PDE's, finite elements, implicit numerical integration, constrained dynamics, Lagrangian simulation, discrete differential geometry.
- *Optimization:* large and sparse QP's, inequality constraints, active-set methods, non-linear optimization, mixed-integer programming, fix and relax techniques.
- *Data-science:* clustering, ML models, data acquisition and processing from depth cameras and MoCap, topological reconstruction of point-clouds.

## Hobbies and others

- In my free time I enjoy playing jazz/classical guitar, doing handstands and wild camping in the mountains.