

Cooperation in Evolved Modular Soft Robots

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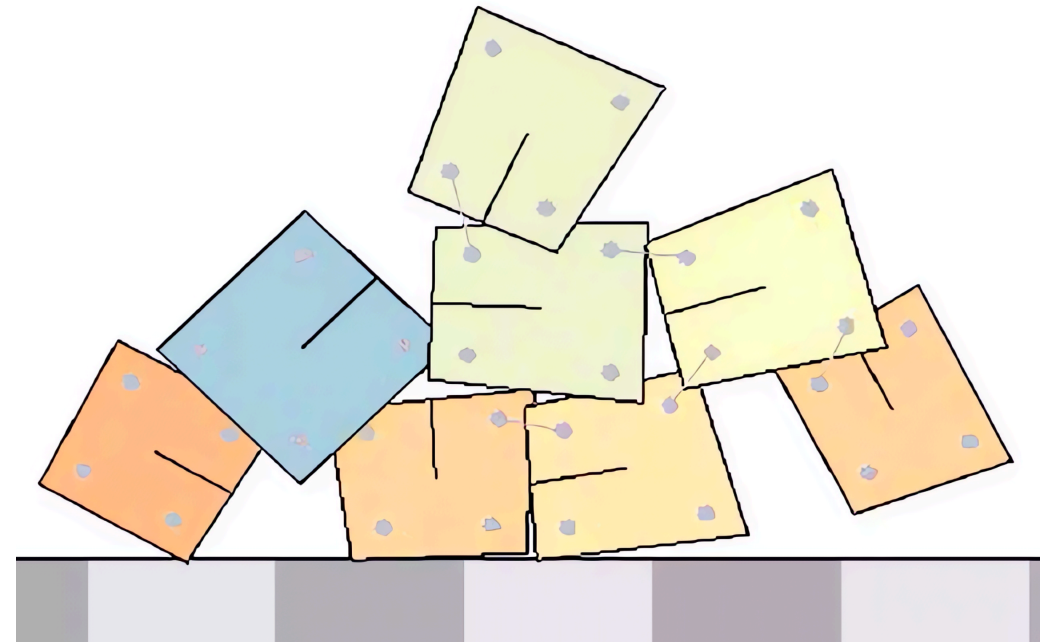
Introduction

- Self-assembly
- Soft robotics



Voxel Soft Robot (VSR)

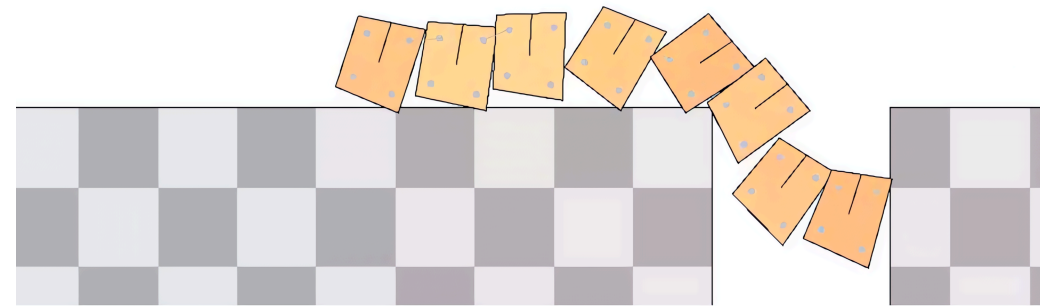
- Accelerometer-like
- Compression sensors
- Proximity & contact sensors
- Directional communication
- Spring actuators
- Directional attachment



Task

Hole passing:

- $\epsilon + \text{size}(r)$
- $\epsilon + \text{size}(r) \cdot 2$
- $\epsilon + \text{size}(r) \cdot 3$

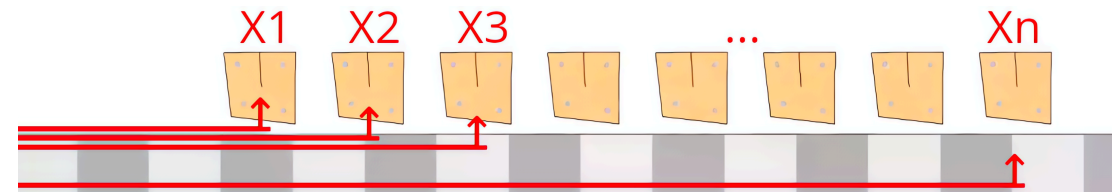


Controller & optimization

- Artificial Neural Network
- Weights optimization (CMA-ES)
- Population size: 24
- Epochs: 375
- Replicas: 60

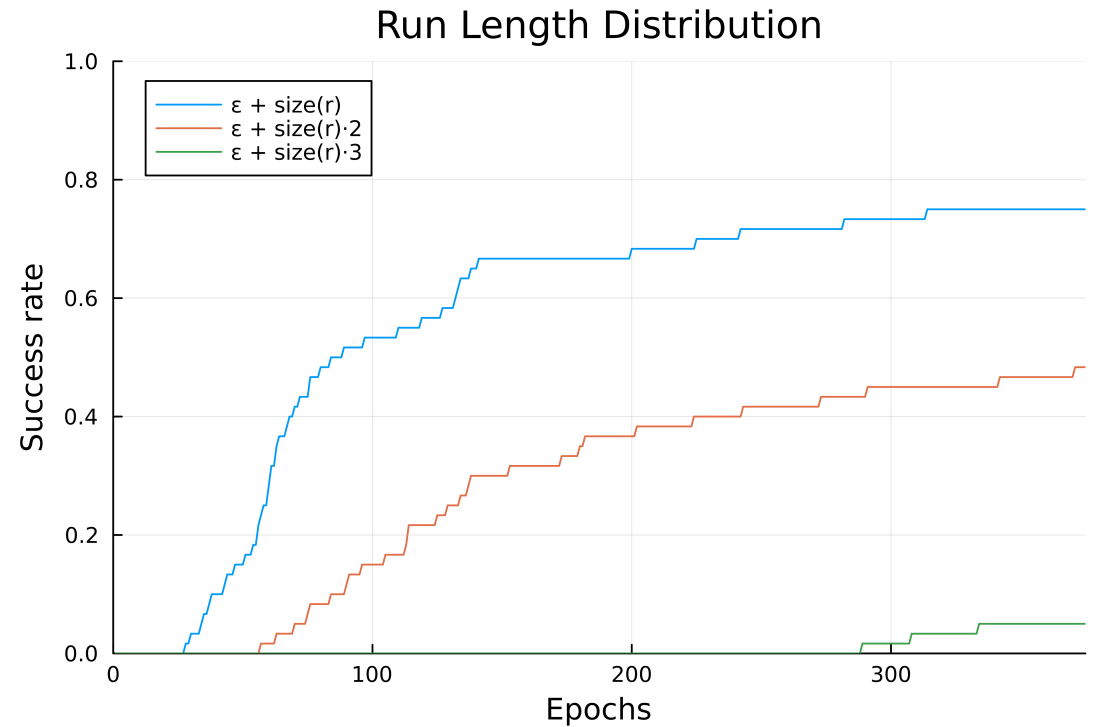
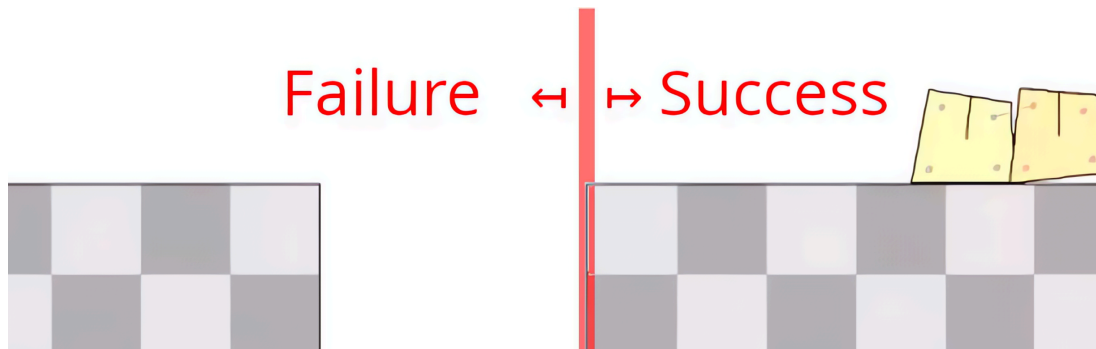
Fitness function:

$$f(t) = \frac{1}{n} \sum_{i=1}^n x_i^t$$



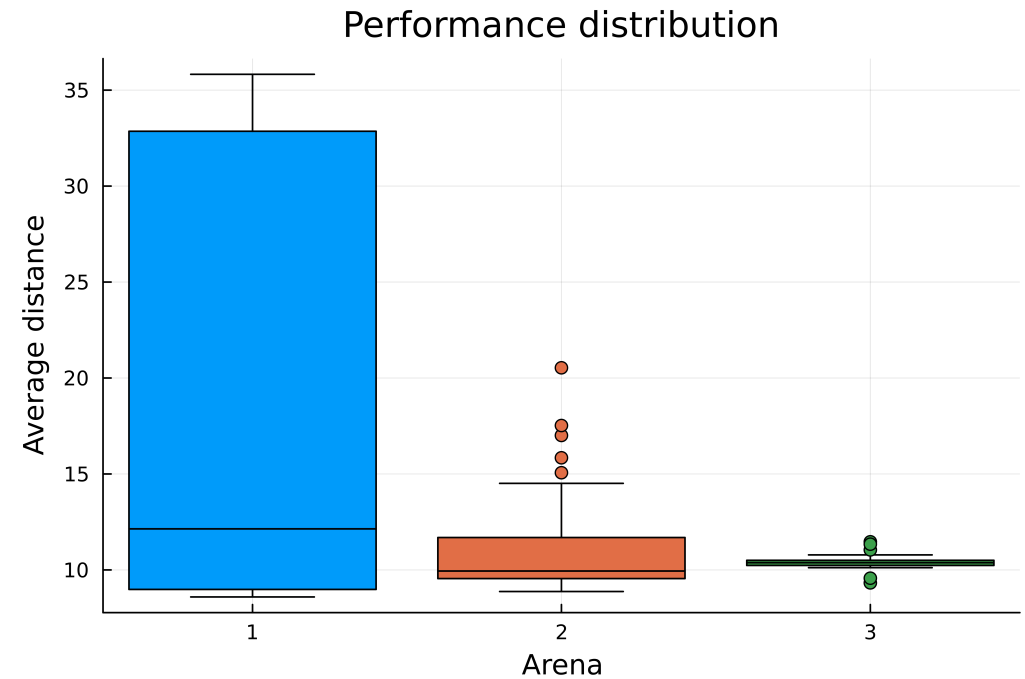
Results

- Success depends on hole size
- No satisfying solution for the largest hole



Results

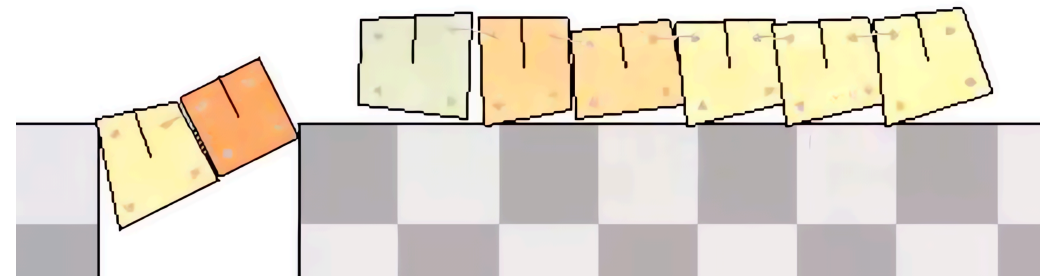
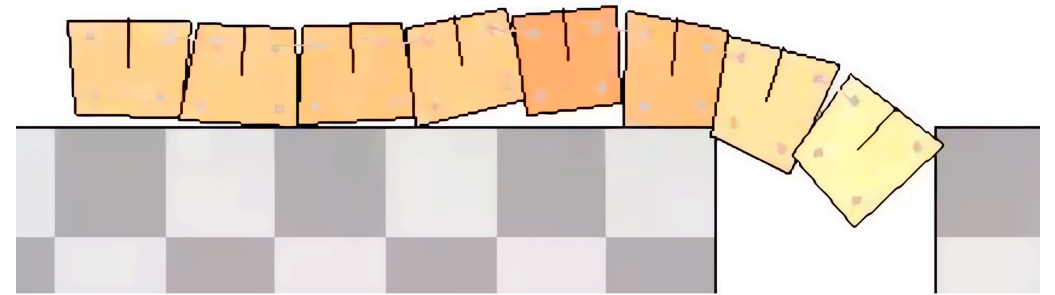
- In first arena most robots pass
- Some losses in second arena
- Interesting result in third arena



Results

In the first 2 arenas, a success!

In the third, it didn't work...

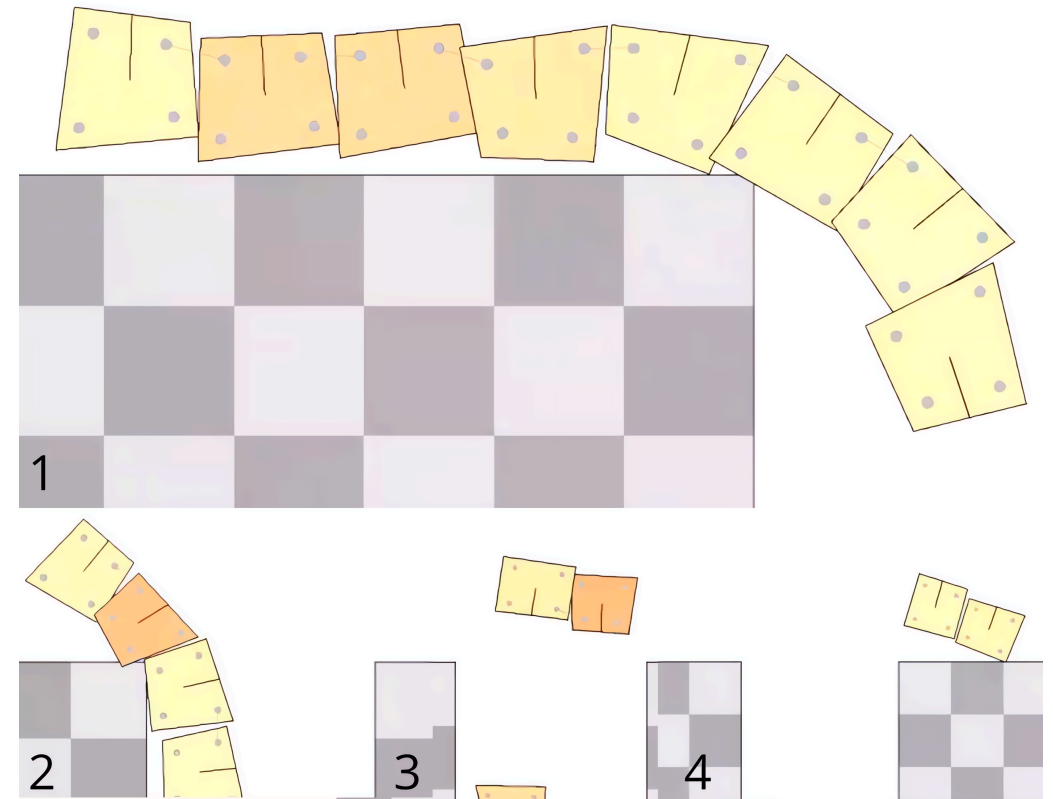


Results

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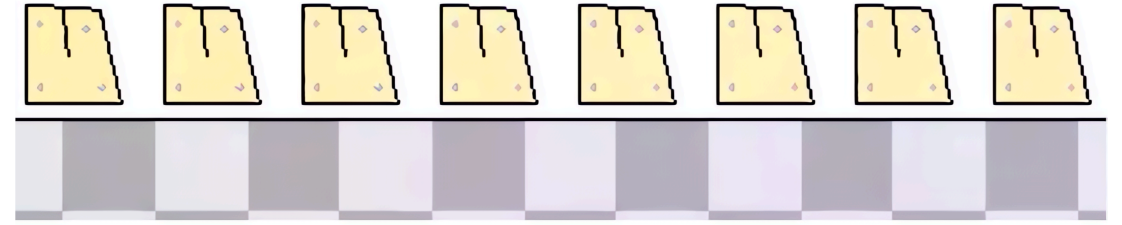
In the third, it didn't work...

... except for *one* solution, which discovered a trick

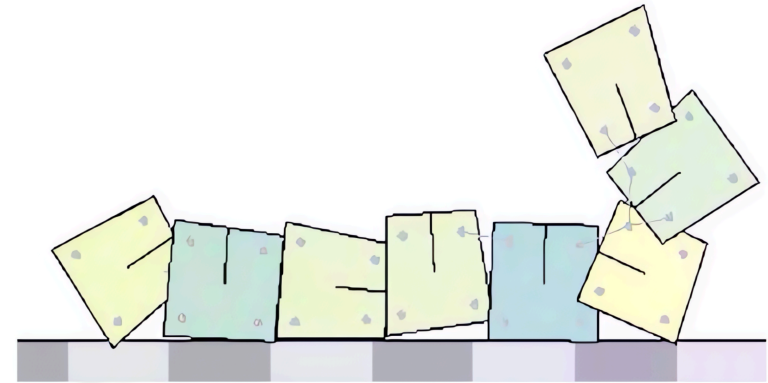


Ongoing experiments

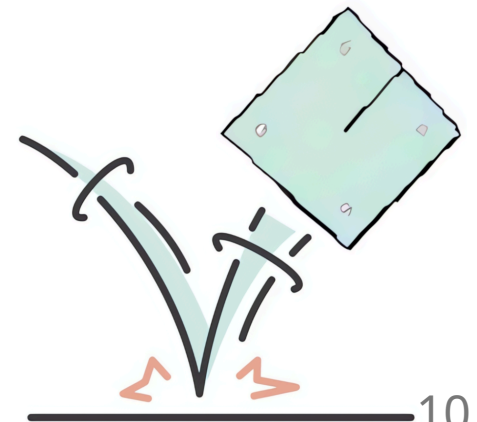
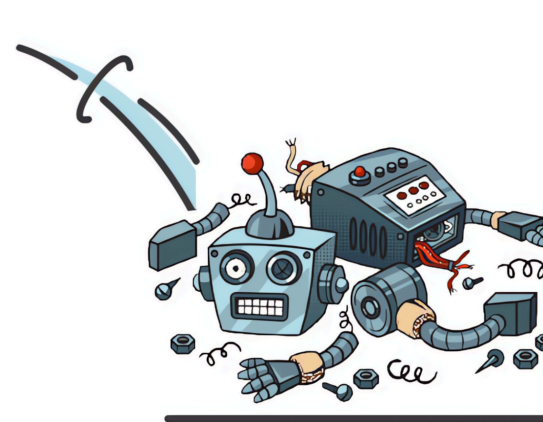
- Can smaller groups keep passing the arenas?
- Can bigger groups pass larger holes?



A)



B)



Conclusion

A) Self-assembly of VSRs is possible

B) Soft-robotics enabled strategies