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Supervisor Expression of Interest
MSCA - Marie Sklodowska Curie Action - (PF) Postdoctoral Fellowship 2024

Supervisor name: Gisella Tomasini – co-supervisor Daniele Rocchi

Email address: gisella.tomasini@polimi.it
Link "Pagina docente":
https://www.mecc.polimi.it/en/research/faculty/prof-gisella-tomasini
https://mecc.polimi.it/ricerca/personale-docente/prof-daniele-rocchi

Department Name: Department of Mechanical Engineering

Research topic:
MSCA-PF Research Area Panels:

- ☐ ECO_Economic Sciences
- **X ENG_Information Science and Engineering**
- ☐ ENV_Environmental and Geosciences
- ☐ LIF_Life Sciences
- ☐ MAT_Mathematics
- ☐ PHY_Physics
- ☐ SOC_Social Sciences and Humanities
- ☐ CHE_Chemistry

Brief description of the Department and Research Group (including URL if applicable):
The mission of Polimi's Department of Mechanical Engineering (7th in the 2023 QS world ranking under the topic "Mechanical, Aeronautical & Manufacturing Engineering") is to promote and develop culture, research and innovation in the mechanical sectors, and, in particular, in transports and sustainable mobility, power technologies, biomechanics and service robotics.
The Train Aerodynamics Group at Polimi's DMEC deals with various topics related to the air-train interaction, such as wind aerodynamic loads, crosswind, slipstream effects, train-tunnel interaction, train infrastructure aerodynamic interaction (wind barriers and ballast lifting), head pressure pulse, etc.
The strength of the research group is the availability of a top-class experimental facility, the GVPM wind tunnel (www.windtunnel.polimi.it), combined with a huge experience in full scale experimental tests (gained thanks to homologation and investigative tests carried out on different high-speed trains i.e. ETR1000, Italo, etc.) and in Computation Fluid Dynamics (CFD) analyses (more info at this link).
The research group is composed of 1 full professor, 2 associate professors, 1 senior assistant professor, 2 technical staff members and several post-docs and PhD students.

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TITLE of the project: Train aerodynamics optimization by using AI-based approaches

Brief project description:
Aerodynamics plays a pivotal role in enhancing the efficiency of railway vehicles, ultimately leading to a reduction in energy consumption. Optimizing aerodynamics in rail transport directly contributes to energy efficiency, environmental sustainability, and cost-effectiveness.
The main efforts to improve the aerodynamic performance of trains are centered around minimizing air resistance, also known as aerodynamic drag, which is a significant factor affecting fuel consumption. By carefully designing the shape of train components, such as roof, nose and underbody zone it is possible to streamline the airflow around the train, reducing drag and improving overall energy efficiency.

The main idea of the research project is to evaluate the impact of different aerodynamic solutions by means of numerical-experimental procedures based on CFD (Computational Fluid Dynamics) simulations and full scale/wind tunnel tests and combine them with AI-based approaches. In fact CFD and wind tunnel/full scale testing offer complementary advantages: experiments on real trains or on railway vehicle scale models allow to collect data in different conditions for the validation phase while CFD provides cost-effective and rapid simulations which can be used especially in the optimization process.
Furthermore, the combination of CFD techniques and AI-based approaches, i.e. machine learning, can lead to an automatization of the design stage. Machine learning algorithms can analyze vast amounts of data coming from CFD simulations to identify patterns and correlations. This data-driven approach allows for the development of predictive models that can optimize the design of train components for improved aerodynamic efficiency.

Finally, machine learning can also assist in identifying the optimal shape and configuration for different train types under various operating conditions. It can analyze the impact of factors such as train speed and wind direction (cross-wind) on aerodynamic performance and could be employed in real-time monitoring and control systems for adaptive aerodynamics. For example, retractable devices, such as flaps or spoilers, can be dynamically adjusted to reduce drag in presence of crosswind or specific weather conditions.
The final aim of the research project is to show how the integration of AI techniques in the design and operation of trains is an effective tool for aerodynamics optimization and improved sustainability in the rail transport sector. List of publications of the supervisor at this link.