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Incorporating transposons into Genetic Algorithms

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Genetic Algorithms

Genetic Algorithms (GAs) are optimization techniques inspired by **natural evolution**, introduced in the 1960s by John Holland.

- Utilize processes like **selection**, **mutation**, and **crossover** to evolve solutions
- Effective in exploring large solution spaces
- **Premature convergence** is a significant challenge, leading to loss of diversity

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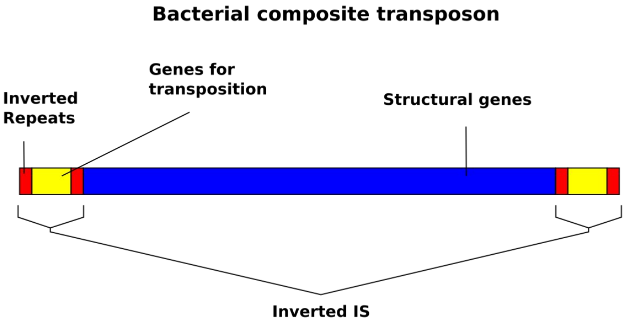
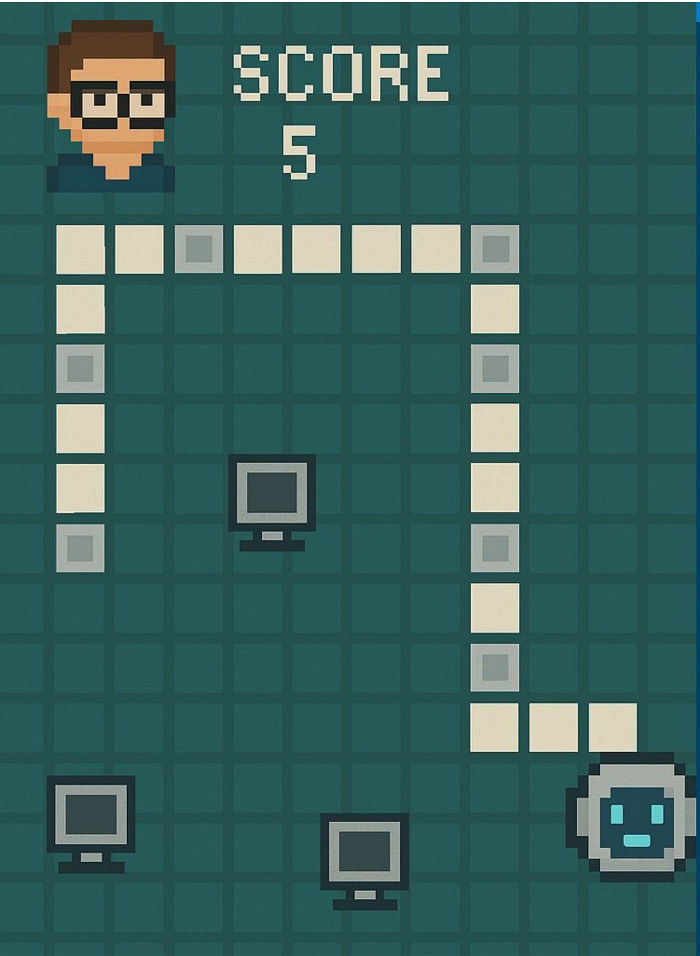


The Role of Transposons

Transposons are **mobile genetic elements** that can enhance genetic diversity within GAs.

- Help maintain genetic variability to prevent **premature convergence**
- Introduce new genetic combinations, promoting exploration of solution spaces
- Two types: **DNA transposons** (direct movement) and **retrotransposons** (move via RNA)



The Snake Game Problem

The Snake Game serves as a testbed for evaluating GAs with transposons.

- A snake in a 2D board that aims at eating as many apples as possible while avoiding the walls and its own body, since it grows with every apple eaten.
- In each cycle, the snake can either turn left, keep its current direction, or turn right, relative to its head's current orientation.

- This problem is simple enough to focus on transposons, but still complex enough so as to being able to observe a decent diversity of behaviors and hence to compare the different algorithm approaches.

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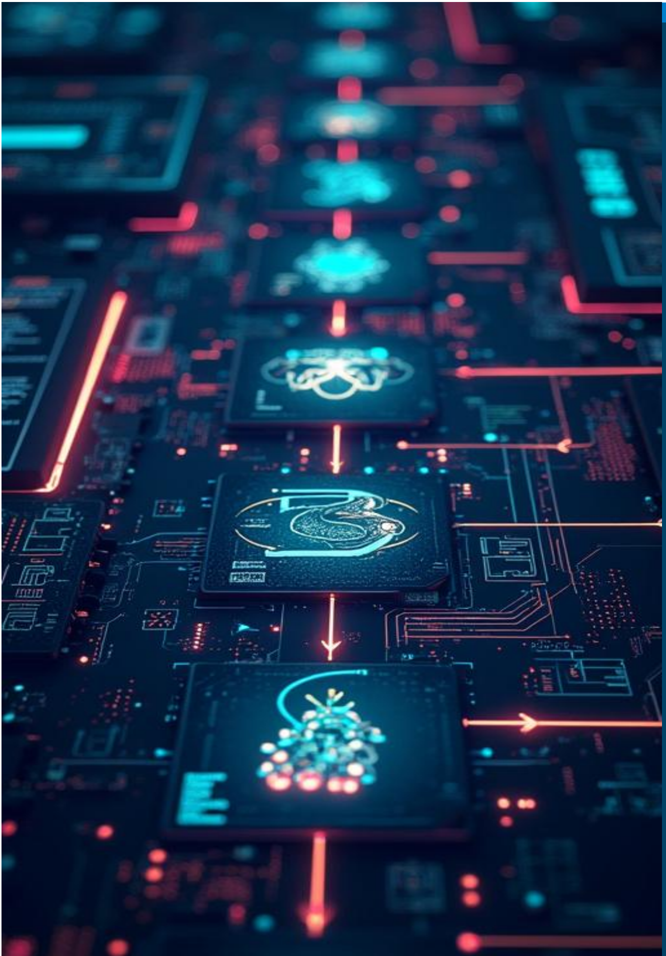

Research Objectives

This study aims at integrating **transposons** into **GAs** in order to enhance optimization performance.

- Main goal: Improve performance in **GAs** using transposons, and preventing premature convergence in optimization issues.

- Secondary objectives: Analyze effectiveness of **transposons** and their **probability settings**

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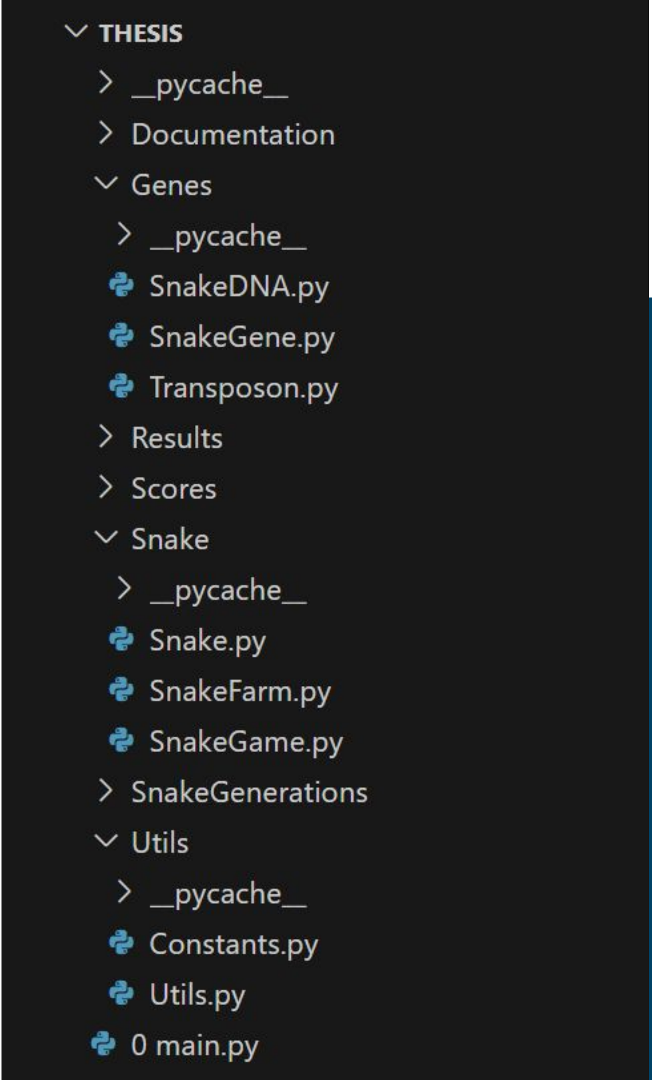

System Architecture Overview

The system consists of several classes designed to simulate genetic operations in the Snake Game.

- **SnakeGene Class**: Defines an individual gene
- **Transposon Class**: Manages transposon mechanisms and (transposon) mutation probability
- **SnakeChromosome Class**: Wraps a list of SnakeGenes and a list of Transposons inside a class, and enriches them with several important methods.

- **Snake Class**: Represents the agent's behavior, with a body and a brain
- **SnakeFarm Class**: Class in charge of executing the Genetic algorithm.
- **SnakeGame Class**: Environment for agent interactions

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Evaluating Transposons in GAs

Three configurations were tested to evaluate the performance of **transposon-enhanced GAs**.

- **Traditional GA**: Baseline with no transposons
- **GA with 20% Transposon Probability**: Lower integration rate
- **GA with 40% Transposon Probability**: Higher integration to assess impact on diversity

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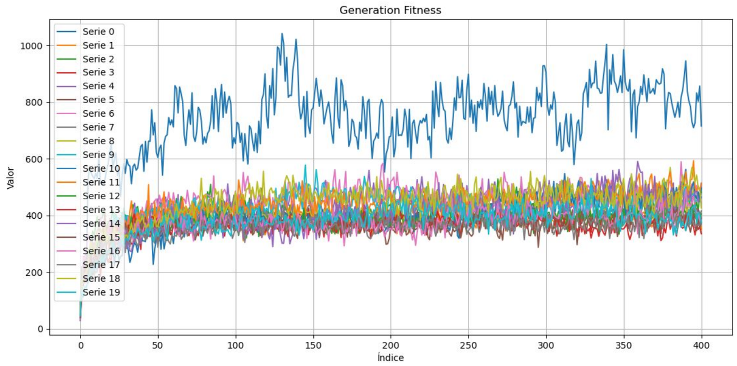
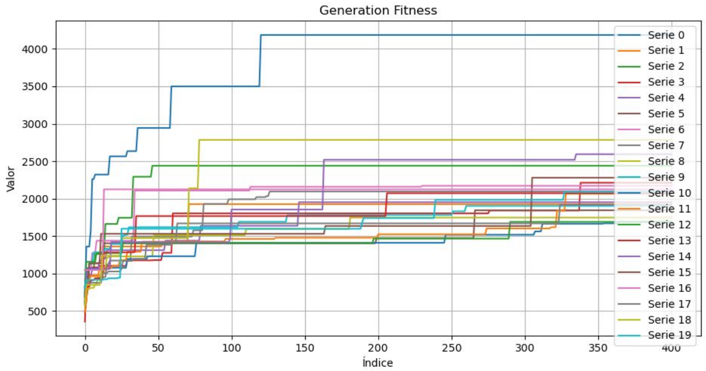
Standard GAs





Mean scores of populations

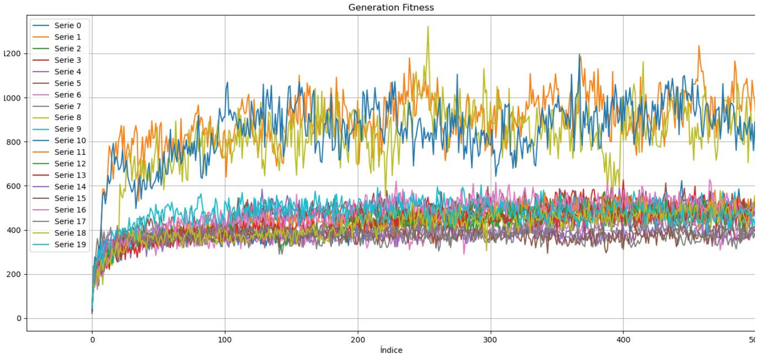
Mean scores of the populations in the different executions

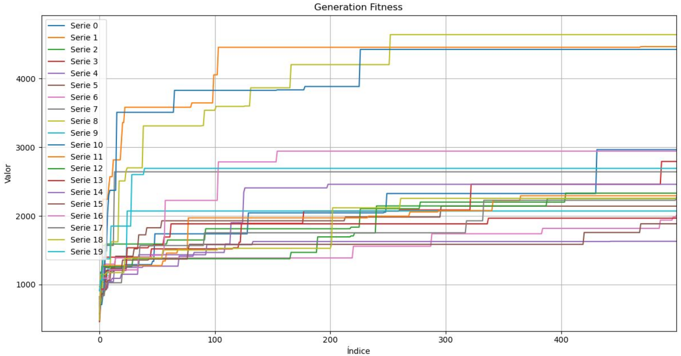
Best scores

Evolution of best scores of the populations in the different executions

GAs with transposons

(maximum probability of mutation: 20%)





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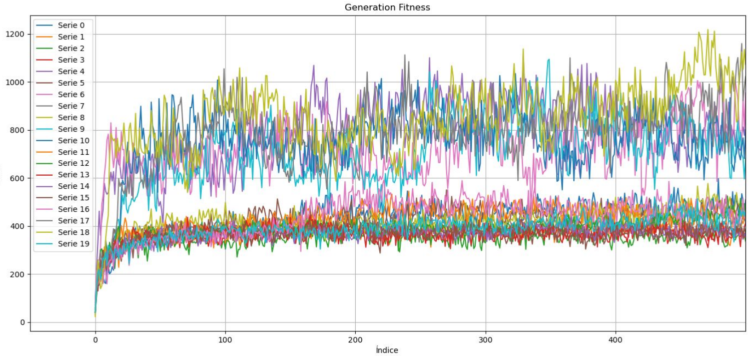

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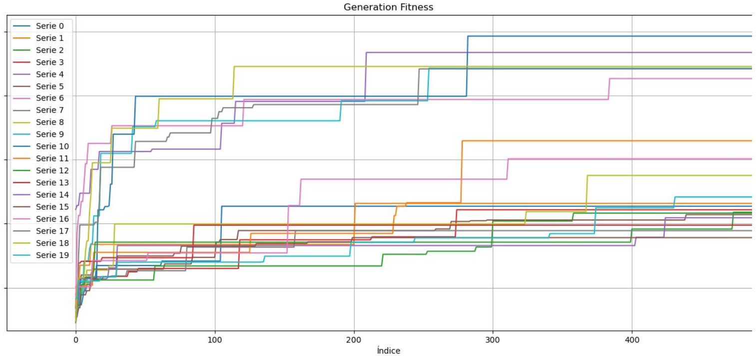

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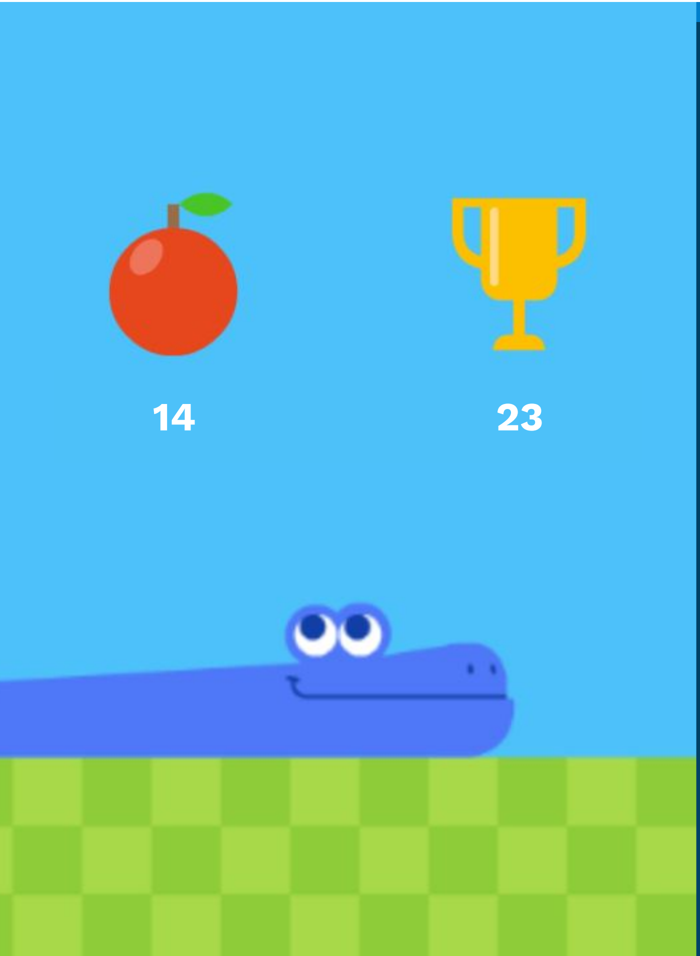

Key Findings and Conclusions

The research indicates that incorporating **transposons** into **GAs** can significantly enhance performance.

- Transposons help maintain **diversity**
- Improved exploration of solution spaces leads to better **optimization outcomes**
- Demonstrated potential for transposons to enhance traditional GAs effectively

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Future Work Directions

Future research will explore additional avenues to further validate findings.

- Implementing different features, such as using A* distances instead of Manhattan, for example.
- Testing in more complex environments to assess **robustness**
- Investigating different types of **transposons** for varied impacts
- Expanding applications of **transposon-enhanced GAs** to other optimization problems

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Thank you

Code available at: https://github.com/Somersault0023/TFM-UAH-Transposons/tree/main