



## Paper 78: Evolving Design Modifiers

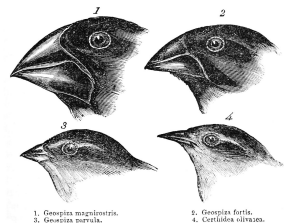
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Andrew Colligan<sup>2</sup>, Mark Price<sup>2</sup> and Andy Tyrrell<sup>1</sup>

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

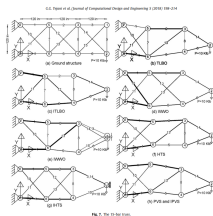
- Engineering design is difficult to automate
- Developmental processes allow immediate, localised feedback to a physical system as it grows.
- Can we *evolve* such processes via EvoDevo?



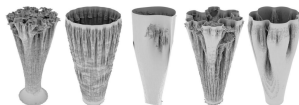
Darwin's finches (source: wikipedia)

# Why EvoDevo?

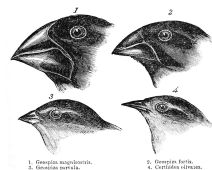
- Evo has nice properties of fitness, but encoding is difficult
- Devo has nice encoding, but fitness is difficult
- EvoDevo
  - Darwin's finches have both - DNA encoding of a growth algorithm that can be evolved
  - Evolve the growth rules/patterns
  - Devo decodes the growth rules, changes the organism (as per the growth rules), and computes the fitness (quality)



Tejani et al (2018)

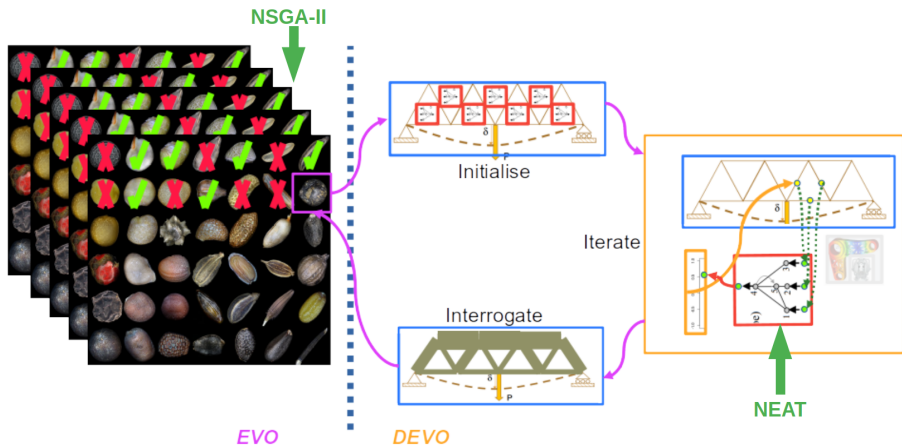


Lomas (2016)

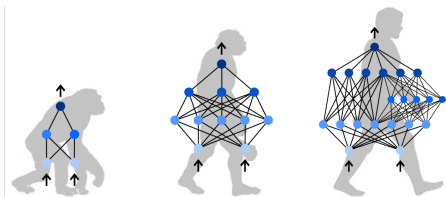


Darwin's finches (wikipedia)

# Algorithm

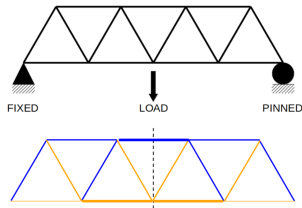


- GRN is the heart of EvoDevo – test the technique using NEAT *Neuro Evolution of Augmenting Topologies*
- **Benefits:** flexible topology; fixed inputs & outputs; evolvable; well understood
- **Challenges:** stateless (unlike GRNs); single-objective; complex config

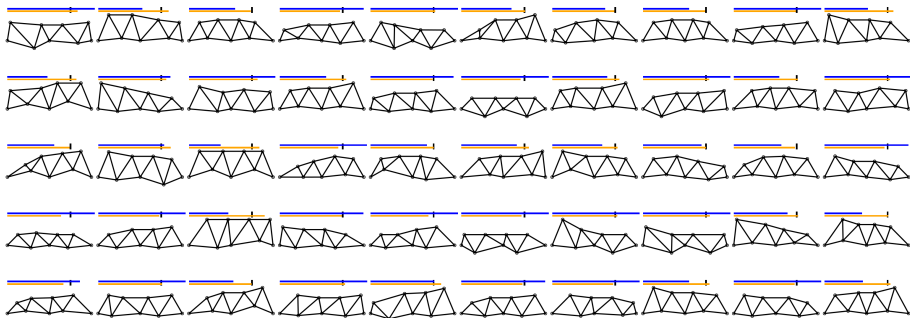
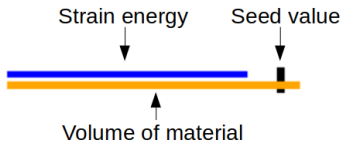


# Configuring the experiment

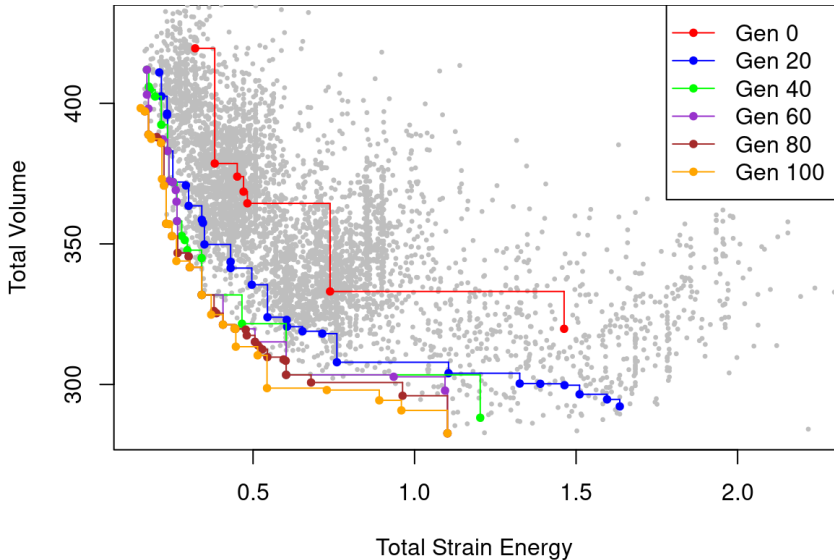
- **Goal:** Improve the design of a 2D planar “Warren” truss via EvoDevo over two objectives: Total strain energy & Total material volume
- “Seed design” is equilateral triangles - each triangle is a devo “cell”
- Commence with a random population of NEAT GRNs
- Devo decodes the growth rules, changes the organism (as per the growth rules), and computes the fitness (quality)
- Evolve the growth rules/patterns against the two objectives



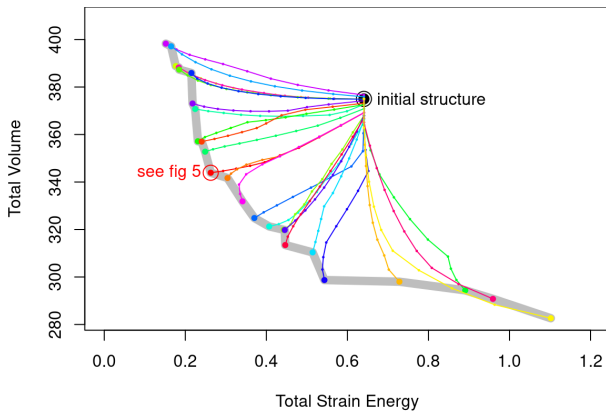
# Initial Population



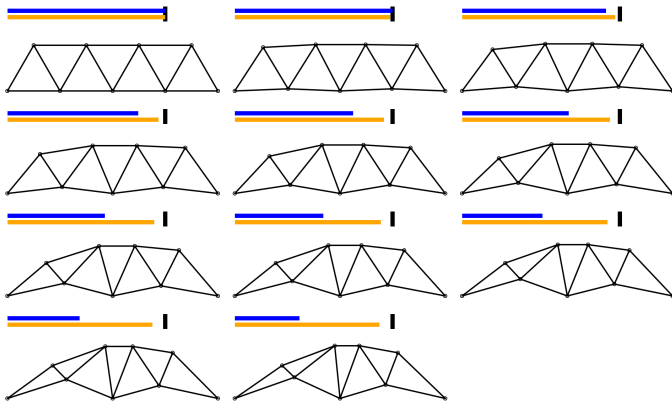
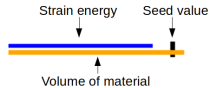
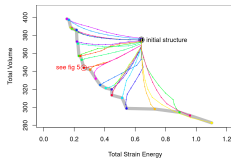
# Pareto Front



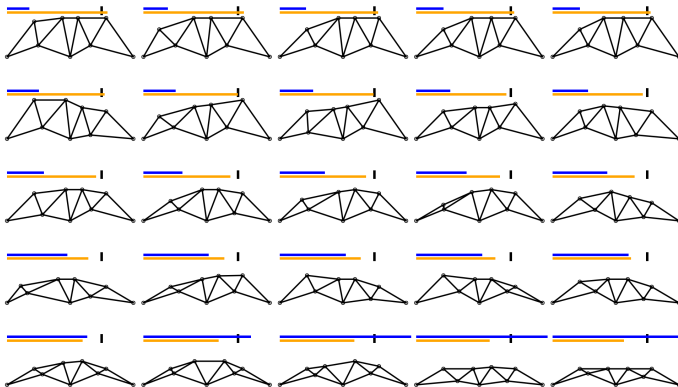
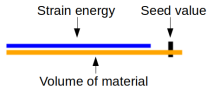
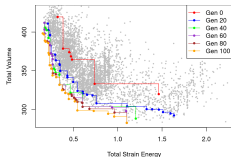
# Devo in fitness space



# Example Devo



# Pareto front designs

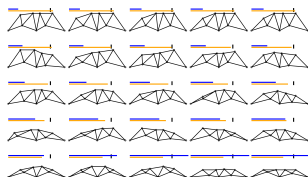
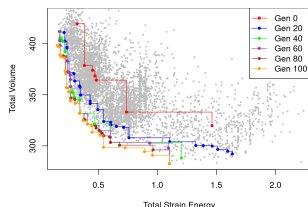


## Summary:

- Successfully demonstrated an evodevo algorithm for design modification
- Improvements delivered over two objectives for a simple design problem

## Further Work:

- “True” devo
- Extend to 3D design
- Extend to more objectives
- Stateful GRN model





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