Evolutionary Algorithms for Mechanical Structures

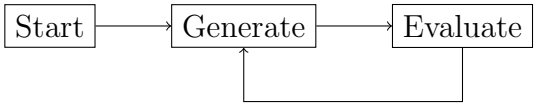
Tobias Jacob

November 15, 2020

Abstract

I want to develop a program that improves mechanical structures using an evolutionary algorithm.

I have always wondered how to simulate continues mechanics and how to use evolutionary Algorithms to solve engineering problems. The evolutionary algorithm is supposed to generate a 2D mechanical structure and then evaluate if it can withstand a certain force.



Each mechanical structure is represented by a 2D boolean array, like the following.

$$\begin{matrix} 0 & 1 & 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 & 1 & 0 \end{matrix}$$

A one is indicating that there is a quadratic element (consisting out of two triangles) present. I may fine tune The structures get evaluated on withstanding a certain force usinge finite elements. To try out if I am able to implement this, I tried it out in python. With the simplification of using just rectangluar isosceles triangles with side length 1, it is not too complicated. Figure 1 shows the results of a test python implementation I created. [1] has a compact introduction on FEM.

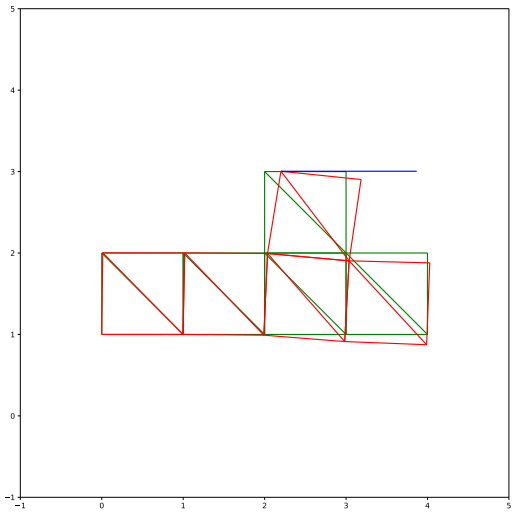


Figure 1: Example of a finite element simulation

A bunch of models can be simulated and it can be checked if it can withstand a certain force. Then the best ones get paired and produce children that are similar but have random alterations. After a while, the structures should become more optimized.

Simulating each model can be parallelized. The simulation itself requires solving a linear equation system with a big sparse, symmetric and positive definite matrix. For a 1000x1000 Grid, it would contain $2 \cdot 10^6$ elements. After each model has been simulated, all workes must submit their testscores. Then, new models have to be generated and the simulation runs again.

References

[1] G. P. Nikishkov. Introduction to the finite element method. `http://homepages.cae.wisc.edu/~suresh/ME964Website/M964Notes/Notes/introfem.pdf`, 2004.