# ARTIFICIAL CREATURES LEARNING TO WALK WITH COMPUTATIONAL INTELLIGENCE


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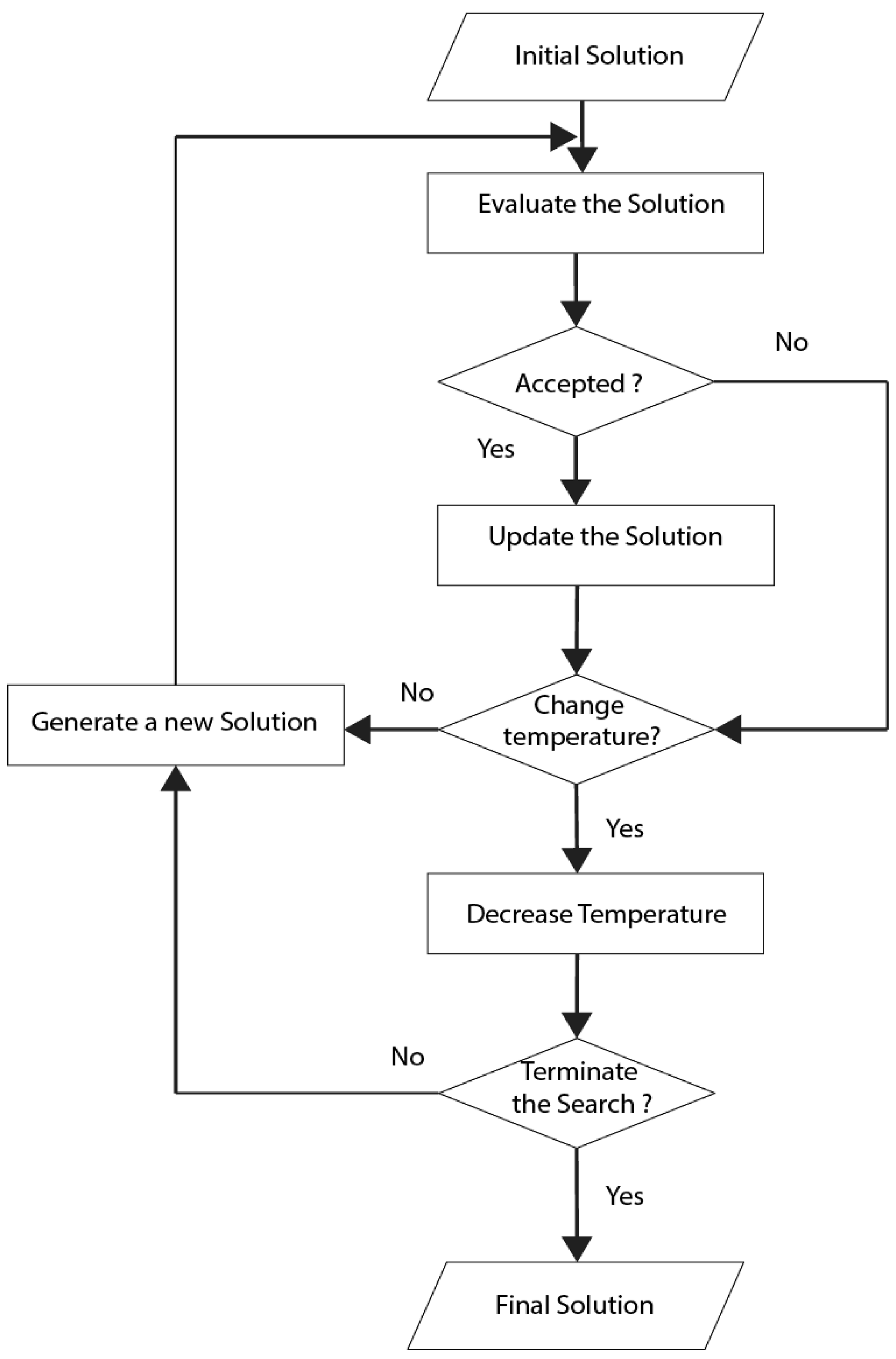
## Summary


Computational intelligence (CI) techniques - especially Evolutionary Algorithm - are widely used techniques to solve various optimization problems such as: elevator efficiency, travelling salesman, bioinformatics, robotics etc. Traditional techniques are not enough for mathematically not well-posed problems like mentioned above. For example in the Cortes's paper, Cortes proposes Evolutionary Algorithm to control a group of elevators because this problem is not well-posed: it is not known if there is a solution exists or not, if there is it is probably not unique and solution must change through the time. Although these CI techniques are slow and not certain, they are relatively easy to implement and because of their ability to not stuck at local minima or maxima (depends on fitness function and problem itself) their usage grows more and more these days.

In this graduation project main focus is walking behavior of creatures and making self-learning artificial creatures that learns how to walk with two CI technique which are: Simulated Annealing and Evolutionary Algorithm. For the Simulated Annealing a six-legged creature (hexapod) and for the Evolutionary Algorithm two legged humanoid creature is selected as model.


## 1. Hexapod Walking

### SIMULATED ANNEALING




Simulated Annealing Algorithm

### ACCEPTANCE

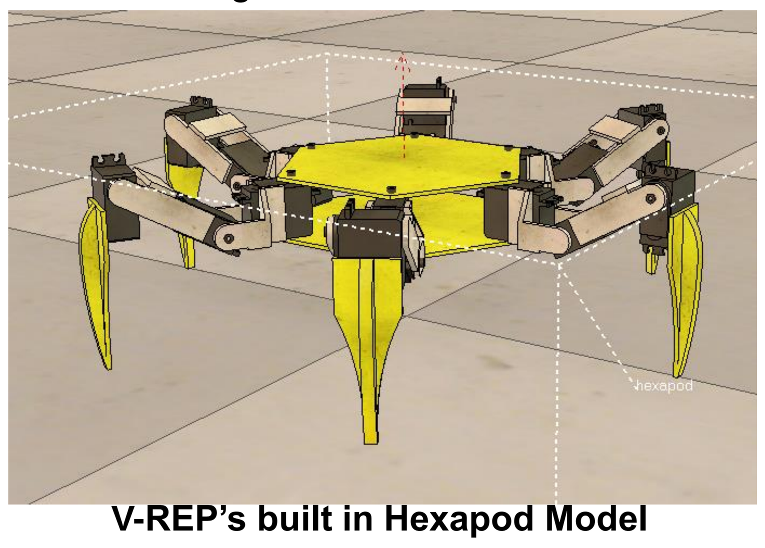
If new solution's error is less than current accept,
Else apply :

$$e^{-\Delta(ne,be)/t} < r$$

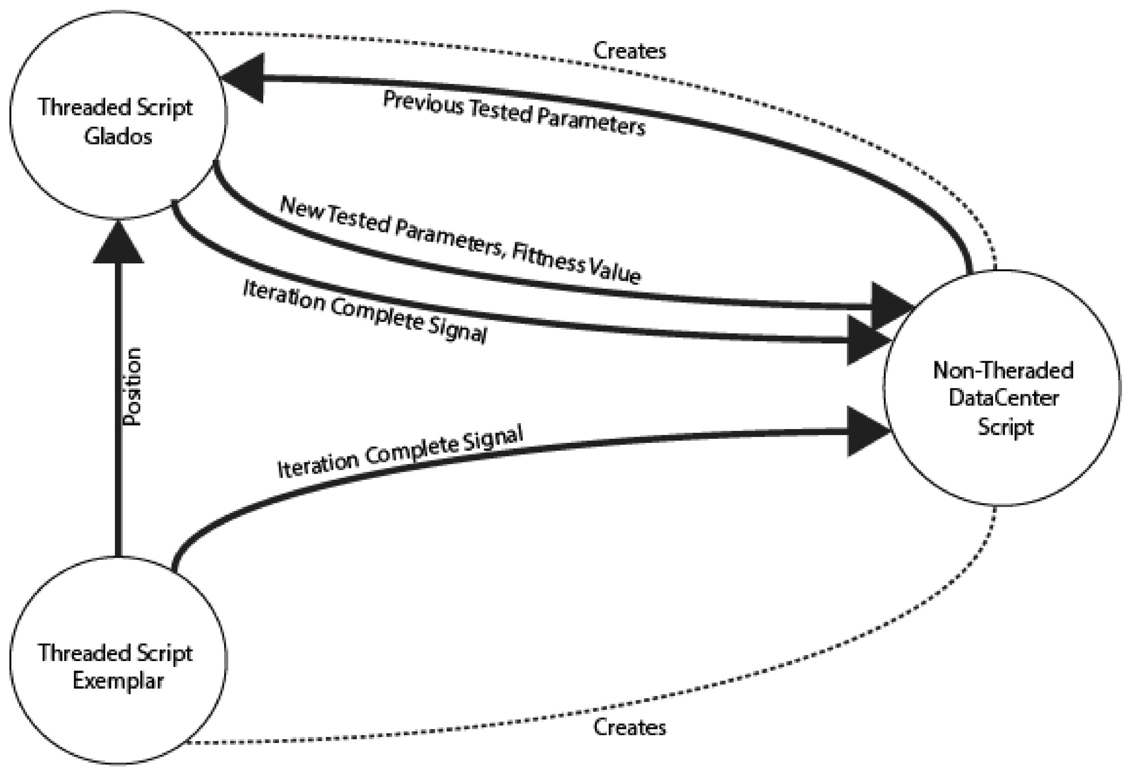
| ne | be | T | probability |
|---|---|---|---|
| 101 | 100 | 300 | 0.996 |
| 200 | 100 | 300 | 0.716 |
| 200 | 100 | 100 | 0.367 |

### PROBLEM & MODELLING

- V-REP's Hexapod model used,
- Default walk function hardcoded as:
  - stepVelocity = 0.9,
  - stepAmplitude = 0.11,
  - stepHeight = 0.02
- Problem is to find these variables automatically with Simulated Annealing



V-REP's built in Hexapod Model

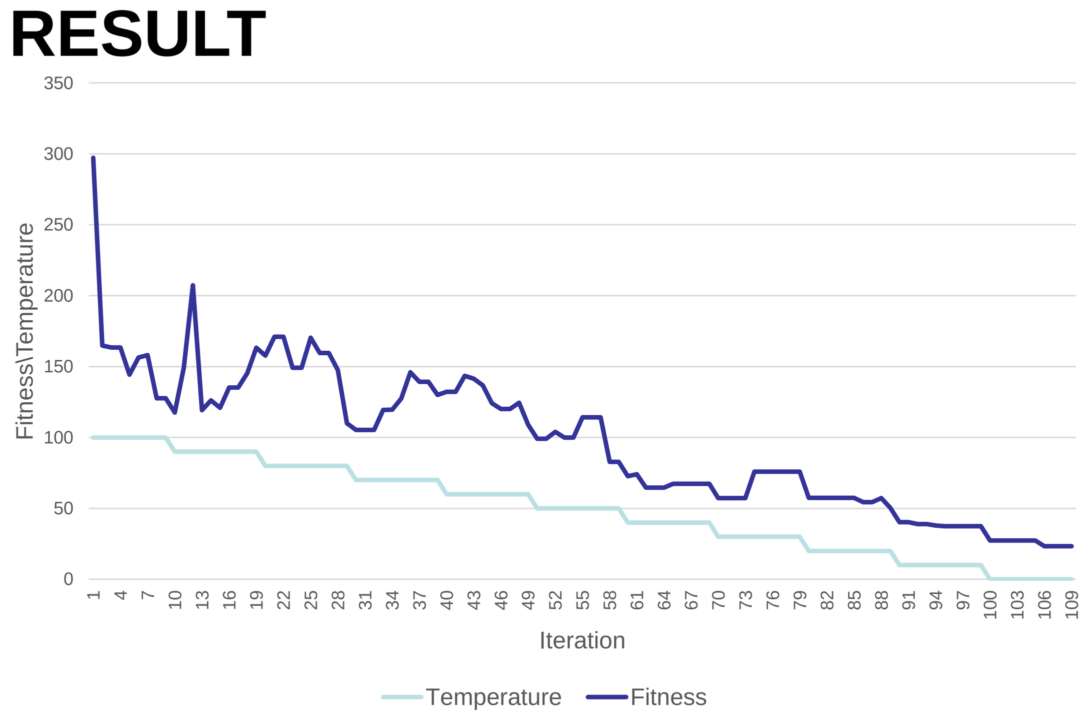



Data Flow Diagram of Hexapod

Project implemented on Windows 8 operation system with V-REP simulation environment. Project contains three models which can be found at models-mobile tab of V-REP.

Two script implemented which are: threaded script of glados, non-threaded script of data center.

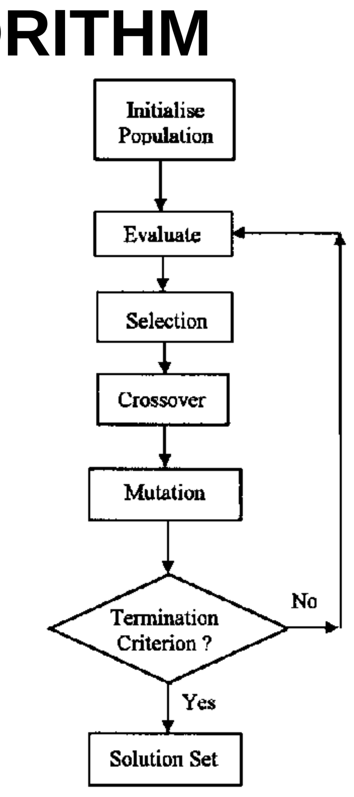
### RESULT




## 2. Humanoid Walking

### EVOLUTIONARY ALGORITHM

- Inspired by Evolution,
- Combination of:
  - Encoding of chromosomes,
  - Selection,
  - Crossover,
  - Mutation,
  - Fitness function
- Usually used as function optimizer



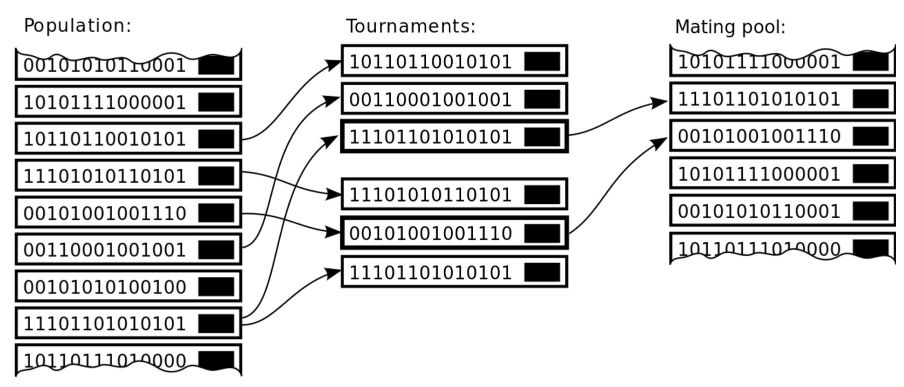

### Encoding

Permutation Encoding : Each chromosome represented as string of numbers.

| | |
|---|---|
| Chromosome A | 1 5 9 8 2 3 4 7 7 7 |
| Chromosome B | 9 3 2 1 1 1 3 2 5 4 |

### Selection

Tournament Selection:
Each tournament contains 2 to n (size of population) individuals that selected randomly from population. Best of each tournament is added to mating pool.

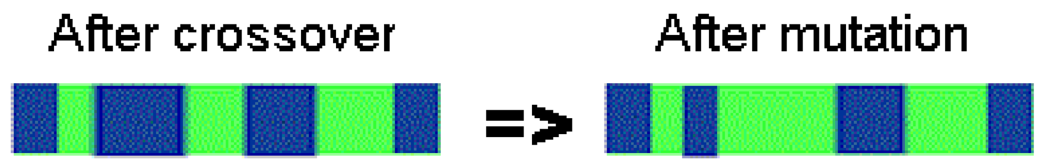



### Crossover

Uniform Crossover:
all bits are randomly chosen from either first parent or second parent with a probability

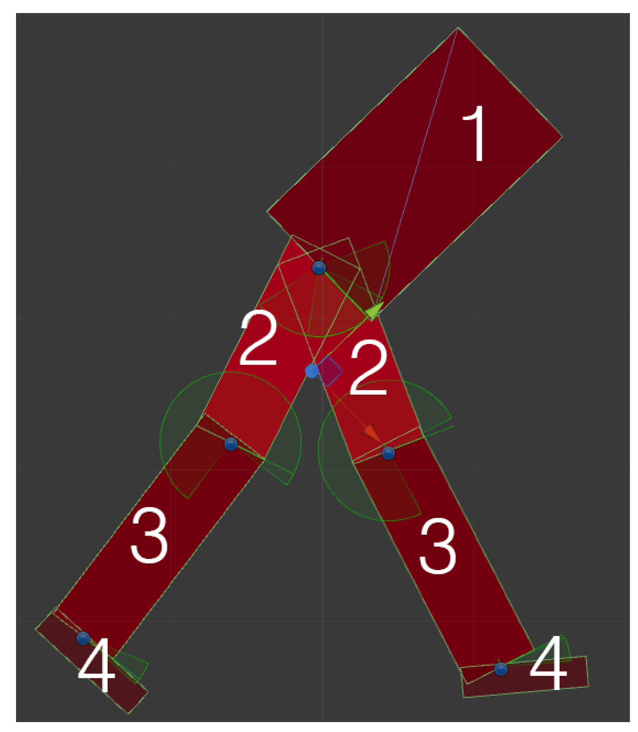

### Mutation

Creep Mutation:
Randomly chosen genes are added or subtracted with a small amount.




### MODELLING

- Body Mass = (50.8 + 9.4 + 2.7*2 + 1.6*2 + 0.5*2) *(61.37 kg/100) = 42.83 kg = 42.83 units on Box2D Physics
- Thigh Mass (each) = (8.3)*(61.37kg/100) = 5.09 kg = 5.09 units
- Shank Mass (each) = (5.5)*(61.37kg/100) = 3.38 kg = 3.38 units
- Foot Mass (each) = (1.2)*(61.37kg/100) = 0.74 kg = 0.74 units




| Joint | Upper limit (degrees) | Lower limit (degrees) |
|---|---|---|
| Between body and thighs | 0 | -120 |
| On knee | 0 | 270 |
| On ankle | 0 | 20 |

### FITNESS FUNCTION

$$f = (fp * 0.01) + (lx - sx)$$

### RESULTS