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PI1 Name: Jonathan Natanian

Scientific abstract – ***Solar urban districts: A generative method for multicriteria solar design of dense urban fabrics***

Solar approaches to sustainable design have been with us since the dawn of civilization and have been rooted in the core of architectural practices for centuries. Computational adaptations of solar-design approaches are more recent and mostly revolve around the solar-envelope (SE) concept. The SE is the calculated maximal spatial volume that ensures solar availability for a specific time of year. However, the SE concept is limited in its ability (i) to respond to the several contrasting facets of solar design in a dense urban environment, (ii) to holistically consider multiple environmental considerations, and (iii) to offer the designer a spatial morphology at different scales that represents these trade-offs rather than a maximal boundary. Moreover, recent advancements in digital tools for environmental performance predictions are opening new horizons for both architectural design and research. These include prediction metamodels that are trained to emulate the physical performance of different environmental criteria using machine learning (ML) and multiobjective optimization (MOO) algorithms that allow us to explore multiple design iterations, screen them based on reliable metrics or metamodels, and allow the user to interactively visualize the results. By substantially reducing computational time, these advancements enable us to explore new scales and tradeoffs between several environmental criteria.

The proposed research aims to advance the existing scientific knowledge on solar design by harnessing these technological advances. This project explores a generative SE approach at a district scale, in which a combination of solar-driven metrics drives the form-finding process of a dense district based on ML and MOO methods. The workflow will be applied to a real district case study in Tel Aviv and will yield a large set of spatial solar-driven building masses, rather than one SE volume, which will correspond to the different trade-offs between the environmental performance metrics applied. The project is divided into four tasks: (1) establishing the generative design and analytical computation workflow, (2) identifying and exploring solar-based prediction metamodels and metrics, (3) setting up the optimization module, and (4) exploring diverse climatic and urban contexts to ensure the robustness of the approach.

By establishing a generative approach in which performative insights directly influence the design process, the solar approach developed and employed in this project will advance our capacity to integrate environmental engineering and design. Beyond marking a new computational chapter in the field of solar-driven design, insights from this project will advance our knowledge of architectural design optimization and the use of machine learning for environmental analysis, environmentally driven design in hot climates, future-proof environmental design, and holistic workflows for environmental evaluations.