

A Quantitative Fitness Function for an Evolutionary Algorithm that Generates Digital Surfaces

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Genr8 is a Design Tool for Finding Digital Surfaces Based

Genr8 (Hemberg 2001, Hemberg & O'Reilly 2004) is an architect's digital surface (i.e. form) design tool based on Evolutionary Computation (EC) and an organic growth model. The evolutionary algorithm helps the user find interesting forms. Assigning fitness to anything that has artistic or creative qualities is a complicated issue and there is a difficult trade off between quantitative criteria and subjective ranking provided by the user.

The Fitness Function is for Exploration, not Optimisation

In Genr8 the fitness function is metaphorically a steering wheel that helps the user guide the evolutionary search. It is automated to allow a larger portion of the search space to be explored.

There are Six Fitness Criteria Relating to Different Features of the Surface

The user chooses a target value, t_i , and a fractional weight, w_i , for each feature. In order to calculate fitness, each feature is assessed (yielding a value s_i) and compared with the user specified target values.

$$\text{Fitness} = \sum_{i=1}^6 w_i |t_i - s_i| \quad (1)$$

Size This criterion measures the extent of the surface in the $x - y$ plane.

Symmetry The symmetry measure gives a rough idea of the symmetry.

Soft boundaries This criterion can be used to allow the surface to grow through the boundary wall at a fitness penalty.

Subdivisions This criterion measures how articulated the surface is.

Smoothness Measures the extent of local variations in the z plane.

Undulation A global measure of the variations in the z plane.

Understanding the meaning of the numerical values of the target values is not direct and the user must develop intuition via experience with Genr8 to understand how the parameters contribute to the fitnesses of surfaces.

Genr8 has been used for two years at graduate program Emergent Design and Technologies at the Architectural Association (AA) in London. More information about Genr8 can be found at <http://www.ai.mit.edu/projects/emergentDesign/genr8>.

References

M. Hemberg (2001). 'Genr8 - A Design Tool For Surface Generation'. Master's thesis, Chalmers University of Technology.

M. Hemberg & U.-M. O'Reilly (2004). 'Extending Grammatical Evolution to Evolve Digital Surfaces with Genr8'. In *European Conference on Genetic Programming*, pp. 299–308.

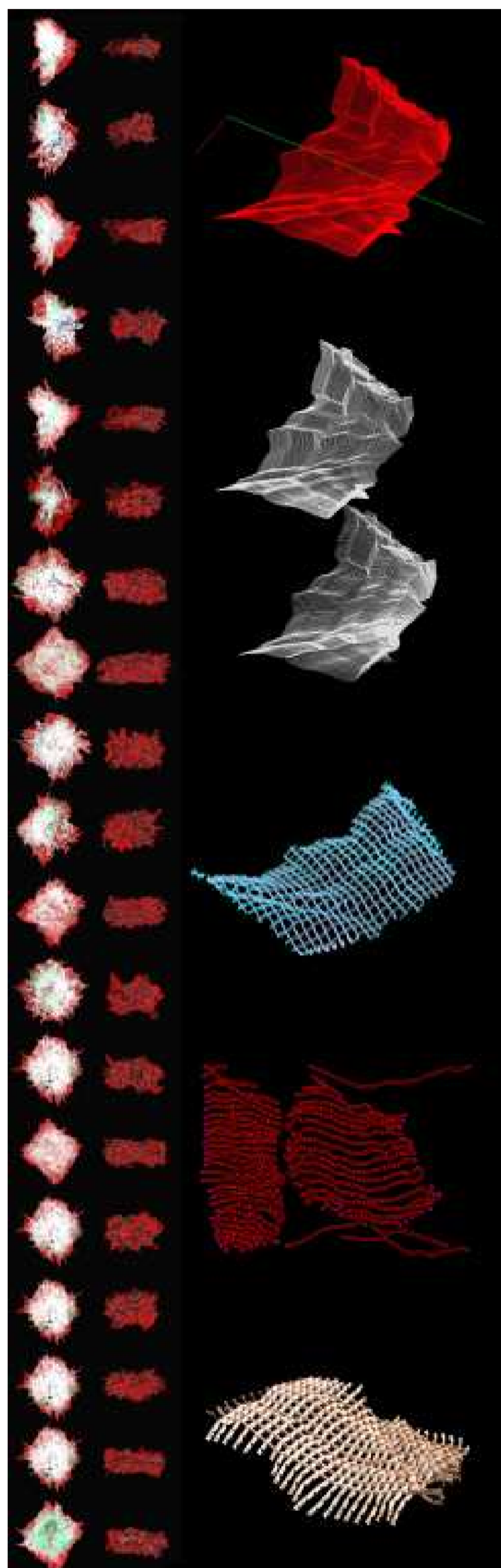


Figure 1: A Genr8 surface made by Elisa Simonetti at the AA. The large images to the right show how the surface is being manipulated in order to produce a physical model. Genr8 is intended to be a tool that should be used with other tools when developing a surface.

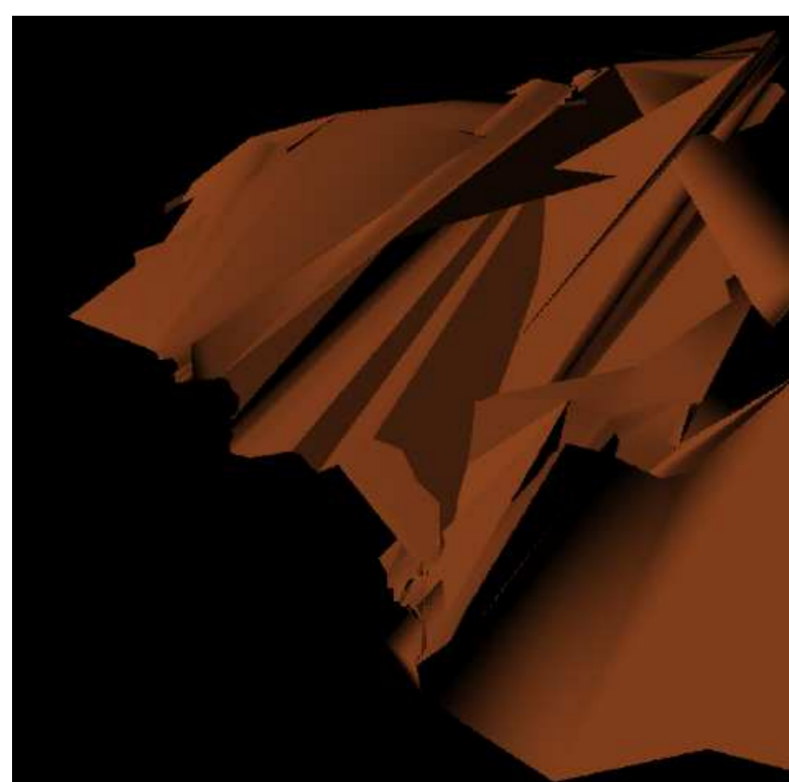


Figure 2: A rendered image of a surface evolved with Genr8. The fitness criteria has been set to select for highly articulated surfaces.

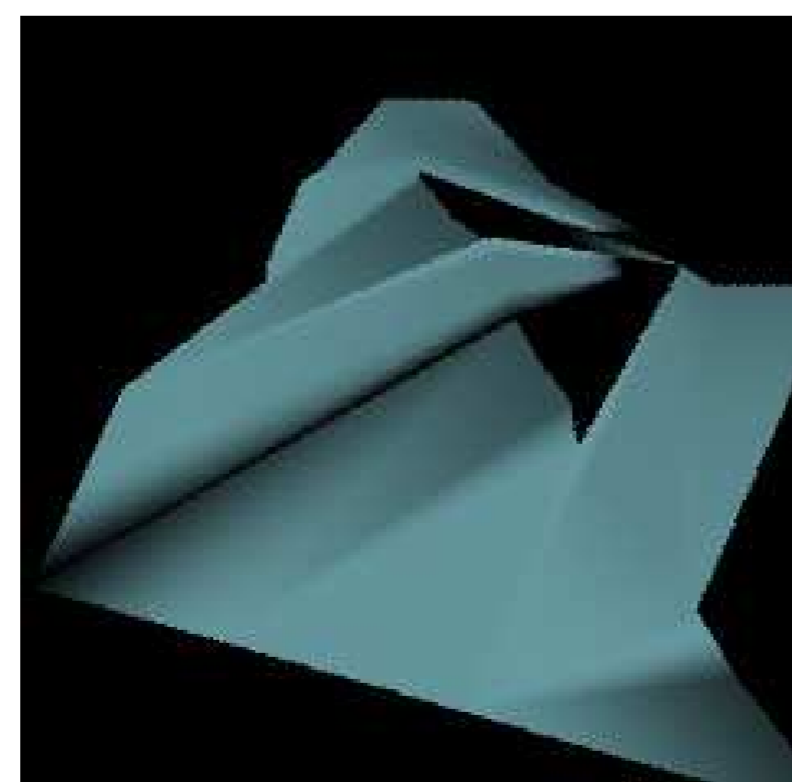


Figure 3: A rendered image of an evolved Genr8 surface. The articulation is not as pronounced here in contrast with Figure 2.

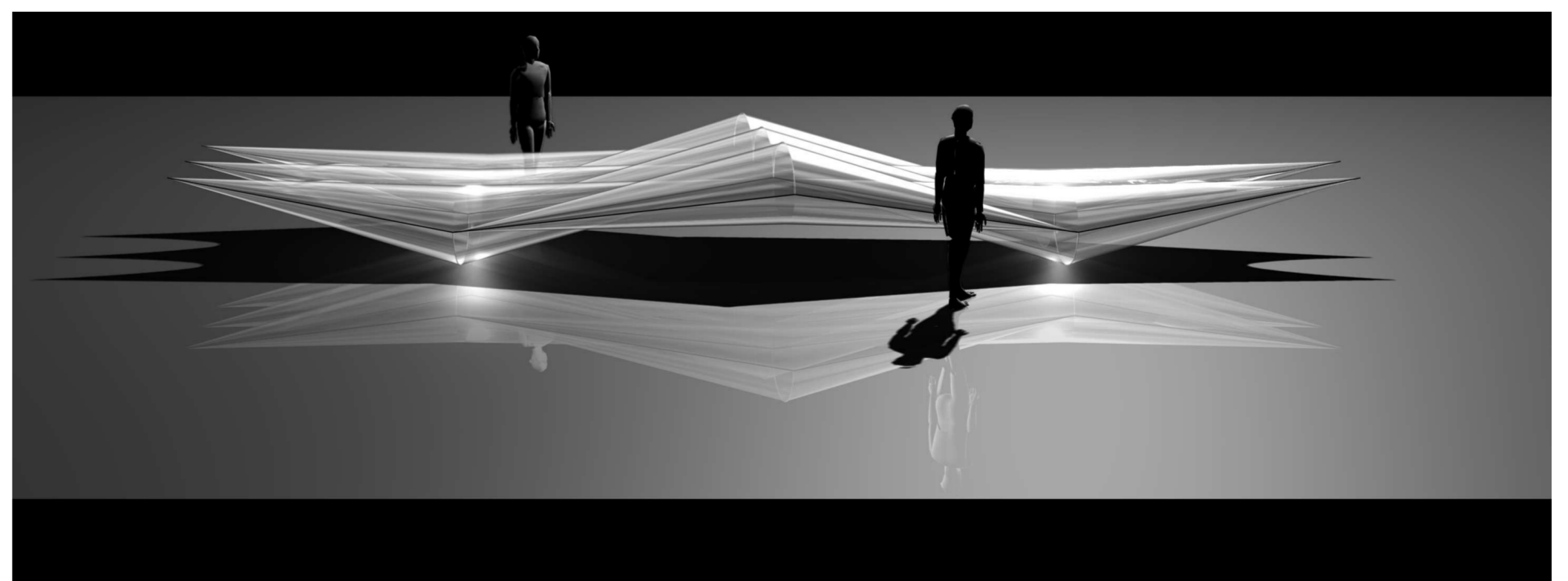


Figure 4: A rendered image of a design for a pneumatic strawberry/champagne bar by Achim Menges at the AA. The strawberry bar is the largest design based on Genr8 that has been physically actualized. The design process was quite intricate and the parameters for the EA involved a population size of 50 evaluated over more than 1000 generations.