CIVIL AND ENVIRONMENTAL ENGINEERING

DIATI - Pollutant dynamics in the urban atmosphere: the case of Turin

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Context of the research activity	Development of a mathematical model for urban air quality assessment, emphasizing Turin's context. Integrating meteorological conditions, vehicle fleet composition, urban geometry, and industrial/civil emissions, the model spans from single streets to city-wide scales. Utilizing complex network theory and deep learning, the aim is rapid and accurate air quality simulation, crucial for urban planning and management.
Objectives	The research concerns the creation of a mathematical model for the evaluation of air quality at the urban scale, with a particular emphasis on the context of Turin. The importance of this research lies (i) in the growing awareness of the severe impacts of air pollution on human health and the environment and (ii) in the need to adopt advanced approaches capable of providing reliable, precise, and high-resolution spatiotemporal operational tools. These tools are fundamental for modern urban management and planning. The primary goal of the research project is therefore to develop an integrated model that considers the determining factors of urban air pollution, including weather conditions, vehicle fleet composition, urban geometry, and industrial and civil emissions. The model will cover spatial scales ranging from single streets (considering the presence of vegetation) to the scale of the entire city; at the same time, temporal scales will range from hourly intervals to multiple years. The model will be based on the description of the physical and chemical processes that determine the dispersion of pollutants, combined with techniques derived from complex network theory. The latter, in particular, offers highly innovative approaches to respond quickly and effectively to concrete questions, such as optimizing vehicle traffic emission control, creating optimal air pollution monitoring networks, evaluating the effects of urban changes, and assessing the impact of urban greenery.

	Two additional distinctive features will make this proposed research innovative. The first will be the collaboration with DIATI experts specializing in field measurements. By using measured data for validation and data assimilation, the aim is to improve the reliability and accuracy of the proposed model while simultaneously reducing computational costs. The second feature involves the use of deep learning techniques to create AI-based models to complement the fundamental (and physically-based) model described earlier. The goal is to provide AI systems (trained on the main model) capable of rapidly simulating air quality. Rapid simulation times are crucial in emergencies or when comparing multiple urban intervention proposals (e.g., in traffic management decisions). The final result of the entire project will be an air quality model - in both its physically-based and AI-based versions - that can be implemented in the digital twin of the city of Turin. This model will enable local authorities to predict and evaluate the effects of strategic decisions on urban air quality. This integrated approach will encourage greater involvement of the academic and industrial sectors in the decision-making process, promoting a culture open to innovation and effective interaction between research, industry, and public administration.

Skills and competencies for the development of the activity	Candidates have to possess knowledge about fluid mechanics, mathematical modeling and numerical simulation. Proficiency in programming languages such as Python and/or MATLAB is desirable, along with experience in complex network theory. Fluency in Italian is essential, enabling effective communication with project stakeholders.