Designing Environmentally Informed Facades for Algae Growth using Digital Fabrication

Dana Molzhigit, Andreas Korner, Meng Jingyuan

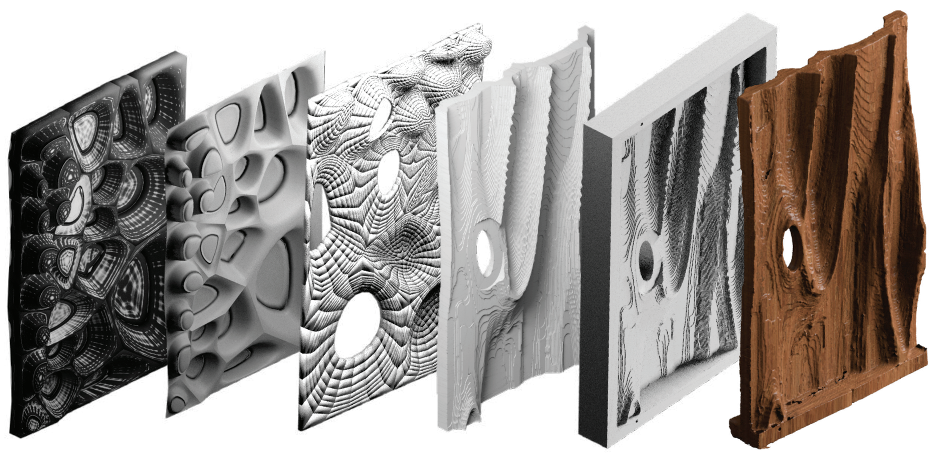
ABSTRACT

Green walls and living walls have gained popularity for their environmental benefits in modern buildings. They help control climate, filter air pollutants, and reduce heat. However, their practicality and cost are limited by water pumping systems, maintenance, and carbon dioxide uptake. In contrast, a pioneering method of living walls eliminates the need for mechanical irrigation systems. The building itself acts as a host, fostering microorganisms and other organisms.

This ongoing research explores the intersection of computational design, digital fabrication, and environmental analysis. It focuses on creating favorable microclimates for micro green algae. The research involves designing geometries that maximize algae growth efficiency and stability through rain surface runoff, heat transfer, and solar analysis. The resulting panels dynamically respond to climatic conditions and communicate microclimatic parameters to users. The study emphasizes the importance of a feedback loop between designs, simulations, and fabrication iterations.

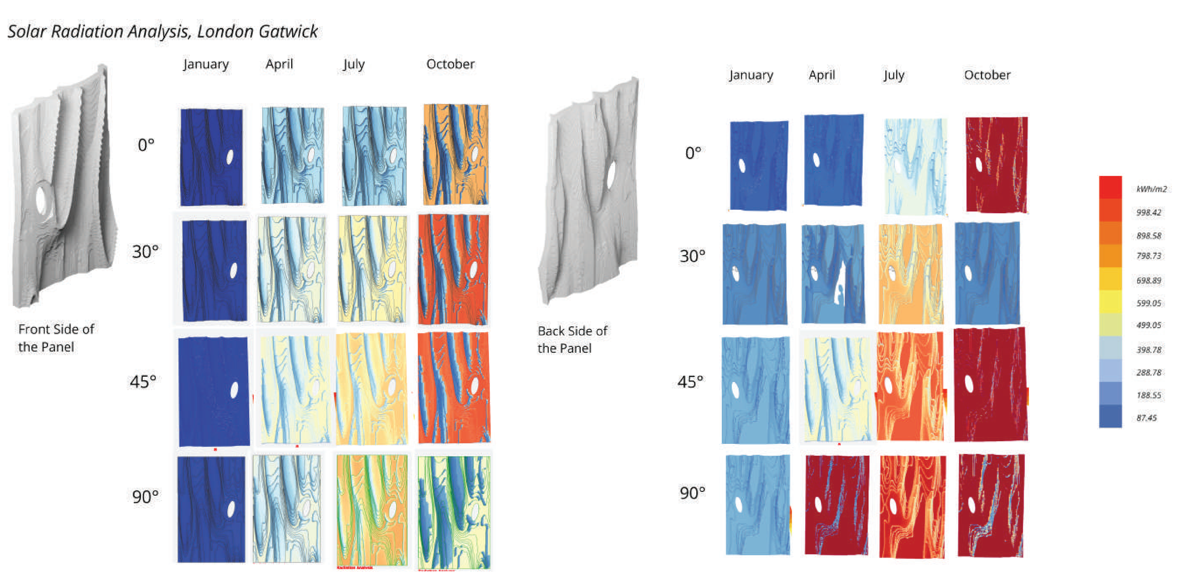
Methodology

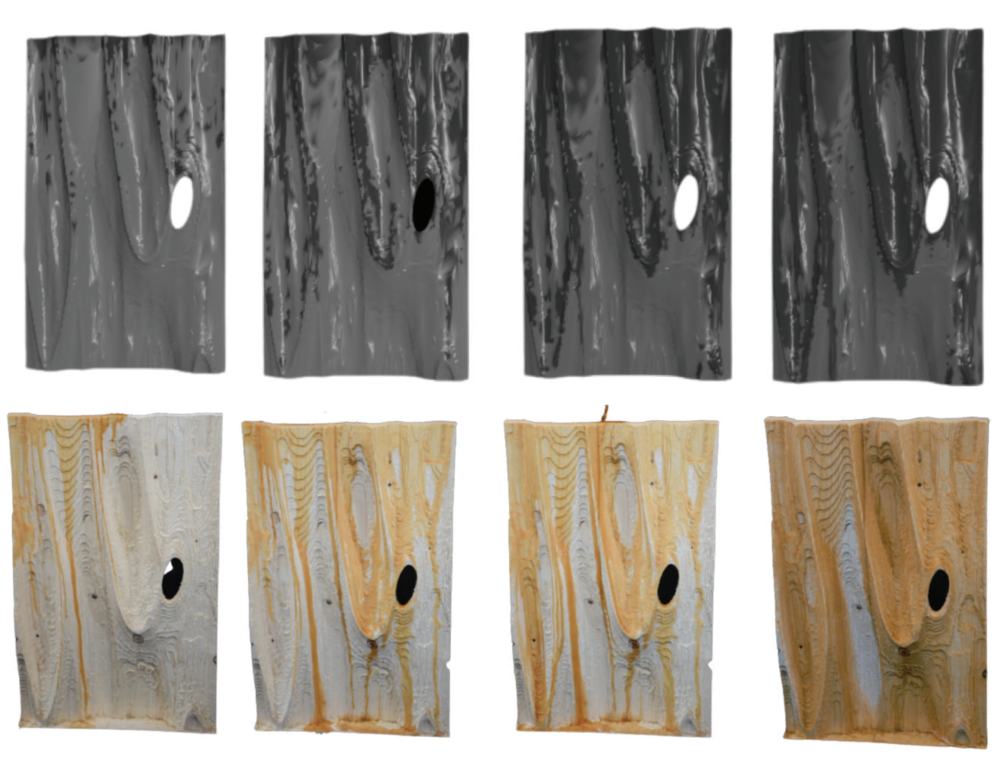
The research followed a scientific methodology using SideFX Houdini and Grasshopper for initial design development. Designs were simplified and imported back to Houdini for rain runoff simulations. Prototypes were CNC-ed and subjected to physical water tests. Iterations and evaluations were conducted based on initial designs and water test results. Further design iterations, CNC fabrication, and digital and water tests were performed. The final design, incorporating all the learnings, underwent CNC fabrication and digital/physical water, solar, and thermal tests.



Environmental Tests

To validate the designs, physical water tests were conducted using CNC-ed prototypes. Environmental tests were performed after each design iteration, allowing for refinement and improvement.

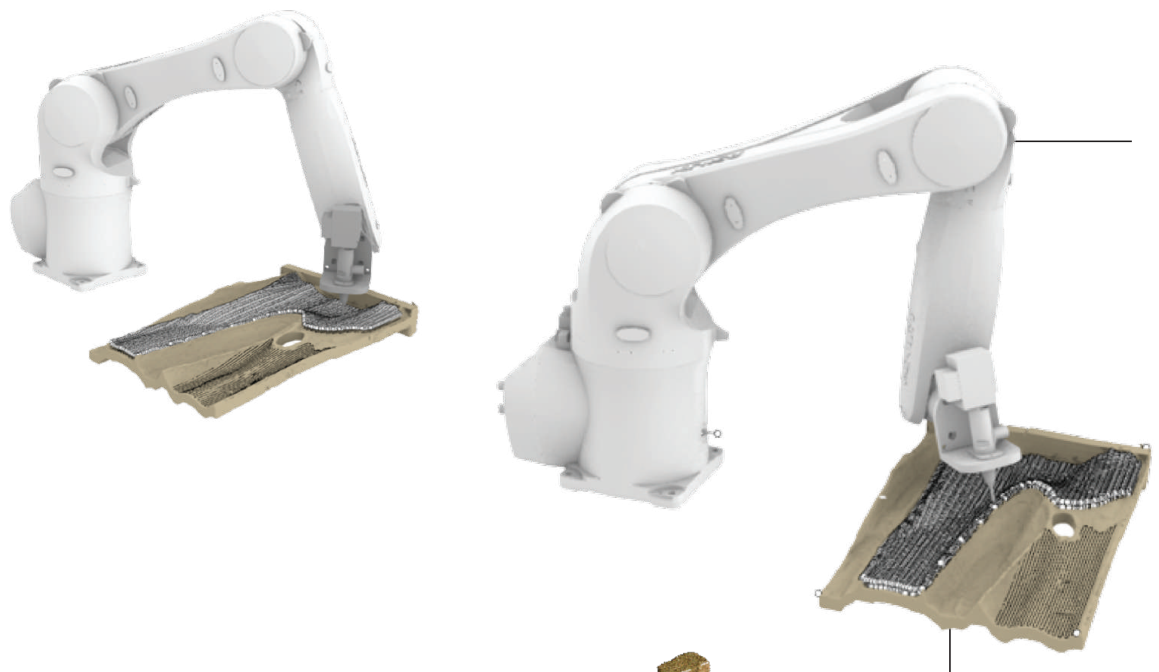


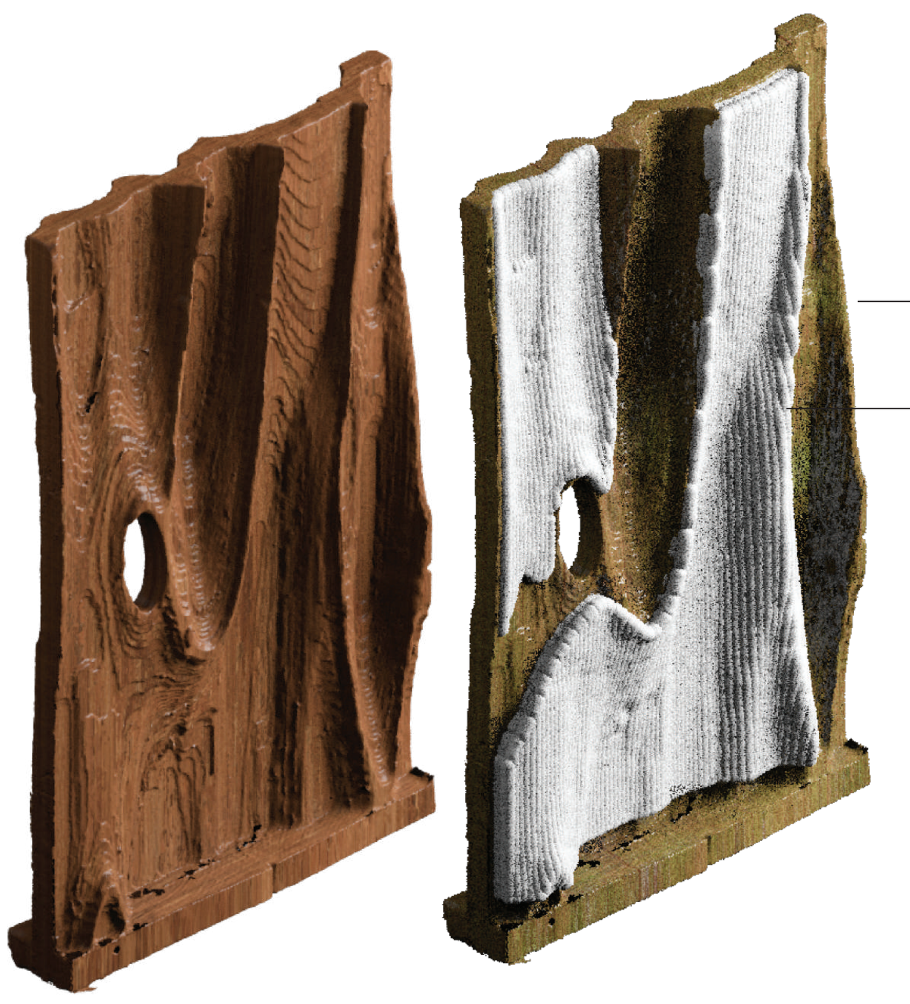


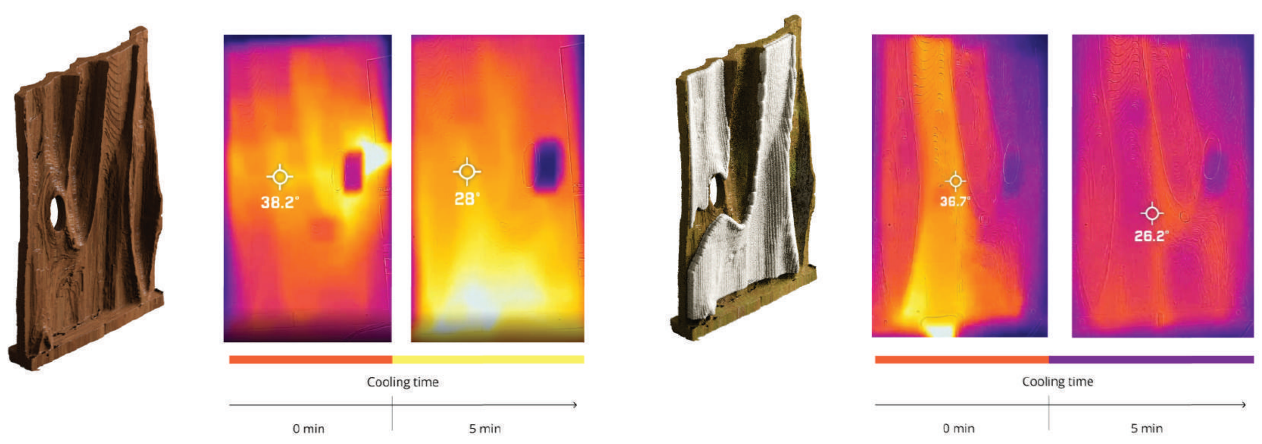
CNC Milling and Robotic Fabrication

Subsequent stages included further design iterations, CNC fabrication of new prototypes, and conducting both digital and water tests. This iterative approach allowed for continuous evaluation and enhancement of the design.

The final design represents the culmination of the research, incorporating all the learnings from previous iterations. It was fabricated using CNC technology and subjected to digital and physical water tests, as well as solar analysis and thermal tests.







Findings

Through digital fabrication and environmental analysis, the research discovered that specific design geometries and surface treatments can significantly influence microclimate conditions. By optimizing the design parameters, such as shape, orientation, and texture, the panels were able to create preferred microclimates for the growth of micro green algae. These findings were supported by thermal tests, which showed that the panels effectively regulated temperature and provided suitable conditions for algae growth.

Additionally, the research identified that certain surface treatments, such as the incorporation of heat-absorbing materials or reflective coatings, could enhance or mitigate solar heat gain, depending on the desired outcome. Through a combination of digital simulations and physical tests, the team was able to fine-tune the panel designs to optimize solar performance.

Conclusion

In conclusion, the research undertaken in the field of digital fabrication, environmental analysis, and thermal tests has yielded significant findings that contribute to the advancement of sustainable architectural systems. Through meticulous design iterations and simulations, coupled with physical testing and analysis, key insights have been gained.

The research highlights the potential of specific design geometries, surface treatments, and material choices in creating optimal microclimates for the growth of micro green algae. By leveraging digital fabrication techniques, such as CNC milling and robotic printing, precise and tailored panel designs were achieved, leading to improved efficiency and stability in algae growth. In conclusion, the research undertaken in the field of digital fabrication, environmental analysis, and thermal tests has yielded significant findings that contribute to the advancement of sustainable architectural systems.