PhD Open Days

Algorithmic Optimized Patterns for Facade Design

DOCTORAL PROGRAM IN ARCHITECTURE

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Algorithmic Design

Current architectural facades present complex shapes and patterns, a trend supported by recent digital technologies. Also, due to their aesthetical and environmental relevance, the design of facades has been combined with analysis and optimization processes, aiming at achieving better performing solutions. A new design approach has been promoting the development of complex facade designs, Algorithmic Design (AD), which promotes the description of shapes through algorithms. Nevertheless, architects still suffer limitations when using AD, mainly:

- the need for specialized expertise;
- the fragmentation resulting from the integration of analysis and optimization processes in an AD workflow, which involves using multiple models/tools, thus becoming error-prone, time-consuming, and hard-working;
- the limitations on the AD design freedom, derived from physical (structural performance and fabrication), time, and cost constraints.

DrAFT Framework

To reduce the time spent in the programming task, we propose a theoretical framework to facilitate the mathematical description of algorithmic-based facade designs together with the implementation of the most used analysis and optimization processes, merging these in a continuous design workflow. The framework includes:

- a classification of facades based on different categorical dimensions considered computationally relevant;
- fundamental algorithms and strategies to address the needs of each dimension;
- guidelines to help architects select and combine the most useful algorithms for a given facade design;
- algorithms for cost efficiency and assembly processes to ensure the obtained solutions can be manufactured.

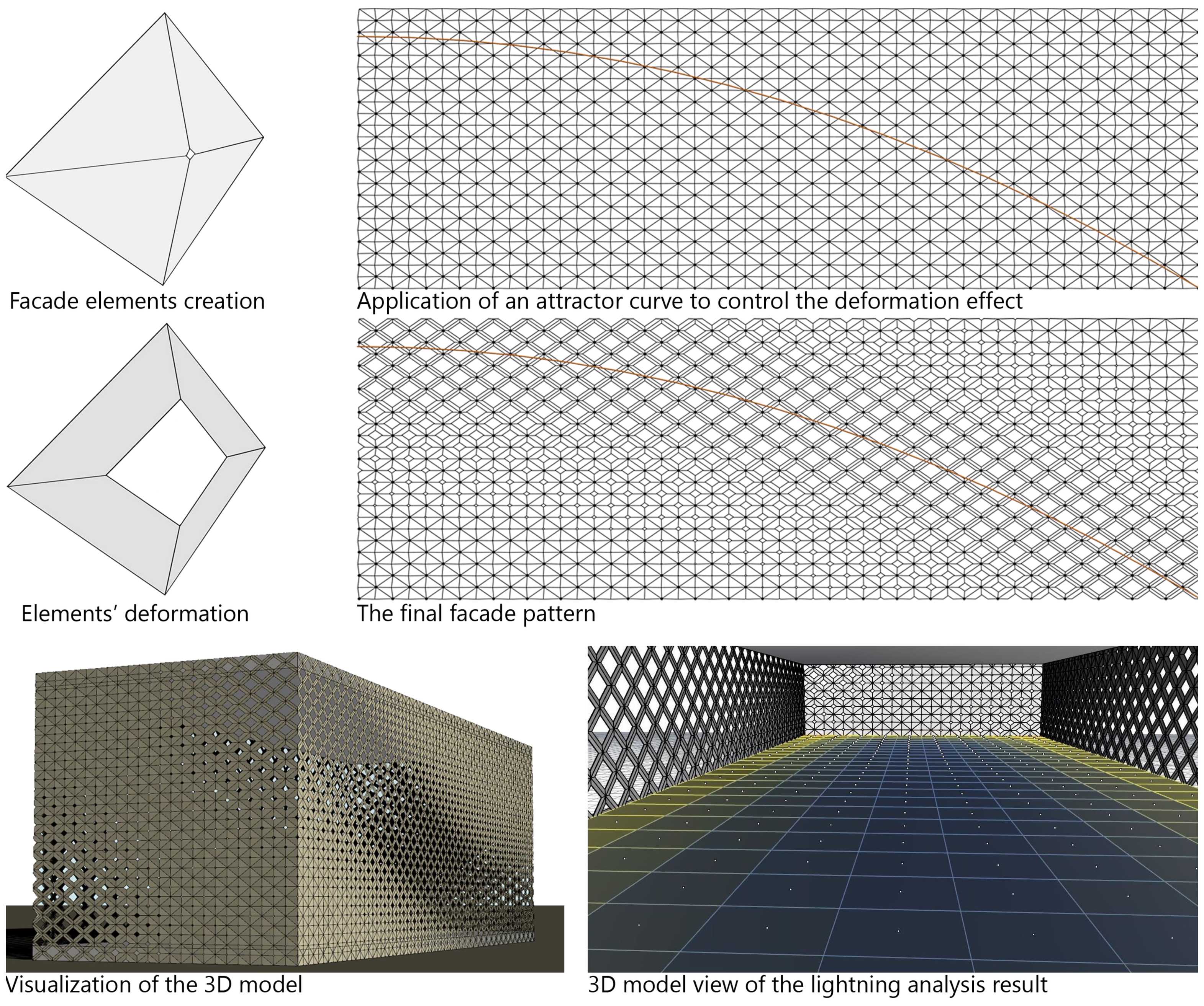

FIGURE 1: A case study developed using DrAFT framework.

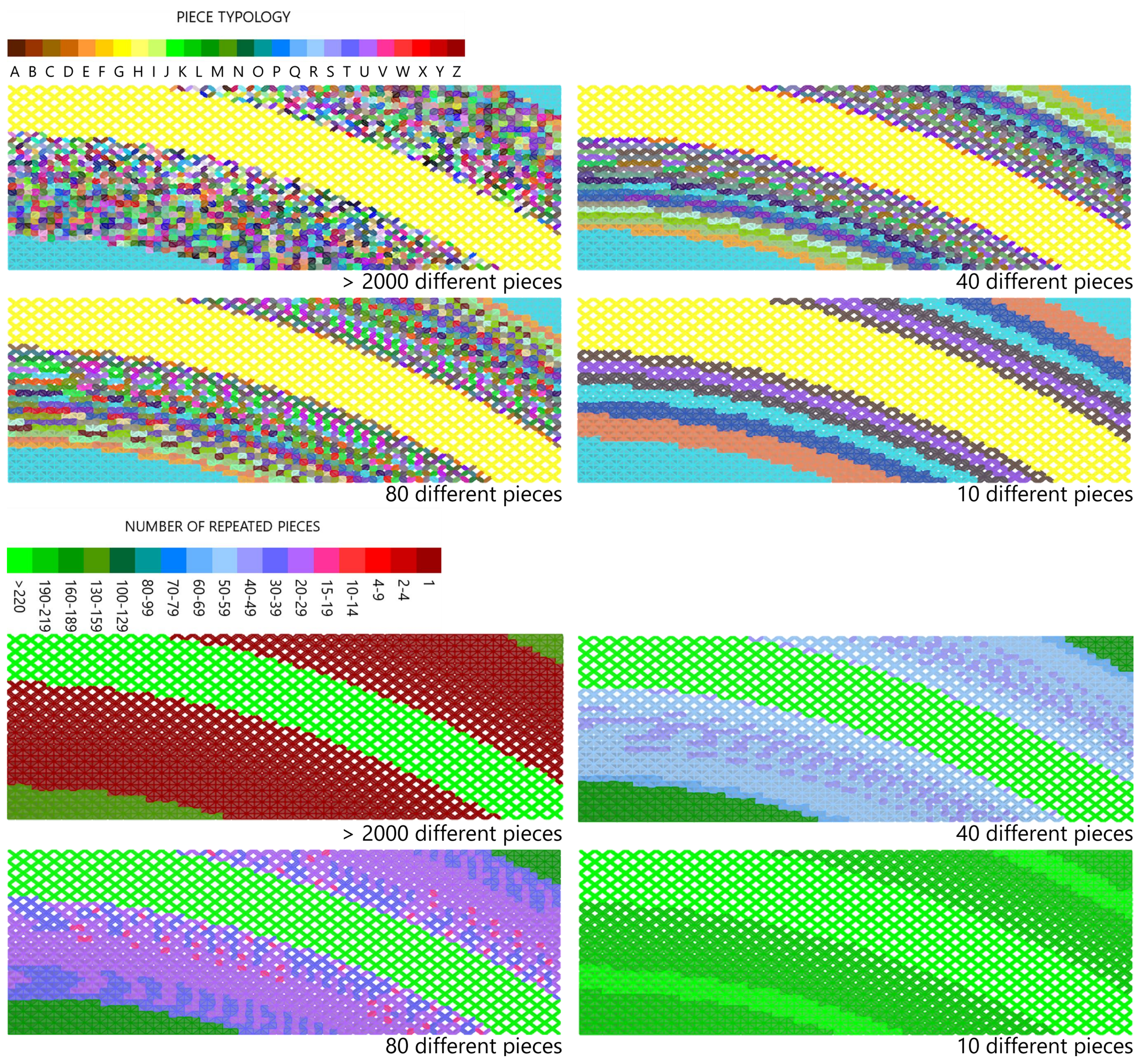

FIGURE 2: Facade rationalization process: the variety of existing typologies (top); each typology repetition (bottom).

Case Study

The DrAFT framework was used to develop the facades of a rectangular building with a geometrical pattern composed of several parametric diamond-shaped elements of different apertures (Figure 1). The apertures variation should satisfy the need for natural light inside, while matching the design's aesthetical criteria: a parabola curve shaped effect along the facades. Several DrAFT algorithms were combined to:

- shape the facade's surfaces;
- produce the chess grid of points;
- shape the units into a diamond-shaped pyramid geometry;
- apply a deformation to the units (their aperture), which depends on their distance to the attractor curve.

The final pattern was composed of 2424 different pieces, in a total of 6144, and the manufacturing process required the creation of molds, which was clearly unsustainable in terms of cost and material waste. To solve this, we used DrAFT's rationalization algorithms to control the number of different pieces composing each design solution, enabling a trade-off between the production cost and the original design concept. First, we dictated the maximum number of different pieces composing the pattern and, then, we visualized the corresponding model. This process was repeated, allowing us to generate and evaluate several design variations until a desirable solution was found.

Figure 2 (top) represents each type of facade panel with a different color. In general, the more colors a facade solution has, the more expensive its fabrication will be, and Figure 2 (down) demonstrates this. Figure 2 top-left solutions correspond to the pattern before the rationalization process, whereas the other three examples result from it.