Structural Sculpting

An Architectural Study through Inverse Agent-Based Modelling

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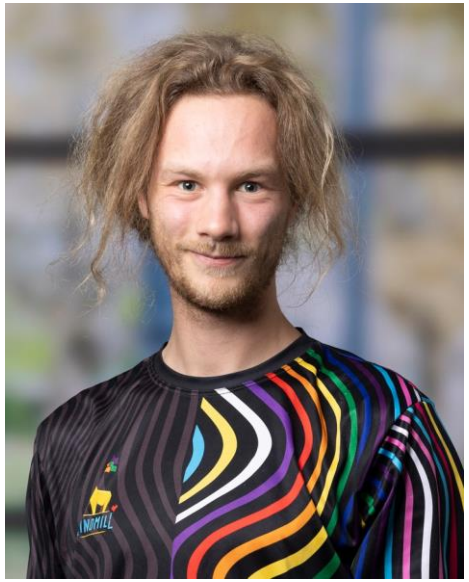
Energy Transition Lab

These two are here, too!


Emile Chappin


Gerdien de Vries


Lynn de Jager


It’s me!


Geeske Scholz

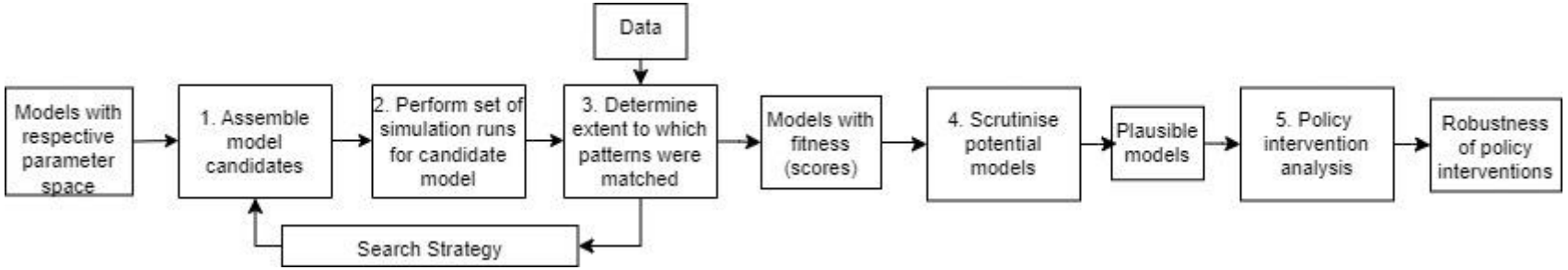

Mariëlle Rietkerk

→ https://www.tudelft.nl/tbm/energy-transition-lab

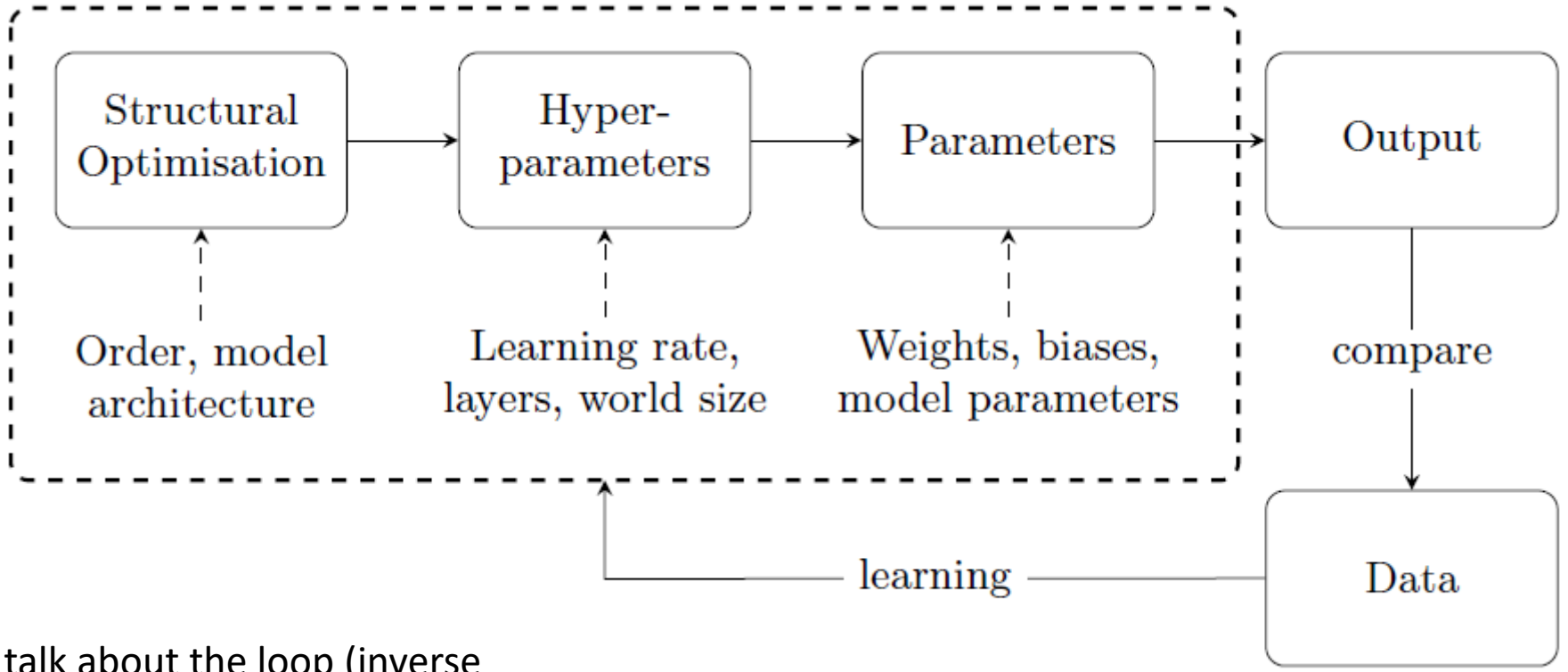
What's on the (far) horizon?

Modelling for exploring pathways to desired outcomes, but:

- Not one model, but multiple
- Real data fed in
- Ways to deal with parametric AND structural uncertainty
- Behaviourally and structurally scrutinised
- Social science informed and informing

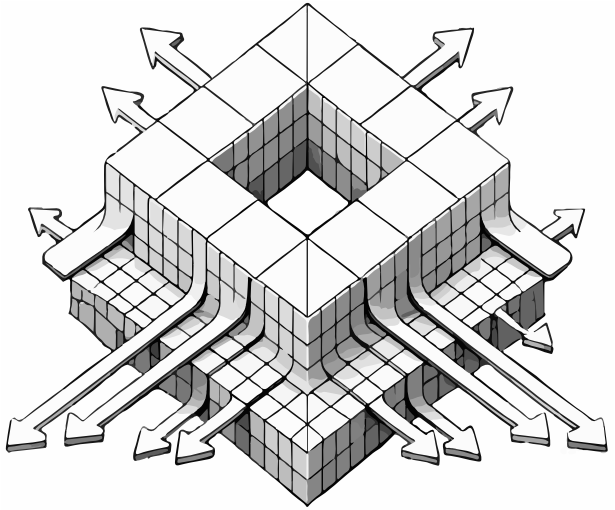


What this research is (and isn't) (proposal)



→ We need to talk about the loop (inverse modelling) and the notion of structure (building blocks). This talk is a methodological example!

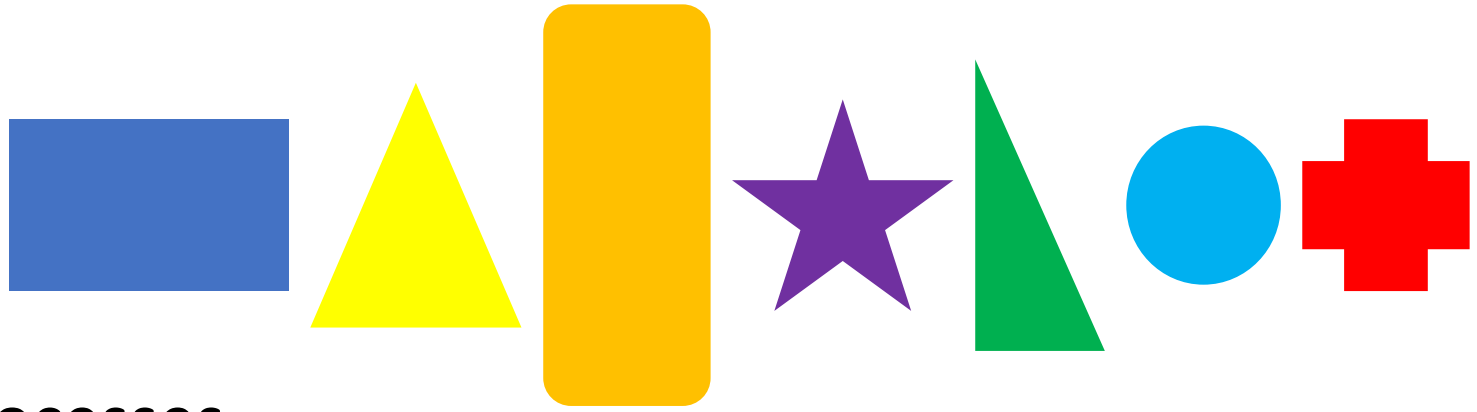
Inverse Modelling



- “Inverse Generative Social Science”
  - Generative social science (Epstein, 1999)
  - Inversion (Epstein, 2023)
- Inverse modelling (Jensen & Chappin, 2017) only the modelling part
- So, multiple forward problem for macro-pattern matching
- Teething problems:
  - Overfitting (genetic algorithms, lack of large/diverse data)
  - No stochasticity or chaos control
  - Conceptual, little steps towards generative-ness

→ Aim: Inverse modelling and structural changes

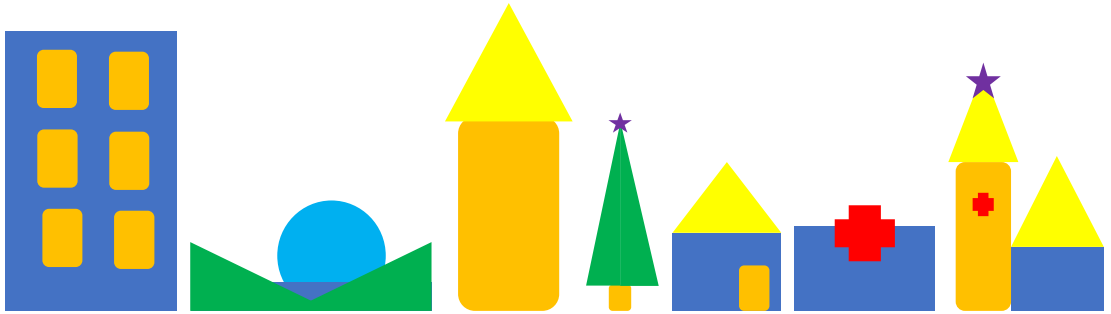
Building Blocks:



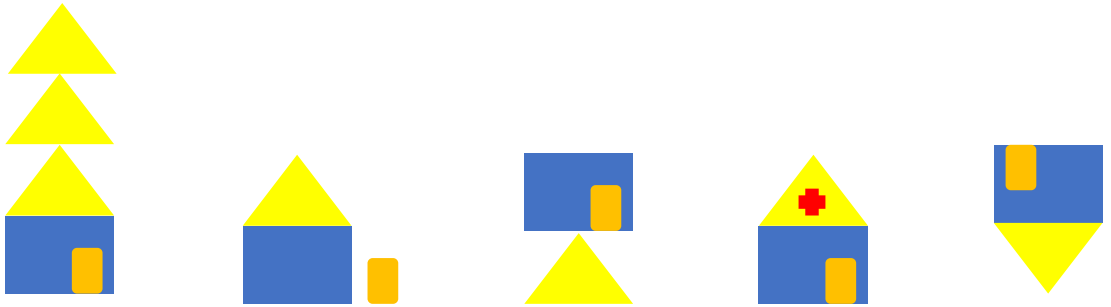
- “submodels describing processes that are relevant for a broad range of ABM in a certain application domain” (Grimm et al., 2022)
- More transparency, scrutiny, & reproducibility of models/results
- Also: Many other model candidates are possible

→ Aim: Can we do pattern matching structurally?

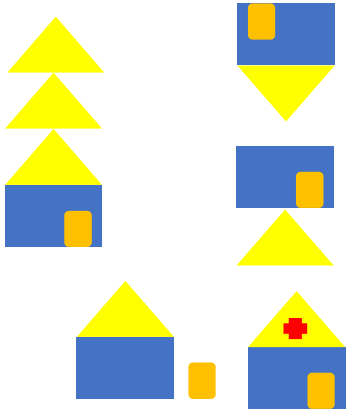
We can build all types of things (houses & not houses)

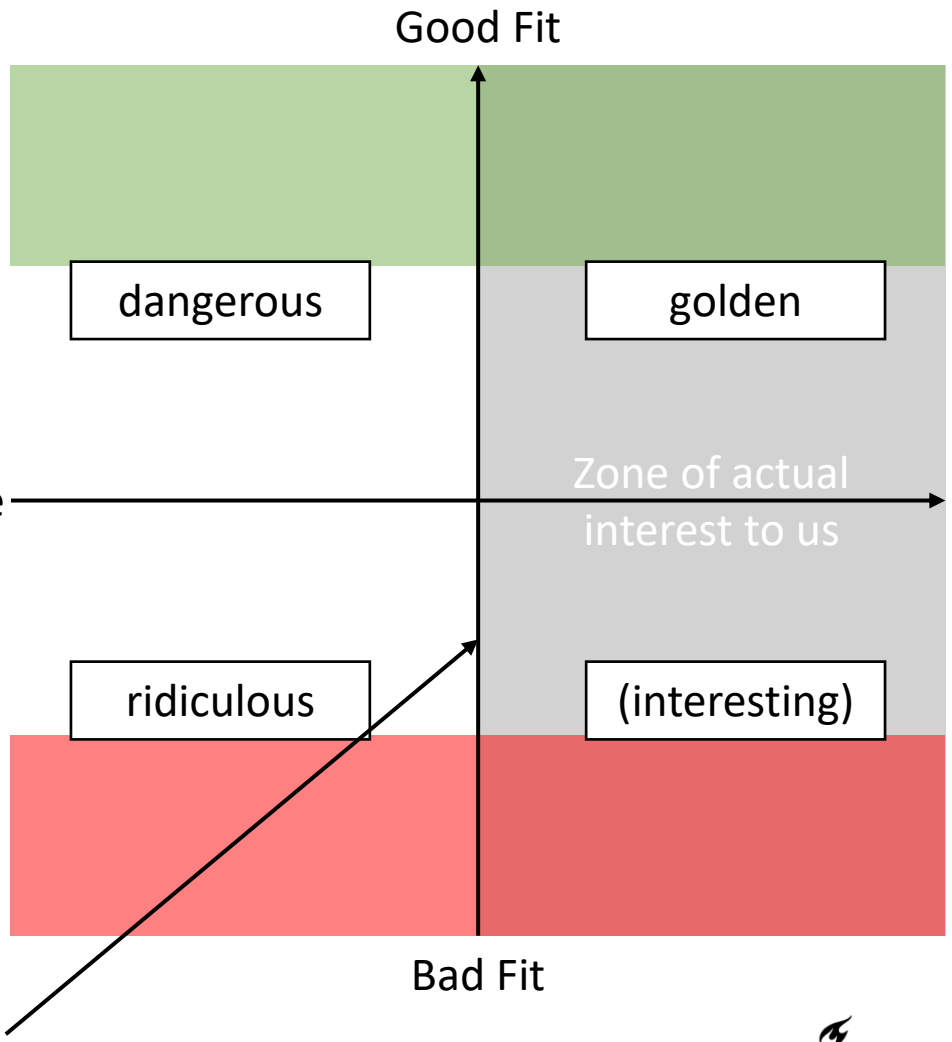


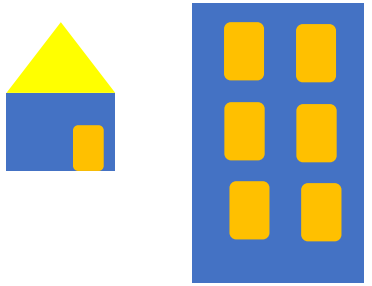
But also houses that just don’t make sense …

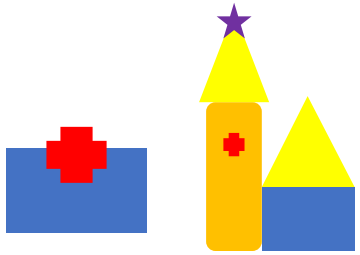


What this research is (and isn't) (to-do list)





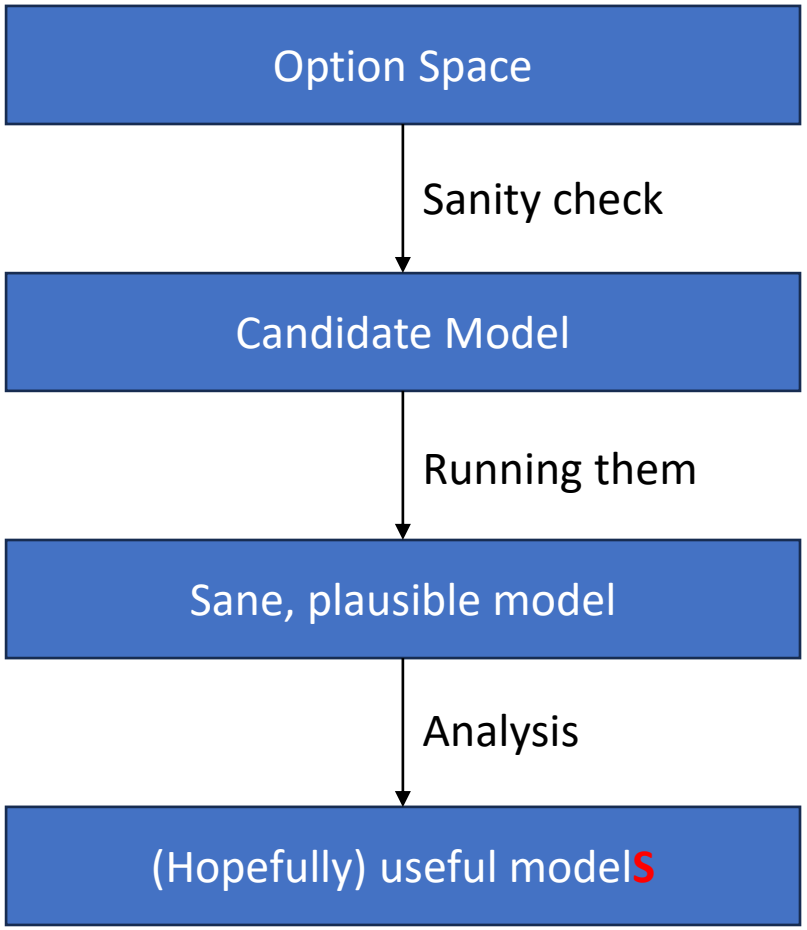




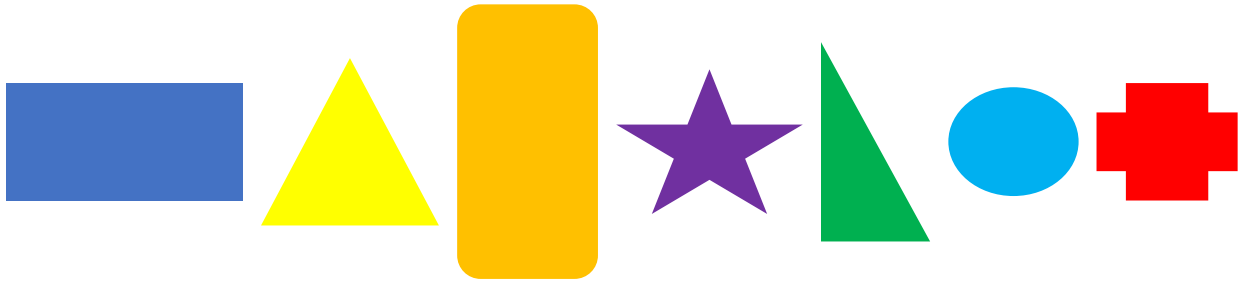
This is (relatively) easy!

What this research is (and isn't) (meta)

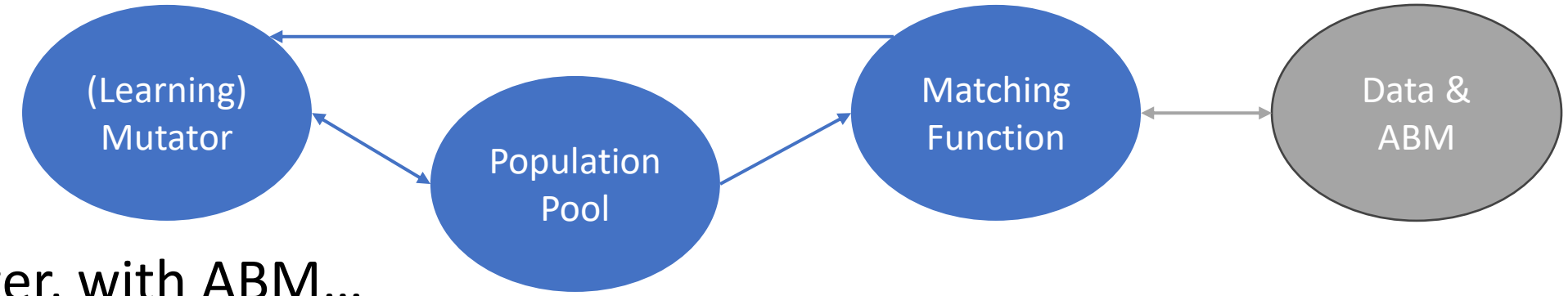
- Problems with inverse modelling: structure, initial conditions, chaos, growth-pattern identification
- But: Multiple models instead of one
- "That's mindless fitting!"
  - Yes – but it doesn't end there!
  - Systematically question assumptions structurally
  - Systematically test robustness of implementation of theories
  - Just as modelling, this is a participatory process, too



Example Setting

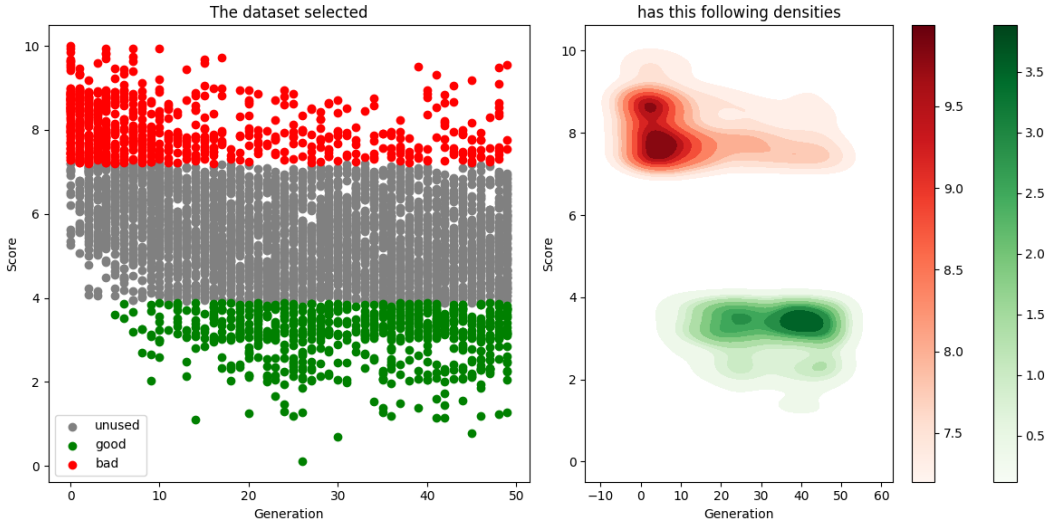


- Target is list of fictious functions, e.g. ['action8', 'action7', 'action10', 'action9', 'action8', 'action2', 'action10', 'action1']
- Initialise population with random sequence, mutate (genetically and/or through learning model) to fit target best
- Evaluate candidates' score by hamming distance, feedback as training



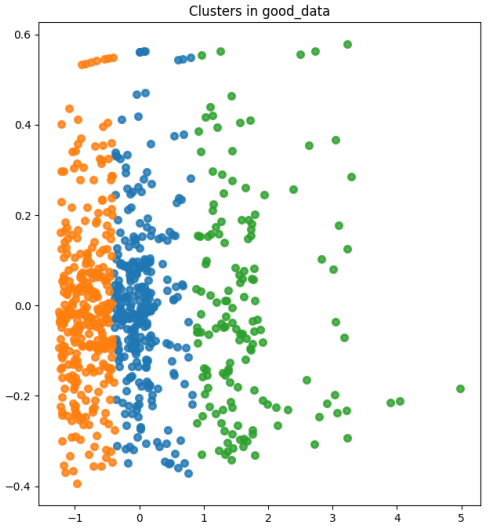
- Later, with ABM…

Data Analysis (I of II)

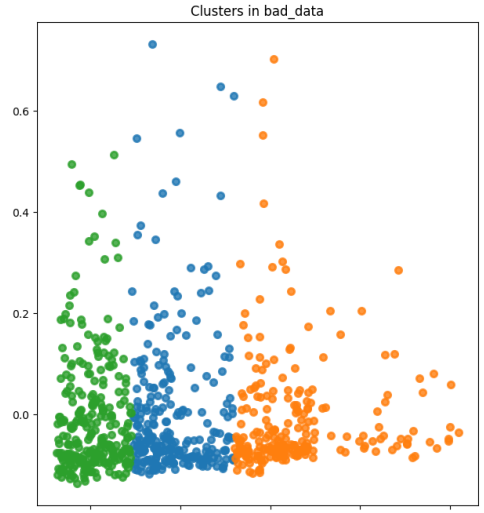


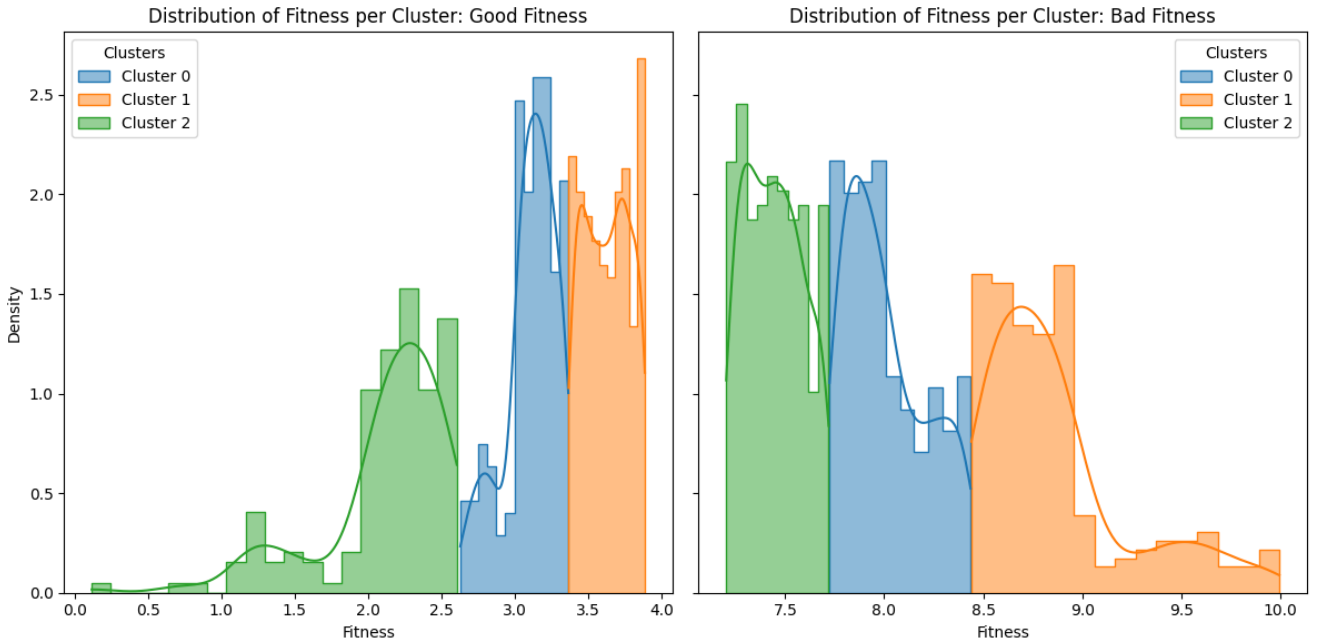
→ Algorithm prefers to cluster by fitness, not by list similarity (Hamming) distance, so let's do pattern mining …

Good data (green)



Bad data (red)





e.g. ['action8', 'action7', 'action10', 'action9', 'action8']

Data Analysis (II of II)

- Go through all good and bad candidates and mine for patterns in the lists
- Take significant outliers, get something like this →
- This is the latest point (imo) where to consult other people (social scientists) from outside!

Good outliers are these:

	support	itemsets	length
52	0.873333	(action7, action4, action10)	3
53	0.896000	(action4, action8, action10)	3
58	0.925333	(action7, action8, action10)	3
70	0.849333	(action7, action4, action8)	3

Bad outliers are these:

	support	itemsets	length
20	0.573333	(action4, action10)	2
23	0.557333	(action7, action10)	2
24	0.636000	(action8, action10)	2
41	0.497333	(action7, action4)	2
42	0.576000	(action4, action8)	2
51	0.558667	(action7, action8)	2
67	0.286667	(action3, action8, action10)	3
71	0.413333	(action7, action4, action10)	3
72	0.476000	(action4, action8, action10)	3
78	0.474667	(action7, action8, action10)	3
99	0.414667	(action7, action4, action8)	3

Conclusions

- Methodologically possible to model structurally and inversely
- Methodologically possible to extract patterns from many simulation runs
- Not without requirements →

Thus, a (timid) step towards the horizon

- Further steps: ABM integration (paper 1, solar panel adoption), uncertainty & chaos (paper 2)

```
to go
  ; Sanity I
  if not any? turtles [ stop ]
  if not any? wolves and count sheep > max-sheep [ user-message "The sheep have i
  ; This can be varied:
  move-sheep
  update-energy-sheep
  penalty-sheep
  sheep-eat-grass
  sheep-maybe-die
  sheep-reproduce
  wolves-move
  update-energy-wolves
  penalty-wolves
  wolf-catch-sheep
  wolf-maybe-die
  wolves-reproduce
  grow-grass
  ; Sanity II
  tick
end
```

References

- Grimm, V., Berger, U., & Filatova, T. (2022). *Reusable building blocks for agent-based modelling: Benefits, challenges, and a template for their release*.
- Epstein, J. M. (1999). Agent-based computational models and generative social science. *Complexity*, *4*(5), 41–60.
- Epstein, J. M. (2023). Inverse Generative Social Science: Backward to the Future. *Journal of Artificial Societies and Social Simulation*, *26*(2), 9.
- Jensen, T., & Chappin, É. J. L. (2017). Automating agent-based modeling: Data-driven generation and application of innovation diffusion models. *Environmental Modelling & Software*, *92*, 261–268.