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LEVERAGING MODEL ORDER REDUCTION TECHNIQUES FOR URBAN PHYSICS DIGITAL TWINS

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In modern societies, critical infrastructure plays a vital role, and ensuring public safety during potential disruptions is of utmost importance. The digital twin (DT) framework has recently emerged as a key tool for analysis and forecasting, owing to significant developments in the field. To construct an accurate virtual representation of infrastructure, a solid understanding of the physical system and its dynamic behavior is essential. However, high-fidelity physics-based models can quickly become complex and computationally expensive, making it challenging to produce meaningful real-time results – especially in crisis situations or when exploring multiple "what-if" scenarios. Model order reduction (MOR) methods offer a promising solution to this challenge.

Building on reduced-order modeling, the recent work in [1] presents initial steps toward a DT for real-time prediction of airborne contaminant transport in urban environments at moderate Reynolds numbers. The proposed framework leverages open-source geographic data to automatically generate a discretized computational domain and employs a POD-Galerkin scheme combined with DEIM to accelerate the evaluation of the wind field. To further assess the efficiency of different MOR strategies, a comparative study with the non-intrusive PODI method is conducted. While PODI yields a significantly higher speed-up, it also introduces a higher, though still acceptable, prediction error. Based on these findings, the framework is further refined by applying model reduction to the advection-diffusion equation governing contaminant transport. To support scenario analysis, an interactive dashboard is developed to visualize contaminated areas within an urban domain based on user-defined parameters.

REFERENCES

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