Leveraging Generative Design in Design for Additive Manufacturing

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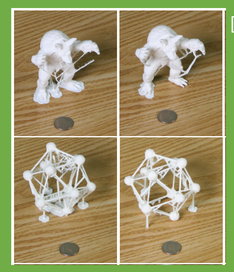
The Problem

Additive Manufacturing and 3D printing are becoming increasingly popular, both in industry and for hobbyists. But the tools and methods used for designing accordingly haven't kept pace.


[1]

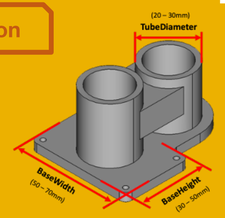
Generative Design is a growing design technique that uses algorithms to automatically produce many designs.


[2]

Generative Design shows potential as an assistive tool in Design for Additive Manufacturing (DfAM). *The goal of this project is to develop a CAD plug-in or tool that assists users with optimising their designs for this purpose.*

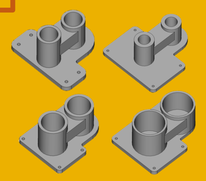
The Process

Initiation



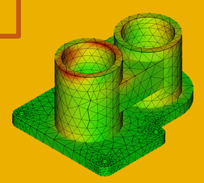
- Define parameters to be varied
- Define loads and constraints

Generation



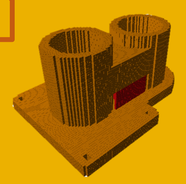
- Produce many part generations by varying the parameters

Analysis



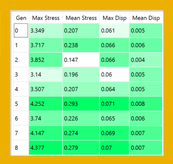
- Analyse the mechanical performance for all generations

Refinement



- Calculate part volume for 3D printing
- Generate support material

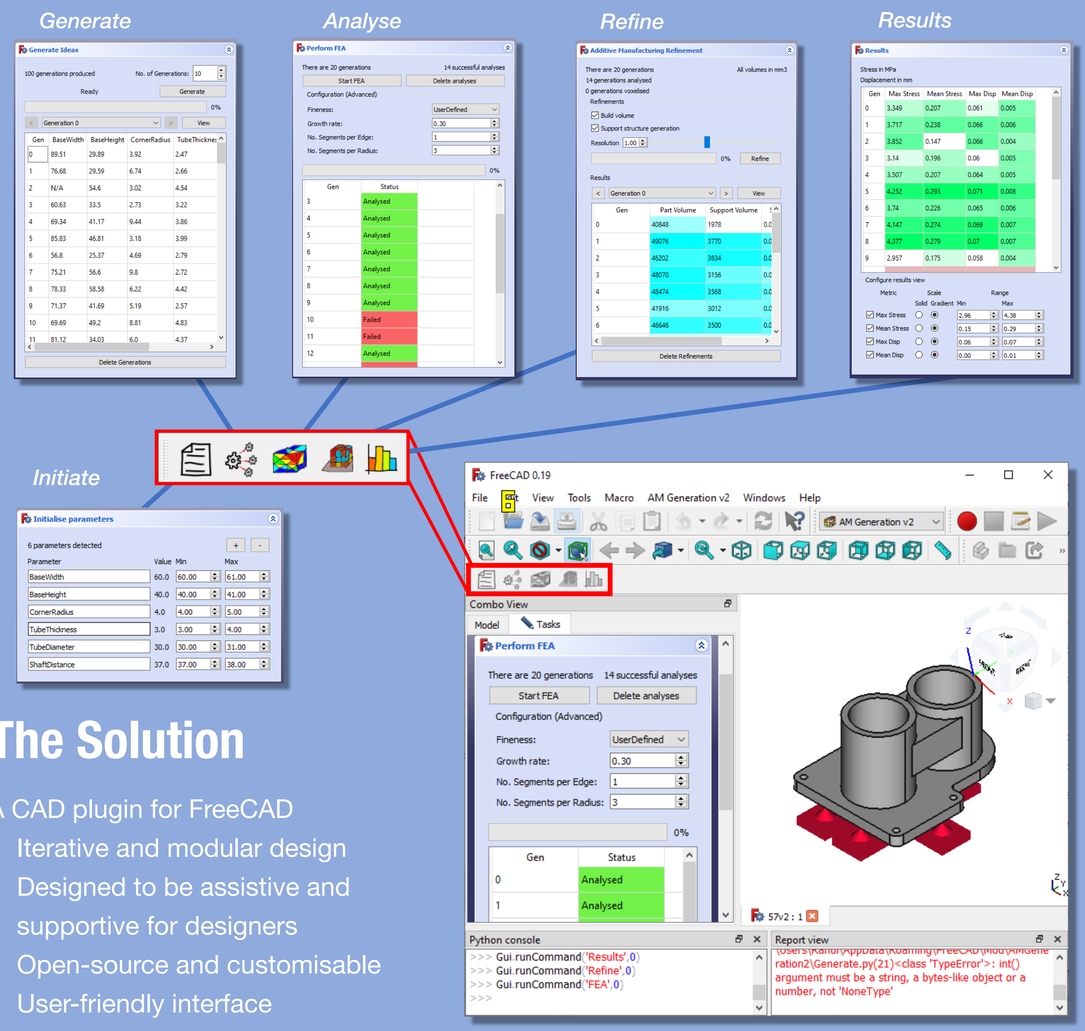
Results



Gen	Max Stress	Mean Stress	Max Disp	Mean Disp
0	3.349	0.207	0.061	0.005
1	3.717	0.238	0.066	0.006
2	3.852	0.147	0.066	0.004
3	3.14	0.196	0.06	0.005
4	3.507	0.207	0.064	0.005
5	4.252	0.293	0.071	0.008
6	3.74	0.226	0.065	0.006
7	4.147	0.274	0.069	0.007
8	4.377	0.279	0.07	0.007

- Calculate statistics for all generations
- Choose the best generation

The Solution



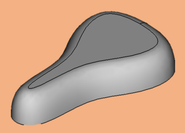
A CAD plugin for FreeCAD

- Iterative and modular design
- Designed to be assistive and supportive for designers
- Open-source and customisable
- User-friendly interface

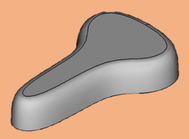
The Results

A number of design case studies were devised to test how practical and effective the solution was. These were the most prominent case studes

Case Study 1: Bicycle seat

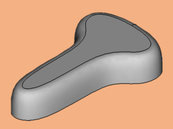


Task
Parameterise and generate new designs for a bicycle seat shell to try and find different designs

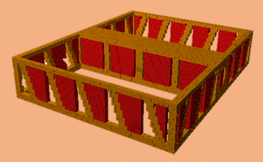


Objective
- Explore the creative design space

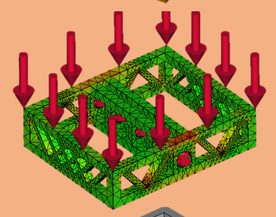
Results
- **Good variety of designs produced successfully**
- **Successful demonstration of the plugin's ease of use**



Case Study 2: Bicycle pedal

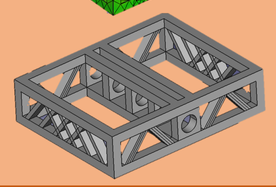


Task
Design an optimise a bicycle peal made from a frame of struts for 3D printing

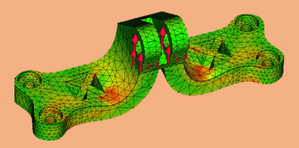


Objectives
- Minimise part volume
- Minimise support structures

Results:
- **34% decrease in volume**
- **Successful demonstration that the plugin aids the designer's creative process**



Case Study 3: GE Jet Bracket



Task
Take an existing optimised design for a part and improve on it by combining other ideas

Objectives
- Minimise part volume
- Maximise mean stress

Results:
- **Modest 4.3% decrease in part volume**
- **Significant increase in mean stress**
- **Low support volume ratio of 0.1**

Conclusion

These results show that the foundation for a Generative Design for Additive Manufacturing (G-DfAM) software module has been successfully built.

This is a good step towards democratisation of Generative Design and more broadly Artificial Intelligence in design.

MEng Integrated Mechanical and Electrical Engineering **Rahul Jhuree** **Academic Year** 2020/21

References: [1] Krish S. A practical generative design method. CAD Comput Aided Des [Internet]. 2011;43(1):88–100. Available from: http://dx.doi.org/10.1016/j.cad.2010.09.009
[2] Vanek J, Galicia JAG, Benes B. Clever Support: Efficient Support Structure Generation for Digital Fabrication. Eurographics Symp Geom Process. 2014;33(5).

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