CM3020 Artificial Intelligence

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PART B - Experimenting with genetic algorithms and evolved creatures

Hyper-parameter exploration

To investigate the impact of various parameter settings on the evolution of creatures, I have done various experminents which I am going to explain in this report.

I have created a Python script which exports each generation max fitness score, mean fitness score, mean and max links to the csv file during the evaluation of the genetic algorithm. I then imported those csv files to the Jupyter notebook and used various python packages like pandas, matplotlib and seaborn to analyse the data and plot them into table and charts.

The machine I used for experiment is Macbook Air 2017 (2 cores 4 threads) and set the pool size to 4 in test_ga.py.

I have experiemented with the following parameters:-
1. Population size
2. Mutation rate and the amount of mutation
3. Gene count

I have done 5 runs for each of the parameters.

1. Population size

For this experiment, I did 3 sets of experiments to see if the population size has any influence on the maximum and mean fitness score. The three sets of Population I used here are 10, 100, 1000 for the gene count of 3 and the default mutation rate (point mutation - 0.1, shrink mutation - 0.25, grow mutation = 0.1). The total generation size used here is 100.

The resulted values in a table format is given below:-

1. **Population Size 10**

	generation	fittest max	fittest mean	mean links	max links
0	0	2.435	2.069	6.0	13
1	1	2.435	2.042	4.0	7
2	2	2.435	2.114	4.0	7
3	3	2.547	2.125	3.0	5
4	4	2.903	2.277	2.0	9
...	...	...	...	...	...
95	95	7.561	2.920	2.0	4
96	96	7.561	3.909	4.0	13
97	97	7.561	3.017	3.0	7
98	98	7.561	3.058	3.0	4
99	99	7.561	2.816	2.0	5

100 rows × 5 columns

2. **Population Size 50**

	generation	fittest max	fittest mean	mean links	max links
0	1	3.434	2.117	6.0	13
1	2	5.241	2.266	6.0	16
2	3	5.709	2.360	5.0	18
3	4	5.709	2.433	5.0	17
4	5	5.709	2.331	5.0	17
...	...	...	...	...	...
95	96	9.074	2.802	3.0	10
96	97	9.074	2.646	3.0	7
97	98	9.074	2.519	2.0	9
98	99	9.074	2.157	3.0	10
99	100	9.152	2.751	3.0	7

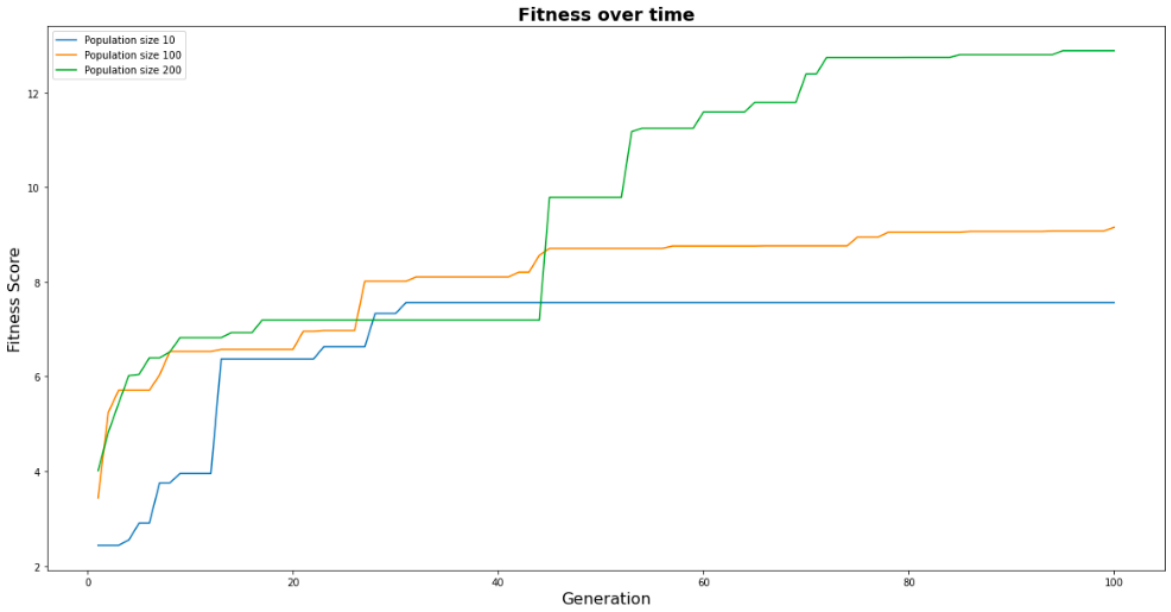
100 rows × 5 columns

3. **Population Size 100**

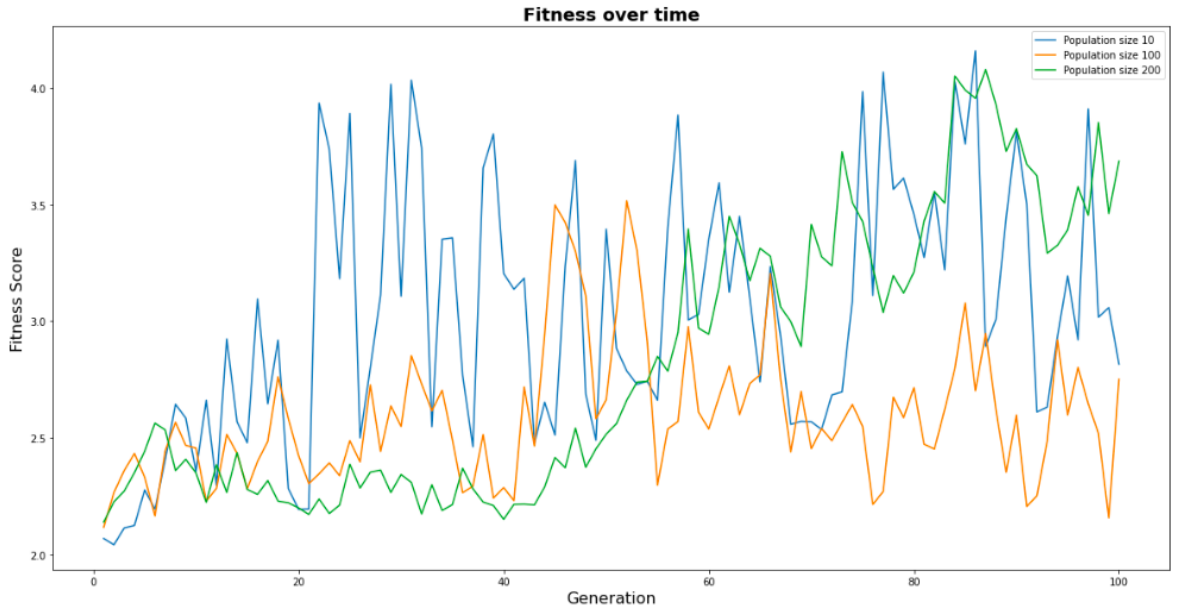
	generation	fittest max	fittest mean	mean links	max links
0	2	4.011	2.139	6.0	13
1	3	4.820	2.226	6.0	28
2	4	5.431	2.272	5.0	40
3	5	6.020	2.351	5.0	22
4	6	6.045	2.443	4.0	14
...	...	...	...	...	...
95	97	12.883	3.576	4.0	22
96	98	12.883	3.454	4.0	16
97	99	12.883	3.851	5.0	31
98	100	12.883	3.461	5.0	19
99	101	12.883	3.685	4.0	22

100 rows × 5 columns

Generation vs Fitness Score (Max) [Population size - 10,50,100]



Generation vs Fitness Score (Mean) [Population size - 10,50,100]



The increase in population size does increase the fitness score (max) of that generation. Although thee doesn't seem to be much correlation between population size and mean fitness score.

2. Mutation rate and the amount of mutation

For this experiement, I did 4 sets of experiements to see if the mutation rate and the amount of mutation has any impact on the fitness score. The three sets which I choose are as follows:-

Constant parameters in all 4 sets:-
Population size - 100
Gene count - 4

i.) Low mutation rate and default amount of mutation (point mutation - 0.1, shrink mutation - 0.25, grow mutation = 0.1, mutation amount = 0.1)

Low mutation rate

	generation	fittest max	fittest mean	mean links	max links
0	2	4.049	2.109	9.0	40
1	3	4.049	2.167	9.0	28
2	4	4.995	2.172	9.0	31
3	5	4.995	2.092	7.0	28
4	6	4.995	2.076	7.0	28
...	...	...	...	...	...
95	97	7.227	2.538	4.0	31
96	98	7.227	2.874	4.0	13
97	99	7.227	2.709	4.0	13
98	100	7.227	2.665	4.0	13
99	101	7.227	2.790	4.0	13

100 rows × 5 columns

ii.) Medium mutation rate and default amount of mutation (point mutation - 0.50, shrink mutation - 0.50, grow mutation = 0.50, mutation amount = 0.25)

Medium mutation rate

	generation	fittest max	fittest mean	mean links	max links
0	2	4.505	2.199	10.0	31
1	3	4.505	2.120	9.0	34
2	4	4.529	2.162	9.0	57
3	5	5.514	2.298	9.0	42
4	6	5.514	2.121	8.0	40
...	...	...	...	...	...
95	97	7.749	1.996	5.0	27
96	98	7.749	2.044	5.0	25
97	99	7.749	2.090	5.0	52
98	100	7.749	2.251	4.0	19
99	101	7.749	2.254	5.0	22

100 rows × 5 columns

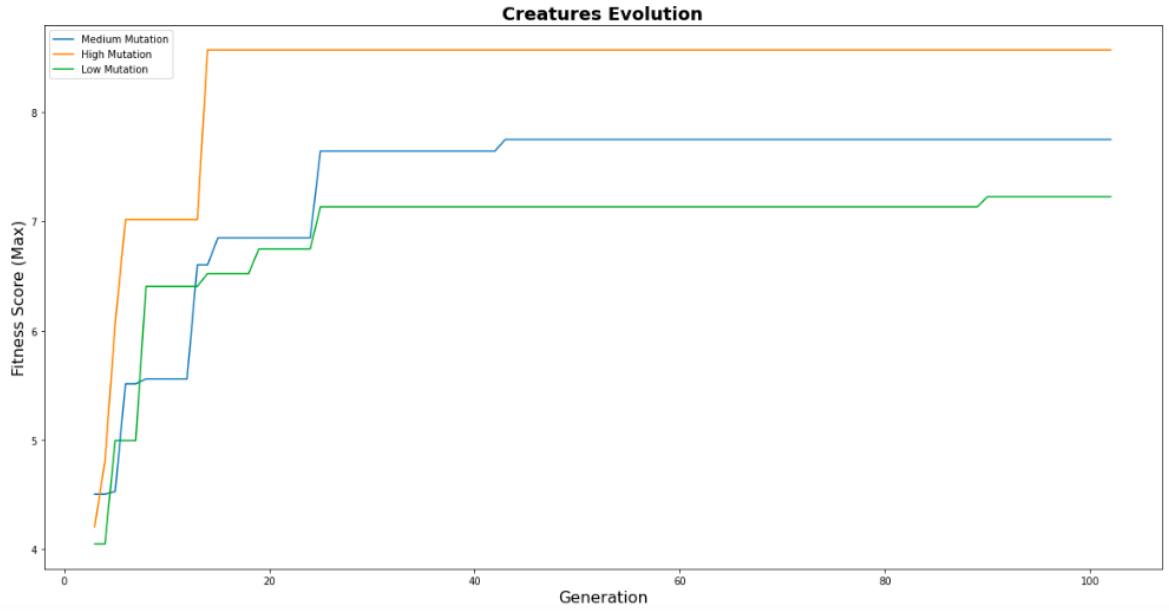
iii.) High mutation rate and default amount of mutation (point mutation - 0.90, shrink mutation - 0.90, grow mutation = 0.90, mutation amount = 0.50)

High Mutation

	generation	fittest max	fittest mean	mean links	max links
0	2	4.207	2.185	10.0	40
1	3	4.807	2.126	11.0	40
2	4	6.065	2.098	10.0	42
3	5	7.016	2.100	9.0	34
4	6	7.016	2.183	9.0	36
...	...	...	...	...	...
95	97	8.568	2.215	4.0	34
96	98	8.568	2.166	4.0	33
97	99	8.568	2.113	4.0	22
98	100	8.568	2.107	4.0	37
99	101	8.568	2.186	4.0	25

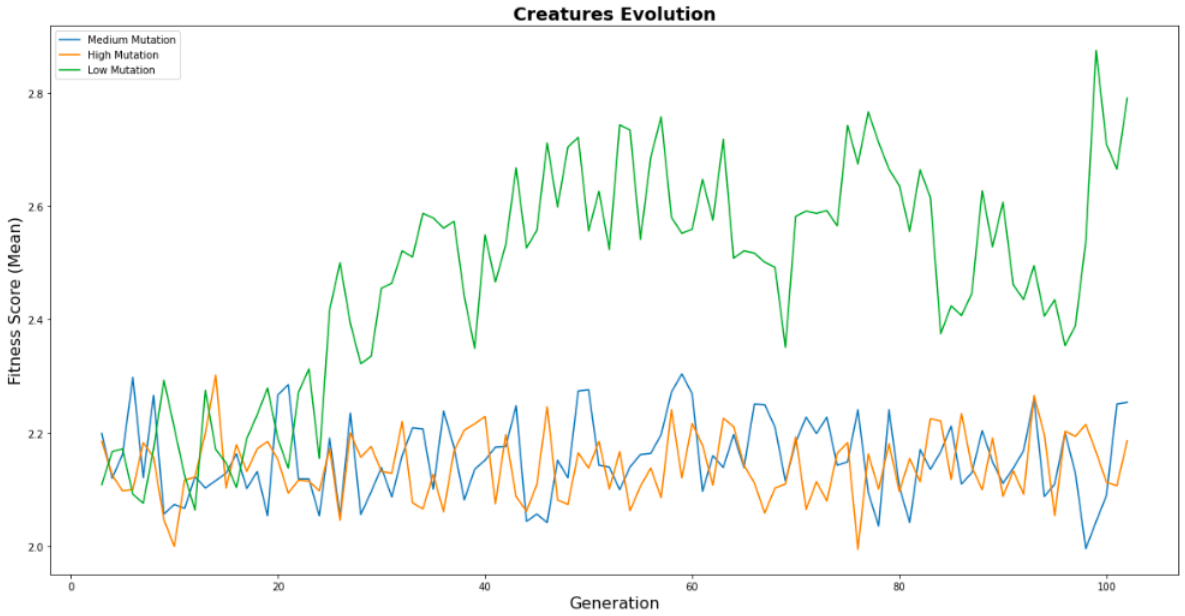
100 rows × 5 columns

Generation vs Fitness Score (Max)



The graph shows that Fitness score (Max) for a generation seems to be better in creatures with high mutation.

Generation vs Fitness Score (Mean)



The graph shows that Fitness score (Mean) for a generation with Low, Medium and High mutation respectively.

3. Gene count

For this experiment, I did 3 sets of experiment to see the imapct of gene count on fitness score and quality of the evolved creature. I ran each set 5 times. The three sets which I choose are as follows:-

Constant parameters in all 3 sets:-
Population szie - 100
mutation rate - (point mutation - 0.1, shrink mutation - 0.25, grow mutation = 0.1, mutation amount = 0.25)

Variable parameters-
i.) Gene count - 3

	generation	fittest max	fittest mean	mean links	max links
0	1	4.011	2.139	6.0	13
1	2	4.820	2.226	6.0	28
2	3	5.431	2.272	5.0	40
3	4	6.020	2.351	5.0	22
4	5	6.045	2.443	4.0	14
...	...	...	...	...	...
95	96	12.883	3.576	4.0	22
96	97	12.883	3.454	4.0	16
97	98	12.883	3.851	5.0	31
98	99	12.883	3.461	5.0	19
99	100	12.883	3.685	4.0	22

100 rows × 5 columns

ii.) Gene count - 4

	generation	fittest max	fittest mean	mean links	max links
0	1	3.451	2.229	11.0	40
1	2	5.110	2.160	9.0	37
2	3	5.110	2.258	8.0	49
3	4	5.110	2.259	6.0	28
4	5	5.676	2.301	5.0	27
...	...	...	...	...	...
95	96	9.162	2.334	3.0	13
96	97	9.162	2.208	3.0	31
97	98	9.162	2.243	3.0	31
98	99	9.162	2.142	3.0	13
99	100	9.162	2.237	3.0	13

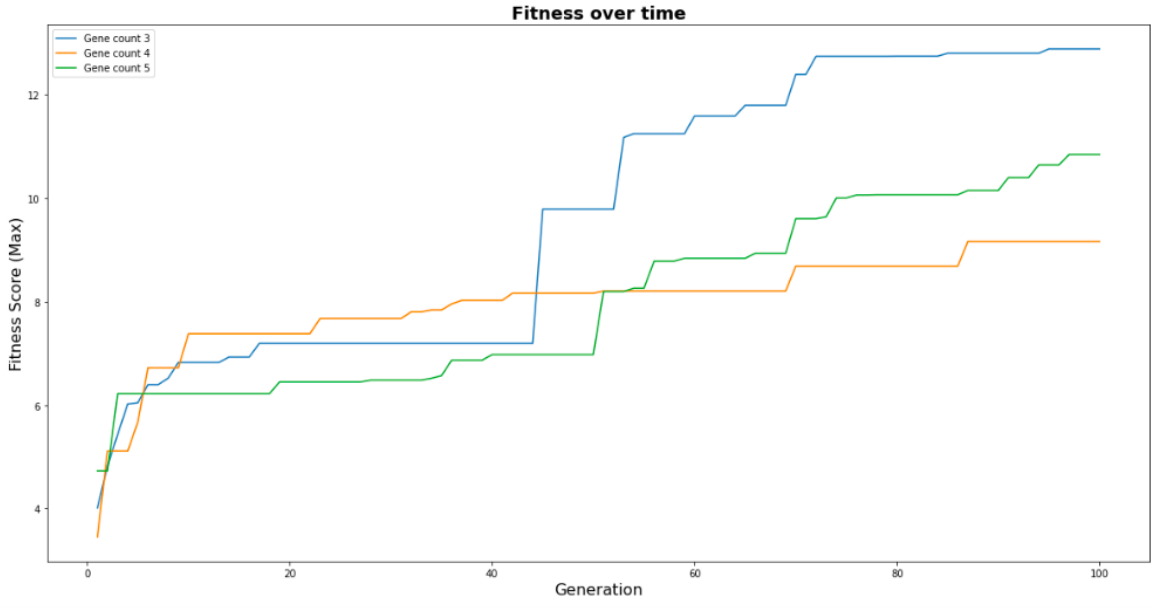
100 rows × 5 columns

iii.) Gene count - 5

	generation	fittest max	fittest mean	mean links	max links
0	1	4.726	2.155	16.0	49
1	2	4.726	2.120	13.0	46
2	3	6.219	2.209	10.0	64
3	4	6.219	2.267	8.0	31
4	5	6.219	2.261	6.0	63
...	...	...	...	...	...
95	96	10.642	2.607	3.0	9
96	97	10.842	2.629	3.0	13
97	98	10.842	2.531	3.0	21
98	99	10.842	2.415	3.0	22
99	100	10.842	2.341	3.0	9

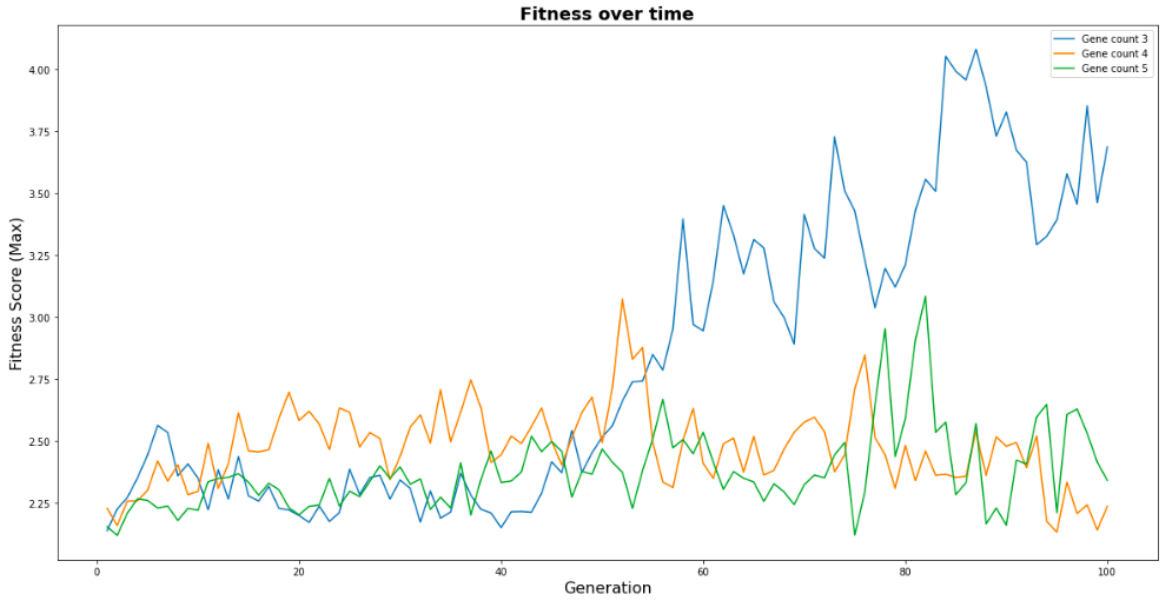
100 rows × 5 columns

Fitness Score (Max) over time



The max fitness score doesn’t seem to depend on the gene count. Although the max fitness score is directly proportional to generation i.e. max fitness score increases with generation.

Mean Fitness score over time



The time to run and the overall performance of the genetic algorithm do depends on both the population size and generation. The increase in population size greatly reduces the performance of the algoritm even though it does benefit in generating a better fitness score. The increase in generation size also affect performance slighlty but helps to generate creature with better fitness score.

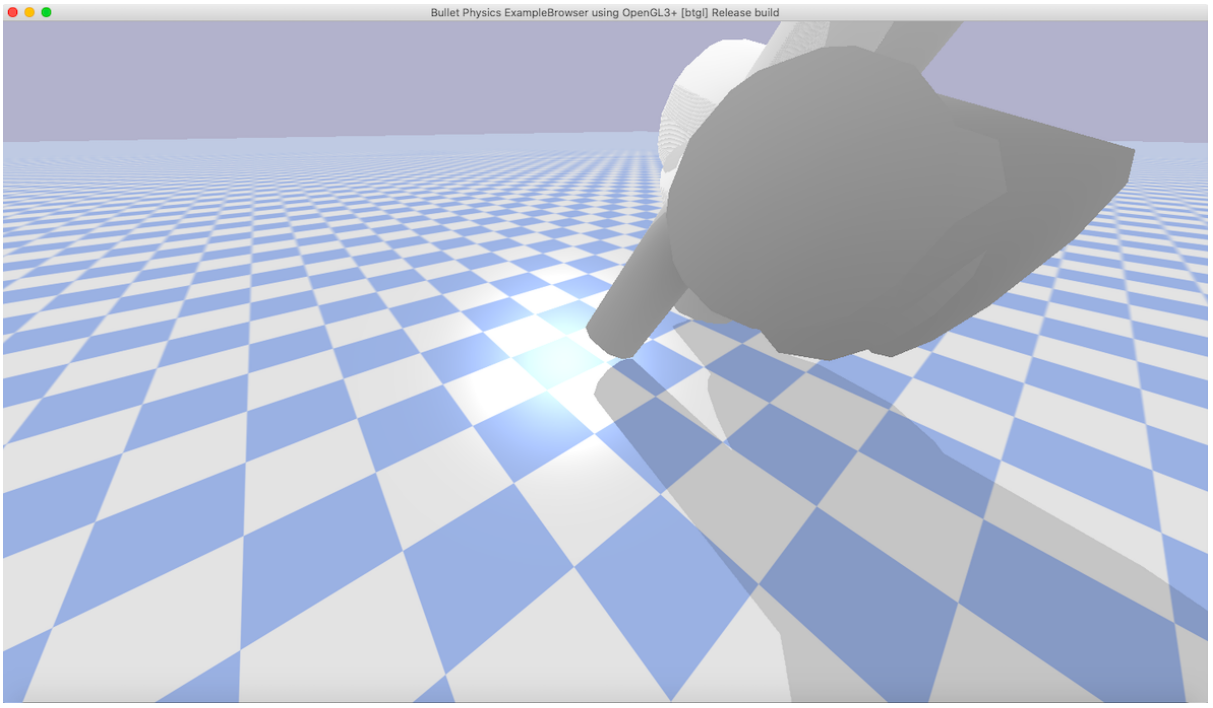
For eg. for the population size of 10, gene count 3, number of generation as 100, normal mutation rate has the run time of 81.314s wherease with the population size of 100, the run time greatly increased to 970.364s on my machine.

Experiment with the encoding scheme

I have experimented with encoding scheme by changing various parameters such as link shape, link length, link radius, link recurrence, link mass, joint type etc. The results are as follows:-

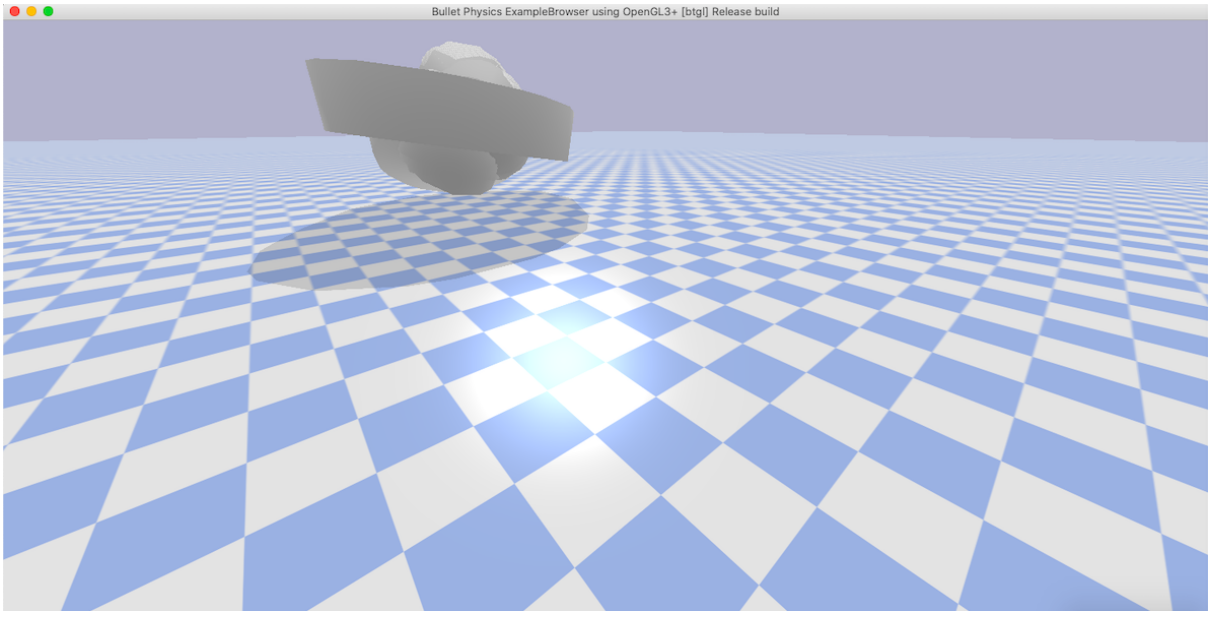
1. Changing link length and link mass to a higher value tends to increase the creature size.

   For e.g. changing link length to the scale of 5 and link mass to the scale of 3 outputs the below creature, total genes = 5, generation = 21, population size = 100



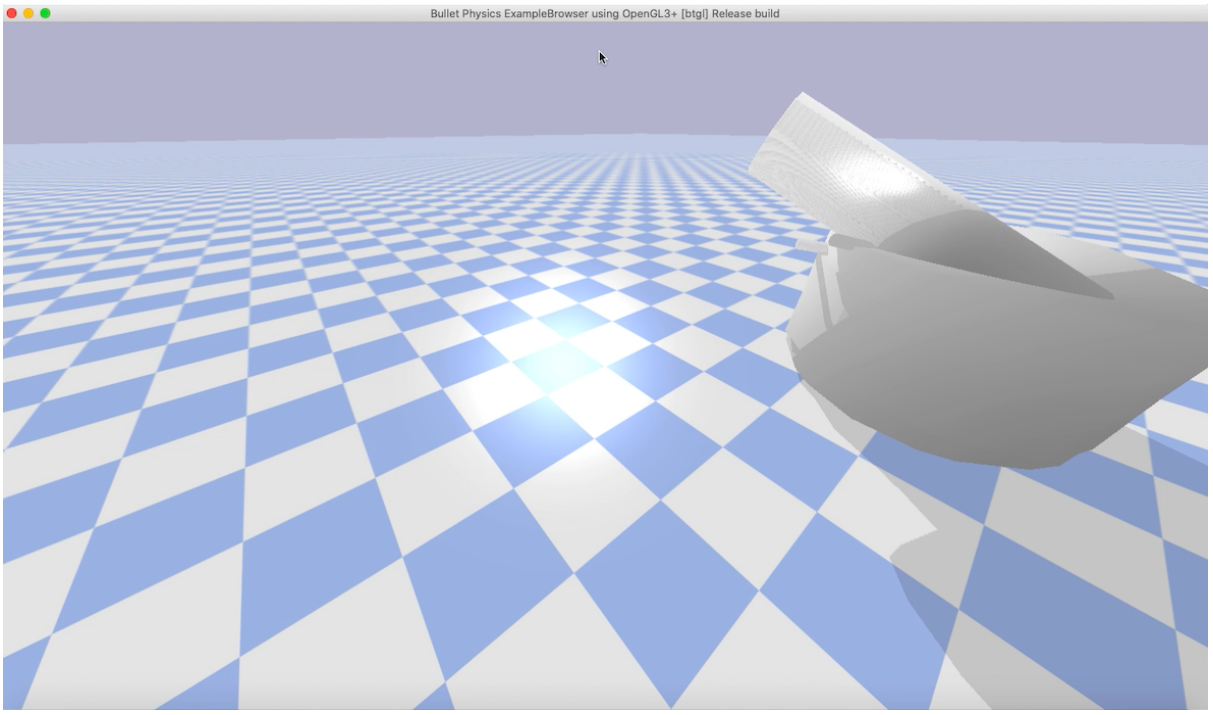
2. Increasing link radius tends to make the creature to jump out of the plane and return back to the surface after the fall. After the fall, creature starts moving normally.

   Creature settings - total genes = 5, generation = 25, population size = 100, mass length, radius set to scale of 3.



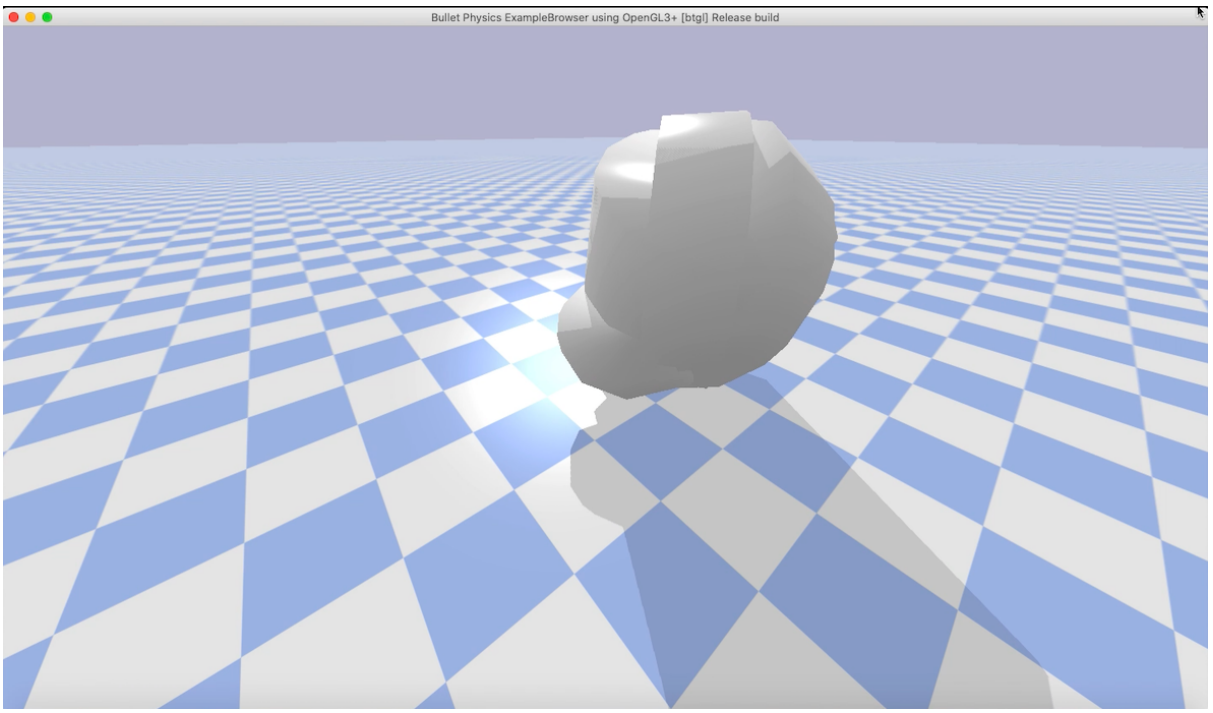
3. Tank like creature - which moves its one joined in different position while moving.

   Creature settings - Multiple genome parameters configuration was changed such as link shape, link mass and link radius to the scale of 2 and the link length to the scale of 5, total genes = 5, generation = 12, population size = 100.



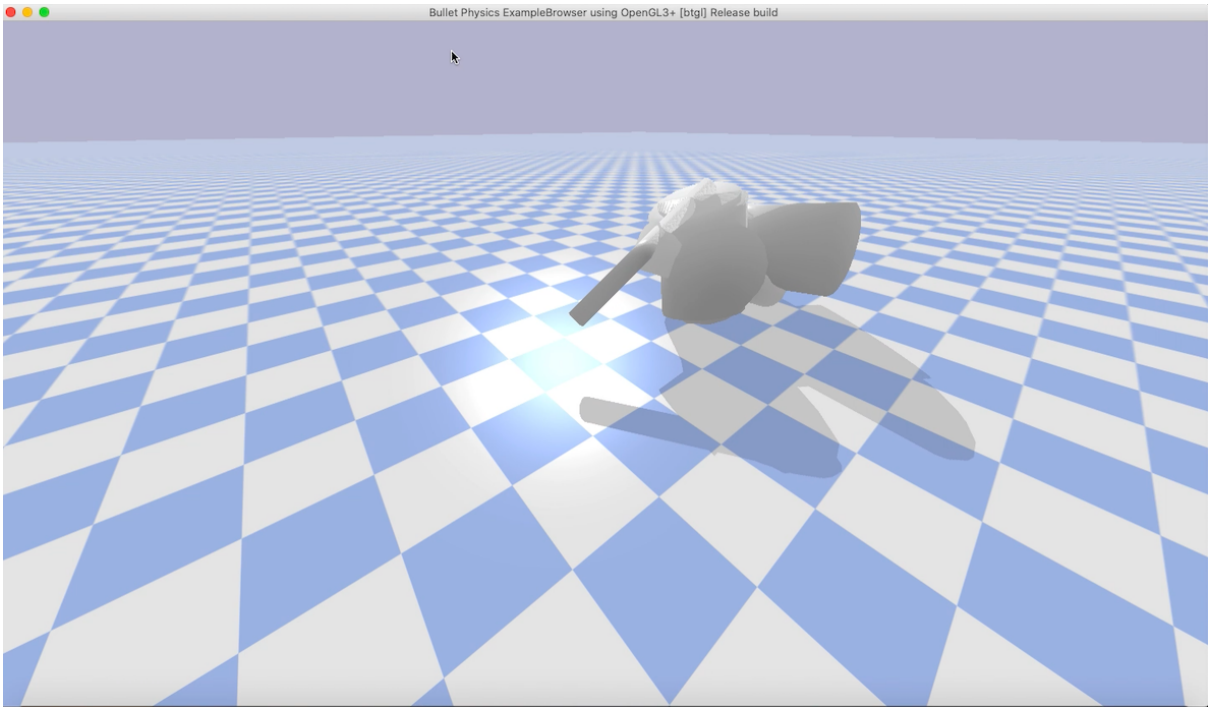
4. Rotating creature - which rotates at a single point.

   The creature was created using link shape and mass at the scale of 5, link length, radius and joint type at the scale of 2 and control amplitude increased to 0.5, control frequency increased to the scale of 2. The total number of genes in this creature are 5, total genes = 5, generation = 45, population size = 100.



5. Snail-like creature - which moves very slowly and has similar animation as the snail.

   The creature was created using link shape of 2, link length, mass, recurrence set to the scale of 3, total genes = 5, generation = 5, population size = 100.



6. Creature with wings like animation - which moves while flapping with both wings shaped joint. The creature was created using link shape, mass set to 2, recurrence

set to 3, joint type set to 2 and link radius set to 3, total genes = 5, generation = 68, population size = 100.