Miguel Alfonso Mendez

Current position and Personal information

Dr. Miguel A. Mendez, Associate Professor
Waterloosesteenweg 72
B-1640 Sint-Genesius-Rode, Belgium
tel: Office +32 (0)2 3599611
Mobile +32 (0)493 431175
mendez@vki.ac.be, ResearchGate Profile
Born: Maracay (Venezuela), 31th October 1987
Nationality: Italian

Research Interest

- Data processing algorithms and machine learning, including data-driven decompositions, model reduction, sparse sampling and dynamical system-based processing (Proper Orthogonal Decomposition, Koopman Theory, Resolvent Analysis), system identification, time series forecasting, artificial neural networks and deep learning.
- Experimental Fluid Mechanics, with a particular interest in optical techniques (PIV, High-Speed imaging, LIF, Light Absorption) and related image processing (PIV/PTV Interrogation, Dynamic Masking, Optical Flows, Feature Detection/Tracking and Pattern Recognition).
- Engineering modelling and control of fluid flows, including integral boundary layer models for liquid films, coating flows, stability analysis, oscillating shear layers, particle-laden flows, cavitation and flow control.

Education

- **2013-2018 , PhD in Engineering**, Universitè Libre de Bruxelles (ULB).
- **2012-2013 , MRes. in Experimental Fluid Mechanics**, von Karman Institute. Graduated with Honors and von Karman Prize for achieving the best overall result in the course work and research project.
- **2009-2012 , M.Sc. in Energy and Nuclear Engineering**, University of Florence (UniFI). GPA: 110/110 *cum laude*.
- **2010-2011 , 5th Year In Industrial Engineering**, Erasmus Exchange at the Higher Technical School of Engineering (ETSI), Seville. GPA: 8.9/10.
- **2006-2009 , B.Sc. in Mechanical Engineering**, University of L'Aquila (UniAq) GPA- 107/110.

Ongoing Teaching Activities

- **Data Driven Modal Analysis (12 hours, DDMA)**. Topics: Fundamentals of Galerkin Projections and Approximation theory, Modal Analysis of fluid flows, Proper Orthogonal Decomposition, Dynamic Mode Decomposition, Spectral PODs and Mutliscale Proper Orthogonal Decomposition.
- **Machine Learning for Fluid Dynamics (28 hours, MLFD)**. Topics: Fundamentals of Machine Learning, Fundamentals of Regression and Uncertainty Quantification, Gradient-based Optimization (Stochastic, Momentum Accelerated and Quasi-Newton), Bio-inspired Optimization (Genetic Algorithms and Particle Swarms), Genetic Programming, Regularized and Sparse Regression Methods, Gaussian Processes and Bayesian Optimization, Artificial Neural Networks and Deep Learning, Depp Learning for Turbulence

Modeling, Data Assimilation and Inverse Methods, Neural ODEs, Introduction to Autoencoders and Manifold Learning, Principal Component Analysis (PCA) and Multi-dimensional scaling, Kernel PCA and ANN-based autoencoders, Review of recent Manifold Learning methods (LLE, Isomaps and t-SNE), fundamentals of Ffow control and Reinforcement learning.

- **Hands on Machine Learning for Fluid Dynamics (32 hours)**. Same topic as MLFD with additional tutorial sessions on Python. Open to externals and given within the new VKI LS-like format 'hands on course'. Both the first edition in 2022 and the second edition reached >130 participants.
- **Tools for Scientific Computing (10 hours, TSC)**. Topics: Introduction to Python programming, Python for Scientific computing (with Object Oriented programming and parallel computing), Debugging, Good practices and Repositories. Tools for machine learning.
- **Fundamentals of Fluid Dynamics (20 hours, FFD)**. Topics: Conservation laws, constitutive laws and kinematics, boundary layers, similarity and scaling laws, compressible flows, special forms of the energy equation, vorticity and potential flows, waves in fluids, dynamical systems and linear stability analysis, transport phenomena and heat transfer.
- **Contribution to Introduction to Measurement Techniques (6 hours, IMT)**. Topics: Introduction to Measurement Systems, Image Processing, Particle Image Velocimetry.

Supervised PhDs

1. Barreiro, D. (2018-ongoing) *Numerical models for the simulation of gas-liquid flows in the galvanization process*, Ongoing PhD Thesis at UDC, University of A Coruña, Spain. Supported by Research contract with Arcelormittal.
2. Fiorini, D. (2018-ongoing) *Gas-Liquid Interface Dynamics in Non-Isothermal Sloshing: Experimental Analysis and Simplified Modeling*, Ongoing PhD Thesis at KU Leuven University, Belgium. Supported by a FWO grant.
3. Fiore, M. (2019-ongoing) *Thermal turbulence modelling for low Prandtl number fluid flows via data analysis and machine learning*, Ongoing PhD Thesis at UCL, Louvain University, Belgium. Supported by a FRIA grant.
4. Fabio, P. (2019-ongoing) *Feedback Control of Liquid Metal Coatings*, Ongoing PhD Thesis at Universitè Libre de Bruxelles (ULB), Belgium. Supported by a FRIA grant.
5. Poletti, R. (2019-ongoing). Real Time Optimization of bio-inspired wings using the deformable overset method and machine learning. PhD thesis at UGent, Ghent University. Supported by a FWO grant
6. Marques, P. (2021- ongoing), Thermo-fluid Dynamics of Cryogenic Liquid Storage: Modelling and Experiments, PhD Thesis at ULB, co-supervised with Prof. B. Scheid and Dr. Simonini. Supported by a FRIA grant.
7. van Den Berghe J. (2021-ongoing), Reconciling engineering models of ejectors with experiments and CFD using physics-informed machine learning, PhD Thesis at UCL. co-supervised with Prof. Yann Bartosiewicz. Supported by a FRIA grant.
8. Schena L. (2022-ongoing), Reinforced (Model) Based control of wind turbines and wind farms, PhD Thesis at VUB. co-supervised with Prof. Ian Helsen. Supported by a FWO grant.

9. Rigutto, D. (2023-ongoing). On the origin of localized defects in the deep coating, PhD Thesis at ULB. Co-supervised with Prof. Benoit Scheid. Submitted to FRIA
10. Ratz, M., Development of URANS data assimilation for 3D velocimetry with application to low Reynolds number propeller, PhD Thesis at ULB. co-supervised with Prof. Alessandro Parente Submitted by FRIA

Visiting PhDs

1. Kyriakidis, L. (2022-ongoing) *Investigation and Development of Efficient Optimization Methods for the Optimal Operation of Energy Conversion Systems* , Ongoing PhD Thesis at German Aerospace Center, Cottbus, Germany, co-supervised with Dr. Martin Bähr.
2. Tirelli, I. (2021-ongoing) *Physics Constrained Super Resolution of PTV data using Radial Basis Functions and Ensemble Averaging* , Ongoing PhD Thesis at PhD candidate of University Carlos III de Madrid, Leganés (UC3M), co-supervised with Prof. Discetti and Prof. Ianiro.
3. Tirelli, I. (2023-ongoing) *Modelling and Control of Sloshing Phenomena for new Generation Space Missions* , Ongoing PhD Thesis at PhD candidate of ISAE-SUPAERO, co-supervised with Prof. Sanfedino.

Research Masters (ongoing)

1. Randino, S. Reinforcement twinning for self learning models of wind turbine and wind farm control. Co-supervised with E. Gyllis , N. Coudou and L. Schena.
2. Hubay, C. Building of a reduced order model for wind loads on ships?. Co-supervised with M. Fiore and G. Glabeke
3. Federico, F. Active Thermodynamic Control of Cryogenic Tanks, co-supervised with J. Pinho
4. Kucuk, S. Probabilistic modelling of extreme weather events happening in North Sea, co-supervised with L. Schena
5. Novi, A. Simulation of boiling phenomena in cryogenic storage tank, co-supervised with S. Ahizi and A. Cantiani
6. Ruben Antonissen, Reinforcement twinning for variable pitch propellers- towards self learning models of propeller dynamics , co-supervised with Prof. Schram and A. Zarri

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Previous Projects (RMs and STPs)

1. Ratz, M. (RM 2022-2023) A Physics-constrained RBF framework for data assimilation in image velocimetry.
2. Rigutto, D. (RM 2022-2023) *Experimental analysis of dynamic menisci in dip coating*
3. Monteiro, F. (RM 2022-2023) *On Isothermal Sloshing for Space Applications: From a Ground-Based Experimental Characterisation to Microgravity Conditions*,
4. Zucchelli, U. (RM 2022-2023) *Augmented thermal turbulence model for low Prandtl numberflows with data-driven techniques*
5. Saccaggi, E (STP 2022-2023) Analysis and tuning of a data-driven algebraic model for the turbulent heat flux using Artificial Neural Networks

6. Randino S. (STP 2022-2023) Implementation and Testing of Wind Turbine Control using Machine Learning techniques
7. Angieri, T. (STP 2022-2023) Development of an Adjoint-based constraint framework for training ANN based LES closure
8. Ferreira, D. (STP 2022-2023) Experimental analysis of the contact angle influence in capillary flows
9. Zumbo, A. (STP 2022-2023) Thermodynamic Modeling and Data Assimilation of Cryogenic Liquid Storage Systems
10. Magnani F (STP 2022-2023) Active flow control of 3D coating undulation using Deep Reinforcement Learning
11. Bombardi, E. (STP 2022-2023) High-fidelity environment coupling CFD and multibody dynamics for the study of flapping drone aerodynamics
12. Barucca, M. (STP 2022-2023) Fluid-structure interaction solver for a flexible flapping wing
13. Ferrigno, A. (STP 2022-2023) Development of a Spectral Methods for the BLEW solver.
14. Brandi, G. (STP 2022-2023) Development and validation of an inverse method for heat transfer in mini cooling channels
15. Baierl, C. (STP 2021-2022) Experimental Analysis of an nonlinear sloshing
16. Schena, L. (RM 2020-2021). Control of a wind turbine using machine learning techniques. co uspervised with W. Munters, E. Gyllis and S. Buckhingam.
17. Calado, A. (RM 2021-2022), CFD-Driven, Self-Calibration of Reduced Order Models for Flapping Aerodynamics. Co-supervised with R. Poletti and L. Koloszar.
18. Sperotto, P. (RM 2021-2022) A meshless method to compute pressure fields from 2D and 3D PIV/PTV fields, co-supervised with Goncalo Cruz and Dr. Simonini.
19. Ahizi, S. (RM 2021-2022), Hybrid turbulence modelling with Machine learning. Co-Supervised with M. Fiore and L. Koloszar
20. Meneghella, D., (STP 2021-2022), Experimental analysis of linear and nonlinear sloshing in cryogenic fluids with damping estimation. Co supervised with Pedro Marques and Dr. Simonini
21. Giacopino, R. (STP 2020-2021), Development of Machine Learning Methods for Flow Control (T/N), Cosupervised with F. Pino
22. Gamba, G. (STP 2021-2022), Development of a Finite Volume Code for Simulating Liquid Films Instabilities in hot-Dip Galvanization. Co-supervised with F. Pino
23. Delbeque, L. (STP 2021-2022) Modelling of Supersonic Ejectors using Machine Learning and 1D Gas Dynamics, co-supervised with J. van Den Berghe.
24. Rigutto, D. (STP 2021-2022), Scaling Analysis and Design of the Laboratory Model of a Hot Dip Galvanizing Line. Co-Supervised with M. Delsipee
25. Monteiro, F. (STP 2021-2022), Cryogenic non-isothermal sloshing for space application. Co supervised with Pedro Marques and Dr. Simonini

26. Fonsdituri, G. (STP 2021-2022), Analysis and tuning of a data-driven algebraic model for the turbulent heat flux using Artificial Neural Networks. Co supervised with M. Fiore and L. Koloszar
27. Fiore, M. (STP 2021-2022), Experimental characterization of subcooled flow boiling in 3D printed minichannels, Co Supervised with M.T. Scelzo
28. A. Scarponi(STP 2021-2022), Development of modeling tools for in-space refueling strategies, Co Supervised with A. Simonini and J. Pinho
29. Schena, L, ARO 2020-2021, Flow Control of Liquid Metal coatings.
30. Merhaben, C., (STP 2020-2021) Advanced Surrogate Modeling of Gas-Surface Interaction for Hypersonic Re-entry, co-supervised with Dr. A. Turchi and Prof. T. Magin.
31. Sperotto, P. (STP 2020-2021), A Meshless Method to Measure Pressure Fields from Image Velocimetry via Radial Basis Functions, co-supervised with Prof. Pieraccini. Master Thesis at Politecnico di Torino, Italy.
32. Conti, L., (STP 2020-2021), Analysis of non-linear wave propagation mechanisms in a Mach 3 jet using time-resolved schlieren data and machine-learning techniques, co-supervised with Prof. Schram and Prof. Pieraccini. Master Thesis at Politecnico di Torino, Italy.
33. Ivanova, T. (RM 2020-2021), Physics-based and Data-driven Modelling of Nonlinear Waves in Liquid Films. co-supervised with F. Pino.
34. Sala, R. (RM 2020-2021), Nowcasting for wind turbines applications with a machine-learning approach. Co-supervised with Dr. Buckingham.
35. Marques, P. (RM 2020-2021), Experimental Characterization and Modeling of non-Isothermal Sloshing. Co-supervised with Ir. Peveroni and Dr. Simonini.
36. Van Der Berghe, J. (RM 2020-2021), Transient Analysis of Supersonic Ejectors using 1D Gas Dynamics and Deep Learning. Co-supervised with Dr. Diaz.
37. Gkimisis, L. (RM 2020-2021), Data-Driven Modelling for Space Debris Degradation. Co-supervised with Dr. Diaz, Dr. A. Turchi and Prof. T. Magin
38. Ratz, M. (STP 2020) Experimental Analysis of the Contact Line Dynamics using Optical Techniques and Inverse Methods, STP2020, co-supervised with Prof. Cierpla. Master Thesis at TU Ilmenau, Germany.
39. Deseau, J. (STP 2020) Feedback Control of Liquid Sloshing in Cylindrical Reservoirs, STP2020, co-supervised with Prof. Johan Steelant. Master Thesis at KU Leuven.
40. Desmet, M. (STP 2020) Reinforcement Learning for Active Flow Control, co-supervised with F. Pino. STP 2020.
41. Anfuso, E. (RM 2019-2020), An investigation of the dynamics of plasma jet flows using data driven modal analysis, co-supervised with Simon Demange, Andrea Fagnani, Francisco Torres-Herrador.
42. Kovalcsik, A. (RM 2019-2020), Experimental Analysis of Dynamic Contact Lines, co-supervised with Domenico Fiorini and Alessia Simonini.

43. Marques, P.A. (STP 2019-2020), Model-based Scaling Laws for the Non-Isothermal Sloshing Problem, co-supervised with Alessia Simonini and Prof. L. Eça. Master Thesis at Instituto Superior Técnico de Lisboa, Portugal.
44. Lorenzo, S. (STP 2019-2020), Implementation and Comparative Analysis of Machine Learning methods for the closed-loop control of fluid flows, co-supervised with Fabio Pino and Prof. Pieraccini. Master Thesis at Politecnico di Torino, Italy.
45. van den Berghe, J. (STP 2019-2020), Neural Network Models of Turbulent Wall Pressure Spectra, co-supervised with Joachim Dominique and Prof. M. Runacres. Master Thesis at Vrije Universiteit Brussel, Belgium.
46. Theo, K, Implementation of iterative Multigrid and Window Deformation Schemes in the OpenPIV Python Package (STP), VKI SR 2020-05.
47. Moreira Da Luz, Comparison between CFD and experimental results of the sloshing rising wave in a microgravity environment (STP), Master Thesis at Linköping University VKI SR 2019-36.
48. Ninni, D., MODULO: A package for Multiscale Proper Orthogonal Decomposition (ARO), TN223-2020.
49. Ninni, D., Development of a software package for the integral modelling of the jet wiping process, Master Thesis at the University of Bari (STP), Italy, STP SR 2019-22.
50. Senman, O., Instantaneous PIV & PTV measurements in dusty highly-swirled flow (RM), VKI PR 2018-18.
51. Mutafchiev, M., Low Order Modeling of Numerical and Experimental Data (STP), VKI SR 2017-42.
52. Barreiro, D., URANS-VOF Simulation of the Free Drag-out and the Jet Wiping Process (STP), VKI SR 2017-27.
53. Enache, A., Flow control in the jet wiping process (RM), VKI PR 2017. Confidential report.
54. Paoli. L., Numerical Simulation and Development of a Flow Control Method for Oscillating Impinging Gas jets (STP), Master Thesis at the University of Pisa, Italy, VKI SR 2017-34.
55. Zohreh, A.,N., Transposition of a 1D Model for Oscillating Jet Flow to Wind Turbine Wake Meandering (STP), VKI SR 2017-30.
56. Resende, D., Time-Resolved PIV and flow visualization laboratory for impinging jet flows(STP), VKI SR 2017-11.
57. Zdybal, K., POD and DMD Decomposition of Numerical and Experimental Data (STP), VKI SR 2016-28.
58. Dumoulin, D., Numerical Characterization of an Oscillating Impingig Jet Flow (STP), VKI SR 2016-2.
59. Di Nardo, M., Numerical characterization of confinement-driven jet flow instabilities (STP), VKI SR 2016-06.
60. Scelzo, M.T., Flow Control of Confinement-Driven Oscillation of Impinging Jets (RM),VKI PR 2016-24.

61. Scarpeccio, I., Experimental characterization of confinement driven instabilities of a slot jet impinging on a flexible membrane (STP), Master Thesis at the University of Ancona, Italy, VKI SR 2015-49.
62. Adelchi, J., Wire Coating (RM), VKI PR 2015.
63. Nemeth, L., Experimental Investigation of Falling Liquid Films (STP), Master Thesis at the Budapest University of Technology, Hungary, VKI SR 2015-09.
64. Biler, H., Characterization of Gas Jet Impinging on Liquid Film (STP),VKI SR 2014-24.
65. Martinez, H.A., Experimental Characterization of a Turbulent Plane (STP), VKI SR 2014-01.

Invited Seminars and Keynote Lectures

- Keynote lecture at 12th Ankara International Aerospace Conference link September 2023
- *Lectures on Machine learning for Fluid Dynamics* at the FJOH Summer school "Digital Twins> New Horizons in Nuclear Reactor Design and Optimization" link September 2023
- *Seminar at Extrality* link, 5 September 2023
- *Data Driven Decompositions in Fluid Mechanics*, a short course given at the American Univesity of Beirut, Center for Advanced Mathematical Studies (CAMS). Given on February 23 and 24 2022. Invited by Prof. Najem. link1 link2
- *Analyses modales dynamiques - multi-èchelles*, invited lecture at the JT51 - Postraitement des donnèes, organized by the Association Francophone de Vèlocimètrie Laser (AFVL) on the topic "Postraitement des donnèes". 17 novembre 2022 at CNRS Bellevue cenetr, Meudon, France" link
- *Comparative analysis of machine learning methods for active flow control*, Seminar at the FLOW group, KTH, invited by Prof. Vinuesa, September 22nd, 2022. Stockholm, Sweden. link
- *La Décomposition Modale pour l'Analyse de Visualisations d'écoulements.* Keynote lecture at the Congrés Francophone de Technique Laser (CFTL), Leuven on 12-16 September 2022. link
- *Perspectives on Machine Learning in Fluid Dynamics.* Seminar at the Campus Industrial, Universidade Da Coruña, invited by Prof. A. Gosset, September 6th 2022. Ferrol, Spain.link
- *Comparative analysis of Machine leanrning methods for active felow control*, talk at the workshop *Challenges and Benchmarks for quantitative AI in Complex Fluids and Complex Flows*, invited by Prof. Biferale, July 6-8 2022, Rome. Italy. link
- *From Multiscale Modal Decompositions to Machine Learning for Fluid Dynamics.* AE590 Seminar from the Aerospace Engineering Department, November 16, 2020, invited by Prof. Villafane, Ilinois University, the US.
- *The von Karman Institute for Fluid Dynamics.* Lunch Lectures from the AWEP Society, December 14, 2020, invited by AWEP Society from the TU Delft, the Netherlands.

- *Generalized and Multiscale Modal Decompositions for Fluid Dynamics.* Southampton Aerodynamics & Flight Mechanics seminars, October 23, 2019, invited by Prof. Lasagna from the University of Southampton, the UK.
- *An Introduction to Multiscale Data-Driven Modal Analysis and Model Reduction*, Seminar on Data Processing, February 22, 2019, invited by Prof. Ianiro, Univ Carlos III, Madrid, Spain.
- *Multiscale Data-Driven Modal Analysis*, Seminar on Data Analyis, February 7, 2019, LadHyx, invited by Prof. G.Amselem, Université Paris Saclay, Paris, France.
- *Multiscale Data-Driven Decompositions*, TIPs seminars, TIPS Laboratory (ULB), invited by Prof. P. Colinet, 8 December 2017, Bruxelles.
- *Multiscale Modal Analysis of Experimental and Numerical Data*,Keynote Lecture at the Experiments in Fluid Mechanics (ExFM) conference 23-24 October 2017, invited by Prof. J. Rokicki. Institute of Aeronautics and Applied Mechanics, Warsaw University, Poland.
- *Image Processing by POD Filtering*, Ledith Seminar, Multiphase Fluids, March 20, 2017, von Karman Institute.

Service and event organization

Organizer, director and main lecturer of the Hands on Course on Machine Learning 2022 and 2023 (Link. Both events reached >130 participants)

Co-organizer and co-director of the VKI lecture series Fundamentals and recent advances in Particle Image Velocimetry and Lagrangian Particle Tracking 2021 (Link, ≈ 60 participants)

Co-organizer of the European Coating Symposium 2021 (Link)

Co-director of the VKI Lecture Series Introduction to Measurement Techniques 2020.

Organizer and director of the VKI Lecture Series 'Machine Learning for Fluid Dynamics' (the largest LS in the history of VKI, with >230 participants) 2020 (Link). The lectures note have been published as a book by Cambridge University Press: Link.

Member of the European Coating Symposium (ECS) Scientific Committee `http://www.european-coating-symposium.eu/committee.html`

Reviewer for Journal of Fluids Mechanics, Experimental Thermal and Fluid Science, Physics of Fluids, Chemical Engineering Science, International Journal of Multiphase Flow, Industrial & Engineering Chemistry Research, Journal of Coatings Technology and Research and European Journal of Operational Research.

Awards and Fellowships

- *Emerging Leader 2022*, awarded by the journal Measurement Science and Technology (link)
- *Outstanding Paper Award 2020* by the journal Measurement Science and Technology (link
- *Solvay PhD Thesis Award* for research excellence. Awarded during the Solvay Awards ceremony (see link1, link2)

- *AFVL PhD Thesis Award* for the contributions to Laser diagnostics in fluid mechanics. Awarded at the CFTL 2018 (see link)
- *Best Oral Presentation* at the Annual VKI PhD Symposium 2015-2016.
- *Best Oral Presentation* of the Experimental Fluid Mechanics Conference 2015.
- *FNRS-FRIA* grant Fellowship 2013-2017.
- *von Karman Prize* for best overall result in course work and research project in the RM 2012-2013.

Panel member in academic examinations

- Member of the PhD evaluation jury of Kamila Zdybal, PhD defense at Université libre de Bruxelles. Defended on 6th March 2023.
- Member of the PhD evaluation jury of Mushin Akkart, PhD defense at Ghent University. Defended on 3rd October 2023.
- Member of the PhD evaluation jury of Sagar Adatreo, PhD defense at TU Delft. Defended on 27th November 2023.