Leveraging Generative **Design in Design for Additive Manufacturing**

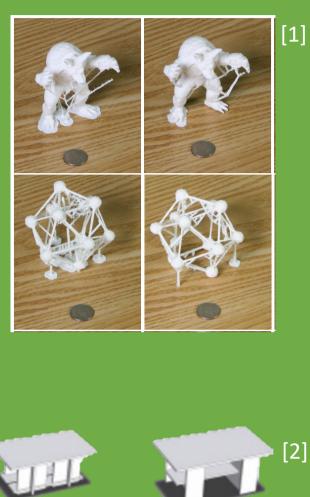
Supervisor: Dr Nic Zhang **Assessor:** Dr Rob Wortham

The Problem

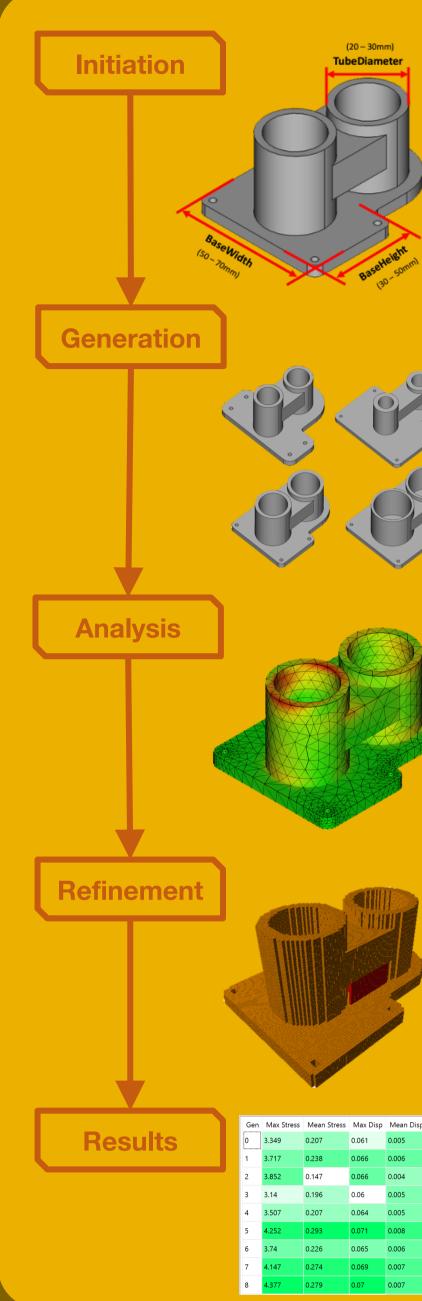
Additive Manufacturing and 3D printing are becoming increasingly popular, both in industry and for hobbyists. But the tools and methods used for designing accordingly haven't kept pace.

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

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 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

Task

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

MEng Integrated Mechanical and Electrical Engineering

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).

The Process

be varied

constraints

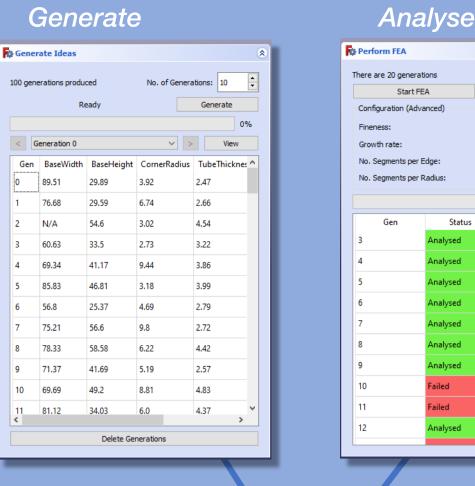
• Define parameters to

Define loads and

- Produce many part generations by varying the parameters



- Analyse the mechanical performance for all generations
- Calculate part volume for 3D printing
- Generate support material
- Calculate statistics for all generations
- Choose the best generation



Perform FEA		
There are 20 gener	ations	14 successful analyses
Start	FEA	Delete analyses
Configuration (Ad	lvanced)	
Fineness:		UserDefined V
Growth rate:		0.30 🚖
No. Segments pe	-	1
No. Segments pe	r Radius:	3
		0%
Gen	Status	^
3	Analysed	
4	Analysed	
5	Analysed	
6	Analysed	
7	Analysed	
8	Analysed	
9	Analysed	
10	Failed	
11	Failed	
12	Analysed	

Initiate

🙀 Initialise parameters					۲
6 parameters detected				+	-
Parameter	Value	Min		Max	
BaseWidth	60.0	60.00	-	61.00	-
BaseHeight	40.0	40.00	-	41.00	-
CornerRadius	4.0	4.00	\$	5.00	\$
TubeThickness	3.0	3.00	\$	4.00	÷
TubeDiameter	30.0	30.00	-	31.00	÷
ShaftDistance	37.0	37.00	-	38.00	-

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

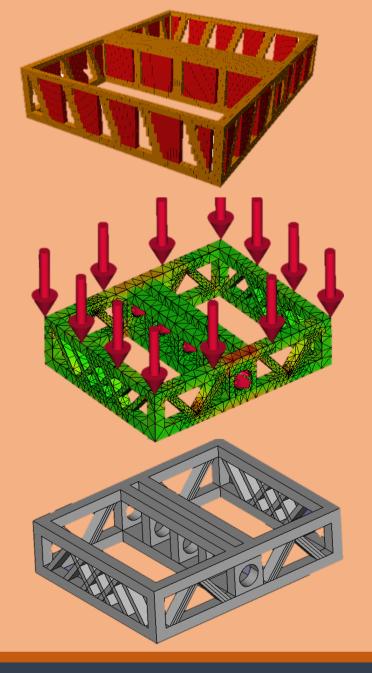
Case Study 2: **Bicycle pedal**

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

Objectives

• Minimise part volume • Minimise support structures

Results:



Case Study 3: GE Jet Bracket

🗐 🤹 🧭 📠

Task

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

Objectives

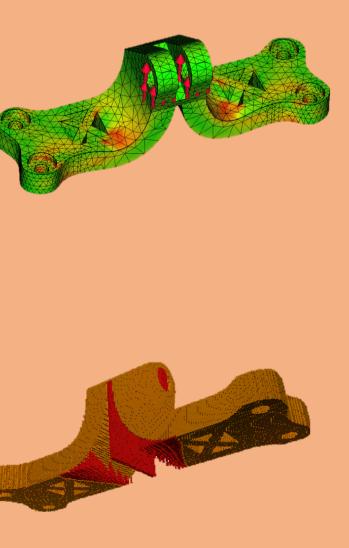
- Minimise part volume
- Maximise mean stress

Results:

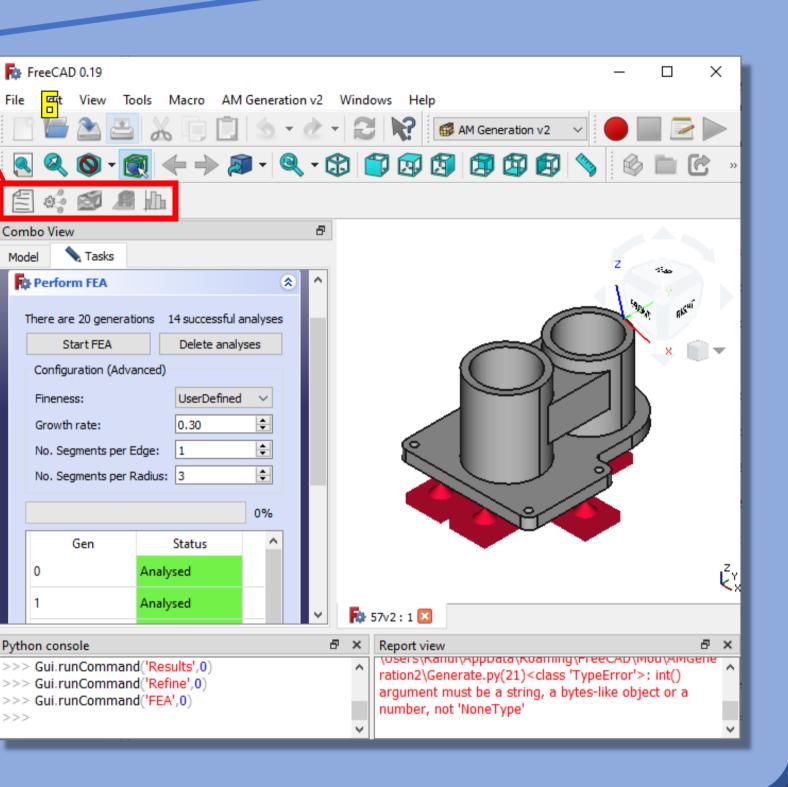
- Modest 4.3% decrease in part volume
- Significant increase in mean stress
- Low support volume ratio of 0.1



Rahul Jhuree



Additive Man	ufacturing Refinemen	t	۲	Fo	Result	ts		_	
There are 20 gen 14 generations a		All volu	umes in mm3	-	tress in isplacer	MPa ment in mm			
0 generations vo Refinements	xelised				Gen	Max Stress	Mean Stress	Max Disp	Mean Disp
Build volum	e				0	3.349	0.207	0.061	0.005
	- ucture generation				1	3.717	0.238	0.066	0.006
Resolution 1.0	0 😫				2	3.852	0.147	0.066	0.004
		0% R	efine		3	3.14	0.196	0.06	0.005
Results					4	3.507	0.207	0.064	0.005
< Genera	tion 0	~ > V	/iew		5	4.252	0.293	0.071	0.008
Gen	Part Volume	Support Volum	e :^		6	3.74	0.226	0.065	0.006
0	40848	1978	0.0		7	4.147	0.274	0.069	0.007
1	49076	3770	0.0		8	4.377	0.279	0.07	0.007
2	46202	3834	0.0		9	2.957	0.175	0.058	0.004
3	48070	3156	0.0		Config	ure results viev	v		
4	48474	3568	0.0			letric	Scale	Ra	ange
5	41916	3012	0.0		- M-	Sol x Stress	id Gradient Mir	n 96 🗘	Max 4.38
6	46646	3500	0.0			an Stress			
<			>		Ma	-			



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.

Faculty of Engineering & Design



