**VIRTUAL EVOLUTION OF 2D SOFT ROBOTS**

NT Conradie & Dr. MP Venter

Department of Mechanical and Mechatronic Engineering, University of Stellenbosch, Stellenbosch, South Africa

***Introduction:*** Soft robotics is an emerging and fast-growing field with many potential applications. 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 behaviour.

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.

The project also aims to make its work replicable and easy to continue with for further research.

***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.

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, LSDyna 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 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.

***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.

Conclusions: The field of soft robotics has a lot of potential for discovery. This project aims to explore some of that potential and provide interesting results, through a process of application of current knowledge across multiple fields.