**Polyominoes**

Polyominoes are shapes composed of connected unit squares, forming a finite set of cells within a 2-D grid. These shapes are also commonly referred to as lattice animals in the physical and chemical fields. Polyominoes can be further enhanced by assigning labels to individual cells, providing additional information for each cell within the structure, which are called labeled polyominoes.

**Parameters:**
- \( \text{polyomino} \)
- \( \text{grammars} \)
- \( \text{scoring criteria, c} \)
- \( \text{overwriting flag, o} \)

**Example of the development of a polyomino:**
\[ g = (2,3,3,1) \]
\[ o = \text{Overwrite True} \]

**Mapping starts with the axiom; select non-terminal to expand (thick black border).**

**Conservative grammar to select rule, and expand polyomino if conditions are met.**

**Development and representation variant analysis:**
We compared three scoring criteria (recency, sides, and position), the overwriting flag (true or false) and five representations (dots, axial, 0, and 1D, and 2D) and varied the length. The analysis consists in three metrics in which a higher value is better: validity, uniqueness, and locality.

**Analysis of the development variant:**
- Overwriting resulted in a higher number of valid polyominoes.
- The sides criteria showed lower uniqueness, while Recency exhibited greater uniqueness.
- Larger polyominoes show lower locality, which is generally unfavorable.

**Analysis of the representation:**
- Larger validity does not always mean more unique phenotypes.
- Concerning locality, structured, 2D and radial, score, in general, better.

**Both analysis show that:**
- Differences are more visible between grammars than between variants.
- Algorithm is robust with respect to its parameters.

**Grammars:**
- Monodirectional
- Bidirectional
- Alternated

**Worm 1**

**Worm 2**

**Dog**

**Examples of the evolution of polyominoes:**
Figures show an example of polyominoes in generation 1, an intermediate generation, and the generation where best fitness is achieved.

**Grammars:**
- Worm 1
- Worm 2
- Dog

**Target shapes:**
- Chess
- Circle

**Target:**
- Dog

**Generation 1**
- Fitness: 0.0000

**Generation 2**
- Fitness: 0.0000

**Generation 3**
- Fitness: 0.0000

**Generation 4**
- Fitness: 0.0000

**Generation 5**
- Fitness: 0.0000

**Generation 6**
- Fitness: 0.0000

**Generation 7**
- Fitness: 0.0000

**Conclusion and future work:**
The results align with existing literature of GEP algorithms, which says that grammar design can greatly impact the behavior of the algorithm. The proposed algorithm integrated within EAs is able to evolve polyominoes towards a specific target, while satisfying some predefined constraints encoded in a designed PoCFG.

Future work aims to explore the applicability of the algorithm to evolving polyominoes in more complex problems, such as the generation and evolution of modular robots, maps for games, or DNA shapes.