SHAPE TOPOLOGY OPTIMISATION

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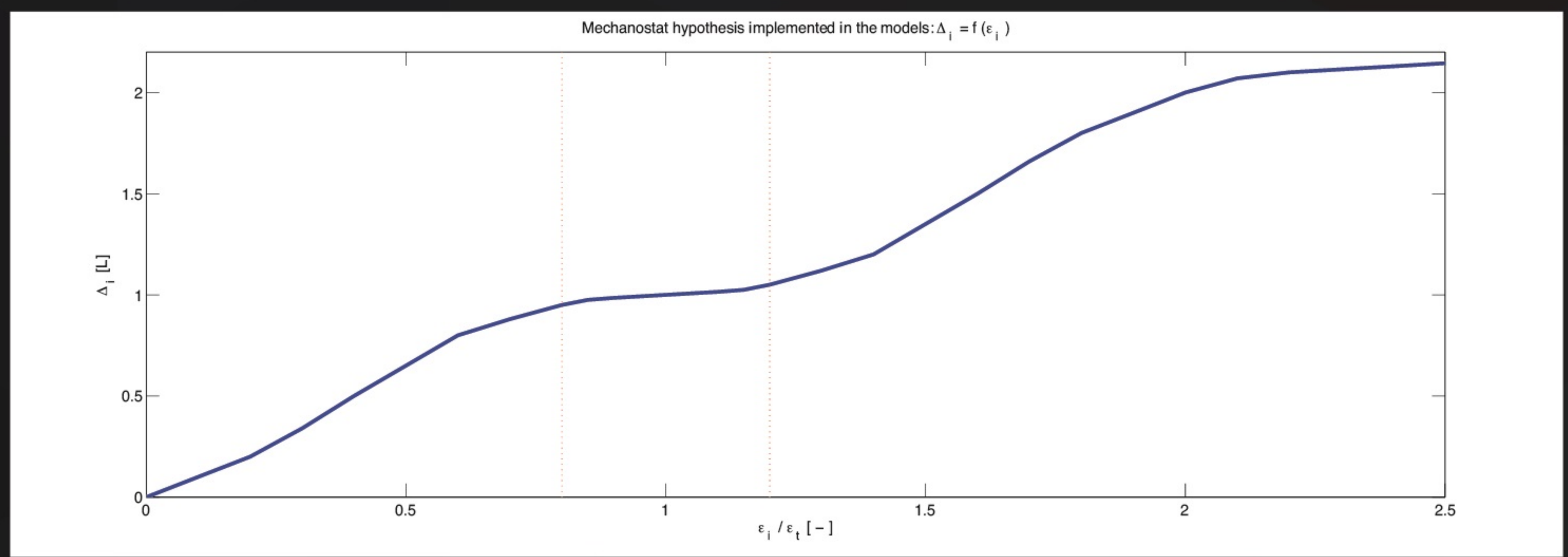
1. Introduction:

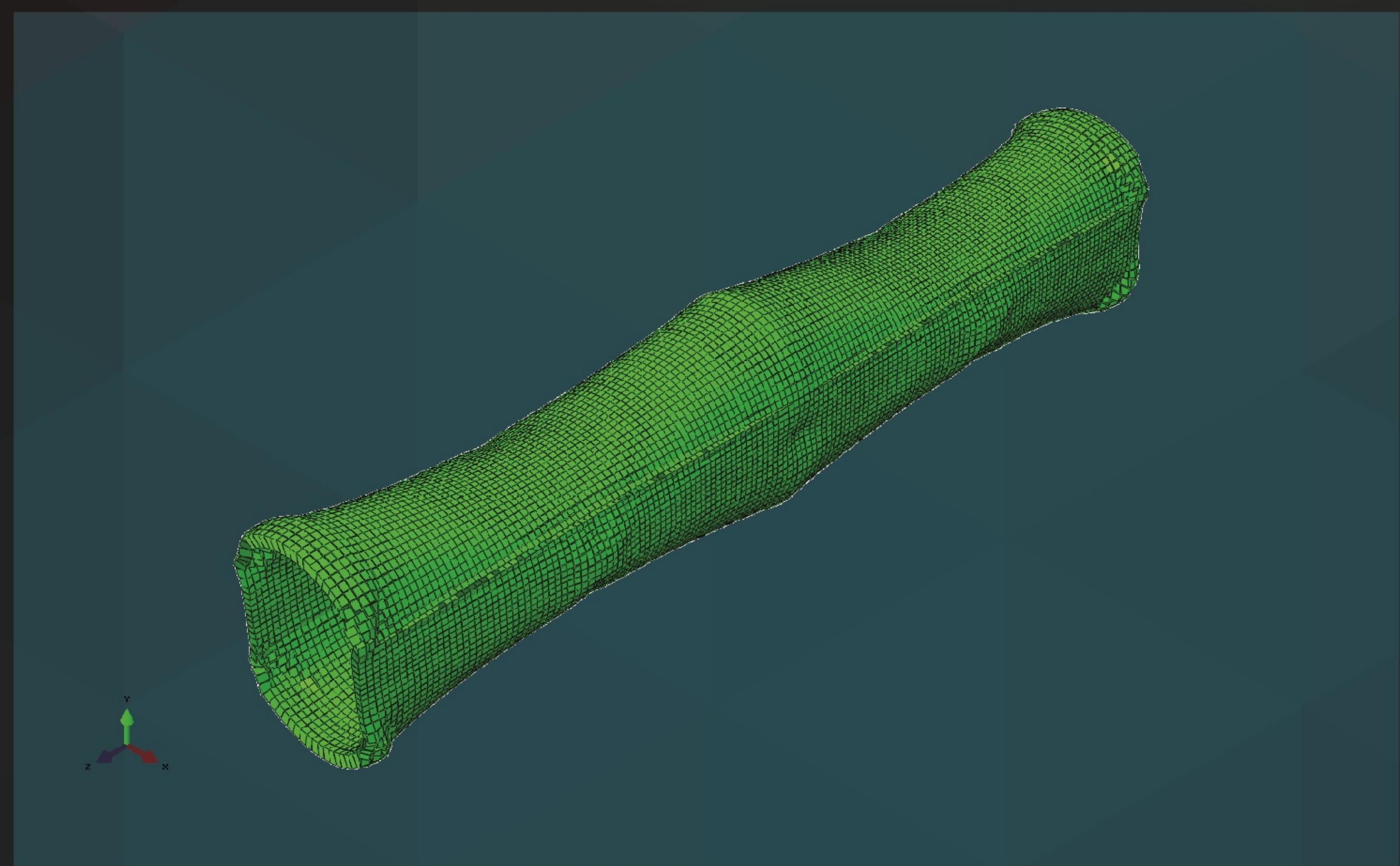
Structural optimisation has been used to improve the performance of multiple structures. It has also been applied in structural biomechanics, to optimise bone structures under loading.

This study created models to optimise the shape of structures; they were designed to resist load in bending. The mass of the structures were optimised. This was done by adding and removing bone mass from areas of high and low strained areas. These models were designed to apply to bones. Bone remodelling laws drove the adaptation. Frost's mechanostat hypothesis was how this was applied to an algorithm.



2. Methods:

The structures were iterated. Upon every iteration, the position of nodes were edited and the associated thickness of elements. This repeated until convergence was achieved. Convergence was defined as when every element was within a target strain range, 1 000 - 1500 micro-strains. The models were able to adapt the structures' thickness, shape or both. This would change each sections' second moment of area, which effects bending resistance.

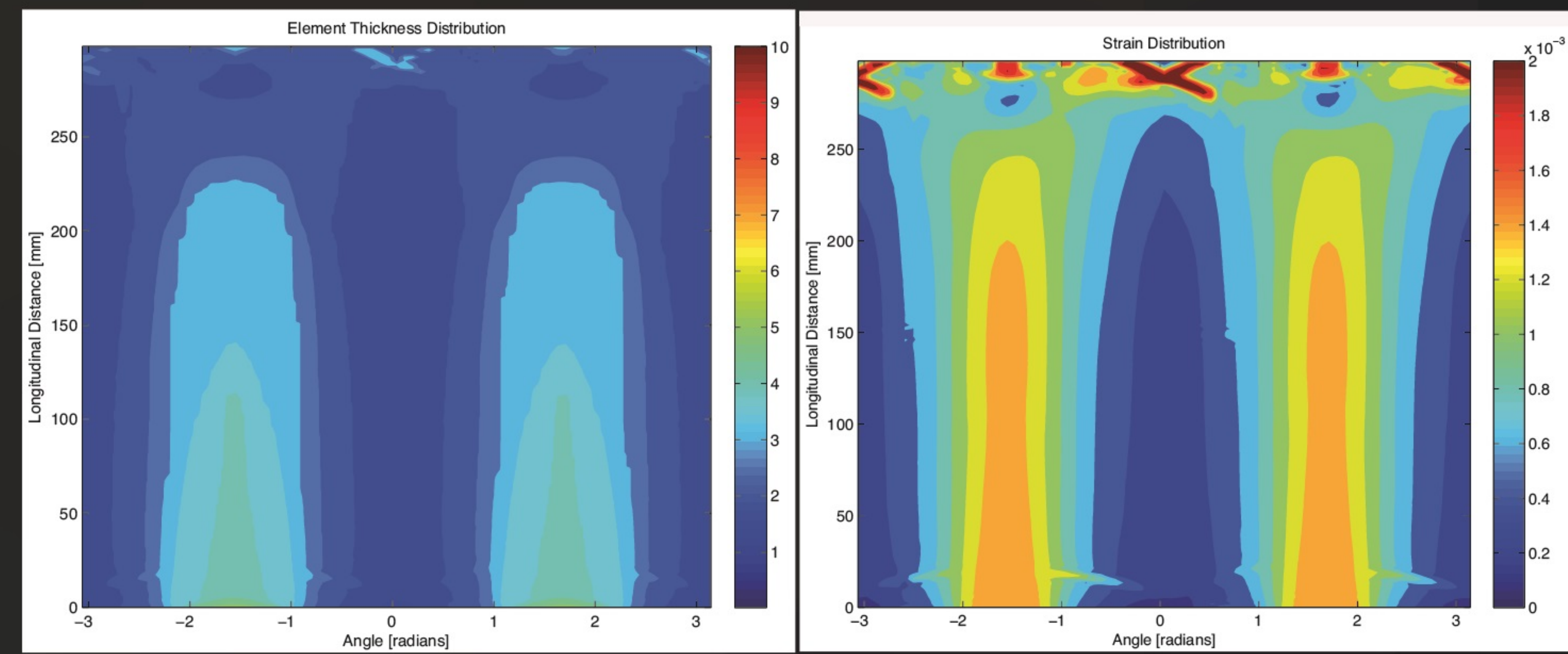


3. Applications:

The models were applied to a cantilevered with an end point load; a centrally loaded simple beam; an axially loaded cantilver structure; and a human femur.

The different models, produced similar structures for the same initial structures. Taller cross sections improves bending resistance for vertical loading. Elements can thin to increase the loading which they bare.

The shaft of the femur was optimised using the model. The models needed to be developed further to predict the shape.



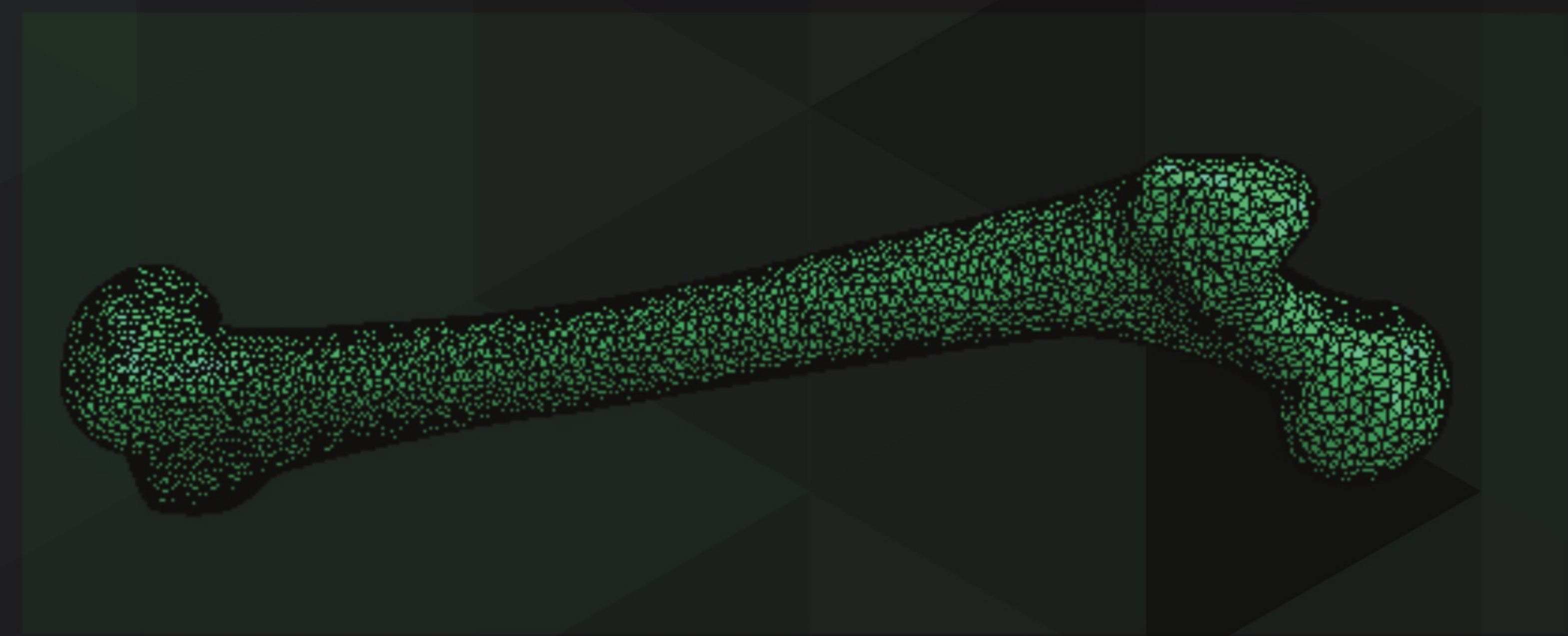
Thickness variaion of elements within the structure; and the strain distirubtion in the structure.

4. Results:

The cantilever structure achieved 45% convergence after 145 iterations. The structure had an average strain of 0.64 εt.

The simply supported structure achieved 51% convergence after 61 iterations with an average strain of 0.80 εt.

The femur's shaft achieved 37% convergence after 377 iterations. the average strain in the structure was 0.94 εt. The strains in the structure were in the range of 2.76 εt and 0.03 εt.



5. Acknowledgements:

I would like to thank Dr. Andrew Phillips for all of his help and guidanceduring the project. I would also like to thank my family for their continued patience and support during this reasearch project.