Paper 43: Morphogenic Shape Grammars for the Design of Engineering Structures

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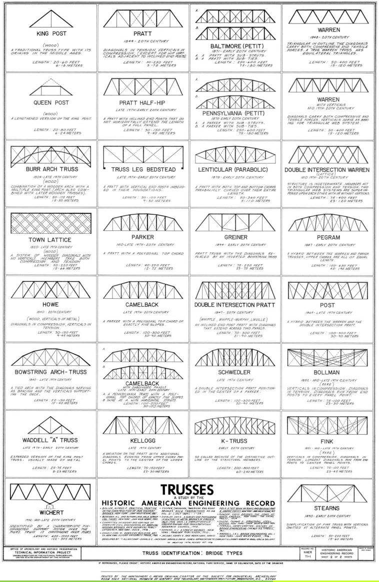
EPSRC programme Grant Ref **EP/V007335/1**,
"RIED: Re-Imagining Engineering Design"



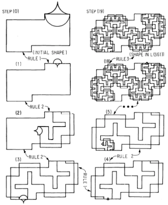
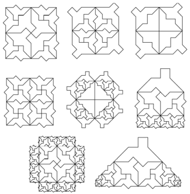
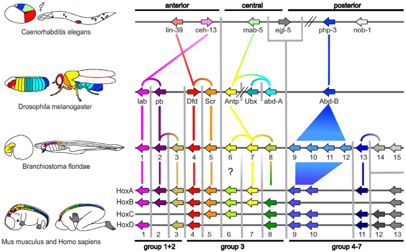


Figure 6-3. Generation of a shape using SG1.

Stiny & Gips (1972)



Grasl & Economou (2018)



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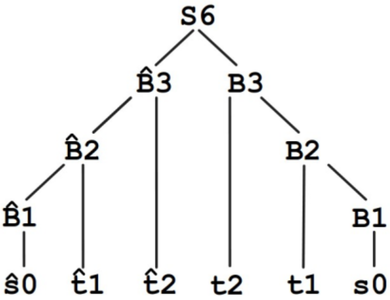
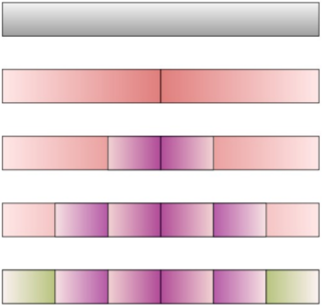
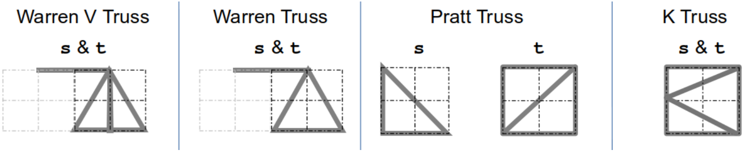
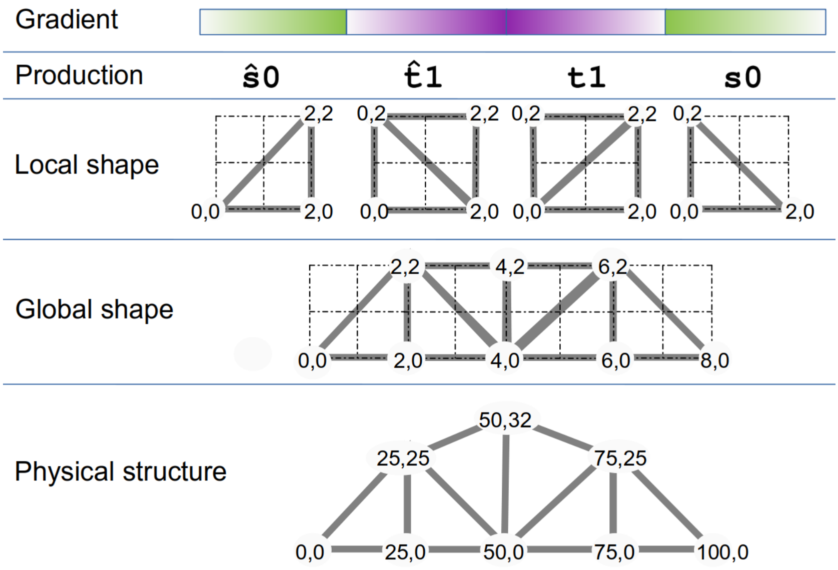
Morphogen Analogy





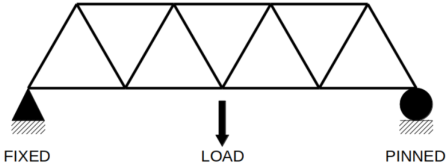


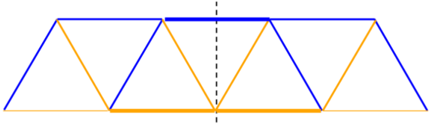
Example grammar - all steps



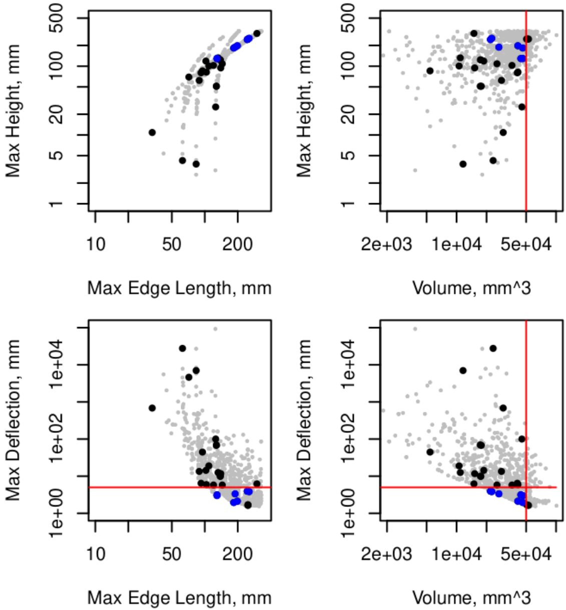
Evolutionary search

- NSGA II algorithm, with 4 objectives to minimise: **material volume**; **deflection under load**; **maximum edge length**; **maximum height**.
- Genes for: truss type; member cross-sectional area; number of segments; attribute-to-height ratio
- FEA analysis using Calculix simulation software gives deflection value
- population 200, run for 100 generations

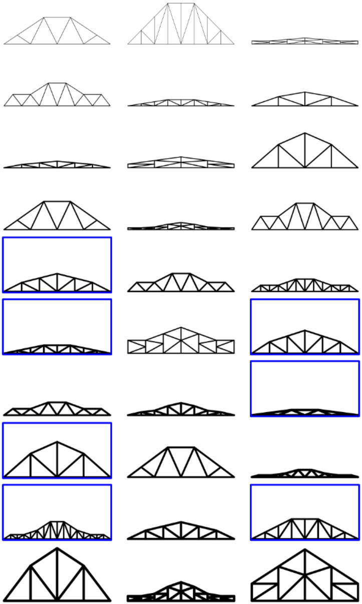




Fitness Landscape

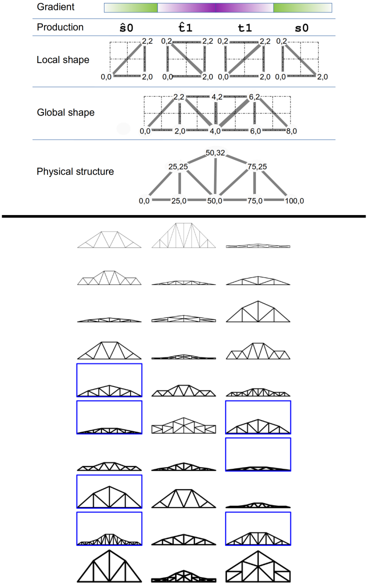


Pareto structures



- Wide range of structures generated
- Real engineering considerations can drive the search
- Search over a *range* of topologies made possible. Scope for topology optimisation beyond this stage.

Summary



- The complexity of real engineering structures can be described via shape grammars with attributes that emulate chemical gradients
- A genetic encoding of these grammars allows evolutionary search for suitable structures
- This approach allows feedback from FEA simulations to influence the gestalt form of engineering designs

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