

# Kinetic Equations and Learning Control (KiLearn)

## Project Overview

The project explores new connections between Machine Learning and PDEs to solve complex real-world problems. It combines advanced mathematical modeling, data-driven methods, and interdisciplinary collaboration to achieve scientific and societal impact.

## Project Identity

**Acronym:** KiLearn  
**Duration:** September 2021 – May 2025  
**Funding program:** Retos de la Sociedad, convocatoria de 2020  
MINECO, Ministerio de Ciencia e Innovación  
**Subproject reference:** PID2020-112617GB-C22/AEI/10.13039/501100011033  
**Website:** <https://cmc.deusto.eus/kilearn/>

## OBJECTIVES

A coordinated research project between the University of the Basque Country (PI: Prof. Miguel Escobedo Martínez, Faculty of Science and Technology, UPV/EHU) and Fundación Deusto (PI: Prof. Enrique Zuazua Iriondo, Chair of Computational Mathematics, Fundación Deusto–Universidad de Deusto). Both teams work collaboratively on complementary objectives within a common research framework.



**1** Wave turbulence: Regular solutions for a three waves kinetic equation

**2** Fragmentation equation and protein division: Experimental design and Mellin inversion

**3** Asymptotic of Deep neural networks (NN)

- Sparsity in NNs
- General turnpike results for NN
- Variable-with NN
- Fractional and non-local NN

**4** Control and complex dynamics

- Model Predictive Control and the Random Batch Method (MPC-RBM) analysis of Neural Networks
- Control of multi-agents systems and population dynamic
- Optimal location of sensors and actuators
- Optimal design for the Hamilton-Jacobi-Bellman equation

**5** Computational platform

## RESEARCH TEAM SUBPROJECT PID2020-112617GB-C22



## RESEARCH RESULTS AND PROJECT COMMUNICATION DISSEMINATIONS

Key scientific achievements and outreach activities led by the project team.

### SCIENTIFIC ACHIEVEMENTS

**4** PhD degrees awarded

- "Analysis, control and singular limits for hyperbolic conservation laws" (2023)
- "Some control aspects in Mathematical Biology and Deep Learning" (2023)
- "Mathematical Patterns Associated with Genetic Recombination in HIV-1 and SARS-CoV-2 via Explainability in CNNs" (2025)
- "The art of cyber threat hunting: harnessing AI for addressing newfangled cybersecurity challenges" (2025)

**3** PhD theses in progress

- "From Optimal Control to Random and Neural Network Approximation"
- "Optimización de compra de energía eléctrica mediante IA"
- "Application of natural language processing algorithms for cyber security"

**43** High-impact scientific publications

<https://cmc.deusto.eus/kilearn/>

**1** Competitive ERC project awarded

<https://cmc.deusto.eus/codefel/>



**100%** Subproject objectives achieved

### COLLABORATIONS

**2** Direct collaborations with the Autonomous University of Madrid and Friedrich-Alexander-Universität Erlangen–Nürnberg

**2** Collaborations with socio-economic partners directly linked to the subproject

### WORKSHOPS & TRAINING ACTIVITIES

Kinetics and Machine Learning Workshop (Aug–Sep 2022) — organized by the project team

<https://www.benasque.org/2022pde/>

EECI-IGSC 2024: Control and Machine Learning Workshop (Croatia) — organized and attended by team members

<https://dcn.nat.fau.eu/events/eeci-igsc-2024/>

Machine Learning and PDEs Workshop (MLPDES25) — designed, organized and led by the project team

<https://dcn.nat.fau.eu/mlpdes25/>

### DISSEMINATION & OUREACH

Participation in 13 international conferences related to the project objectives

Project website providing access to news, publications, and resources

<https://cmc.deusto.eus/kilearn/>

Project blog for sharing research highlights and outreach content

KiLearn Toolbox, developed to facilitate learning and research in Machine Learning and PDEs

Active dissemination of research results through workshops, conferences, and collaborations

Promotion of knowledge transfer and interdisciplinary exchange within the international research community