

A framework for multi-species multi-agent interactions



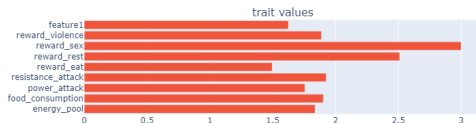
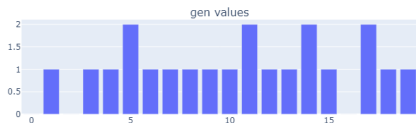
- Gargula simulation framework
- Some first results
- Prospects and conclusions

*Specialization of species happens when its population is greatly reduced, passing through a genetic bottleneck, or the throat of a **Gargoyle**.*

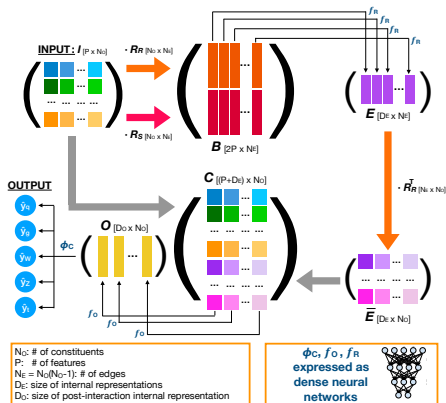
- The individuals are called **homo-virtualis (HV)**.
- Each HV has a **genetics** which determines its **phenotype**.
- Each HV has a **mind** that is used to decide **actions**.
- Mind's **memories** are based on an interaction network (arXiv:1908.05318).
- Decision policy is based on a Deep Q Learning algorithm ().

Genetics and Phenotype

- The HV genes are determined by a father and a mother halogene.
- Each halogene is a vector composed of 0s and 1s. E.g. $[0\ 0\ 1\ 1\ 0\ 1\ \dots\ 0\ 0]$
- A **expression function** maps the genes to **phenotype**
- HVs reproduce through sexual relation, the child receives half of each parent's halogenes randomly.



- Each HV has a **mind** to decide actions based on a Deep Q Learning algorithm.
- The **mind** perception is an interaction network



- N_0 : number of HVs
- P : number of features, e.g. energy, energy_pool, power_attack, resistance_attack, etc
- O : action types

Image from arXiv:1908.05318 (make my own with better names)

- The actions are decided based on the matrix $O_{[D_O \times N_O]}$ (for instance taking the largest value).
- D_O correspond to the actions and N_O to the target HV.
- Each action comes with an effect on the state and a **reward** to the perpetrator HV.
- The **reward** depends on the phenotype and on specific rules of the simulation dynamics, e.g. an HV may resist an attack or an attempt of sex.
- The state is updated following a Deep Q Learning algorithm.

Implementation

- Programming language: Python
- Mind (IN and DQL) implemented with PyTorch.
- Visualization tools implemented in the form of a web app with Dash/Plotly.
- Data analysis and visualization with pandas, jupyter, seaborn and matplotlib.

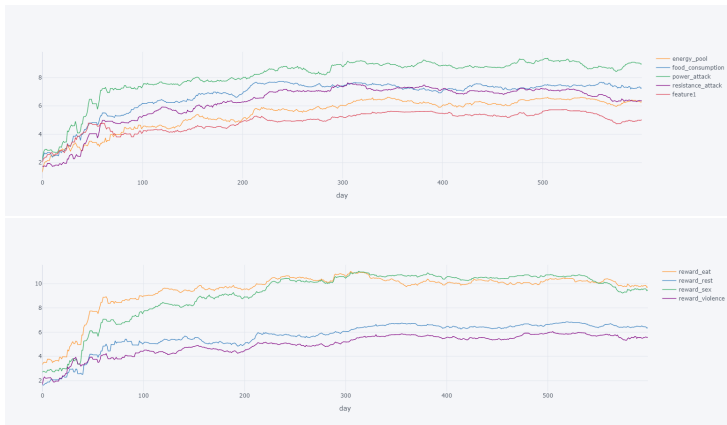
Some first results

Setup:

- All minds have same structure and hyperparameters
- Teaching is automatic. Father's mind is passed to son.
- Possible actions: eat, rest, sex (targeted), attack (targeted)
- Resistance to attack and sex is deterministic: if 'agent power \geq target resistance' action succeeds.
- Reward is determined by the genes for each type of action.
- For targeted action, if succeed reward*4, otherwise reward/2. (For attack action an extra reward bonus is given by the damaged caused).

Evolution

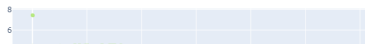
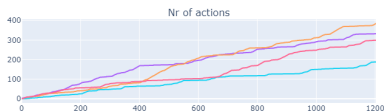
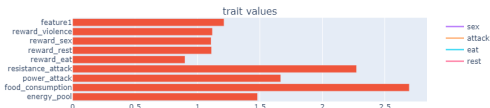
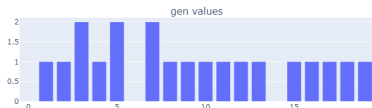
- The following are the traits averaged over the whole population at a certain day.
- It can be seen a evolutionary pressure for high values. There is also a strong correlation among traits.



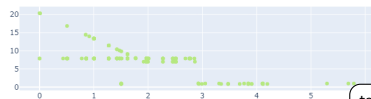
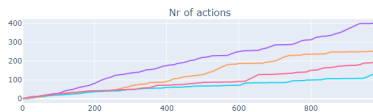
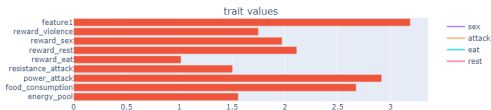
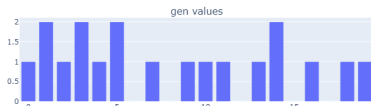
Learning

Are HVs learning? Choosing actions with better reward?

- For this analysis I set very low energy unit to keep the same first HVs living very long.
- Adam chooses mostly attack and sex after a period of learning.
- He seems to have found a weaker HV (power_attack $\sim 1.5 >$ target resistance) so he can get reward bonus (reward_sex $\times 4$) ~ 4

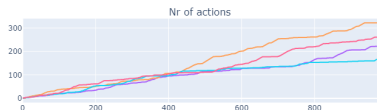
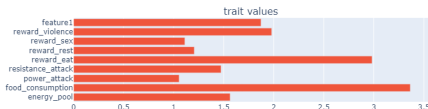
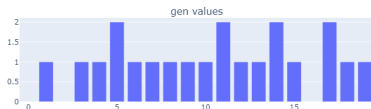


- This one is strong and appreciate sex and violence.
- It can beat most of its companions to get the 4 times factor bonus.



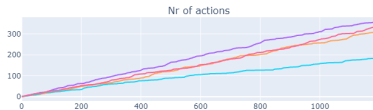
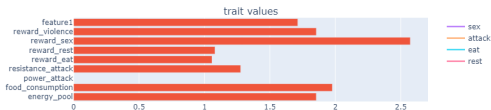
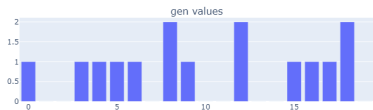
target resistance

- This one is weaker and doesn't appreciate sex as much as it likes to rest.
- But still he found a weaker HV to molest, so he chooses mostly to attack it and gain reward_violence*4~ 8.



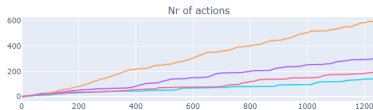
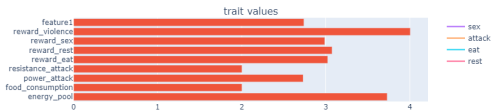
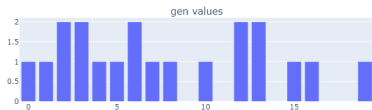
target resistance

- This one is very weak (power ~ 0 but it still enjoys trying to have sex, with half of the reward, more than resting or eating.



target resistance

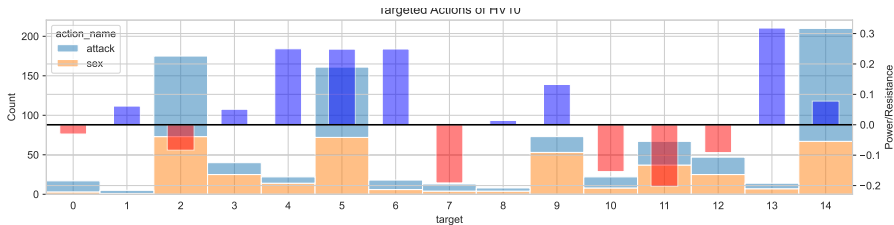
- This one is very very violent and strong, so he is most of the time beating people up.



target resistance

Are HVs using the Interaction Network? Attacking or trying sex with weaker HVs.

- Adam indeed chose two HVs willing to accept its will.
- It was also stuck with a harder mate, but that happens with the best of us. Maybe he was too young.



- Some ongoing implementations: mind hyperparameters as phenotype, teaching as action
- Physical agents (spacial and features) implementation in Unity and continuous-time Markov decision.
- Definition of sociological and genetic metrics: aggressiveness, cooperation, concept of species etc.
- And much more.