CS7.301 **2^{nd} April, 2020**

MDL Assignment-3

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Contents

1 File Structure

Upon running the file *solution.py*, we get

```
team71
 |__report.pdf:  contains report
 |__client.py:  contains necessary functions for server
 |__set_cur_state.py:  contains necessary functions for vectors
 |__solution.py:  main solution
 |__trace_71.txt:  trace obtained
```

2 Problem Statement

Given coefficients of vectors corresponding to over-fit model, apply Genetic Algorithm (G.A) to reduce over-fitting.
Input:

$$\begin{aligned}\bar{v}_{overfit} = [&-0.00016927573251173823, 0.0010953590656607808,\\ &0.003731869524518327, 0.08922889556431182,\\ &0.03587507175384199, -0.0015634754169704097,\\ &-7.439827367266828e-05, 3.7168210026033343e-06,\\ &1.555252501348866e-08, -2.2215895929103804e-09,\\ &2.306783174308054e-11]\end{aligned}$$

Given a query server to allow for submission of weights (w_i), the following is returned for each query -

$$M.S.E = \frac{\sum_{x \in data} \left(y - f(x)\right)^2}{N}$$

where $f(x)$ is calculated using the weights submitted $[w_1, w_2 \ldots w_{10}]$ -

$$f(x) = \sum_{i=1}^{10} w_i \cdot x_i$$

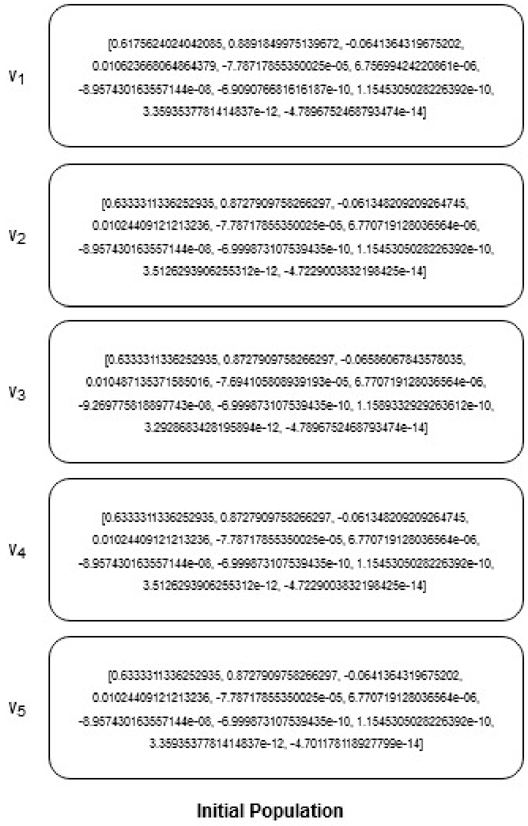
Output: A set of weights $[w_1, w_2 \ldots w_{10}]$ corresponding to best-fit under the conditions-

$$|w_i| \leq 10$$

3 Algorithm Definition

Our Genetic Algorithm consists of 4 steps -

1. **Initialisation of Population**:
   Each generation contains 5 vectors. This is chosen from previous set of population or derived initially randomly.After the algorithm runs, this population is instead chosen from the already saved state in *current_state.pkl.*



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v_2 [0.6333311336252935, 0.8727909758266297, -0.061348209209264745, 0.01024409121213236, -7.78717855350025e-05, 6.770719128036564e-06, -8.957430163557144e-08, -6.999873107539435e-10, 1.1545305028226392e-10, 3.5126293906255312e-12, -4.7229003832198425e-14]

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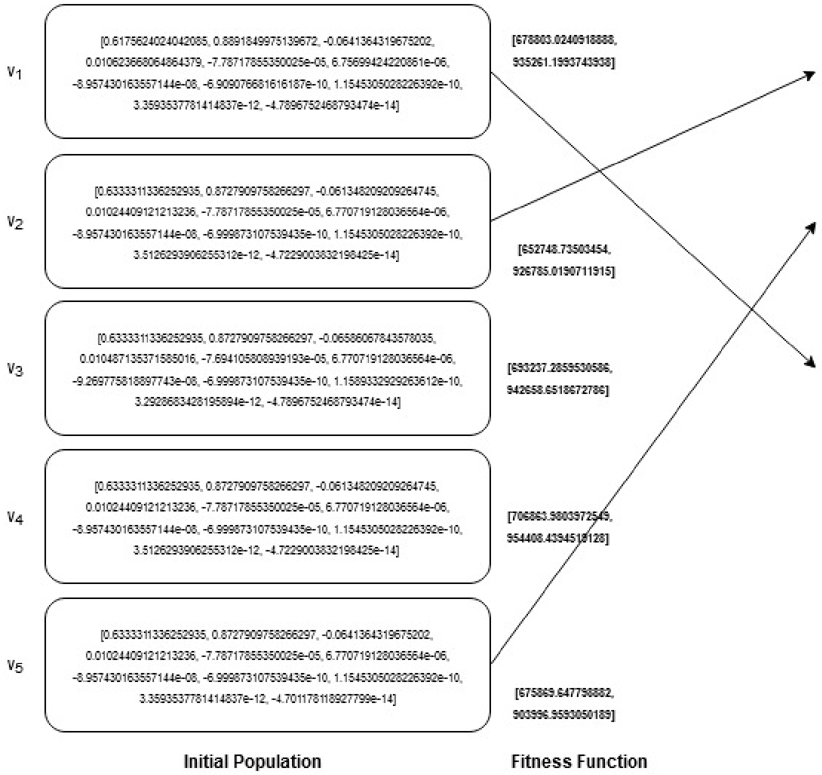
v_4 [0.6333311336252935, 0.8727909758266297, -0.061348209209264745, 0.01024409121213236, -7.78717855350025e-05, 6.770719128036564e-06, -8.957430163557144e-08, -6.999873107539435e-10, 1.1545305028226392e-10, 3.5126293906255312e-12, -4.7229003832198425e-14]

v_5 [0.6333311336252935, 0.8727909758266297, -0.0641364319675202, 0.01024409121213236, -7.78717855350025e-05, 6.770719128036564e-06, -8.957430163557144e-08, -6.999873107539435e-10, 1.1545305028226392e-10, 3.3593537781414837e-12, -4.701178118927799e-14]

Initial Population

population.jpg

2. **Fitness Function**:
   The best three of each iteration survive and give birth to next generation. We chose training error to be out fitness function.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[678803.0240918888, 935261.1993743938]
v_2
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[652748.73503454, 926785.0190711915]
v_3
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[706863.9803972549, 954408.4394518128]
v_5
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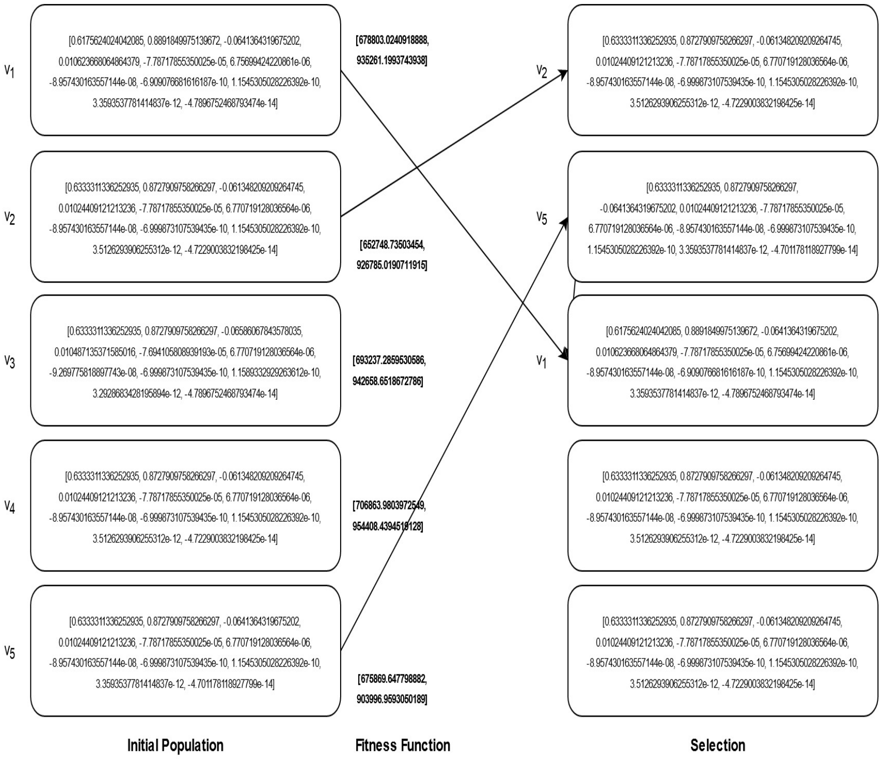
[675869.647798882, 903996.9593050189]
Initial Population
Fitness Function

fitness.jpg

3. **Selection**
   Since we have used training error as our fitness function , the best 3 vectors are **deterministically** chosen from the population. This is where we differ from the normal Genetic Algorithm that the selection is not random.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Initial Population
Fitness Function
Selection

selection.jpg

So if A, B, C, D, E are in sorted order of their fitness function then A, B, C survive.The best three of each iteration survive and give birth to next generation.

4. **Crossover with Mutation**
   Crossover
   We did a probabilistic cross over which is explained below.

   A is best vector and B is second best vector, then let Crossover vector be C.

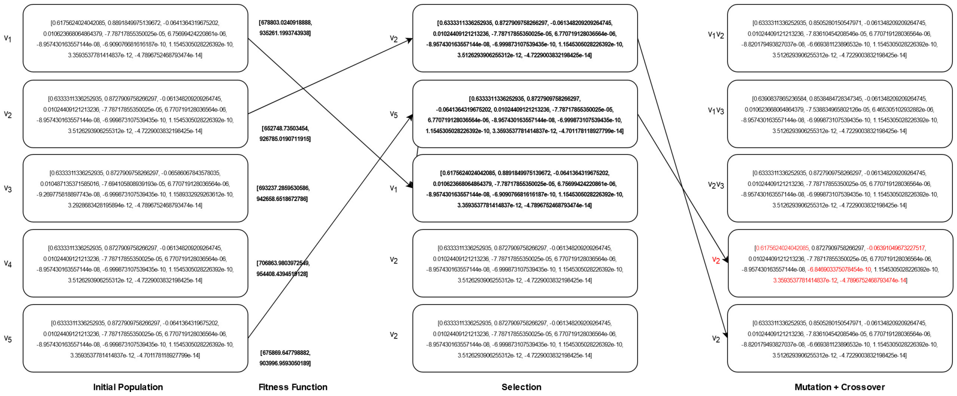
   $$C_i = \begin{Bmatrix} A_i, & \text{with } p_i = 0.6 \\ B_i, & \text{with } q_i = 0.4 \end{Bmatrix}$$

   Mutation The mutation was also probabilistic. Let M be the new mutation vector.

   $$M_i = \begin{Bmatrix} A_i, & \text{with } p_i = 0.6 \\ \in (0.95 * A_i, 1.05 * A_i), & \text{with } q_i = 0.4 \end{Bmatrix}$$

Suppose the chosen population was A,B and C (with A giving the best value in fitness function, B the next best and then C). The new vectors are

- A-B (Crossover with Mutation).
- A-C (Crossover with Mutation).
- B-C (Crossover with Mutation).
- A with mutations: This is A with the following mutation.
- A without any mutation: This is just plain A without any mutation.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Fitness Function
v_2
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Selection
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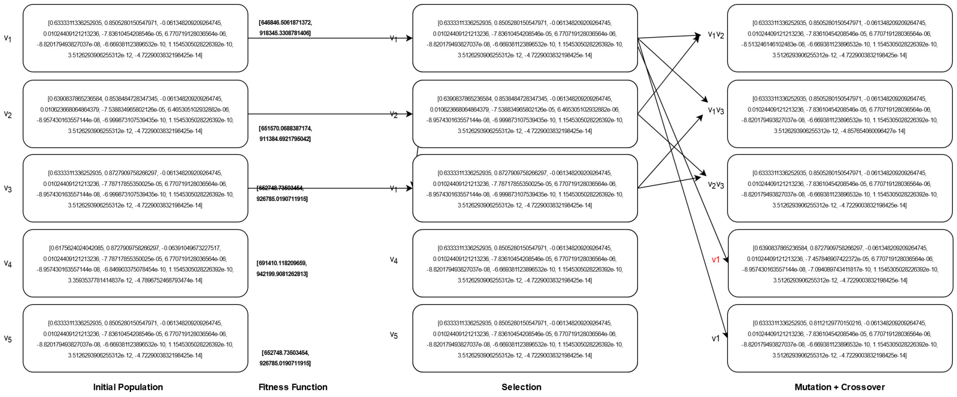
Mutation + Crossover

iteration1.jpg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v_4
[0.6333311336252935, 0.8505280150547971, -0.061348209209264745, 0.01024409121213236, -7.83610454208546e-05, 6.770719128036564e-06, -8.820179493827037e-08, -6.669381123896532e-10, 1.1545305028226392e-10, 3.5126293906255312e-12, -4.7229003832198425e-14]
v_5
[0.6333311336252935, 0.8505280150547971, -0.061348209209264745, 0.01024409121213236, -7.83610454208546e-05, 6.770719128036564e-06, -8.820179493827037e-08, -6.669381123896532e-10, 1.1545305028226392e-10, 3.5126293906255312e-12, -4.7229003832198425e-14]
Selection
v_1v_2
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v_1v_3
[0.6333311336252935, 0.8505280150547971, -0.061348209209264745, 0.01024409121213236, -7.83610454208546e-05, 6.770719128036564e-06, -8.820179493827037e-08, -6.669381123896532e-10, 1.1545305028226392e-10, 3.5126293906255312e-12, -4.857654060096427e-14]
v_2v_3
[0.6333311336252935, 0.8505280150547971, -0.061348209209264745, 0.01024409121213236, -7.83610454208546e-05, 6.770719128036564e-06, -8.820179493827037e-08, -6.669381123896532e-10, 1.1545305028226392e-10, 3.5126293906255312e-12, -4.7229003832198425e-14]
v1
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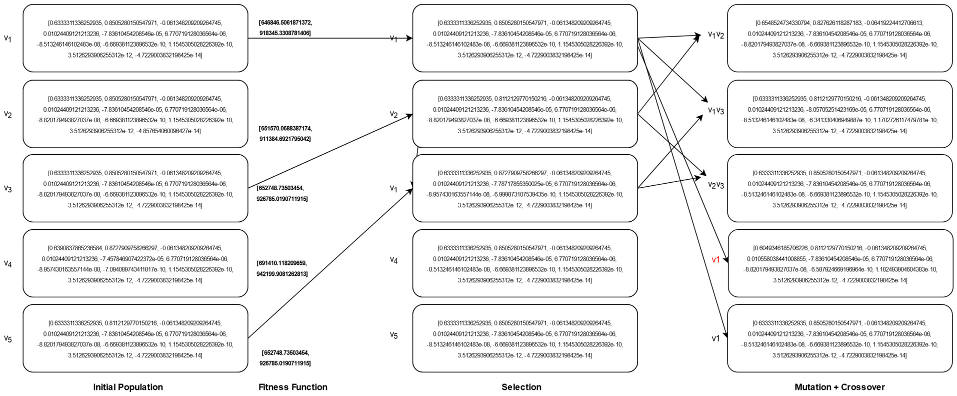
v1
[0.6333311336252935, 0.8112129770150216, -0.061348209209264745, 0.01024409121213236, -7.83610454208546e-05, 6.770719128036564e-06, -8.820179493827037e-08, -6.669381123896532e-10, 1.1545305028226392e-10, 3.5126293906255312e-12, -4.7229003832198425e-14]
Mutation + Crossover

iteration2.jpg


v_1
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v_2
[0.6333311336252935, 0.8505280150547971, -0.061348209209264745, 0.01024409121213236, -7.83610454208546e-05, 6.770719128036564e-06, -8.820179493827037e-08, -6.669381123896532e-10, 1.1545305028226392e-10, 3.5126293906255312e-12, -4.857654060096427e-14]
v_3
[0.6333311336252935, 0.8505280150547971, -0.061348209209264745, 0.01024409121213236, -7.83610454208546e-05, 6.770719128036564e-06, -8.820179493827037e-08, -6.669381123896532e-10, 1.1545305028226392e-10, 3.5126293906255312e-12, -4.7229003832198425e-14]
v_4
[0.6390837865236584, 0.8727909758266297, -0.061348209209264745, 0.01024409121213236, -7.457846907422372e-05, 6.770719128036564e-06, -8.957430163557144e-08, -7.094089743411817e-10, 1.1545305028226392e-10, 3.5126293906255312e-12, -4.7229003832198425e-14]
v_5
[0.6333311336252935, 0.8112129770150216, -0.061348209209264745, 0.01024409121213236, -7.83610454208546e-05, 6.770719128036564e-06, -8.820179493827037e-08, -6.669381123896532e-10, 1.1545305028226392e-10, 3.5126293906255312e-12, -4.7229003832198425e-14]
Initial Population
[646846.5061871372, 918345.3308781406]
[651570.0688387174, 911384.6921795042]
[652748.73503454, 926785.0190711915]
[691410.118209659, 942199.9081262813]
[652748.73503454, 926785.0190711915]
Fitness Function
v_1
[0.6333311336252935, 0.8505280150547971, -0.061348209209264745, 0.01024409121213236, -7.83610454208546e-05, 6.770719128036564e-06, -8.513246146102483e-08, -6.669381123896532e-10, 1.1545305028226392e-10, 3.5126293906255312e-12, -4.7229003832198425e-14]
v_2
[0.6333311336252935, 0.8112129770150216, -0.061348209209264745, 0.01024409121213236, -7.83610454208546e-05, 6.770719128036564e-06, -8.820179493827037e-08, -6.669381123896532e-10, 1.1545305028226392e-10, 3.5126293906255312e-12, -4.7229003832198425e-14]
v_1
[0.6333311336252935, 0.8727909758266297, -0.061348209209264745, 0.01024409121213236, -7.787178555350025e-05, 6.770719128036564e-06, -8.957430163557144e-08, -6.999873107539435e-10, 1.1545305028226392e-10, 3.5126293906255312e-12, -4.7229003832198425e-14]
v_4
[0.6333311336252935, 0.8505280150547971, -0.061348209209264745, 0.01024409121213236, -7.83610454208546e-05, 6.770719128036564e-06, -8.513246146102483e-08, -6.669381123896532e-10, 1.1545305028226392e-10, 3.5126293906255312e-12, -4.7229003832198425e-14]
v_5
[0.6333311336252935, 0.8505280150547971, -0.061348209209264745, 0.01024409121213236, -7.83610454208546e-05, 6.770719128036564e-06, -8.513246146102483e-08, -6.669381123896532e-10, 1.1545305028226392e-10, 3.5126293906255312e-12, -4.7229003832198425e-14]
Selection
v_1v_2
[0.6548524734330794, 0.827626118287183, -0.06419224412706613, 0.01024409121213236, -7.83610454208546e-05, 6.770719128036564e-06, -8.820179493827037e-08, -6.669381123896532e-10, 1.1545305028226392e-10, 3.5126293906255312e-12, -4.7229003832198425e-14]
v_1v_3
[0.6333311336252935, 0.8112129770150216, -0.061348209209264745, 0.01024409121213236, -8.05705251423169e-05, 6.770719128036564e-06, -8.513246146102483e-08, -6.341330406949887e-10, 1.1702726117479781e-10, 3.5126293906255312e-12, -4.7229003832198425e-14]
v_2v_3
[0.6333311336252935, 0.8505280150547971, -0.061348209209264745, 0.01024409121213236, -7.83610454208546e-05, 6.770719128036564e-06, -8.513246146102483e-08, -6.669381123896532e-10, 1.1545305028226392e-10, 3.5126293906255312e-12, -4.7229003832198425e-14]
v1
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v1
[0.6333311336252935, 0.8505280150547971, -0.061348209209264745, 0.01024409121213236, -7.83610454208546e-05, 6.770719128036564e-06, -8.513246146102483e-08, -6.669381123896532e-10, 1.1545305028226392e-10, 3.5126293906255312e-12, -4.7229003832198425e-14]
Mutation + Crossover

iteration3.jpg

The heuristics We did a probabilistic cross over which is explained above. We introduced the concept of survivability The best vector always survive. The best vector also produces a copy of itself with some mutations. This helps in converging towards a minimum. Also as the error becomes less we did a trick. (A-B)[0] survives only if it is better than vector of previous generation.