

# Keen: Kotlin Genetic Algorithms Framework

*Thesis for the degrees of  
Civil Engineer in Computer Science  
and  
Master of Science in Computing*



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## Abstract

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# Chapter 1

## Theoretical Background

### 1.1 Evolutionary Algorithms

In the field of computational intelligence, evolutionary algorithms (EA) [2] are a family of algorithms inspired by the process of natural selection. They are part of the larger field of evolutionary computation,<sup>1</sup> which is a subfield of metaheuristics.<sup>2</sup>

EAs are algorithms that perform optimization or learning tasks by evolving solutions to a given problem. They have 3 main characteristics:

- **Population-based:** this algorithms work with a population of solutions, this allows them to explore the search space in parallel.<sup>3</sup>
- **Fitness-oriented:** the solutions in the population are evaluated using a fitness function, which is a function that assigns a value to each solution based on how good it is. The goal of the algorithm is to find the solution with the highest<sup>4</sup> fitness.
- **Variation-driven:** the candidate solutions are modified using genetic operators to create new solutions. These operators are usually based on the biological processes of mutation and recombination.

### 1.2 Genetic Algorithms

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<sup>1</sup>See definition A.2

<sup>2</sup>See definition A.6

<sup>3</sup>Not to be confused with parallelization, which is a technique used to speed up the execution of an algorithm by running it in parallel in multiple processors. “Parallel” in this context means that the algorithm is exploring multiple points in the search space (Def. A.9) at the same time.

<sup>4</sup>In some cases, the goal is to minimize the fitness function, in which case the algorithm will try to find the solution with the lowest fitness.

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## 1.3 Genetic Programming

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## Chapter 2

# Relevant Work (State of the Art)

### 2.1 Agile Artificial Intelligence in Pharo

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### 2.2 *DEAP*

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## 2.4 *ECJ*

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## 2.5 *GeneticSharp*

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# Chapter 3

## Introduction

### 3.1 Motivation

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### 3.2 Hyphotesis and Research Questions

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### 3.4 Methodology

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### 3.5 Structure

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## Chapter 4

# Keen: Kotlin Evolutionary Algorithms Framework

### 4.1 Introduction

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## 4.2 Architecture

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## 4.3 Genetic Algorithms

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## 4.4 Genetic Programming

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## 4.5 Parallelism

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## 4.6 Extensibility

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## 4.7 Conclusion

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## Chapter 5

# Case Study: OneMax

### 5.1 Introduction

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### 5.2 Problem Description

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## 5.4 Results

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## 5.5 Conclusion

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## Chapter 6

# Case Study: Knapsack Problem

### 6.1 Introduction

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## Chapter 7

# Case Study: Crash Reproduction

### 7.1 Introduction

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## Chapter 8

# Conclusions

### 8.1 Summary

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# Appendix A

## Glossary

In this appendix we present a glossary of terms used throughout this document that may not be familiar to the reader, but are not explained in the main text due to their common use in the field.

### C

**Definition A.1** (Chromosome). Representation of a single column of genetic information of a candidate solution to a given optimization problem.

Formally, a chromosome is a vector  $\mathbf{c} = (g_1, g_2, \dots, g_n)$ , where  $g_i$  is a gene (see definition A.3).

### E

**Definition A.2** (Evolutionary computation). Family of algorithms for global optimization inspired by the process of natural selection.

This typically involves processes mimicking natural selection, mutation, recombination, and survival of the fittest. The solutions to a problem are encoded as a set of “individuals” in a “population”. Over multiple generations, these individuals are selected and modified (via genetic operators like crossover and mutation) in order to find better solutions.

### G

**Definition A.3** (Gene). Representation of a single component of a candidate solution to a given optimization problem.

Formally, for a multi-dimensional function  $f$ , a gene is an element  $g$  in the domain of  $f$ .

**Definition A.4** (Genotype). Representation of the full genetic information of a candidate solution to a given optimization problem.

Formally, a genotype is a matrix  $\mathbf{G} = (\mathbf{c}_1, \mathbf{c}_2, \dots, \mathbf{c}_n)$ , where  $\mathbf{c}_i$  is a chromosome (see definition A.1).

### I

**Definition A.5** (Individual). A candidate solution to a given optimization problem.

Formally, an individual is a pair  $(\mathbf{G}, \mathbf{f})$ , where  $\mathbf{G}$  is the genotype (see definition A.4) and  $\mathbf{f}$  is the fitness value of the individual.

## M

**Definition A.6** (Metaheuristics). Problem-independent algorithmic method that yields a sufficiently good solution within reasonable time for an optimization problem, especially for complex problems where an exact solution is not crucial.

## P

**Definition A.7** (Phenotype). Same as definition A.5.

**Definition A.8** (Population). Set of candidate solutions to a given optimization problem.

## S

**Definition A.9** (Search space). Set of all candidate solutions to a given optimization problem.

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