COMPARING ENCODINGS FOR EVOLVING MODULAR ROBOTS

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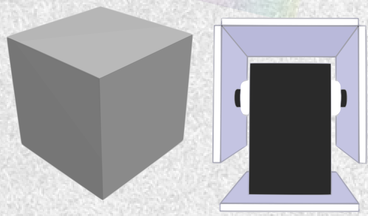
INTRODUCTION

- What type of encoding should be used to evolve modular robots?
- How do these encodings shape performance and phenotypic diversity?

METHODS

- Direct Encoding: Directly map robot tree structure on phenotype
- L-System: Recursively express up to five modules
- Compositional Pattern Producing Network (CPPN): query CPPN to decide if a module should be created at a connection site

Modules used



Steady-state EA

- Random selection
- Replace worst genomes
- Optimized mutation rate for each encoding
- 54,000 evaluations
- population of 90
- 10 Evolutionary runs

Mutation

Direct Encoding

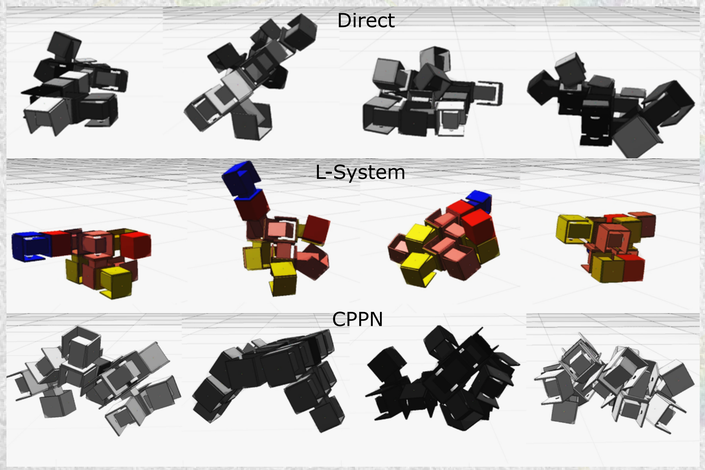
- Add module
- Remove module
- Change orientation
- Mutate controller

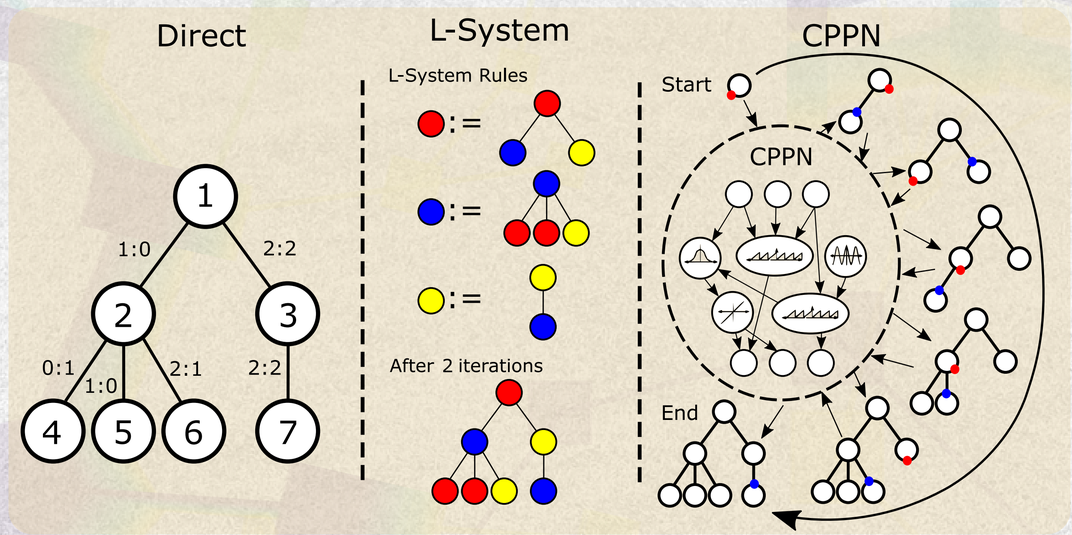
L-System

- Resize rules
- Change rule
- Swap rules
- Mutate controller

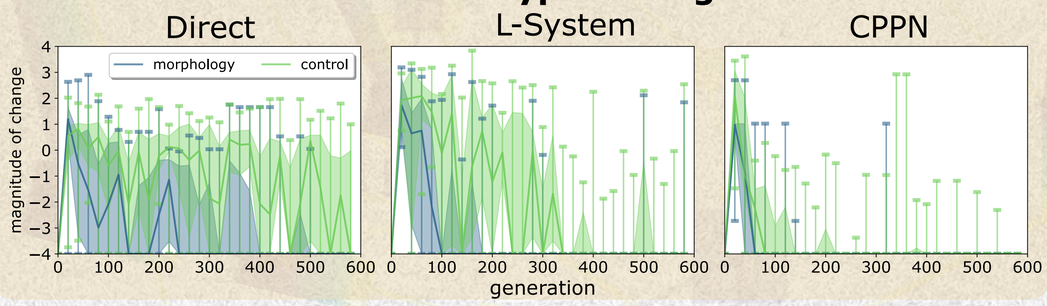
CPPN

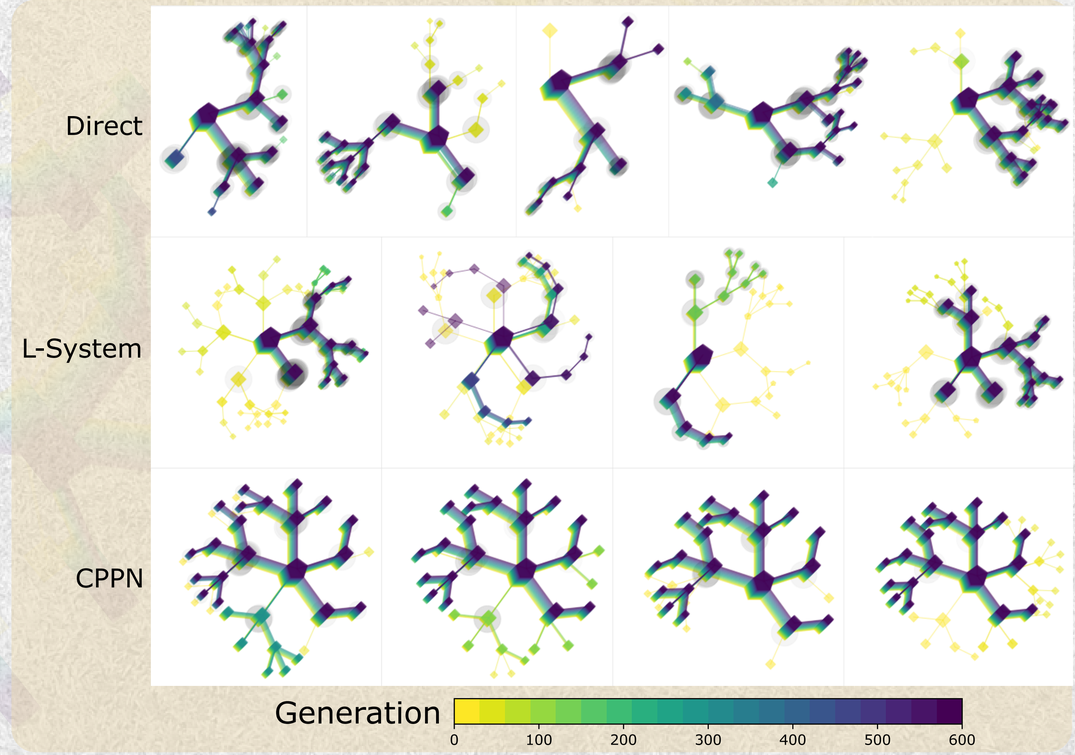
- Mutate connections
- Add neurons
- Remove neurons
- Mutate activation parameters





Phenotypic Change





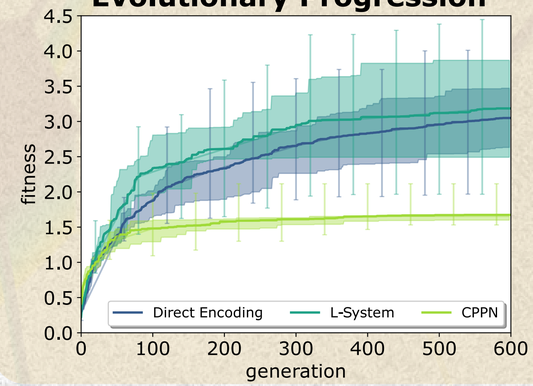
RESULTS

- Higher performance in direct encoding and L-System (significant)
- Morphological change decreases quicker in all encodings (qualitatively)
- Most diversity over time in the direct encoding, followed by the L-System and CPPN (qualitatively)

DISCUSSION

- Premature convergence in the CPPN?
- Generative encodings should outperform direct encodings in a vast search space?
- A hybrid approach might be best

Evolutionary Progression



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