

Mathematical Modeling and NUMerical simulation M²NUM



203.5



:03



204



20.6

The Project

The core of **M2NUM** project (managed by LMI EA3226, INSA Rouen) rests upon the **mathematical modeling of problems stemming from different applications.** The proposed new models are considered through the use of partial differential equations: this field of investigations receives a great deal of attention in Normandy and echoes back to the applications related to regional priorities, namely:

- Imaging sciences,
- Energy, wind power, approximation of wind velocity field,
- Road traffic, eco-mobility, embedded systems...,
- Physics and mechanics.

In this project, we have focused on various theoretical aspects (existence and uniqueness of a convergence results. solution. control. homogenization) as well as more applied ones (finite difference scheme based discretization, finite volume scheme based discretization or finite element based one) to design **algorithms** that are then implemented (with links with the "Centre Régional Informatique et d'Applications Numériques de Normandie" (CRIANN) which deploys high-performance computing infrastructures allowing for the processing of large volume dataset). The project objectives and priorities meet the expectations and criteria included in all strategic documents: Higher Education Regional Plan for Research and Innovation of Normandie, RIN Normandy Digital of Région Normandie, the ERDF operational program (in accordance with the Strategy for Research and Innovation based on a Smart Specialization). The project M2NUM is also in the spirit of the National Strategy for Research (Challenge 7 : Information society and communication and Challenge 8 : Innovative, integrative and adaptive societies).

The potential application fields concern:

- Artificial intelligence and Medical image
- processing, Renewable energy.

- **Deterministic and stochastic modeling**, control and reliability.

- Simulations and numerical performance, in

- connection with the CRIANN computing center.
- Data science Approximation of large datasets.

PhD grants, postdocs, research engineer grants and engineering courses were included in the funding plan

The **leverage effect of the project** is clear through selected ANR projects, recruitments, publications and communications, the organization of conferences and invitations from international researchers in Normandy.





GOALS

The project objectives are related to advances both in fundamental research and in technological research. The practical applications are clearly identified and the expected consequences of the project fall within :

- industrial applications,
- academic results,
- local, national and international developments

PUBLICATIONS & CONFERENCES

Three options are considered

- Articles in international journals,
- Communications in international conferences,
- Communications/seminars dedicated to students.

The M2NUM project has obtained a First Conference Prize at the National Conference Curves and Surfaces.

WORSKSHOPS

Every year, M2NUM conferences, workshops and special days are organized, with the participation of international researchers :

- > High-Performance Computing/ Parallel Computing days.
- Imaging Sciences days : in collaboration with the Fédérations de recherche normandes Normandie Mathématiques and Normastic, the GDR IG and the Labex AMIES.
- Road Traffic modelling workshops...

AN EARTH-OCEAN CONTINUUM



The Project e@lin with the Labex AMIES

Approximation of wind velocity field from Lagrange data

The project **e@lin** has been developed in line with the M2NUM project. This explorative project is funded by the Labex AMIES, in connection with the Compagnie du Vent (ENGIE Group). It proved to be an incentive to setting up the M2NUM project.



Agence pour les mathématiques en interaction avec l'entreprise et la société

AMIES (http://www.agence-maths-entreprises.fr)

Recent recruitments linked to this project @ LMI lab.

Antoine Tonnoir (Asst Pr. LMI INSA, 2016)

> **Zoé Lambert** (IR LMI INSA, 2019)

Maria Kazakova (Asst Pr. MCF LMI INSA, 2019)



ZOOM ON THE COMPANIES AND RESEARCH STRUCTURES THAT TRUST US

SIEMENS GAMESA

In relationship with the CORIA, numerical simulations of wake and whirl effects at the level of the blades

CEREMA Imaging from high resolution images and road traffic

CORIA Numerical simulations

IRSEEM (soon) Embedded systems

GDF SUEZ – La Compagnie du Vent Approximation of wind velocity field, data visualization

INRIA EPI MAGIQUE3D Seismic imaging and numerical simulations

LMI [Project holder] Imaging sciences, wind power, road traffic, modeling and numerical simulations Labex AMIES

e@olin, project related to the Compagnie du Vent

AREELIS (soon) Phase-change materials

ORANGE (soon) Thermal regulation of telecommunication cabinets

LITIS Medical imaging and embedded systems

LMAH PDE

LMRS Imaging sciences and phasechange materials

TOTAL3DSeismic imaging. InrelationshipwithWAGIQUE3DBordeauxSouth West)

Results of M2NUM project - http://mi2.insa-rouen.fr/~m2num	
International relations linked to the	➤ 6 PhD defense
project :	38 publications in international journals
	51 communications in international conferences
• UK : Cambridge University (Image	Leverage effect of M ² NUM project :
processing, Equipe C. Bibiane-Schönlieb).	• ECOS Nord project with Mexico
• USA : UC Los Angeles (L. Vese).	• ANR ICUB : LITIS lab., LE2I, Stereolabs, Peugeot PSA (Velizy)
• MEXICO : UNAM and CIMAT (M. Moreles,	 ANR Qute-HPC (2019-2022, including LMI members)
P. GONZAIEZ, D. CEIVAILES)	 ANR PRCI with Turkey (currently evaluated phasis II)
modelling)	 Research contract LMI / Siemens Gamesa (2019)
Turkov: PALL (L. Pada, imago processing)	• Emergenc-e Project (CH Evreux, AI, image processing :
• Turkey . BAO (L. Rada, intage processing)	segmentation and registration) – Call e-santé project
	 Industrial PhD CIFRE with CEREMA and Routes de France.

Laboratories and Normandy institutions involved in the project







Researchers of M²NUM project

- LMI (10) : I. Ciotir, A. Draux, R. El Assoudi, N. Forcadel, C. Gout, A. Hamdi, M. Kazakova, • C. Le Guyader, A. Tonnoir et A. Zakharova.
- LMRS (7) : I. Danaila et EDP team at LMRS. •
- LITIS (4) : S. Ainouz, A. Bensrhair, C. Petitjean, S. Ruan.
- CEREMA (2) : C. Fauchard, R. Antoine.
- CORIA (3): G. Lartigue, V. Moureau, P. Bénard.
- LMAH (1) : D. Manceau.
- IRSEEM (1) : R. Khemmar.

with PhD students, internships, research engineers, postdocs, Génie Mathématique student projects at INSA Rouen and external collaborators.



Medical imaging

Road traffic simulation

Micro faults detection







Supported by :

NORMANDIE

RÉGION

Wind field approximation & Turbulent flow around the wind turbine



INFORMATIONS:

Nicolas Forcadel (nicolas.forcadel@insa-rouen.fr) Christian Gout (christian.gout@insa-rouen.fr) Carole Le Guyader (carole.le-guyader@insa-rouen.fr) Ionut Danaila (ionut.danaila@univ-rouen.fr) Administration (INSA) : Sandra Hague - Christelle Vandepitte -Vincent Arnoux and Estelle Deilhou.

http:/lmi2.insa-rouen.fr/~m2num

INSA Rouen

Campus du Madrillet 685 avenue de l'Université - BP 08 76801 SAINT-ÉTIENNE-DU-ROUVRAY cedex, France www.insa-rouen.fr



