

# Lorenzo Tieghi

## Curriculum Vitae for Publication

Curriculum Vitae ai fini della pubblicazione

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### Education

- 2020 **Ph.D. in Energy and Environment (3 years course)**  
**Sapienza University of Rome**  
Final thesis on: *"Artificial Intelligence and Turbulence Modeling. Development of data-driven tools for RANS models in Turbomachinery Flows"*.  
Final grade: Excellent  
Supervisor: Prof. Alessandro Corsini.  
Co-Supervisor: Prof. Giovanni Delibra.
- 2016 **MSc in Mechanical Engineering (2 years course)**  
**Sapienza University of Rome**  
Final thesis on: *"Validation of URANS model in open source CFD code – analysis of secondary flows in linear compressor cascade"*.  
Final grade: 111/110  
Supervisor: Prof. Alessandro Corsini.  
Tutor: Dr. Giovanni Delibra.
- 2014 **BSc in Mechanical Engineering (3 years course)**  
**Sapienza University of Rome**  
Final thesis on: *"Build-in obsolescence in common electric equipment"*.  
Final grade: 105/110  
Tutor: Prof. Lorenzo Fedele.

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### Research Experience

- 2020-2023 **Postdoctoral researcher**  
**Sapienza University of Rome**  
The research activities belong to the *"AI powered modelling of multi-scale effects in turbomachinery and energy conversion systems"* - SSD ING-IND/09 research programme.  
Main research topics:
- Numerical simulations of wind farms and turbines: wake interaction, aeroacoustics, layout optimization
  - Machine-learnt modelling of turbulence and turbulent flows
  - Data-driven methods for fluid flow investigation and analysis
  - Numerical simulations of turbomachinery flows and solutions for flow control
- 2021-2022 **Visiting researcher, On the effect of the surge motion in wind turbine blades**  
**Lancaster University, UK**  
This research has been conducted as a visiting researcher, under the supervision of Prof. Sergio Campobasso and funded by the HPC Europa3-Programme. During this period, high fidelity numerical simulations were carried out in OpenFOAM, exploiting the computing resources of ARCHER2 UK national supercomputing center to characterize the wake dynamic of 10 MW DTU floating wind turbine. The influence of the surge motion on the wake dynamics was characterized through a kinematic comparison with the stationary turbine.
- 2020-2021 **Visiting researcher, Machine-learnt detection of vortex induced noise sources in turbomachinery flows**  
**Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany**

This research has been conducted as a visiting researcher, under the supervision of Prof. Stefan Becker and founded by the Bavarian Research Foundation. Unsupervised machine-learning techniques were applied to automatically detect the sources of noise emissions in a axial low-speed fan. The numerical database was generated through a LES approach and validated against experimental measurements. The derived models were additionally applied to have a deeper understanding of the physics underlying such phenomena.

2019-2020 **Research Scholarship on Flooding Forecasting and Alarm**

**Department of Mechanical and Aerospace Engineering, Sapienza University of Rome**

In collaboration with Prof. Cioffi, from DICEA department, Sapienza University of Rome and e-Geos company. The aim was to build a system of alarm for the St. Lucia Island in the East Caribbean, in presence of elevate rainfall and hurricanes. The activity was focused on two main aspects, both implemented in a run-time operative framework:

- *Development of a solver for linearized equation to describe hurricane behaviors.* The solver, implemented in Python, solve the field of motion of the hurricane returning an anisotropic rainfall field. It has been validated against past events.
- *Development of a machine-learning surrogate model for Shallow Water equations.* A multi-layer perceptron was trained on a huge database of simulations of spatially- and time-varying rainfall. Innovative techniques for images and sequences processing were applied to reduce the computational cost of the operations.

2016-2019 **Ph.D. Fellow**

**Department of Mechanical and Aerospace Engineering, Sapienza University of Rome**

● **Turbomachinery-related activities:**

- Development, assessment and validation of design numerical tools based on synthetic models (e.g. axisymmetric algorithms as the actuator disk), for fast performance analysis of industrial fans and turbomachinery
- Implementation and validation of hybrid LES/RANS approach in synthetic models for fan blade design
- Study on the effects of spinner cone modeling and polar curve sensibility in synthetic blade models for axial fans
- Study and assessment on the application of advanced URANS and hybrid LES/RANS turbulence models to advanced solutions for noise control in industrial fans
- Development, implementation and validation of a meta-model for lift and drag coefficient for reversible blade profiles in a cascade configuration

● **Machine-learning related activities:**

- Development, validation and implementation of a multi-layer perceptron neural network-based wall function for steady simulations
- Application of machine learning to near-wall modeling of TKE. A feed-forward neural network has been trained to perform run-time computation of turbulent kinetic energy in a CFD code, to enhance standard wall treatments. Presented at ASME Turboexpo 2019 and awarded with journal-quality.
- Application of machine learning to near-wall modeling in rotating passages. Boundary layer distortion caused by the interaction with rotating in pipe flows and diffusers have been investigated through CFD simulation. An alternative wall treatment was derived and validated in the run-time computation in OpenFoam.
- Application of machine learning to secondary flows in square ducts. Secondary flows physics near corners are incorrectly represented in RANS approach. A machine learning approach to predict Reynolds stress tensor components is currently under development.

2015-2016 **MSc Thesis**

**Department of Mechanical and Aerospace Engineering, Sapienza University of Rome**

- Development and validation of advanced turbulence models for industrial CFD and turbomachinery:
  - URANS models
  - LES models

- LES/RANS models
- Implementation and validation of an advanced URANS model in OpenFOAM
- URANS and Hybrid LES/RANS study of turbulent flows in popular 2D test cases (periodic channel flows, periodic hills)
- URANS and Hybrid LES/RANS analysis of secondary flows in a linear compressor cascade with an accelerating endwall

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## Researcher activities as principal investigator

- 2021-Today **Development of advanced flow control solutions for turbomachinery:** this ongoing project is carried out in cooperation with the Friedrich-Alexander-Universität Erlangen-Nürnberg. The project aims to characterize through a parametric study the effects of leading-edge serration and blade sweeping on both aerodynamic and acoustic performance of low-speed axial fans. Computations are performed using the resources allocated by CINECA ISCRA-C HPC programme.
- 2022-Today **Development of data-driven methods in medical applications:** this project was carried out in cooperation with the Dermatology doctorate school of Sapienza University of Rome. In this work, a large dataset of medical records was first analyzed and later exploited to build a support vector machine regressor to determine the probability of occurrence of severe dermatological diseases.
- 2021-Today **Development of surrogate methods for the simulation of floating wind turbines and wind farms:** this research activity was aimed to developing, optimizing and testing the actuator line method for wind turbine simulation in OpenFOAM. In particular, the actuator line method has been exploited to study of the interaction between wakes of offshore wind turbines. The actuator line has been later modified to take in account of complex body motion to simulate the dynamic of floating wind turbines.
- 2021-2022 **Development of data-driven methodologies to compress experimental measurements and numerical simulations of gas turbine rotors with complex geometries:** in particular, the analysis has been focused on the pressure distribution and heat transfer coefficient in blades modified with tip contouring. A methodology to map the tip shape with the thermo-aerodynamic performance of the blade has been developed and tested. It is an ongoing cooperation with Von Karman Institute.

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## Researcher activities as participant

- 2022-Today **Development of innovative data driven methods for small energy communities:** this ongoing project aims to the analysis and forecast of electricity and heat consumption of Italian energy communities. In particular, the research is focused on the compression in latent spaces of large dataset of power demand curves, through the combination of Variational Auto-Encoders and Feed-Forward neural networks. This project is funded by the Italian Regional Government.
- 2022 **Numerical simulation of urban atmospheric flows:** this research is part of the UPPER initiative, founded by European Found for Regional development. In the initial part of the research, the statistical distribution of wind and temperature in the city of Latina, Italy, based on historical data, was carried out. This analysis was used to determine the initial condition for the numerical simulation of the air flow in the city. The simulations of the urban flows were carried out in OpenFOAM in different scenarios that are potentially dangerous for the population, highlighting the areas of the city with the highest temperature.
- 2018-Today **Numerical simulation of large low speed axial fans in air cooled condensers:** this research activity was originally part of the MinwaterCSP Horizon 2020 program. The results, derived over several years of research, were used for the design, optimization and control of large fans in air cooled condensers. The latest stages of this activity are focused on the characterization of the effects of inflow distortion and interference with the installation facility on the performance of the fan.

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## Industrial research activities

- 2022 **Development of machine-learnt methods for hydrological flows:** in cooperation with e-Geos company. The neural network based framework previously developed and validated for the modelling of St. Lucia Island flash floods is currently under development to be applied for the protection of the archaeological site of Sibari, Italy. The training database has been built using a Shallow Water equation in-house solver and the machine learning framework has been based on Convolutional and LSTM neural networks.
- 2021-Today **Development of machine learning tools for risk assessment in gas turbine enclosures:** this ongoing founded cooperation with Baker Hughes is focused on the safety assessment of Gas Turbines. In the first works, neural network-based tools were applied for the assessment of dangerous zones in gas turbine enclosures in presence of methane leaks. In the latest studies, the interaction between leaks of mixed fuels of hydrogen and methane and the ventilation system of the enclosure has been analyzed. A machine learning modelling of the resulting under-expanded jets is currently under development.
- 2018-Today **Design, optimization and validation of turbomachineries:** the ongoing research topic involves the analysis of incompressible fluid machineries, pumps, axial fans, Wells, tidal and wind turbines. The design and analysis of the performance has been carried out using numerical tools with different level of accuracy, ranging from quasi-3D in-house code to Large Eddy Simulations, in cooperation with several industrial partners, as systemAir fans, EBARA pumps, Fieni.

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## Teaching activities

- 2022 Teacher of the "Turbomachinery" course, MSc in Mechanical Engineering, Sapienza University
- 2019-2022 Teacher of the "Computational Thermo-fluids analysis in fluid machinery" course, MSc in Mechanical Engineering, Sapienza University
- 2020 Tutor in the "Turbomachinery" course, MSc in Mechanical Engineering, Sapienza University
- 2020 Tutor in the "Computational Thermo-fluids analysis in fluid machinery" course, MSc in Mechanical Engineering, Sapienza University
- 2019-today Supervisor of Ph.D. fellows
- 2017-today Supervisor of students for master degree thesis

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## Seminars, workshops and other teaching activities

- 2023 Tutorial "*Normalization and Preprocessing of CFD Data for Machine Learning Algorithms*", ASME Turboexpo 2023 conference - Boston
- 2022 Teacher of Eureka-GIE Course, "*Pre-bachelor sustainability online course*", a CIRPS initiative
- 2022 Teacher of the lecture series on sustainable energy for the Italian national program "*Paths for transversal skills and for orientation*"
- 2022 Tutorial "*Unsupervised learning methods for design space exploration*", ASME Turboexpo 2022 conference - Rotterdam, Netherlands
- 2020 Tutorial "*Machine learning in engineering applications: data-driven methods for fluid dynamics*", ASME Turboexpo 2020 conference - Virtual Conference
- 2018 Speaker at Big Data & Turbomachinery workshop, CMFF18 conference - Budapest, Hungary

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## Conferences & workshops

- 2022 Panelist at Eolica Mediterranean 2022, Rome, Italy
- 2022 Presenting author at CMFF22 conference - Budapest, Hungary
- 2022 Attendance of WWEC 2022 conference, Rimini, Italy
- 2022 Presenting author and session chair at ASME Turboexpo 2022 conference - Rotterdam, Netherlands
- 2022 Participant and moderator at OWEMES 2022 workshop
- 2020 Presenting author, session chair at ASME Turboexpo 2020 conference - Virtual Conference

- 2019 Presenting author and session chair at AMSE Turboexpo 2019 conference - Phoenix, USA
- 2018 Presenting author and session co-chair at AMSE Turboexpo 2018 conference - Oslo, Norway
- 2018 Presenting author at AMSE Turboexpo 2017 conference - Charlotte, USA
- 2018 Presenting author at ERCOFTAC Italian Pilot Center, Lecce, Italy
- 2018 Presenting author at CMFF18 conference - Budapest, Hungary
- 2017 Attendance of PhD summer school, Pisa, Italy

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## Awards

- 2020 Winner of the best paper award at Turboexpo 2020 for "*A machine-learnt wall function for rotating passages.*"
- 2020 Winner of the the Alfano and Caputo prize for the Italian Thermodynamic Association
- 2019 2nd Place in the T-TeC, Telespazio Technology Contest

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## Activities as organizer

- 2022-today Vanguard chair in Fans and Blowers committee - ASME Turboexpo conference
- 2022 Associate editor for Journal of Basic & Applied Science

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## Relevant research skills

- Advanced knowledge of numerical methods for Computational Fluid Dynamics (CFD):
  - *Finite Elements*
  - *Finite Volumes*
  - *Discretization techniques*
  - *Steady-state and time-advancing solutions*
- Advanced knowledge of OpenFOAM and StarCCM software for CFD
- Advanced knowledge of advanced turbulence modelling
- Programming language experience:
  - *Advanced programmer of Python 3.x and Matlab*
  - *Advanced programmer of C++*
  - *Advanced knowledge of Fortran 77*
- Advanced knowledge of APIs for programming language interface: C-Python *Cython*, C++-python *C\_API* and fortran-Python *forpy*
- Advanced knowledge of initial data exploration and the main libraries exploited for this purpose
- Advanced knowledge of machine-learning libraries (Tensorflow, SciKit-learn, Keras, Pytorch)
- Advanced knowledge of post-processing and analysis of CFD results and the major software used to this aims
- Advanced knowledge of both Linux and Windows environments
- Advanced knowledge of Pointwise, Tecplot, Paraview, Matlab, MS Office,  $\LaTeX$ , Ansys

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## HPC Experience

- 2022 CINECA ISCRA-C call, Marconi 100, agreement nr. HP10CU62XI
- 2022 EuroHPC development call: Karolina IT4I innovation center, agreement nr. DD-22-61
- 2021 HPC-Europa3 Programme: ARCHER2 UK National Supercomputing Service, agreement nr. 730897
- 2020-2021 Erlangen Regional Computing Center (RRZE), agreement nr. PDOK-96-20

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## Bibliometric indices

Total Impact factor: 9.35  
Total Citations: 36  
Average Citations per Product: 1.9

Hirsch (H) index: 4  
Normalized H index: 0.7

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## Publications

- 2017 Tieghi L.  
*"Analysis of secondary flows in linear compressor cascade during transient operations with elliptic-relaxation-based U-RANS closure."*  
Student poster for IGTI ASME TurboExpo 2018
- 2017 Angelini G., Bonanni T., Corsini A., Delibra G., Tieghi L., Volponi D.  
*"Optimization of an axial fan for air cooled condensers."*  
ATI 2018 conference
- 2018 Angelini G., Bonanni T., Corsini A., Delibra G., Tieghi L., Volponi D.  
*"Effects of fan inflow distortions on heat exchange in air-cooled condensers. Unsteady computations with synthetic blade model."*  
ASME GT2018-76518
- 2018 Angelini G., Bonanni T., Corsini A., Delibra G., Tieghi L., Volponi D.  
*"A metamodel for deviation in 2D cascade with variable stagger and solidity and reversible profiles."*  
ASME GT2018-76363
- 2018 Angelini G., Bonanni T., Corsini A., Delibra G., Tieghi L., Volponi D.  
*"On surrogate-based optimization of truly reversible blade profiles for axial fans."*  
Issue to Design
- 2018 Angelini G., Volponi D., Wilkinson M., Spuy J., Bonanni T., Tieghi L., Delibra G., Corsini A., Backstrom T.  
*"Noise reduction of a large axial flow fan for CSP air-cooled condenser."*  
Proceeding to FAN 2018
- 2018 Corsini A., Delibra G., Sheard J., Tieghi L.  
*"The use of serrated leading edge for inflow conditioning in centrifugal fan."*  
Proceeding to FAN 2018
- 2019 Angelini G., Corsini A., Delibra G., Tieghi L.  
*"Exploration of axial fan design space using a metamodel for aerodynamic properties of NACA 4-digit profiles."*  
ASME GT2019-91588
- 2019 Angelini G., Corsini A., Delibra G., Giovannelli M., Lucherini G., Minotti S., Rossin S., Tieghi L.  
*"Meta-modelling of gas-leak in gas turbine enclosures."*  
ASME GT2019-91198
- 2019 Angelini G., Corsini A., Delibra G., Giovannelli M., Lucherini G., Minotti S., Rossin S., Tieghi L.  
*"Identification of poorly ventilated zones in gas-turbine enclosures with machine learning."*  
ASME GT2019-91199
- 2019 Angelini G., Corsini A., Delibra G., Tieghi L.  
*"Exploration of Axial Fan Design Space with Data-Driven Approach."*  
International Journal of Turbomachinery Propulsion and Power
- 2020 Angelini G., Corsini A., Delibra G., Giovannelli M., Lucherini G., Minotti S., Rossin S., Tieghi L.  
*"Prediction of ventilation effectiveness for LM9000 package with machine learning."*  
ASME GT2020-14916
- 2020 Tieghi L., Angelini G., Corsini A., Delibra G.  
*"Assessment of a machine-learned adaptive wall-function in a compressor cascade with sinusoidal leading edge."*  
Journal of Engineering for Gas Turbines and Power - GTP-20-1311

- 2020 Tieghi L., Delibra G., Corsini A., Van Der Spuy J.  
*"Numerical investigation of CSP air cooled condenser fan."*  
 E3S Web of Conferences. Vol. 197. EDP Sciences, 2020.
- 2021 Tieghi L., Corsini A., Delibra G., Tucci F.  
*"A machine-learned wall function for rotating passages."*  
 Journal of Turbomachinery - TURBO-20-1368
- 2021 Van Der Spuy J., Tieghi L., Corsini A., Delibra G., Louw F., Zapke A., Els D., Meyer C. J.  
*"Evaluation of the 24 Ft. Diameter Fan Performance in the MinwaterCSP Large Cooling Systems Test Facility."*  
 Proceedings to ASME Turboexpo 2021
- 2021 Tucci F., Delibra G., Tieghi L., Corsini A.  
*"Cascade With Sinusoidal Leading Edges: Identification and Quantification of Losses With Unsupervised Machine Learning."*  
 Proceedings to ASME Turboexpo 2021
- 2022 Castorrini A., Tieghi L., Barnabei V., et al.  
*"Wake interaction in offshore wind farms with mesoscale derived inflow condition and sea waves"*  
 IOP publishing
- 2022 Tieghi L., Becker S., Corsini A., Delibra G., Schoder S., Czwielong F.  
*"Machine-learning clustering methods applied to detection of noise sources in low-speed axial fan"*  
 Turbo Expo: Power for Land, Sea, and Air (Vol. 86021, p. V005T10A008). American Society of Mechanical Engineers.
- 2022 Di Fraia M., Tieghi L., Magri F., Caro G., Michelini S., Pellacani G., Rossi A.  
*"Machine learning algorithm applied to trichoscopy for androgenic alopecia staging and severity assessment"*  
 Dermatology Practical & Conceptual

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## Under Review

- 2022 Cioffi F., Tieghi L., Giannini M., Pirozzoli S.  
*"Flash Flooding Prediction Through Neural Networks"*  
 Under review, submitted to Journal of Applied Water Engineering and Research
- 2022 De Girolamo F., Tieghi L., Delibra G., Barnabei V., Corsini A.  
*"Surrogate modelling of aeroacoustics of NM80 wind turbine"*  
 Under review, proceeding to European Turbomachinery Conference 2023, Budapest
- 2022 Tucci F., Tieghi L., Delibra G., Barnabei V., Corsini A.  
*"Unsupervised Learning for High-Fidelity Compression of Large Experimental Dataset: an Application to HPT Blade Tip Contouring"*  
 Under review, proceeding to European Turbomachinery Conference 2023, Budapest
- 2022 Castorrini A., Barnabei V., Tieghi L., Corsini A.  
*"Investigation of passive morphing blades for Wells turbines using computational fluid-structure interaction"*  
 Under review, proceeding to European Turbomachinery Conference 2023, Budapest
- 2022 Tieghi L., Czwielong F., Barnabei V., Ocker C., Becker S., Delibra G., Corsini A.  
*"Aerodynamics and Aeroacoustics of Leading Edge Serration in Low Speed Axial Fans With Forward Swept Blades"*  
 Under review, proceeding to ASME Turboexpo 2023, Boston
- 2022 Morici V., Castorrini A., Barnabei V., Tieghi L., De Girolamo F., Corsini A.  
*"Investigation of Yaw Controlled Wind Turbine Wakes and Rotor Loads Using a Fluid-Structure Interaction Approach Based on the Actuator Line Method"*  
 Under review, proceeding to ASME Turboexpo 2023, Boston
- 2022 Cerbarano D., Minotti S., Tieghi L., Delibra G., Lo Schiavo E., Corsini A.

*"Characterization of High Pressure Hydrogen Leakages"*

Under review, proceeding to ASME Turboexpo 2023, Boston