

VIRTUAL EVOLUTION OF 2D SOFT ROBOTS

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The project aims to virtually evolve efficiently represented two-dimensional soft robotic bodies using a genetic algorithm. These soft bodies should be accurately modelled using real-world materials and physics, and the results should thus be physically replicable. Initial testing using a simple model will be done to verify the accuracy of the non-linear FEM models used. Unit cells from which the soft bodies will be built will be defined with unique and specific behaviours. Innovative techniques will be used to represent entire complex two-dimensional bodies to be represented in a computationally efficient manner.

Introduction: Soft robotics is an emerging and fast-growing field with many potential applications¹. However, traditional design methodologies are not well-suited to the design of many aspects of soft robots, as their surfaces are often contoured, compliant and complex, and advanced FEM is usually required to accurately model and predict their behaviour².

This project proposes to alleviate these issues by using new, more efficient methods to design and model soft robots.

Objectives: The project aims to demonstrate the viability of virtual evolution as a design methodology for soft robots. The project aims to show that it is computationally efficient and practical, resulting in designs that can be translated into the real world.

Genetic algorithms are robust and capable of exploring large design spaces with relative ease. Due to the difficulty of manually attempting to design soft robots for new and different tasks, these algorithms are a promising solution to this dilemma³. If the models of the soft bodies can be made more computationally efficient, this could vastly improve the genetic algorithms' performance, and by extension, allow for soft robotic design to become easier and more accessible. Thus, this project aims to do so.

The project also aims to make its work replicable and easy to continue with for further research. Stepping up from 2 dimensions to 3 dimensions, while requiring more intensive computations, should be achievable, and modifying the objective functions of the genetic algorithm should be straightforward, to allow for the easy reuse and further development of the project.

Investigative Approach: Virtual bodies will be composed of unit cells with distinctly defined behaviours. Example behaviours, although not necessarily the final behaviours, can be seen in Figure below. The initial shape is indicated with solid black lines and the transformed shape with dotted lines. Unit cells will be deformed first according to their defined behaviours, and the resultant strain energy will then be computed.

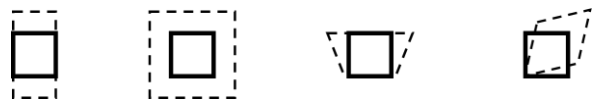


Figure 1: Unit Cell Example Deformations

Two approaches will be considered to model the soft bodies as a whole.

One approach is the usage of Lindenmayer systems, as they have been shown to be very promising as representation methods for complex soft bodies. Lindenmayer systems are composed of recursive grammar rules, replaceable symbols and constants, which are then applied to an initial set of symbols and constants. Using this approach, a complete soft body can be modelled using only the rules, symbols, constants, initial set and a specified level of recursion, where symbols and constants are representative of specific unit cells.

The other approach involves the usage of neural nets as a more efficient method of the representation of soft bodies.

The project will make use of a genetic algorithm to evolve a randomly generated population to best fit some goal.

Virtual bodies and their behaviours will be modelled using non-linear FEM. Different FEM software packages will be tested in order to determine which is sufficiently accurate, applicable and supportable. The different packages considered are Siemens NX, LS Dyna and Marc Mentat. In order to test their viability, a simple model of an empty 2D 10x10 square, as shown in Figure below, will be created in each of the aforementioned packages. The material modelled will be Mold Star 15, and it will be modelled

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as a non-linear, hyper-elastic material. A constant pressure will be applied along the outer edge of the square. Once all three models have been completed, a physical model will be produced. The physical model will naturally have some depth, as opposed to the pure 2D models. The physical model will be placed between 2 glass plates and placed under the same pressure as was simulated. The FEM models will then be compared to the physical model, to verify their accuracy.

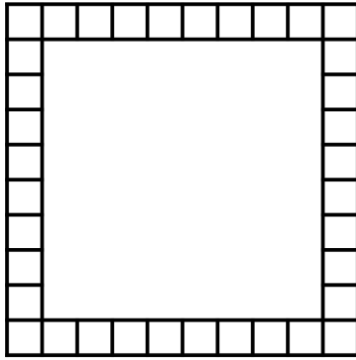


Figure 2: 10x10 Empty Square

Limitations: The bodies will only be modelled in 2 dimensions, so as to severely reduce complexity and computational costs.

Expected Findings: There are no findings yet.

The project is expected to accurately and efficiently evolve and simulate soft robotic bodies in 2 dimensions, in an easily replicable and modifiable manner. The project is also expected to do so in a much more computationally efficient manner than previous attempts.

Conclusions: The field of soft robotics has a lot of potential for discovery. This project aims to explore some of that potential in a more computationally efficient manner, resulting in tools that can be used to further develop this field and design interesting solutions to complex problems.

References:

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