Designing Associativity

3rd assignment

Evolutionary Computation

Institute for advanced architecture of Catalonia

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Define

Our research project for the studio was initially inspired by the Programmable Textiles project of the Self-Assembly lab of MIT. The objective of this project was to program pieces of textile to deform in a specific way after patterns had been 3d-printed on them at a pre-stretched state. The objectives of our research are to understand the mechanisms through which these deformations occur, to add interactive elements and to explore how a structure of these principles could be applied in architecture.

At the first stage, our research was focused on the deformations that occur when simple patterns are being 3d-printed with certain filament on stretched lycra fabric. The conclusions extracted from this stage are important for the form-finding of our final structures in a bigger scale.

The next step of our research was to define a way to enlarge our structures. The PLA filament we mainly used for the 3d-printing is a typical thermoplastic material, meaning that becomes pliable or moldable above a specific temperature and solidifies upon cooling. This way, when the prototypes are heated the printed pattern becomes less stiff and at the same time the forces of the stretching of the fabric prevail and the deformation becomes more intense. Except if an external force is applied, the pattern becomes stiff again when cooled in a new position.

Following this principle, among the heat-responsive polymers we think that the shape memory polymer could have a lot of potential for the further development of our project. Changing the stiffness of the material by heating, in the desired places would offer us control over the form of the structure in a much larger scale.

Sample deformation by 3d-printing on fabric

Sample deformation by adjusting shape memory polymer on fabric

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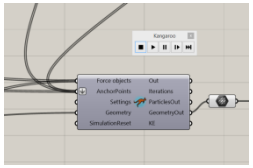
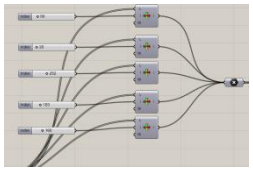
Define

At the current stage of our research, we are trying to control the deformation being caused at a larger piece of textile with the use of the shape memory polymer. We intend to design a canopy the deformation and responsiveness of which is going to be dependent on the temperature and as a result the stiffness of its structural frame made of shape memory polymer.

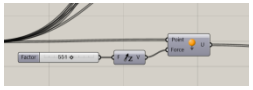
We use Grasshopper and Kangaroo to create a simulation of the fabric with certain anchor points as well as certain amount of unary force that works instead of the structural frame. For the form finding of the structure we can iterate among a grid o points that could be possible anchor points as well as different amounts of unary force.

With Galapagos we are going to automate this process of form finding. We aim to find the form that works best as a shadowing canopy in a specific location, for example the coordinates of IAAC.

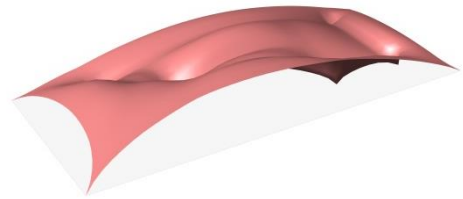


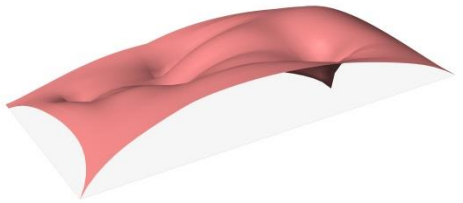


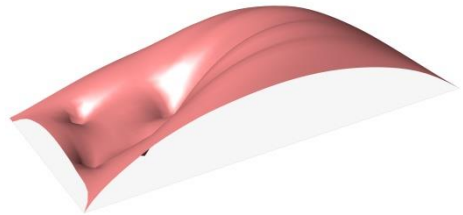
Manual change of the anchor points for form-finding.

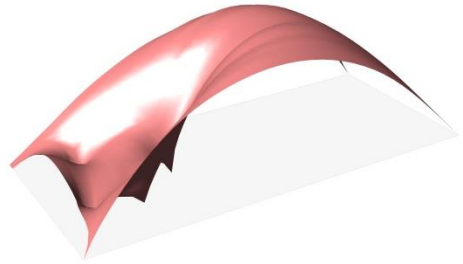


Manual change of the unary force for form-finding.









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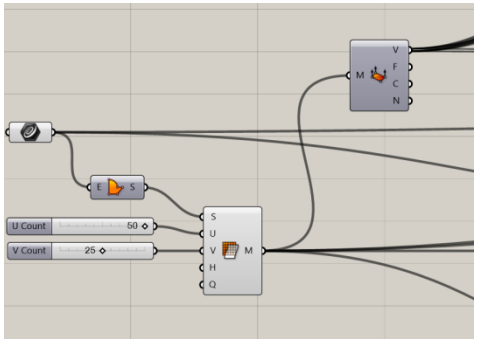
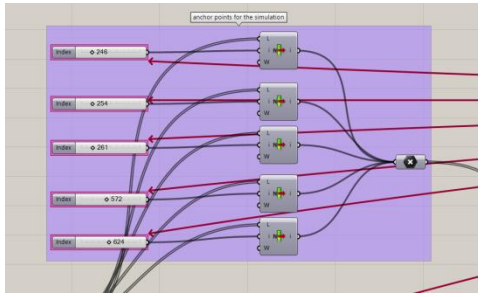
Evolve

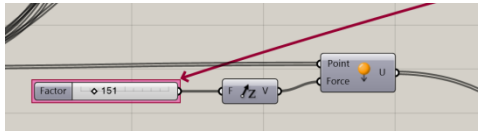
Genomes



Setting the base-mesh and the grid of points that can be anchor points.

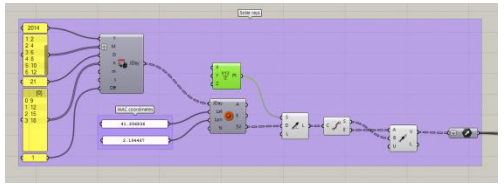


We set sliders for the list item components for all indices of the possible anchor points. These sliders are our genomes.

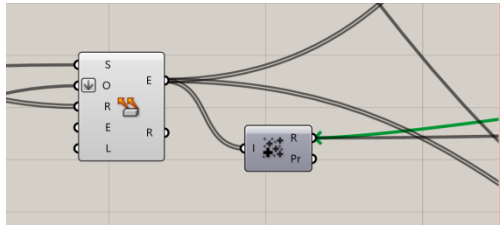


The unary force that controls the height of the deformation is defined by a slider that is also a genome.

Fitness



Creating the solar rays for the desired dates in the year.



Creating the fitness value by using the exposure and the mass addition component.

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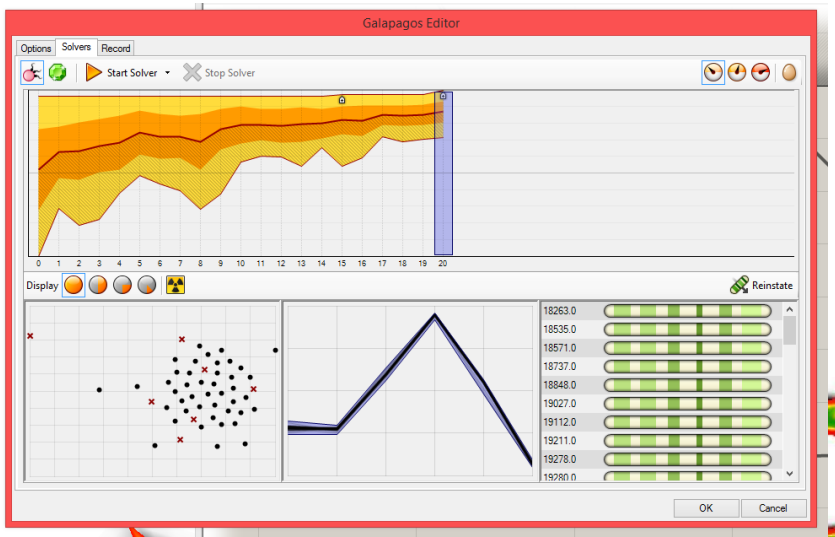
Evolve



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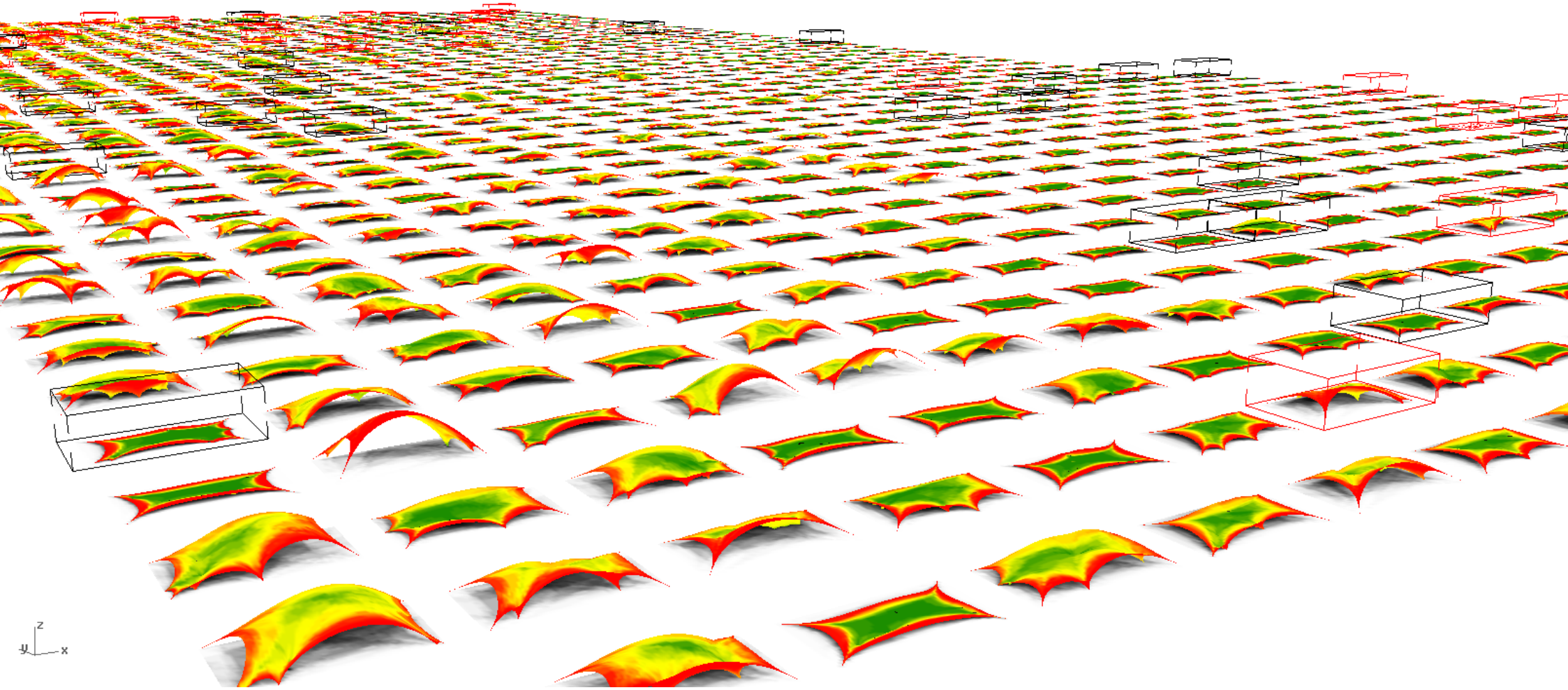
_ Evolve



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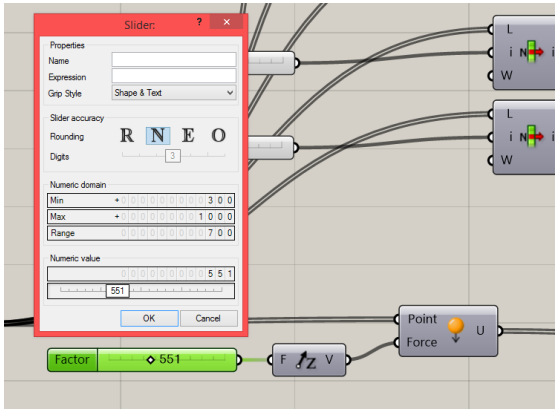
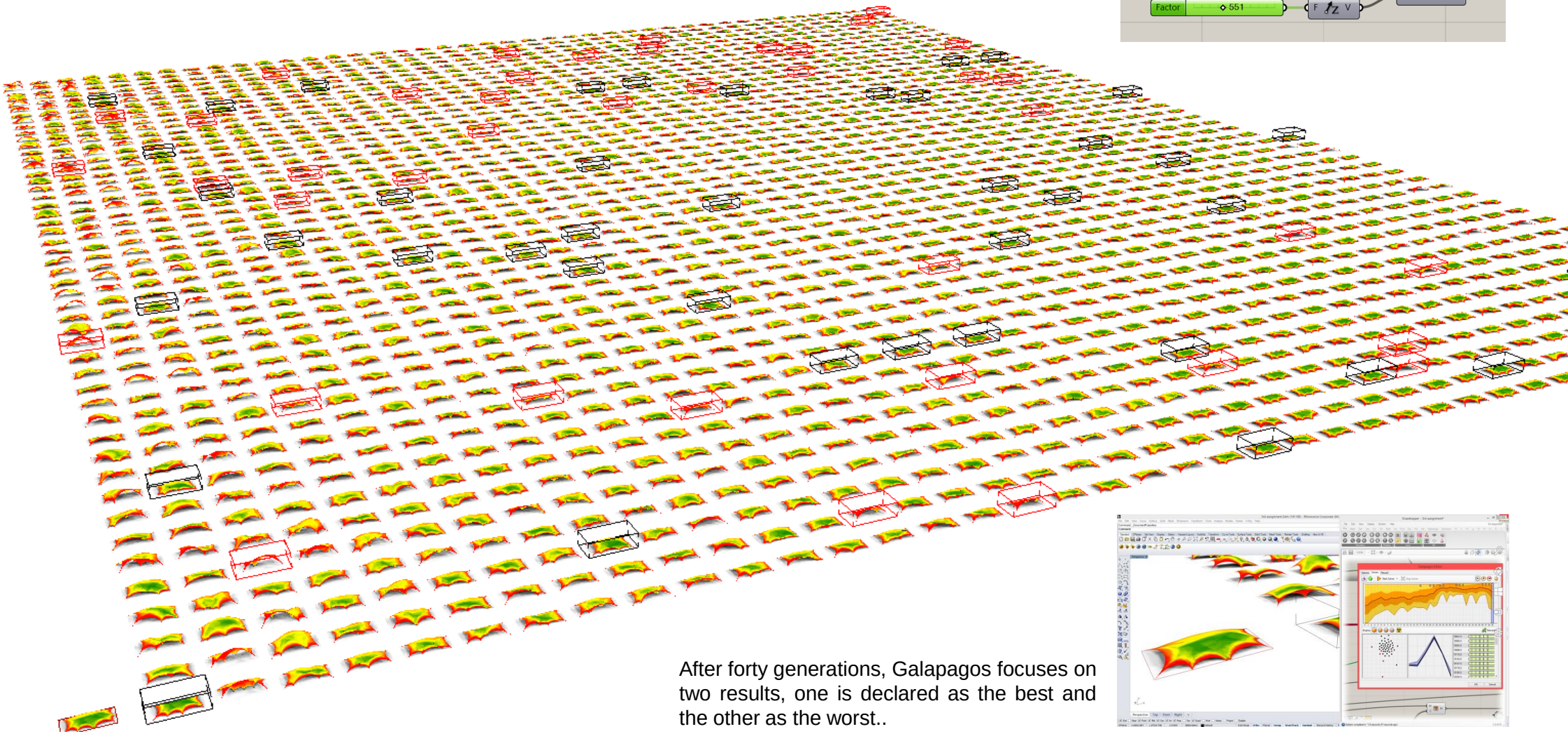
Iterate

After twenty generation, we realize that results tend to become very flat. For that reason we change the unary force slider and set a minimum amount above than 0.





After forty generations, Galapagos focuses on two results, one is declared as the best and the other as the worst..

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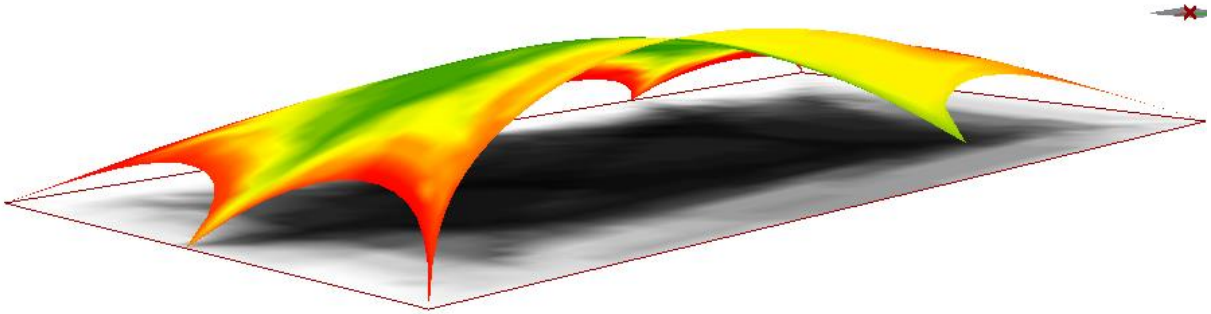
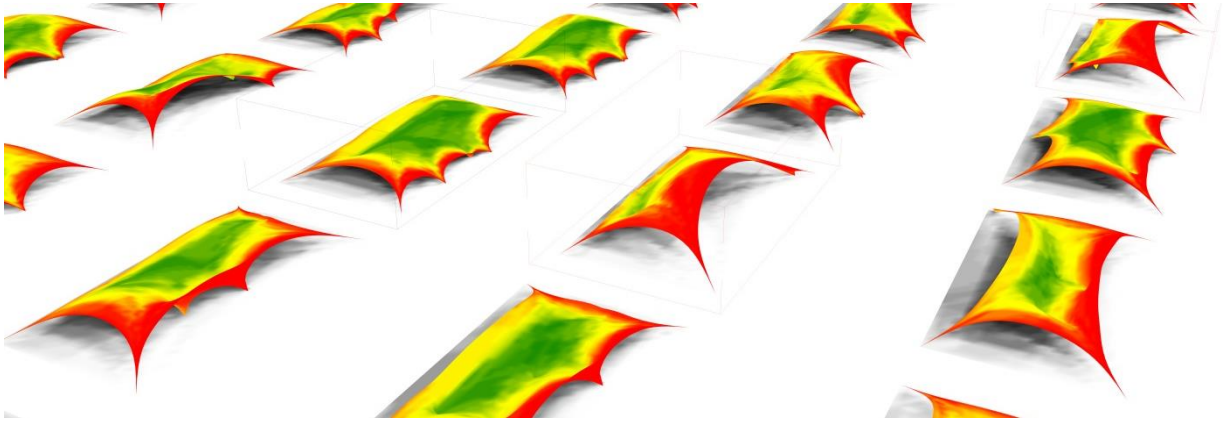
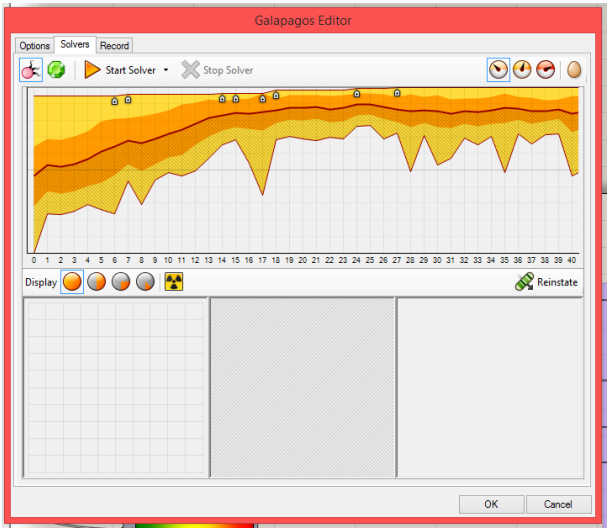
Iterate

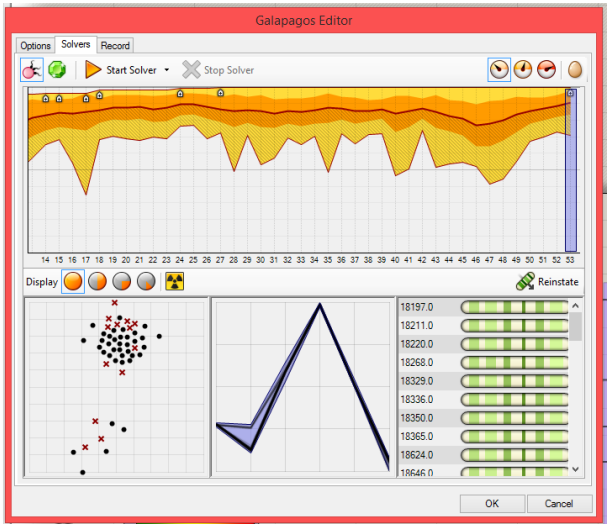
In order to get closer to the desired result, we change the limits of the unary force slider value again. We let Galapagos run for 54 generations and we store all the variables in an array using recorders. At the same time, we map the base mesh with a gradient that simulates that shadow of the structure and the shading structure with a gradient that shows the exposure levels to the sun.

Last the option with the maximum and minimum fitness values of every generation are demonstrated by a bounding box around them.









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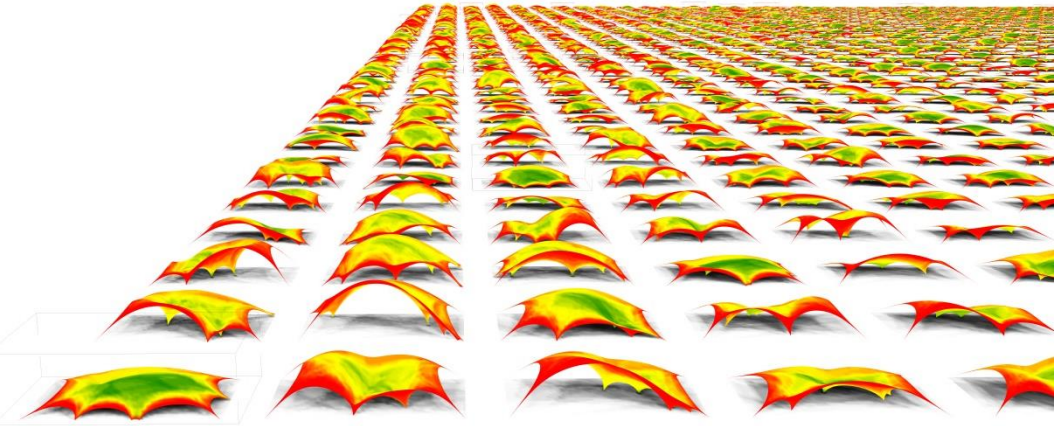
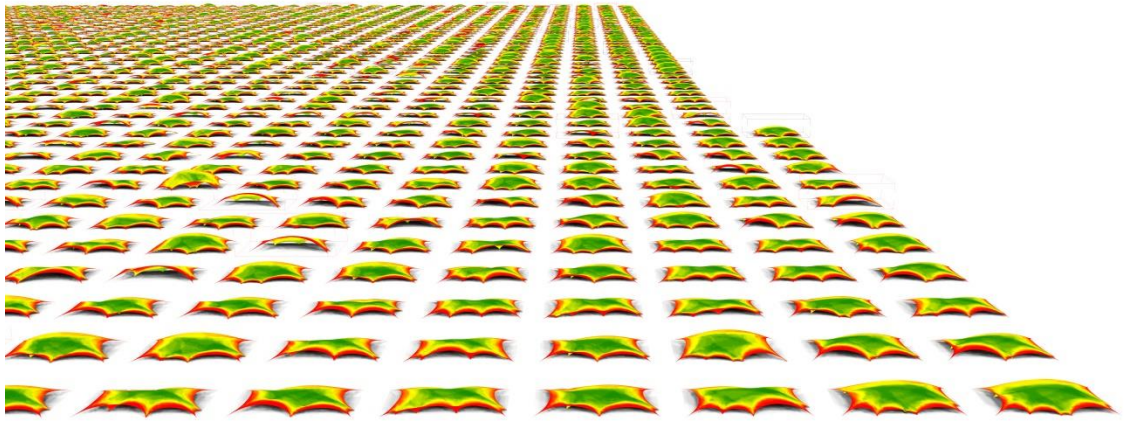
Iterate



The first generations of the results show a great variety between them. We observe very different forms even among the few first.



The last generations of the results are having a much bigger resemblance to each other. Galapagos is focusing on some values and creates alternatives with very small alterations in order to define the best and the worst option.

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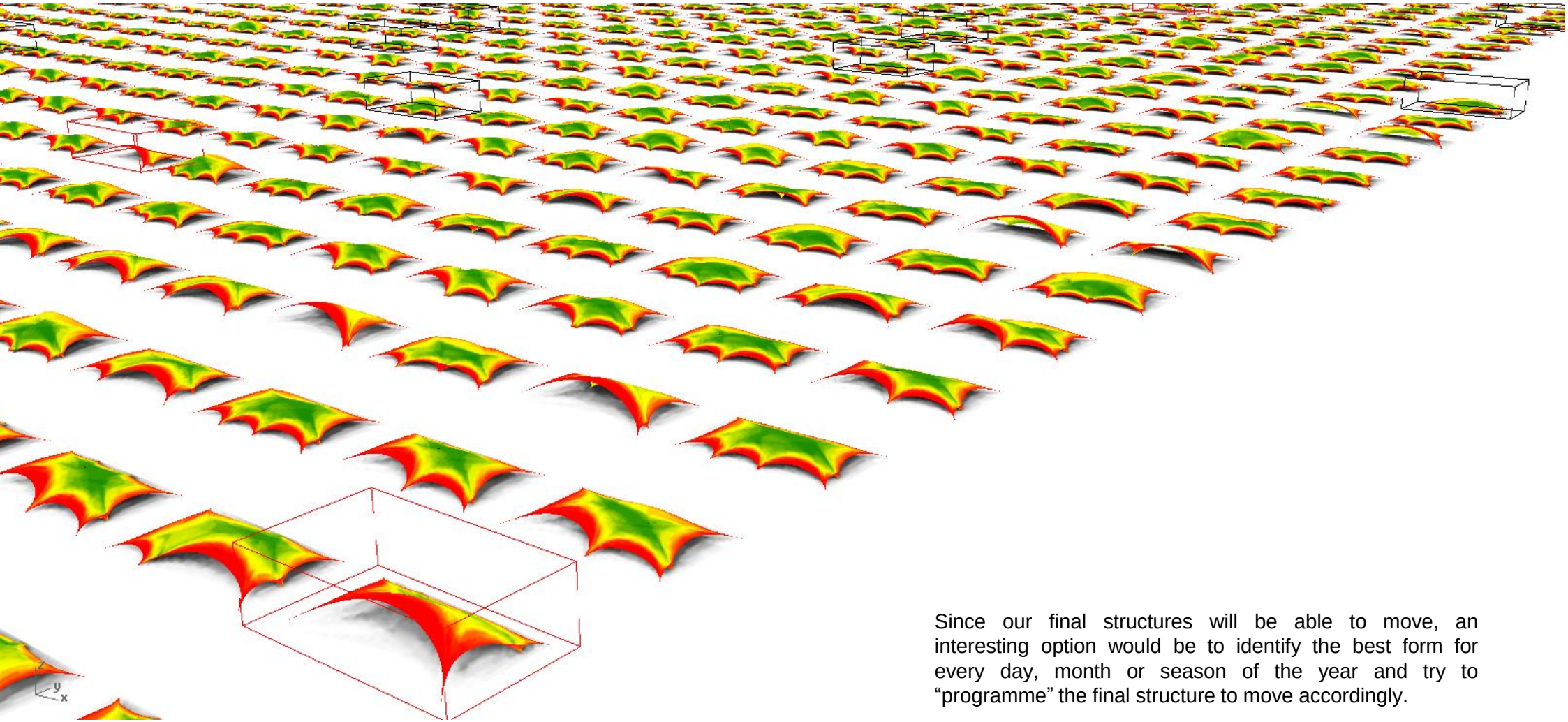
_ Iterate



Since our final structures will be able to move, an interesting option would be to identify the best form for every day, month or season of the year and try to “programme” the final structure to move accordingly.

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