Computational Intelligence

Unit # 4.2

Acknowledgement

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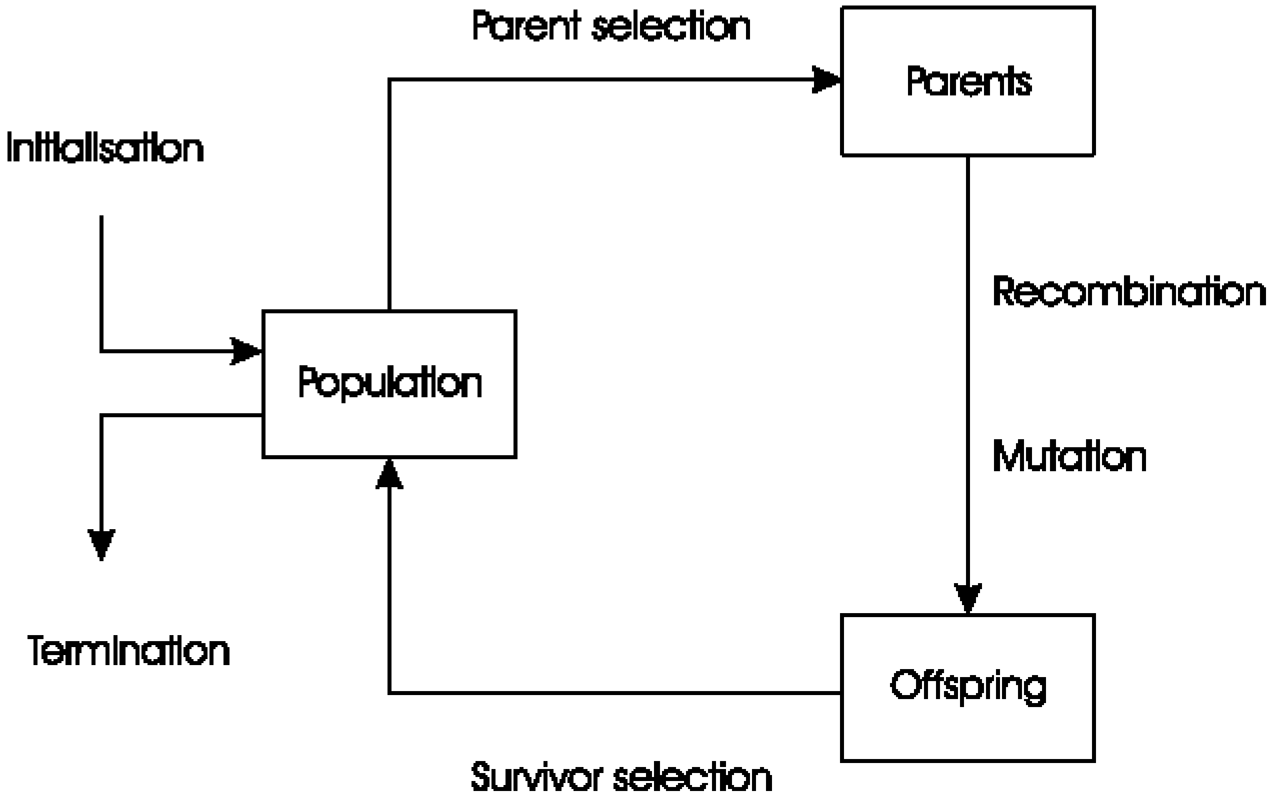
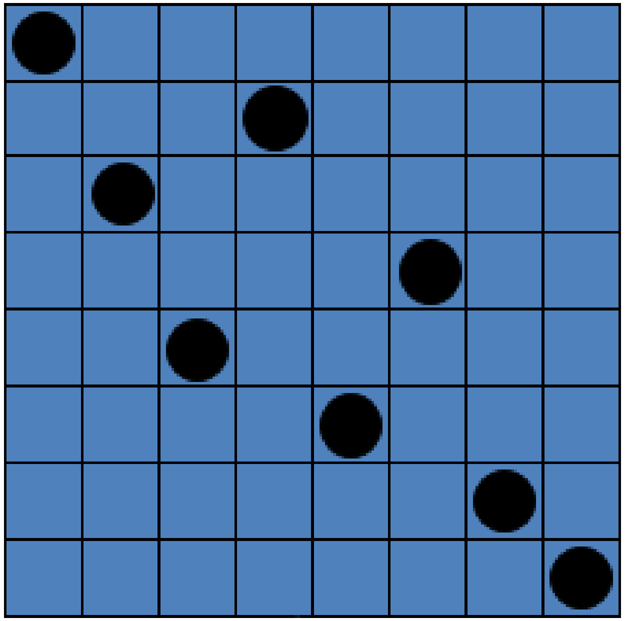
General Scheme of EAs



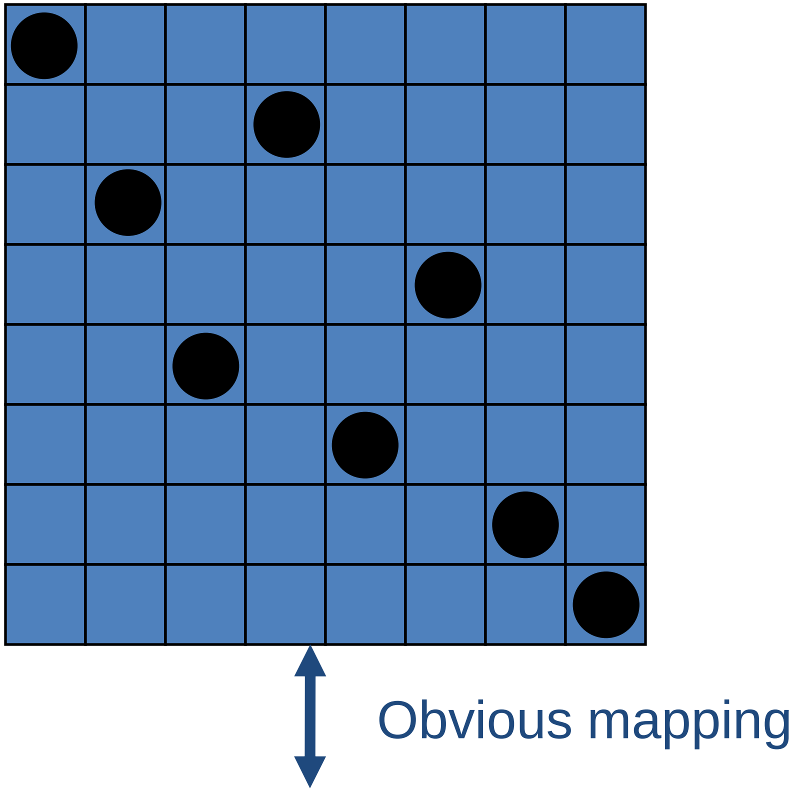
A Typical Evolutionary Algorithm Cycle

1. Let $g = 0$ be the generation counter.
2. Initialize a population C_g of N individuals, i.e. $C_g = \{\vec{C}_{g,n} | n = 1, \cdots, N\}$.
3. While no convergence
   (a) Evaluate the fitness $\mathcal{F}_{EA}(\vec{C}_{g,n})$ of each individual in population C_g
   (b) perform cross-over:
      i. select two individuals $\vec{C}_{g,n_1}$ and $\vec{C}_{g,n_2}$
      ii. produce offspring from $\vec{C}_{g,n_1}$ and $\vec{C}_{g,n_2}$
   (c) perform mutation
      i. select one individual $\vec{C}_{g,n}$
      ii. mutate $\vec{C}_{g,n}$
   (d) select the new generation C_{g+1}
   (e) evolve the next generation: let $g = g + 1$

The 8-Queen Problem



The 8-Queen Problem: Representation



1	3	5	2	6	4	7	8

The 8-Queen Problem: Fitness Evaluation

- Penalty of one queen:
  the number of queens she can check.

- Penalty of a configuration:
  the sum of the penalties of all queens.

- Note: penalty is to be minimized

- Fitness of a configuration:
  inverse penalty to be maximized

The 8-Queen Problem: Mutation

- Small variation in one permutation, e.g.:
  - swapping values of two randomly chosen positions

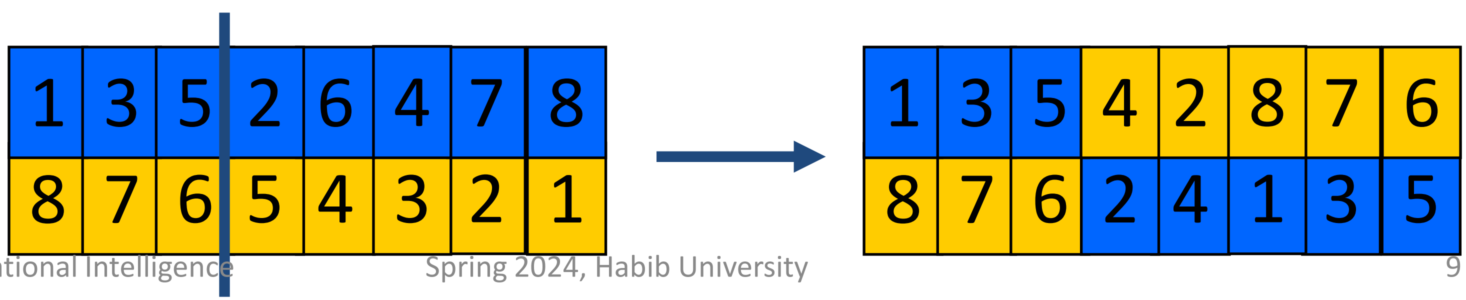
1	3	5	2	6	4	7	8

→

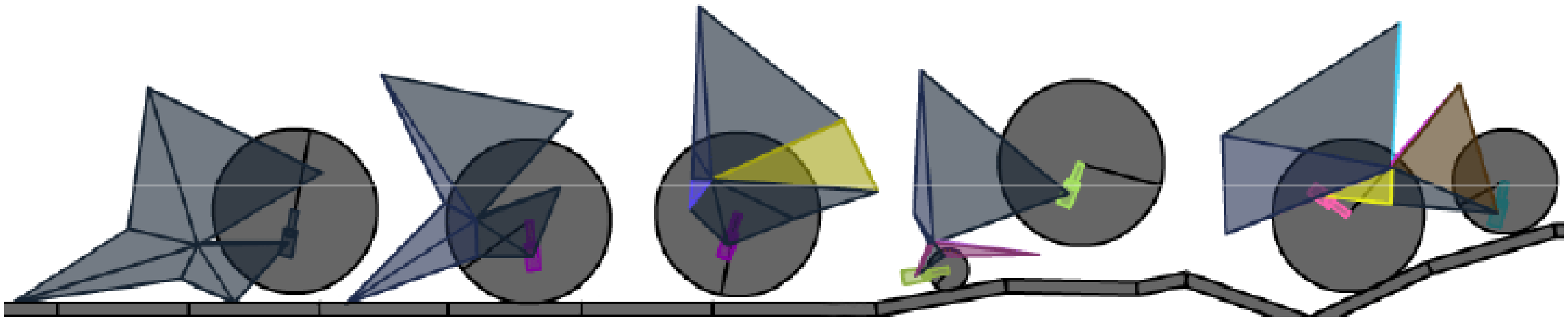
1	3	7	2	6	4	5	8

The 8-Queens Problem: Crossover

- Combining two permutations into two new permutations:
  - choose random crossover point
  - copy first parts into children
  - create second part by inserting values from other parent:
    - in the order they appear there
    - beginning after crossover point
    - skipping values already in child



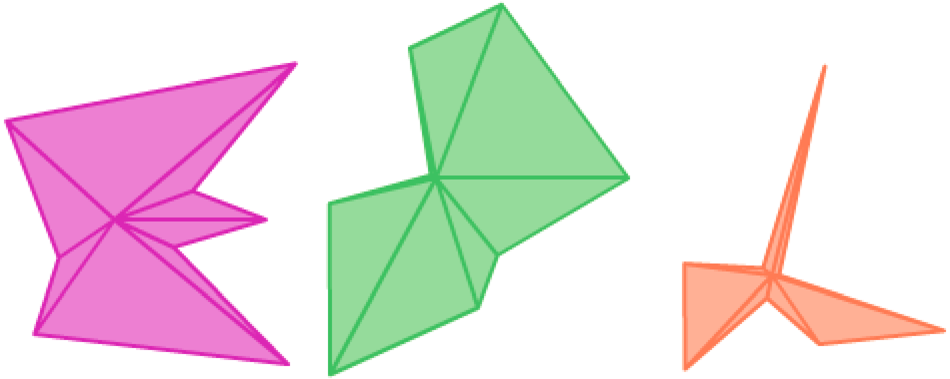
BoxCar 2D - Evolving a Car



http://boxcar2d.com/about.html

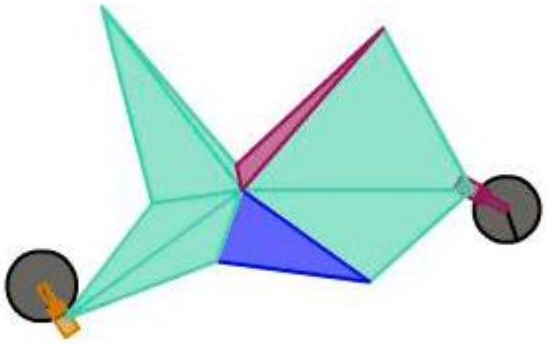
Representation

- Each car is a set of 8 randomly chosen vectors: direction and magnitude. All the vectors radiate from a central point (0,0) and are connected with triangles.



Representation

- For each wheel there is a value specifying its radius and the location of its center along with axle angle.



Chromosome Representation

The design of the chromosome is probably the most important step in making a successful genetic algorithm.

CartAngle$_0$	CartMag$_0$	CartAngle$_1$	CartMag$_1$	...	CartAngle$_7$	CartMag$_7$	WheelVertex$_0$	AxleAngle$_0$	WheelRadius$_0$	WheelVertex$_1$	AxleAngle$_1$	WheelRadius

Fitness: how far the car goes on the terrain when run (using Box2D physics engine).

Crossover

Car	Angle0	Mag0	Angle1	Mag1	...	...	...	...	...	...	...	...	...	...	...	...	WheelVertex0	AxleAngle0	WheelRadius0	WheelVertex1	AxleAngle1	WheelR
A	0.769	2.614	0.584	0.319	0.278	2.883	0.666	1.13	0.305	2.752	0.376	2.507	0.814	1.963	0.392	2.872	3	5.284	0.434	7	2.625	1.191
B	0.535	2.682	0.732	2.256	0.422	0.149	0.676	0.578	0.709	2.774	0.592	2.623	0.519	1.531	0.924	0.404	-1	0.704	0.122	4	0.167	0.409
AB	0.535	2.682	0.584	0.319	0.278	2.883	0.666	1.13	0.305	2.752	0.376	2.507	0.814	1.963	0.392	2.872	3	5.284	0.434	7	2.625	0.409
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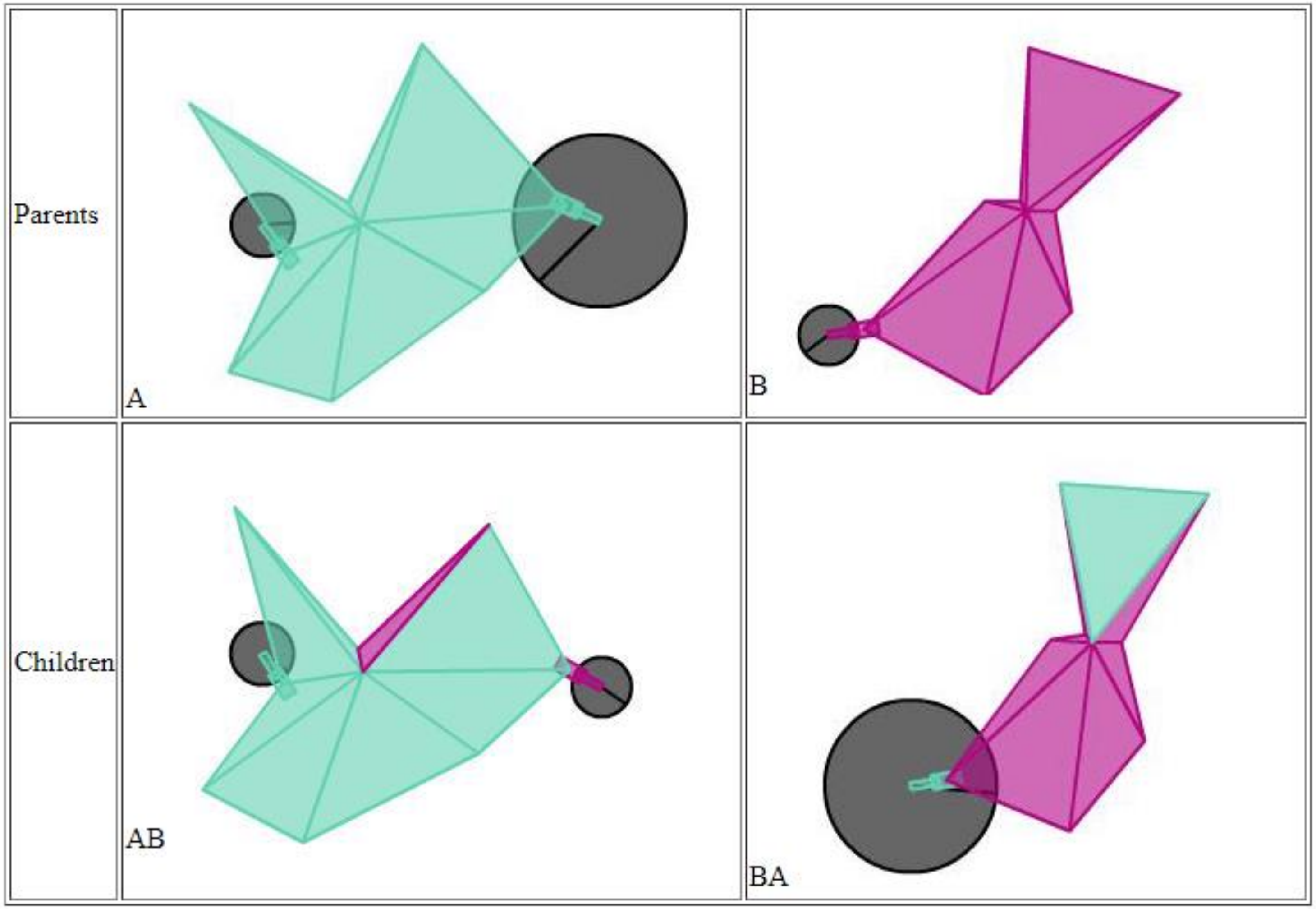
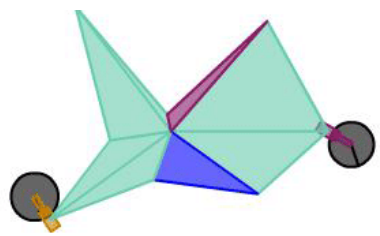
Crossover



Mutation



Car	Angle0	Mag0	...	...	...	...	...	...	...	...	Angle5	Mag5	...	...	...	...	WheelVertex0	AxleAngle0	WheelRadius0	WheelVertex1	AxleAngle1	WheelRadius1
AB	0.535	2.682	0.584	0.319	0.278	2.883	0.666	1.13	0.305	2.752	0.376	2.507	0.814	1.963	0.392	2.872	3	5.284	0.434	7	2.625	0.409
AB_m	0.535	2.682	0.584	0.319	0.278	2.883	0.666	1.13	0.305	2.752	0.376	0.940	0.814	1.963	0.392	2.872	4	5.284	0.434	7	2.625	0.409

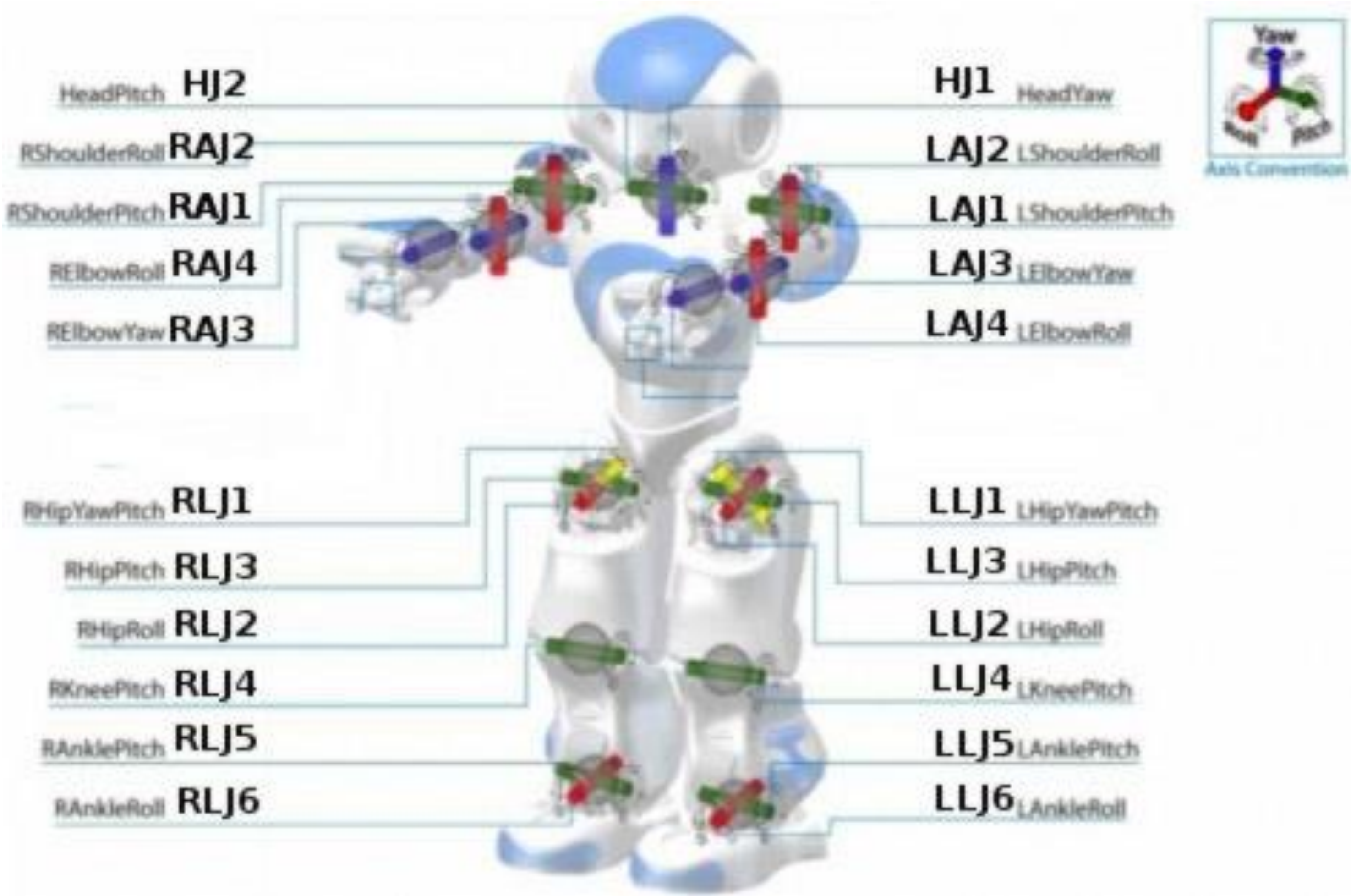
Evolving a Car - Demo

- https://www.youtube.com/watch?v=TLTRb2RQnu0

- 50 generations of boxcar3d:
- https://www.youtube.com/watch?v=TyCwy2IyeeU

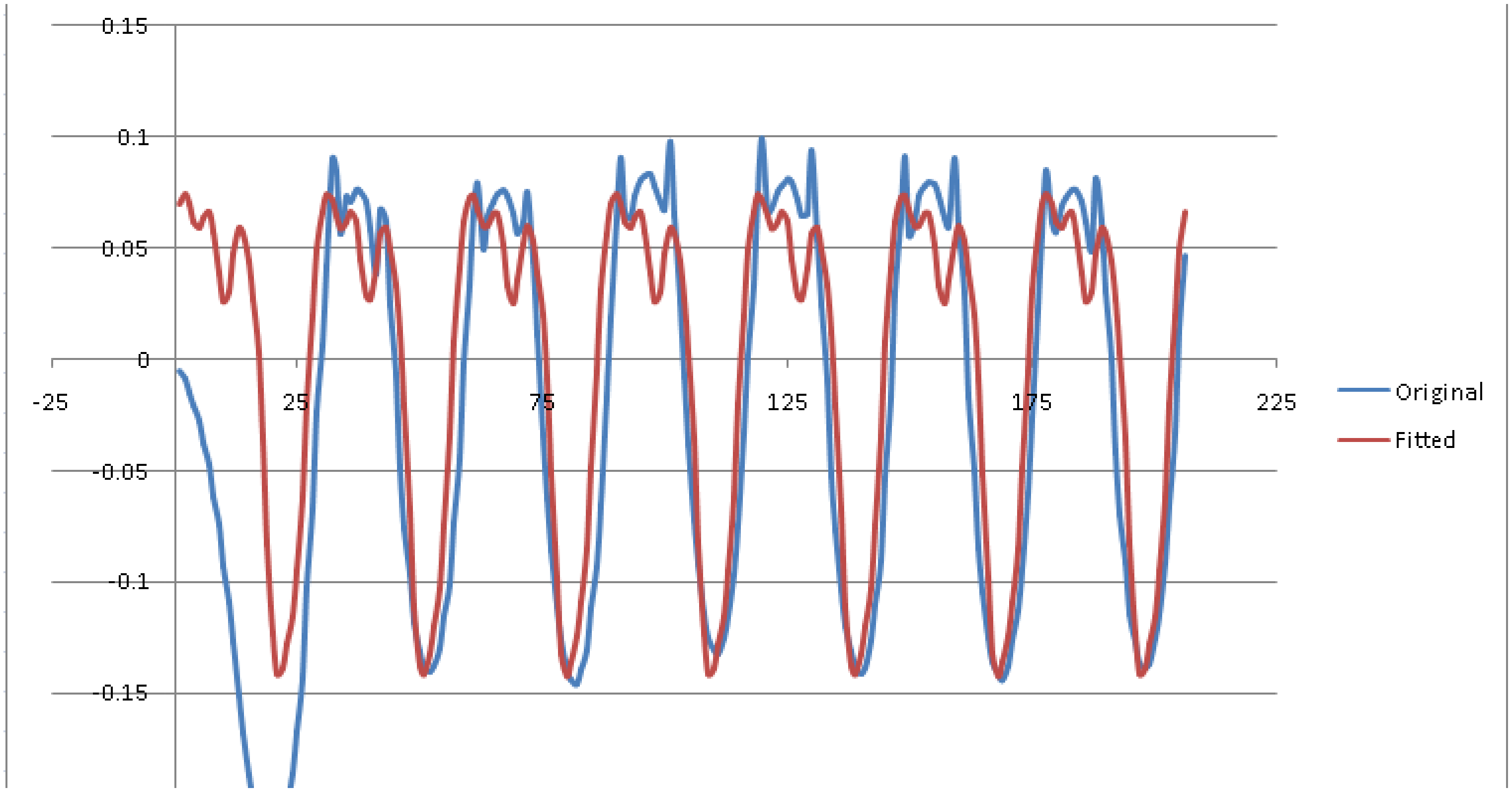
Evolving Bipedal Robot Walk

Nao Body

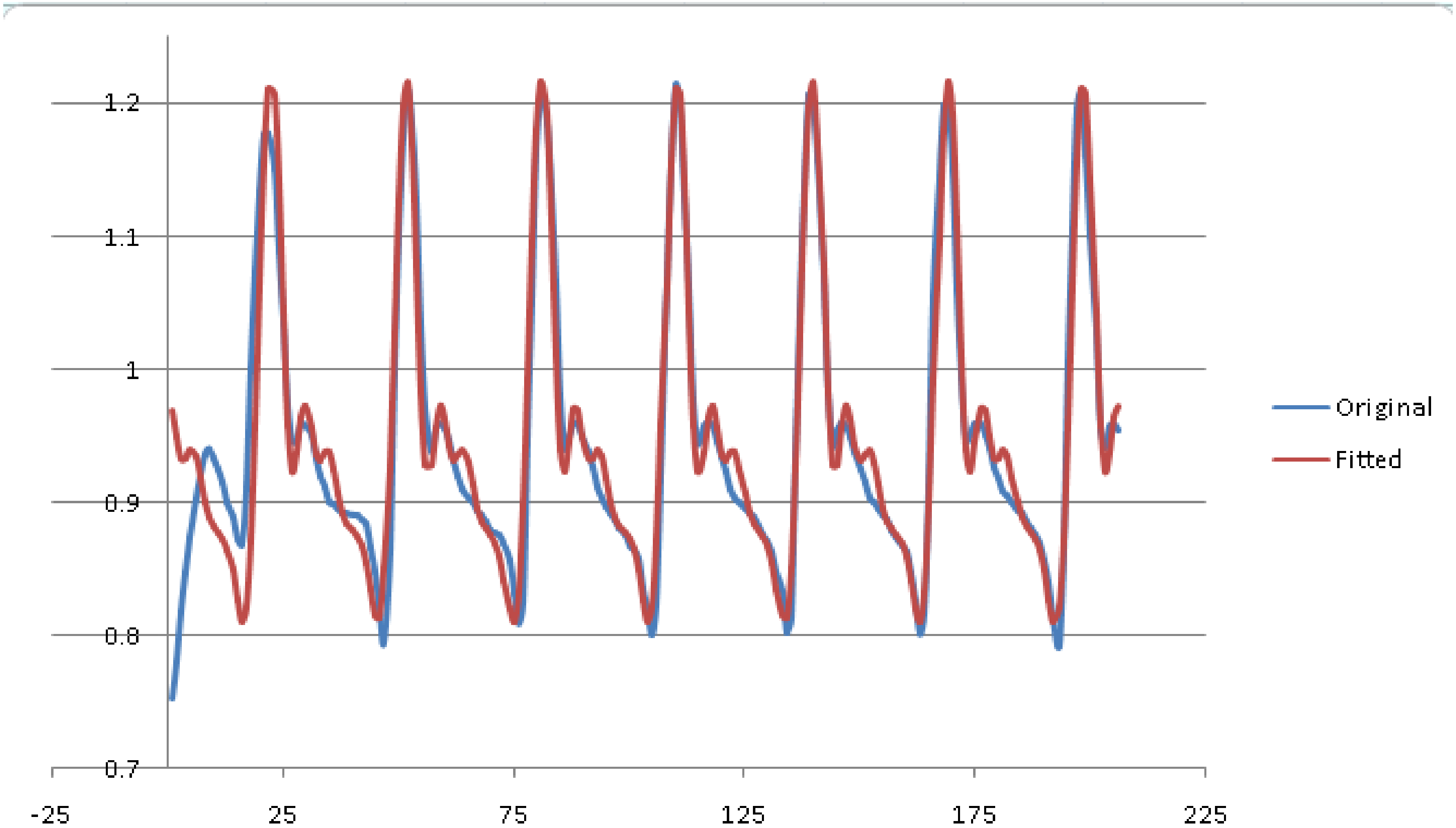


HeadPitch HJ2
RShoulderRoll RAJ2
RShoulderPitch RAJ1
RElbowRoll RAJ4
RElbowYaw RAJ3
RHipYawPitch RLJ1
RHipPitch RLJ3
RHipRoll RLJ2
RKneePitch RLJ4
RAnklePitch RLJ5
RAnkleRoll RLJ6
HJ1 HeadYaw
LAJ2 LShoulderRoll
LAJ1 LShoulderPitch
LAJ3 LElbowYaw
LAJ4 LElbowRoll
LLJ1 LHipYawPitch
LLJ3 LHipPitch
LLJ2 LHipRoll
LLJ4 LKneePitch
LLJ5 LAnklePitch
LLJ6 LAnkleRoll
Yaw
Roll
Pitch
Axis Convention

Knee Pitch



Hip Pitch



Parameter Learning

- Evolutionary algorithms are used to learn the parameters of the following PFS based periodic function:

$$f(t) = C + \sum_{n=1}^{N} A_n \sin\left(n\frac{2\pi}{T}t + \phi_n\right), \forall t \in \Re$$

- N varies for different joints and depending upon its value we need to learn the corresponding number of A, C, T and ϕ parameters.

https://www.desmos.com/calculator/lab9nylxsi

Fitness Function

- During this parameter searching and optimization exercise, the evolutionary algorithm was guided by a composite fitness function that consists of the following characteristics:
  - Speed: Distance traveled by the simulated Nao during the allotted 8 seconds
  - Straightness: Straightness of the walk
  - Stability: Stability of the walk computed through gyroscope reading

Video - Comparison of different walks

- http://www.youtube.com/watch?v=3cj-UQN6rj0

Evolutionary Art: Mona Lisa Evolution

- Problem: paint a replica of the Mona Lisa using only 50 semi transparent polygons

Evolutionary Art: Mona Lisa Evolution

DEMO: https://rogerjohansson.blog/2008/12/07/genetic-programming-evolution-of-mona-lisa/

Evolutionary Art: Mona Lisa Evolution

- A candidate solution is a set of 50 transparent polygons of various colors on the canvas
- Representation: for each polygon there is a real vector
- describing the shape, the location and the color of the
- polygon
- Fitness (to minimize): sum of the differences in color components (RGB) on each pixel between the phenotype and the target image
- Standard crossover and mutation on real vectors

DEMO: https://rogerjohansson.blog/2008/12/07/genetic-programming-evolution-of-mona-lisa/

Thanks