# Report: Fine-tuned version of the summer term results

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## 1. Runs Configurations

**4 Runs:**
- hole_cards_strength+dummy (run1, red)
- board_strength+dummy (run2, blue)
- hole_cards_strength+loose (run3, green)
- board_strength+loose (run4, magenta)

**Obs.:** Two sets of runs with different seeds (4106135931 and 577090034) were executed to ensure that the results are similar even for different seeds.
**Obs.:** Using 20000 sampled hands.

**Parameters:**

- 'reinforcement_parameters': {
  'validation_population': 300
  'champion_population': 1000
  'hall_of_fame': {
  'size': 10,
  'enabled': True,
  'use_as_opponents': True,
  'diversity': 'normalized_compression_distance' # Obs.: I am using a pareto between fitness and diversity to select which teams are kept when the hall of fame is full
  },
- 'training_parameters': {
  'runs_total': 1,
  'generations_total': 250,
  'validate_after_each_generation': 25,
  'populations': {
  'teams': 100,
  'points': 100,
  },
  'replacement_rate': {
  'teams': 0.5,
  'points': 0.2,
  },
  'mutation': {
  'team': {
  'remove_program': 0.7,
  'add_program': 0.7,
  'mutate_program': 0.2, # is applied to all programs in the team, until at least one program is mutated
  },
  'program': {

```
                'remove_instruction': 0.5,
                'add_instruction': 0.5,
                'change_instruction': 1.0,
                'swap_instructions': 1.0,
                'change_action': 0.1,
            },
        },
        'team_size': { # the min and initial size are the total number of actions
            'min': 2,
            'max': 9,
        },
        'program_size': {
            'min': 1,
            'max': 10,
        },
    },
```

- 'advanced_training_parameters': {
  'use_pareto_for_point_population_selection': False, # if False, will select points using uniform probability
  'use_operations': ['+', '-', '*', '/', 'ln', 'exp', 'cos', 'if_lesser_than', 'if_equal_or_higher_than'],
  'extra_registers': 1,
  'diversity': {
    'use_and_show': ['normalized_compression_distance', 'genotype_distance'], # will be applied to fitness and show in the outputs
    'only_show': [], # will be only show in the outputs
    'k': 10,
  },
 },
}
- total inputs: 11 ['0: hand strength', '1: effective potential', '2: pot', '3: bet', '4: pot odds', '5: betting position', '6: round', '7: chips', '8: opponent long-term aggressiveness', '9: opponent short-term aggressiveness', '10: opponent hand aggressiveness']

## 2. Main changes from last report:

- implemented and improved various metrics
- refactored code
- fixed bugs (rule-based opponents were never folding, some introns weren't being removed, diversity wasn't working for hall of fame, the input 'chips' was being calculated wrong)
- rule-based opponents using HS instead of EHS
- removed EHS, and added EP (Effective Potential), so that round 1 = equity, round 2 and 3 = positive potential, round 4 = hand strength
- normalized inputs between 0 and 10
- implemented option to use hall of fame without using it as opponents
- updated NCD (now saving actions as letters instead of numbers, and using state information per hand (seed of the hand, and position) and per round (cards in the board))

**3. Available Metrics** (I will focus on the fitness, validation score, champion score, diversity, and accumulative curves, but all these metrics are available in case you want to see charts or more details):

- **Metrics per Run:**
  - BEST TEAM METRICS PER VALIDATION
    - Best Team Fitness per Validation
    - Best Team Validation Score per Validation (champion)
  - GLOBAL METRICS PER VALIDATION
    - Global Fitness Score per Validation
    - Global Validation Score per Validation
    - Global Opponent Results per Validation [per opponent type]
    - Global Diversities per Validation [per diversity]
    - Global Team Results per Validation [per point type (showdown result, hole_cards_strength label, board_strength label, position, hole_cards_strength label for opponent, board_strength label for opponent)]
  - DISTRIBUTION METRICS PER VALIDATION
    - Distribution of Actions per Validation
    - Distribution of Inputs per Validation (per instruction)
    - Distribution of Inputs per Validation (per team)
    - Points Distribution for the Validation Population [per point type]
    - Points Distribution for the Champion Population [per point type]
    - Points Distribution for the Training Population per Validation [per point type]
    - Hall of Fame per Validation
  - GLOBAL METRICS PER TRAINING
    - Global Fitness Score per Training [overall, per diversity, and per opponent]
    - Global Diversities per Training [per diversity]
  - ACCUMULATIVE PERFORMANCE (individual, accumulative, and team ids)
    - Accumulative Results based on validation score [per point type and per opponent type]
    - Accumulative Results based on validation hands played [per point type and per opponent type]
    - Accumulative Results based on validation hands won [per point type and per opponent type]

- **Metrics per Team (**saved teams: last generation, hall of fame, last pareto front**)**
  - JSON file with the programs and instructions
  - active/inactive programs
  - instructions per program with and without introns
  - fitness, validation score, champion score (if it is a champion)
  - distribution of inputs used by its programs
  - total hands, hands played, and hands won [per point type, for validation and champion]
  - aggressiveness and volatility
  - validation and champions scores [per point type, and per opponent type]
  - diversity values
  - in what other teams its programs participate

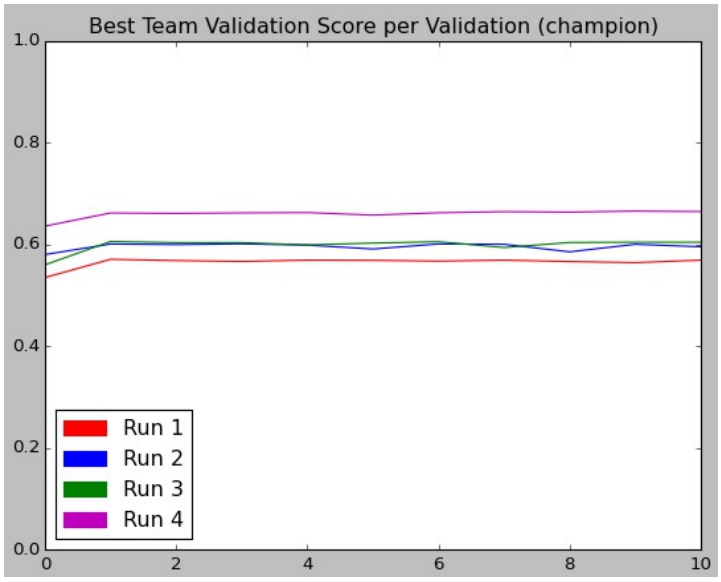
- **Data to generate Stephen's animated chart** [per training or per validation]

## 4. Results:

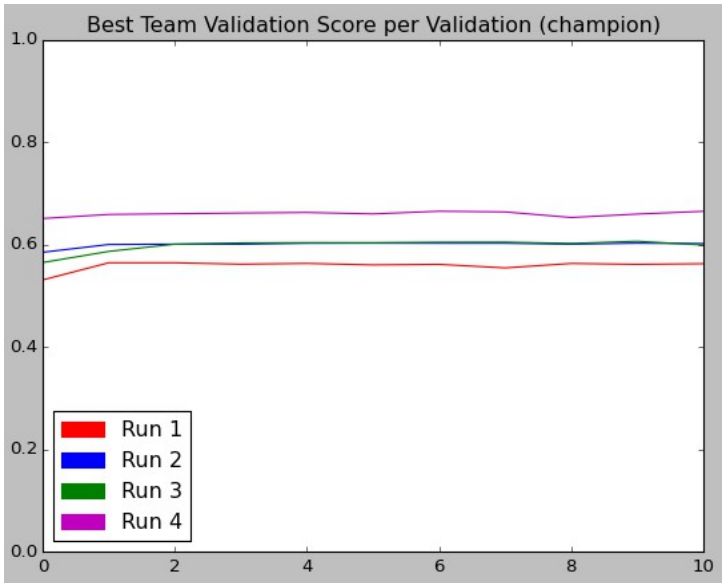
**4 Runs:**
- hole_cards_strength+dummy (run1, red)
- board_strength+dummy (run2, blue)
- hole_cards_strength+loose (run3, green)
- board_strength+loose (run4, magenta)

Validation scores:

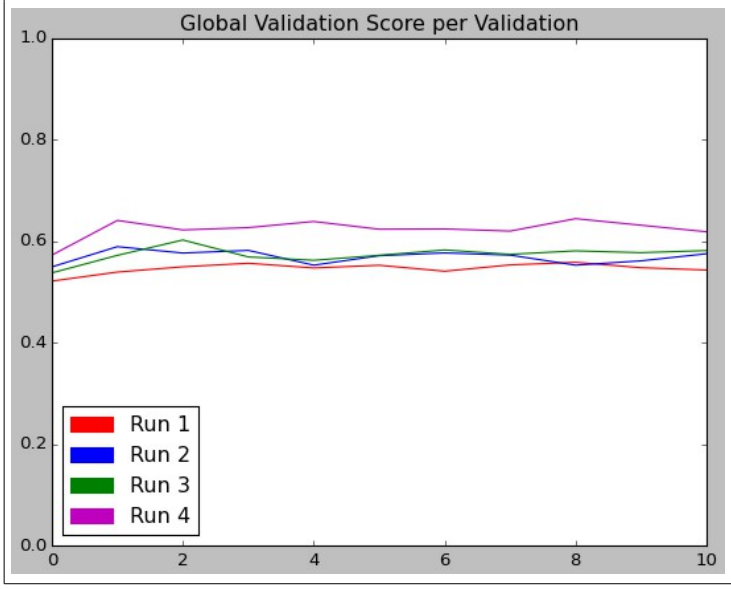
**seed 4106135931**



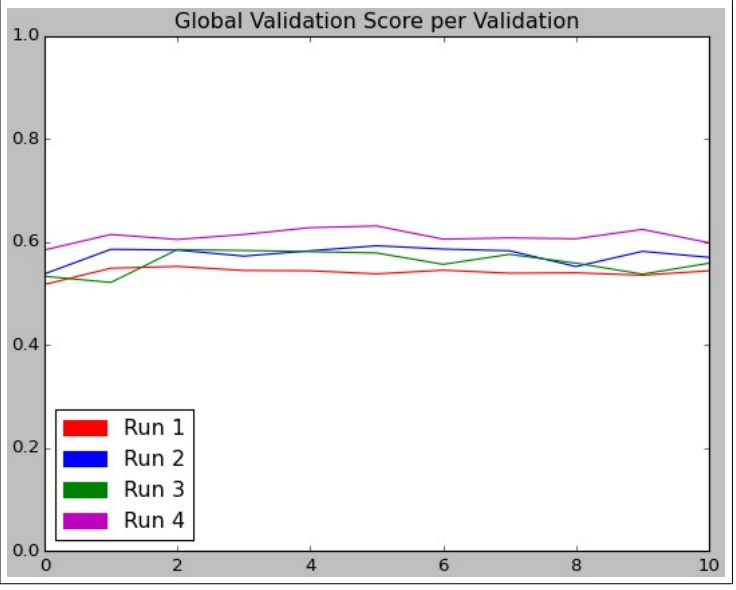

**seed 577090034**




**seed 4106135931**

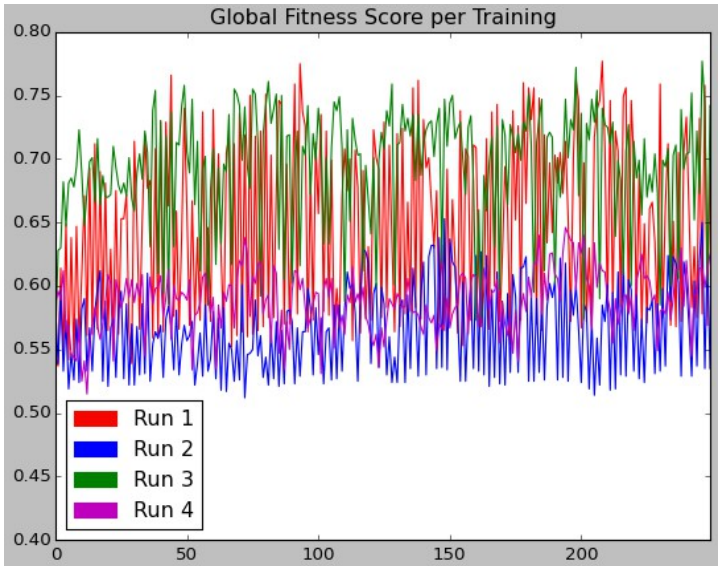



**seed 577090034**

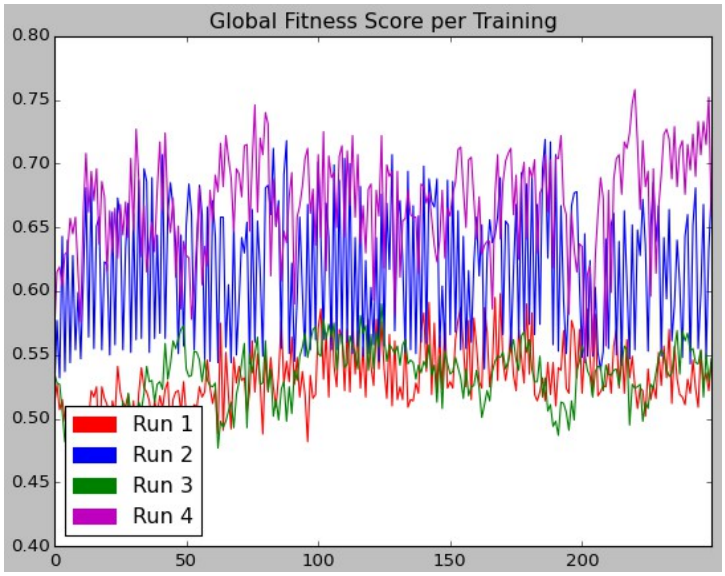



The best team and global validation scores for all runs seem to have stopped improving after the second validation (generation 50). The Run 4 seems to be the only one that has significantly better results.

**seed 4106135931**

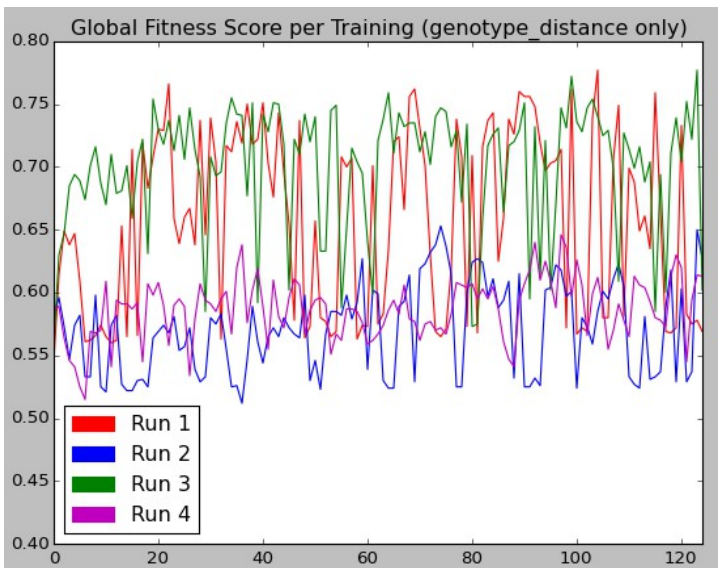


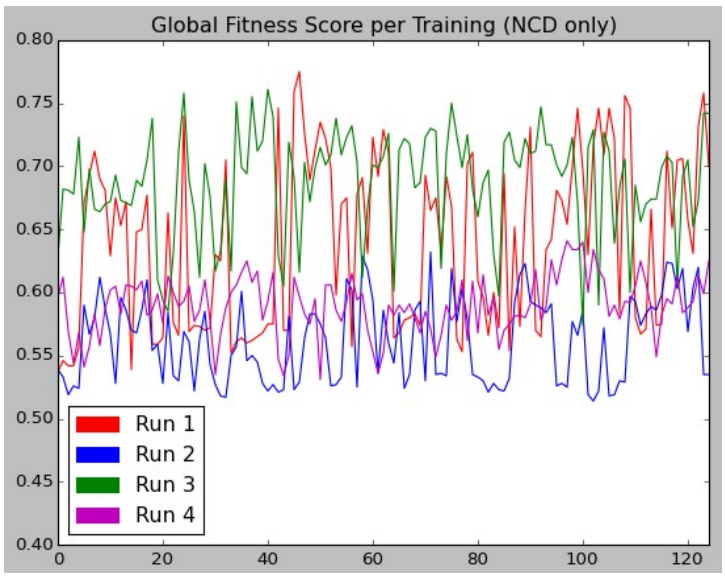

**seed 577090034**

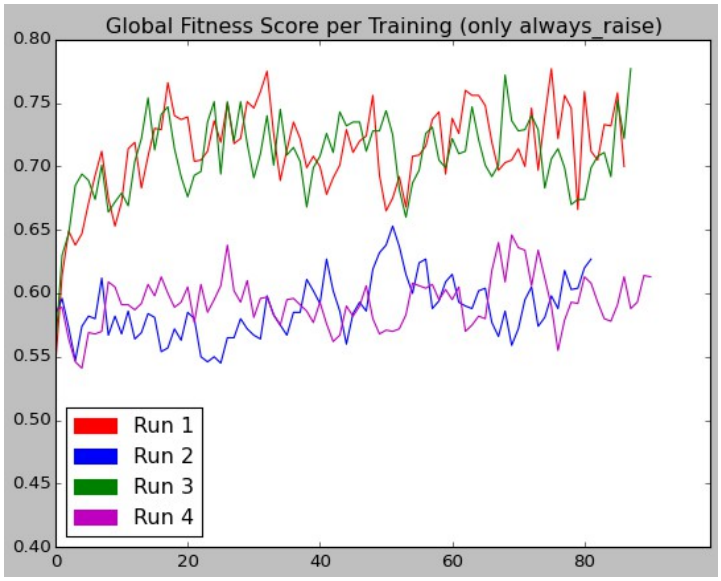


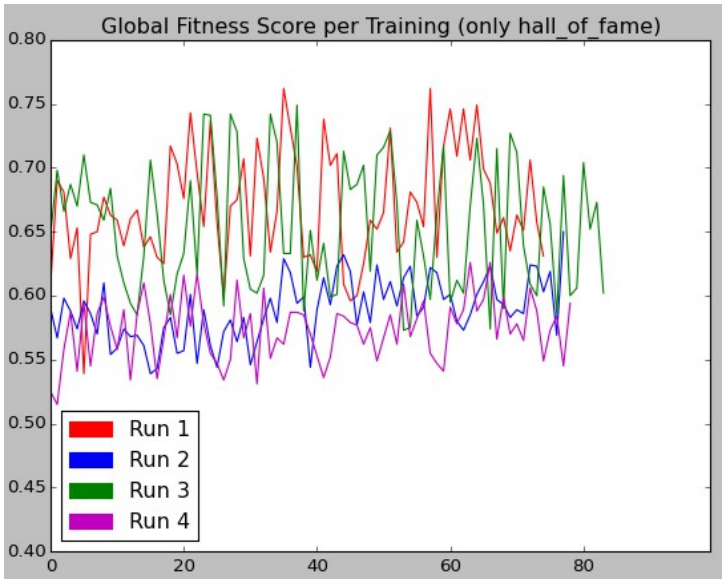

Since the global fitness score was varying a lot, I tried to look at it per diversity and per opponent, to try to find one axis where it was more consistent.

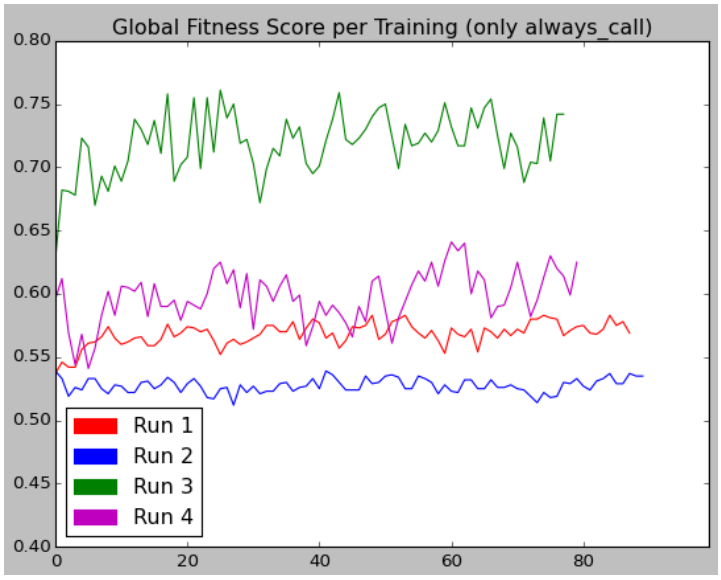
**seed 4106135931**





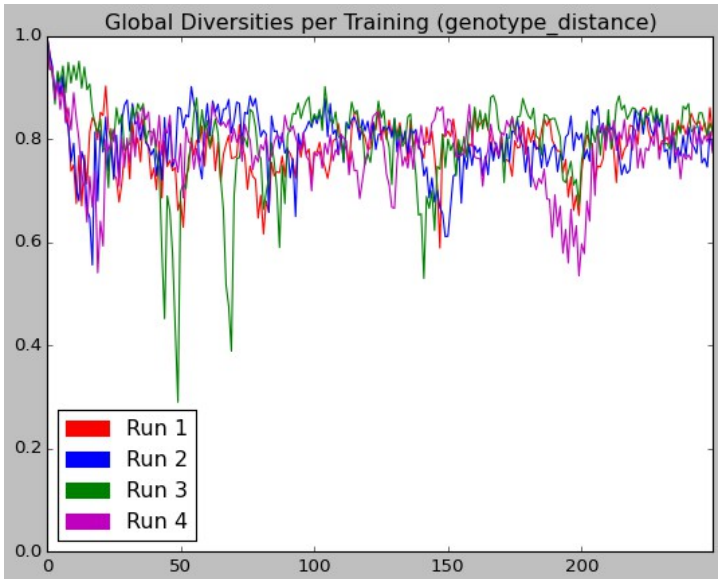



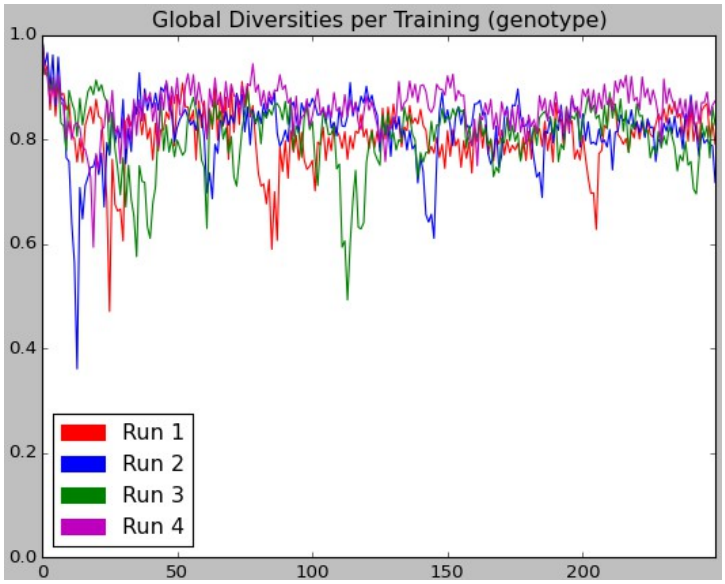

But in all charts it was inconsistent or doesn't seem to improve much over time.

Diversities:

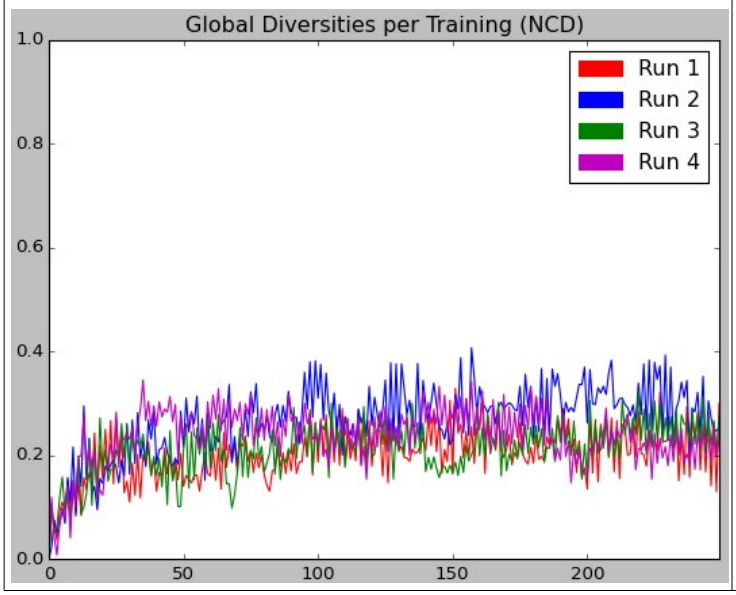
**seed 4106135931**



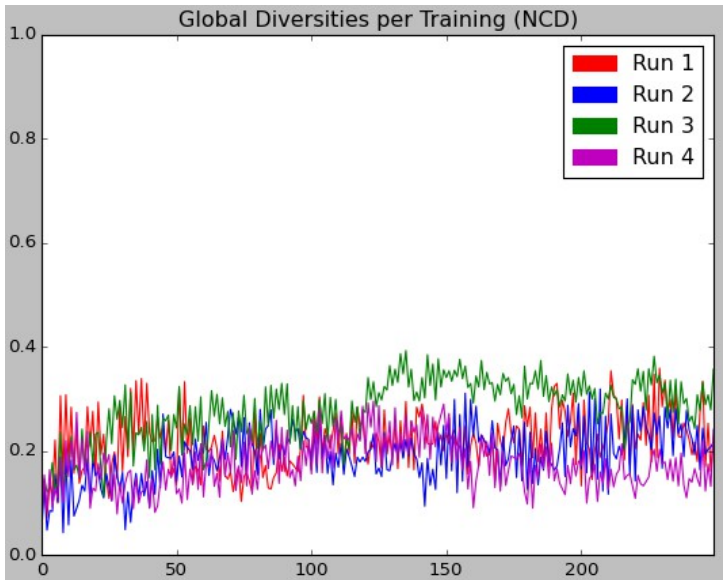

**seed 577090034**



**seed 4106135931**



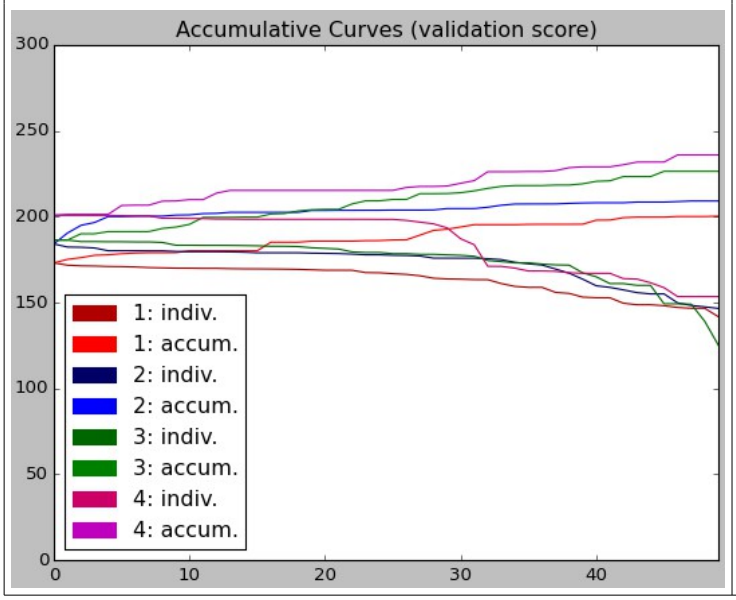

**seed 577090034**



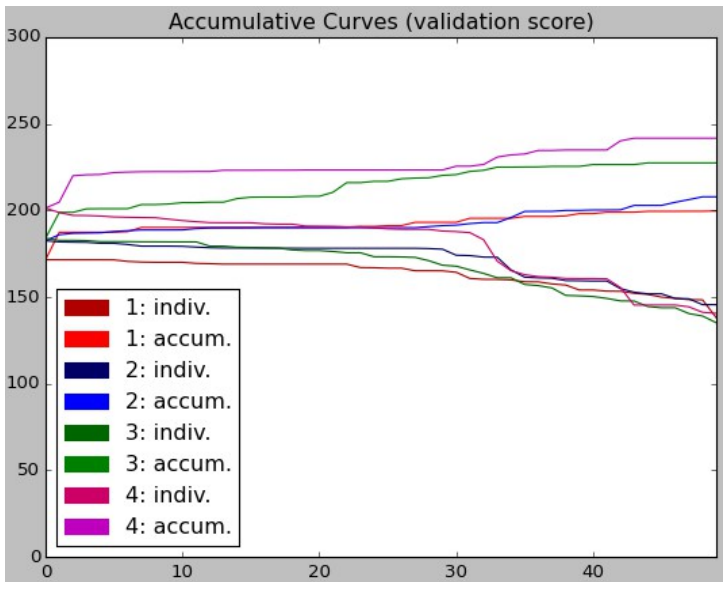

Again, there wasn't much improvement after the generation 50.

So, all results are pointing that there is not enough diversity and that the runs' results are getting mostly stuck after generation 50. Just to be sure of that I plotted the accumulative curves.

**seed 4106135931**




**seed 577090034**




For the first seed, the accumulative curves runs 1 and 4 only improve for the worse teams. The runs 2 and 3 seems to have a better diversity, but not good enough. For the second seed all the runs, besides the run 3, have a sudden improve near the start, but only the runs 3 and 4 keep improving, but mostly at the worst teams.

**Distribution of Inputs per Validation (per team), in the last generation:**

seed 4106135931
[**46**, 13, 18, 7, 1, **47**, 27, 5, 16, 9, 24]
[15, **50**, 3, **31**, 15, 3, 12, 6, 0, 11, 28]
[**34, 46**, 29, 13, 6, 7, 4, 24, 16, 4, **36**]

[11, **45**, 20, 25, 6, 5, **41**, **37**, 0, 9, 8]
Total (sum all runs): [**106**, **154**, 70, 76, 28, 62, 84, 72, 32, 33, **96**]
**Most used inputs across runs** (from the most to the least): '1: effective potential', '0: hand strength', '10: opponent hand aggressiveness', '6: round', '3: bet', '7: chips', '2: pot', '5: betting position', '9: opponent short-term aggressiveness', '8: opponent long-term aggressiveness', '4: pot odds'

seed 577090034
[15, **50**, 12, 28, 6, 5, 16, 29, 21, 21, 30]
[**40**, **46**, **45**, 8, 12, 2, 31, 7, 2, 18, 6]
[**47**, 33, 12, 12, 13, 20, **42**, 33, 7, 22, 29]
[**45**, **38**, 4, 7, 16, 13, 33, 8, 8, 14, 29]
Total (sum all runs): [**147**, **167**, 73, 55, 47, 40, **122**, 77, 38, 75, **94**]
**Most used inputs across runs** (from the most to the least): '1: effective potential', '0: hand strength', '6: round', '10: opponent hand aggressiveness', '7: chips', '9: opponent short-term aggressiveness', '2: pot', '3: bet', '4: pot odds', '5: betting position', '8: opponent long-term aggressiveness'

## 5. Conclusions

- In all runs the results got stuck around generation 50, and the charts points towards a lack of diversity.
- The new inputs 'effective potential' and 'opponent hand aggressiveness' seem to be very useful for the teams.

## 6. Future tasks?

- I think we should schedule a meeting to define the future tasks (good days for me: Monday evening, Tuesday after 15h, Wednesday between 12h~15h30, Thursday after 16h, Friday evening).
- Let me know if you want the charts of metrics I didn't show here for the meeting (like the accumulative curve per a subdivision, such as the cards label).
- I would like your feedback regarding it, but it seems the current runs didn't obtained a good enough diversity, so I am not sure if I should try other predefined diversity metrics or try to create one specifically for poker.
- Also, while I implement the new diversities I could execute runs for NCD alone (instead of along genotype), for genotype alone, and for entropy, to see what kind of diversity can be obtained.
- Another question is if I should keep executing runs for the 4 sets of configurations, or if it is possible to remove one or two of the sets. With the current results I am not sure which one should be removed (run 4 got the best validation scores; runs 1 and 3 got the best fitness scores for the first seed, and 2 and 4 for the second seed; runs 2 and 3 have a better accumulative curve for the first seed, and runs 3 and 4 for the second seed).