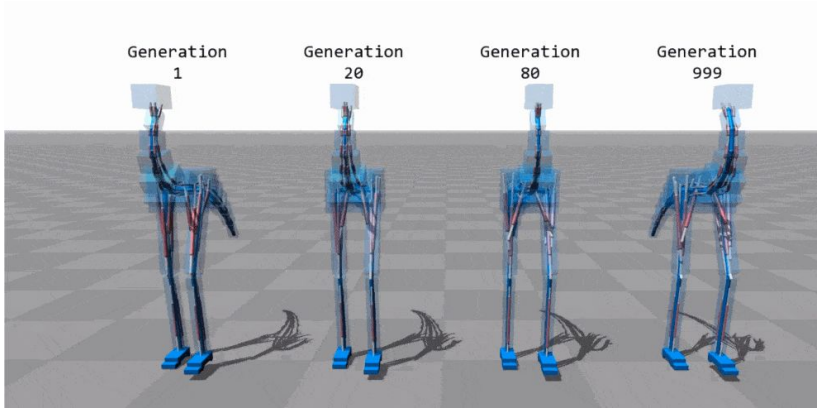
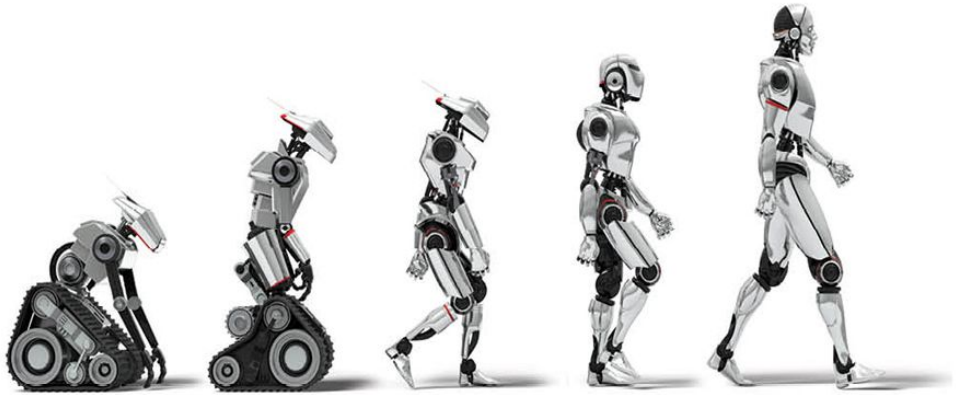
The Influence of Robot Traits and Evolutionary Dynamics on the Reality Gap

Fuda van Diggelen, Eliseo Ferrante, Nihed Harrak, Jie Luo, Daan Zeeuwe and A.E. Eiben

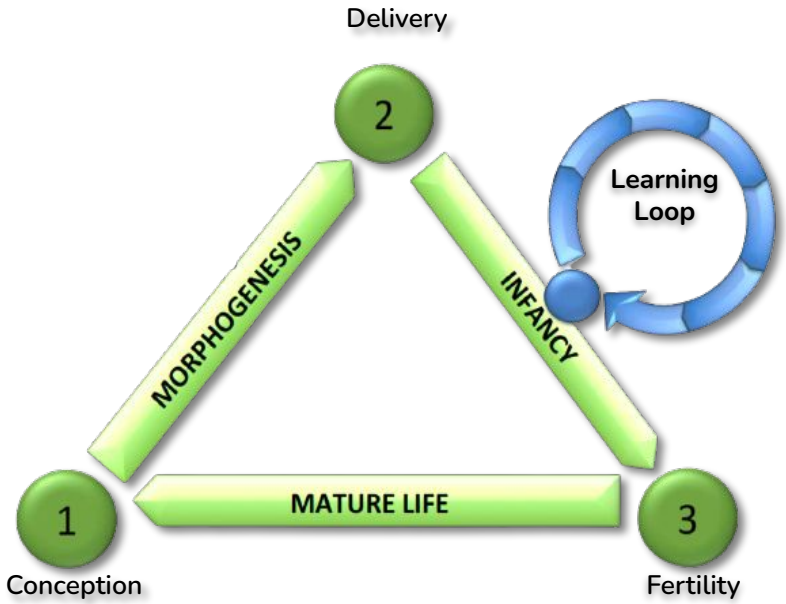
IEEE Transactions on Cognitive and Developmental Systems:
https://ieeexplore.ieee.org/document/9536611

Evolution can be used to automatically optimize robot designs



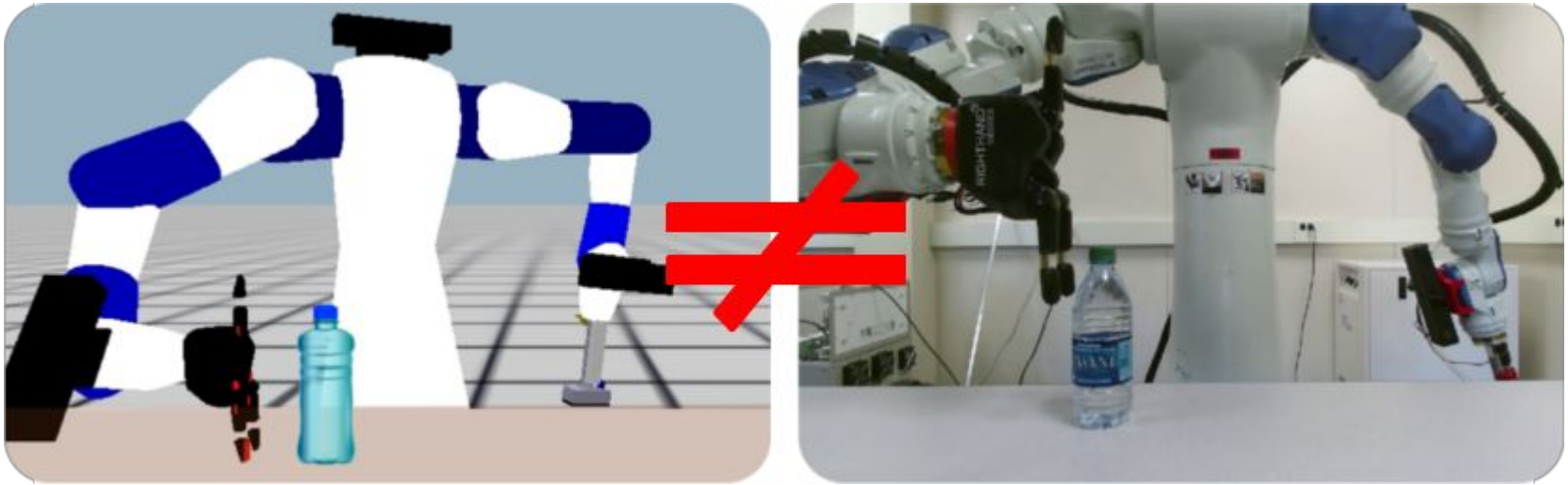


Evolution can be used to automatically optimize robot designs



Optimization often leads to exploitation

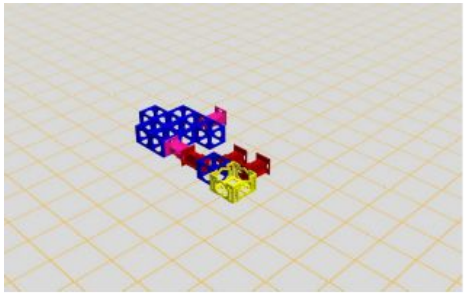
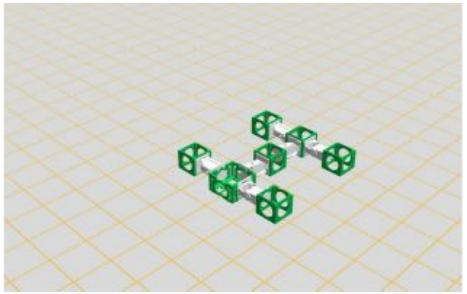
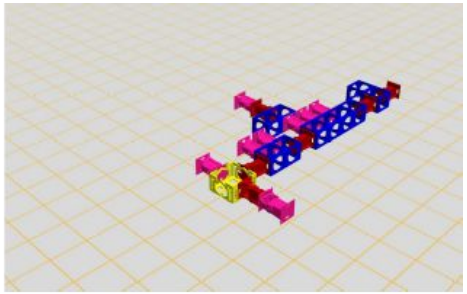
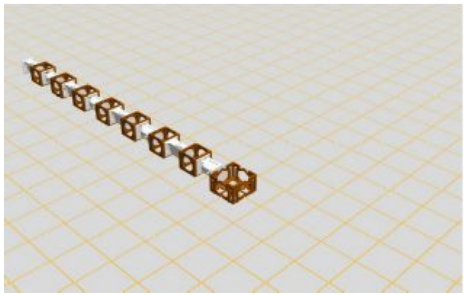
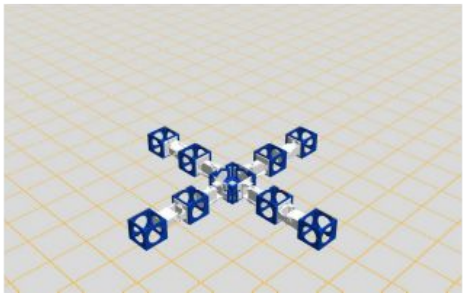
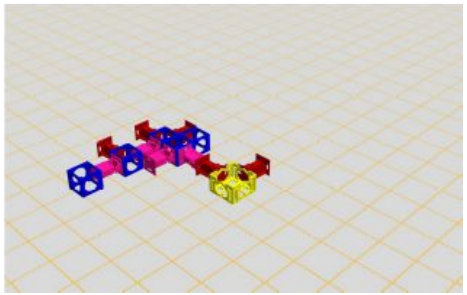
Unfortunately, exploitation in simulation often leads to a so-called reality gap



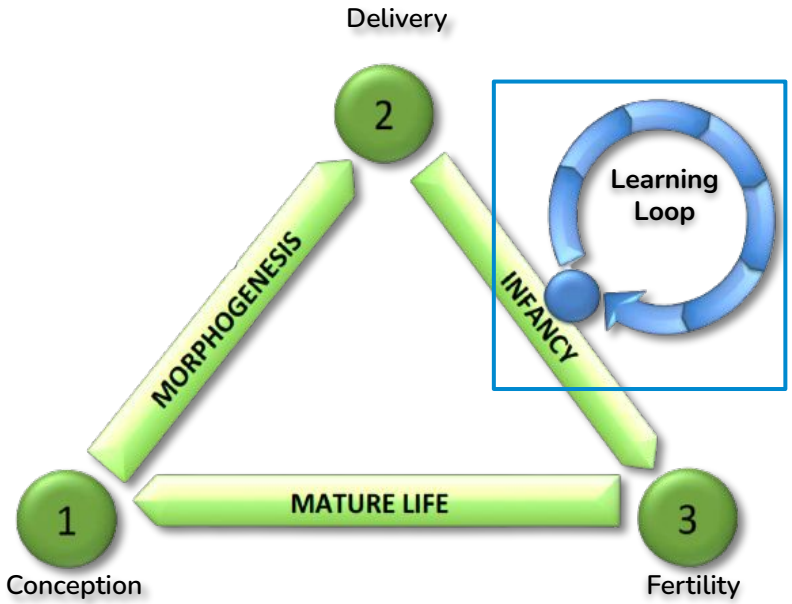
Here, we aim to investigate the onset and progression of the RG

We evolved gait in 6 different morphologies

RevDE, 100 generations 60 ind

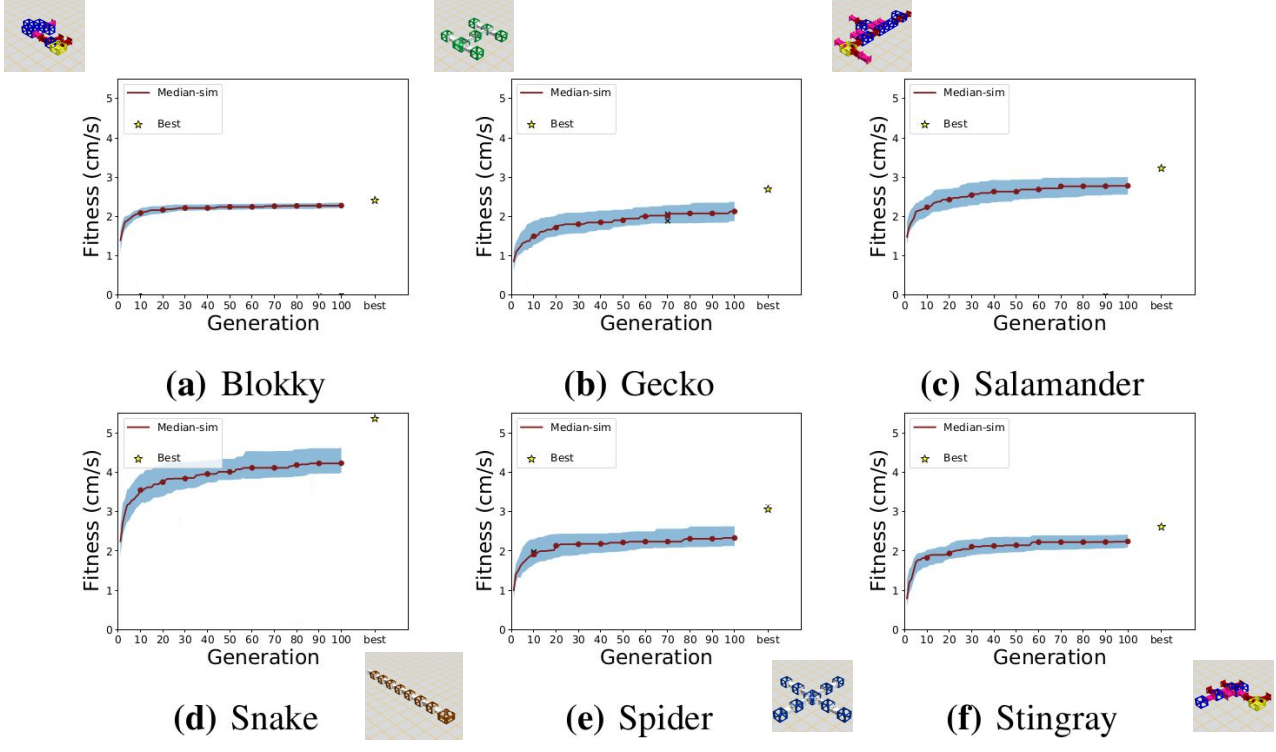







We evolved gait in 6 different morphologies

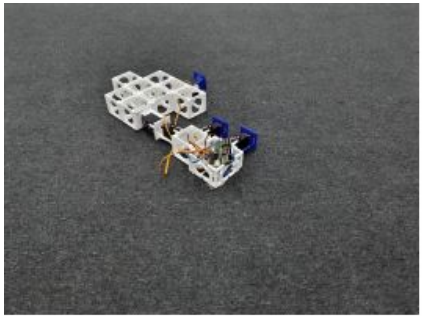
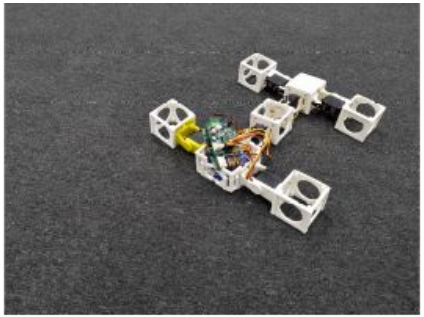
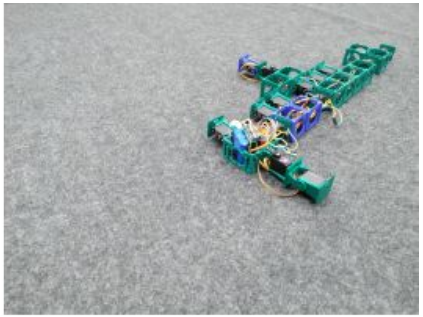
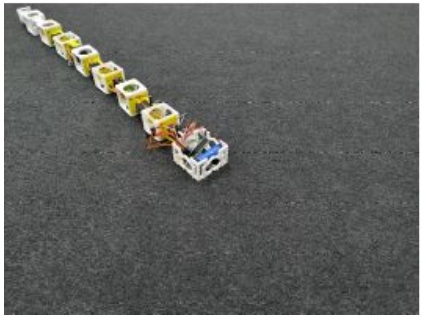
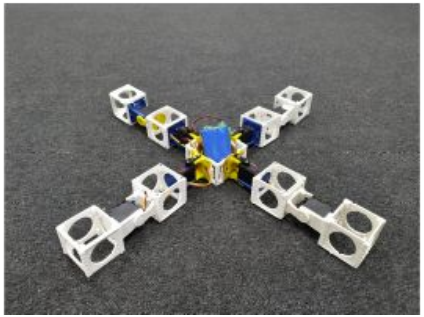
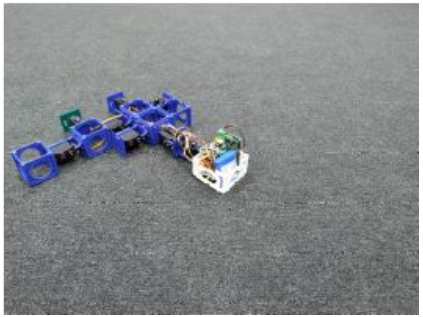


We evolved gait in 6 different morphologies

… and select the median controller out of 31 runs to test in the real world



Subsequently, we test the median controllers in real twins

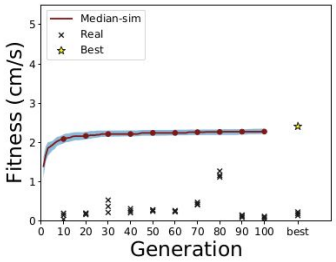
An example video

https://www.youtube.com/watch?v=spetUQIfPdM&t=68s

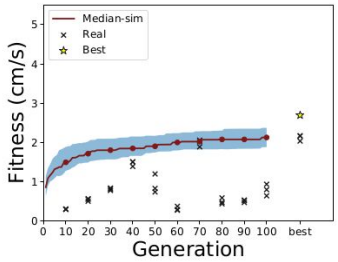
Results: Reality gap as a function of generations

Evolutionary Dynamics

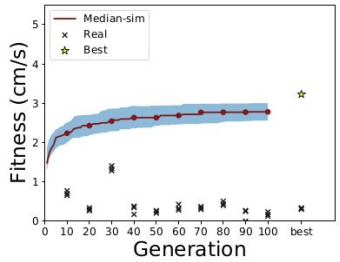




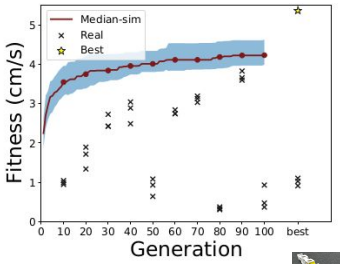
(a) Blokky



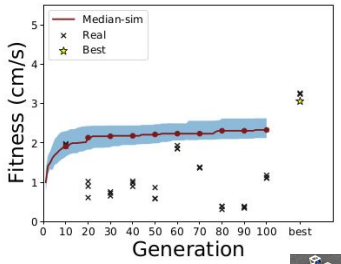
(b) Gecko



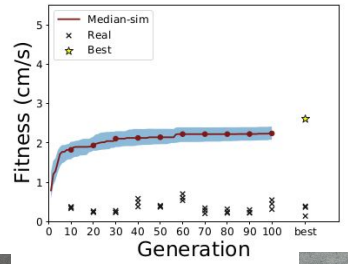
(c) Salamander



(d) Snake



(e) Spider

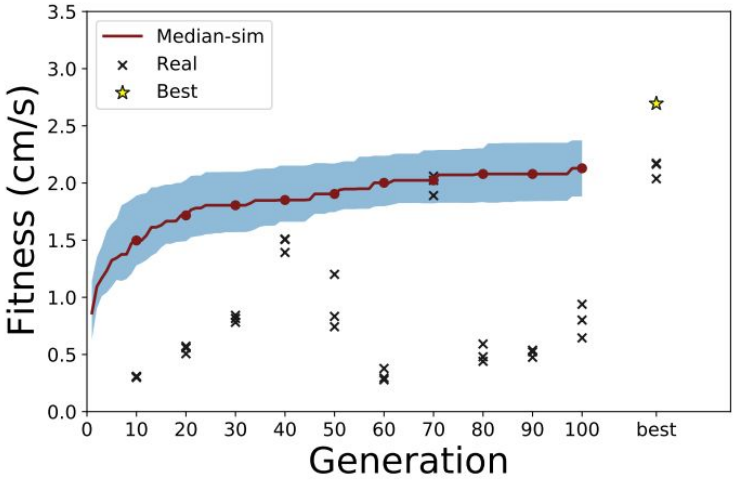


(f) Stingray



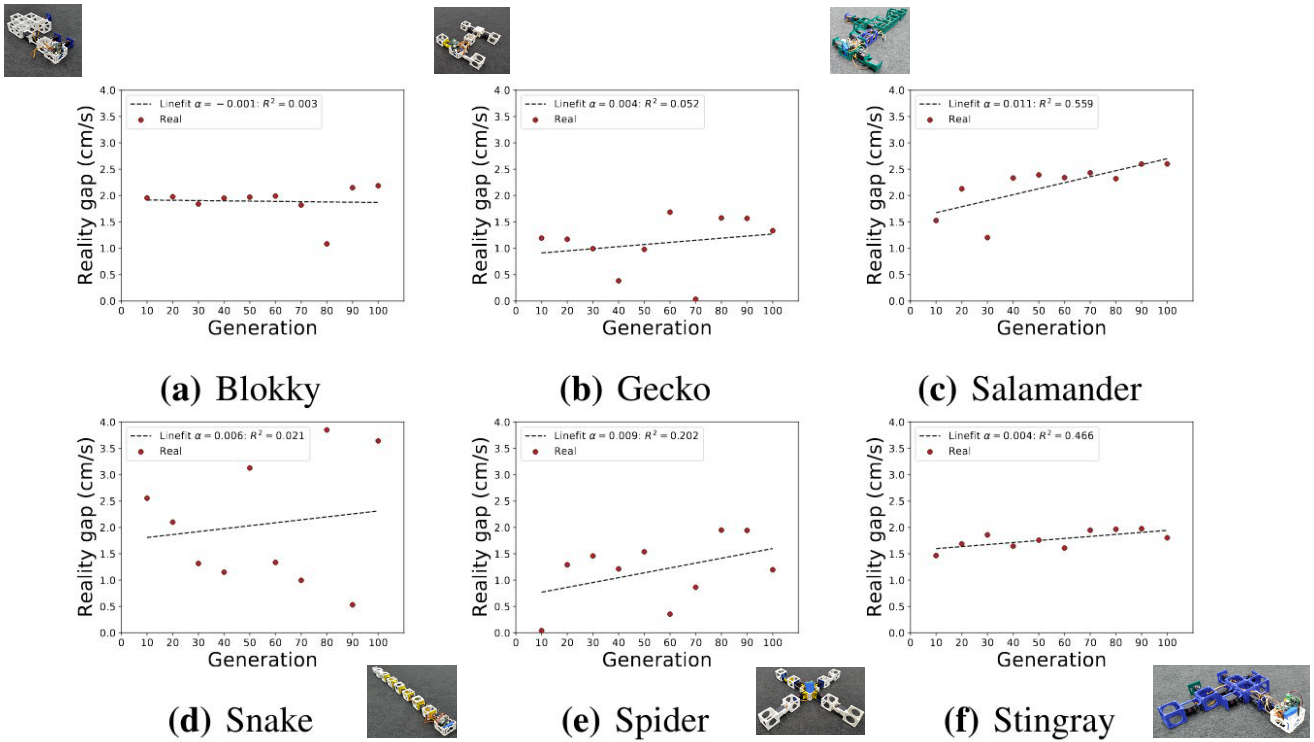
We are interested in predictors of the reality gap

Evolutionary dynamics



Results: Reality gap as a function of generations

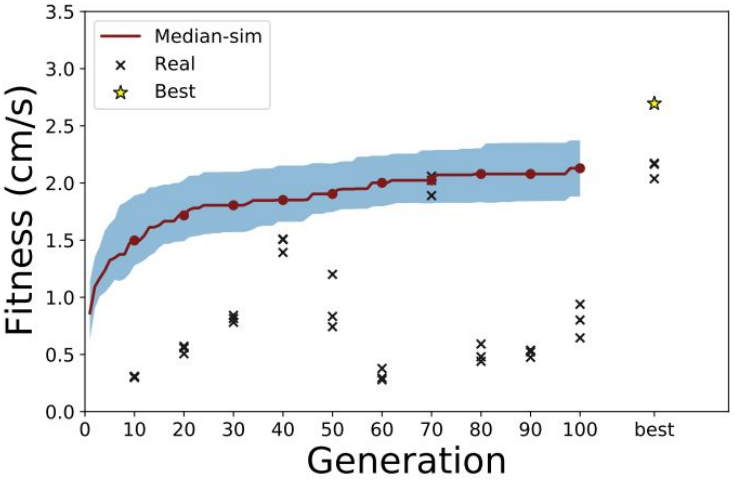
Evolutionary Dynamics

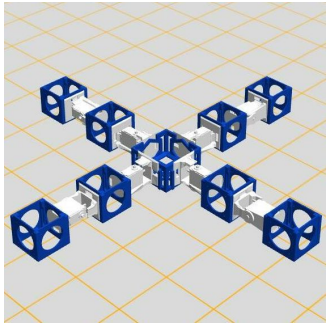


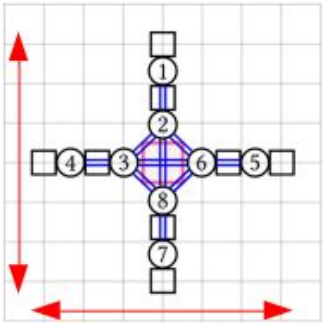
We are interested in predictors of the reality gap

Evolutionary dynamics

Morphological descriptors

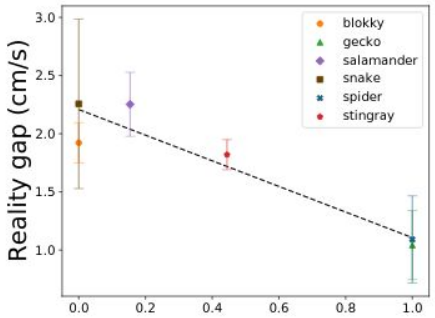




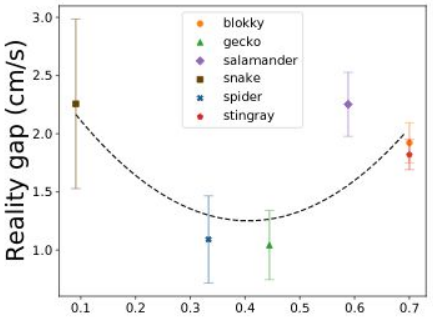


Results: Reality gap as a function of morphology

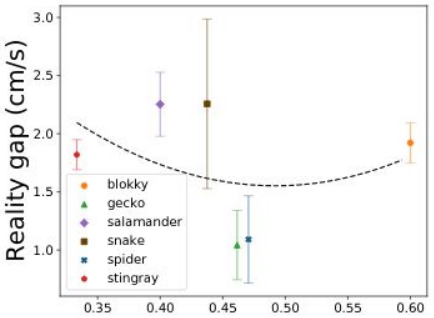
Morphological descriptors



(a) Symmetry



(b) Limb ratio



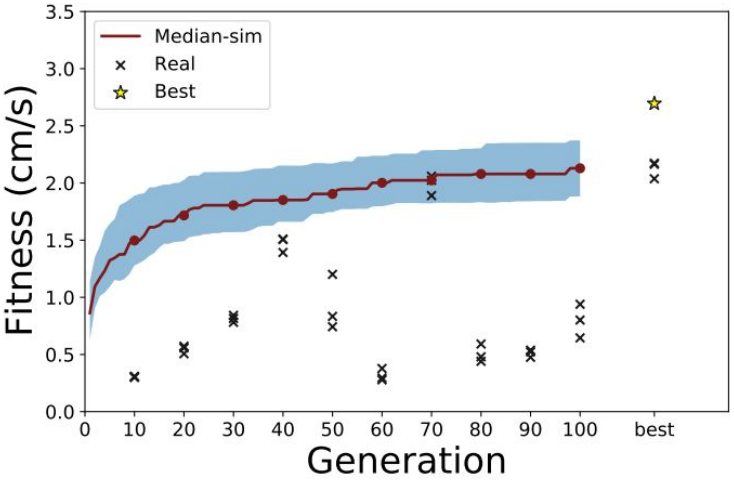
(c) Block ratio

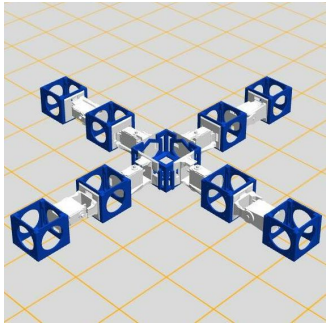
We are interested in predictors of the reality gap

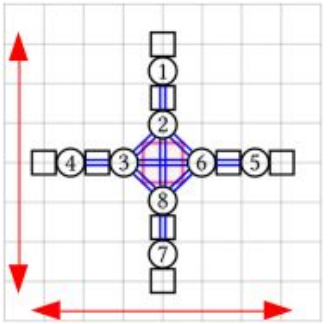
Evolutionary dynamics

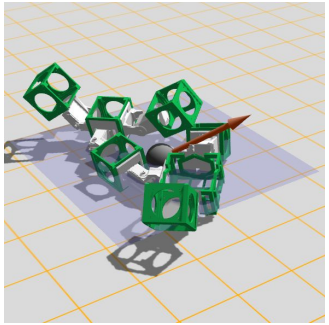
Morphological descriptors

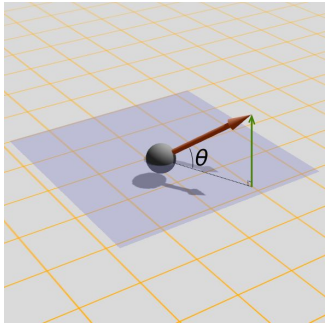
Behavioural measures





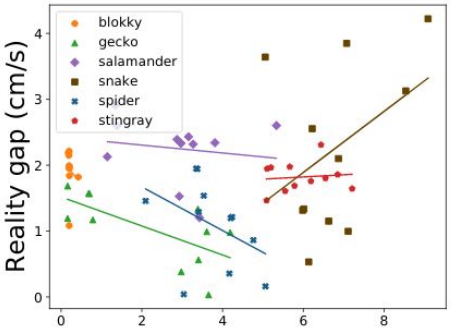




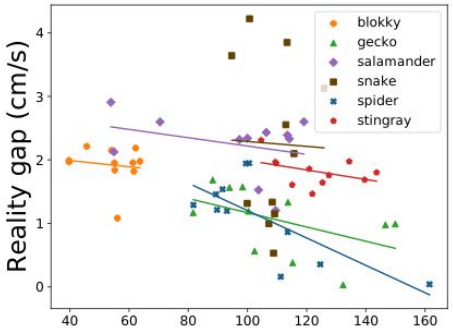


Results: Reality gap as a function of behaviour

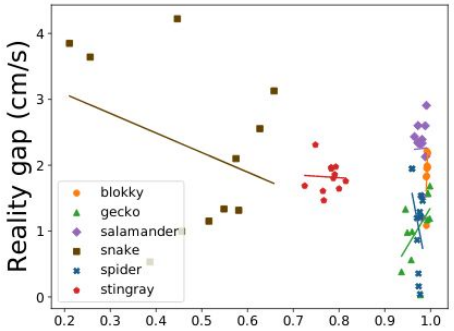
Behavioural descriptors



(a) Vertical speed



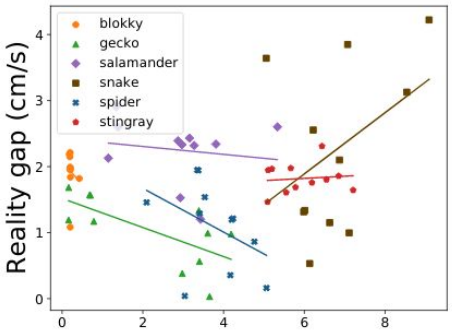
(b) Velocity direction



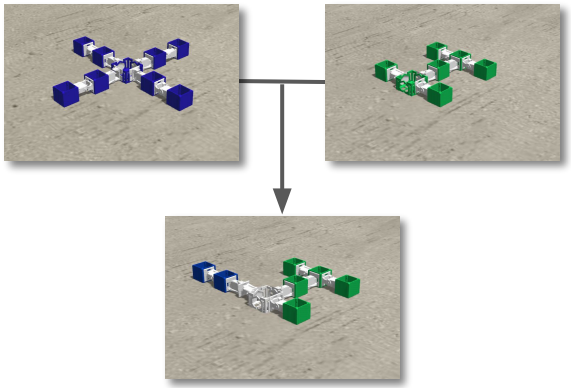
(c) Balance

Application of results

We re-run an evolutionary experiment with the use of a heuristics based on our results



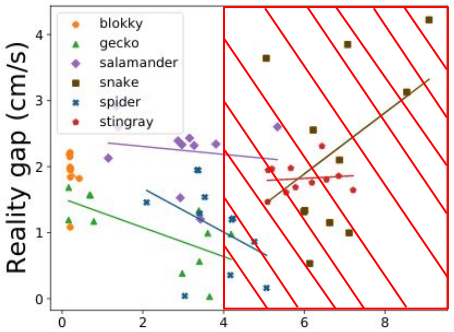
(a) Vertical speed



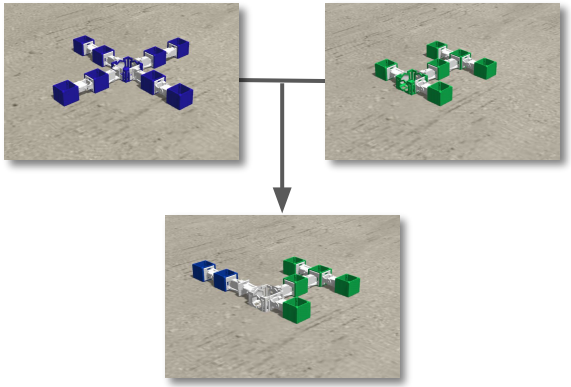
Application of results

We re-run an evolutionary experiment with the use of a heuristics based on our results

if vertical speed > 4 cm/s fitness set to 0

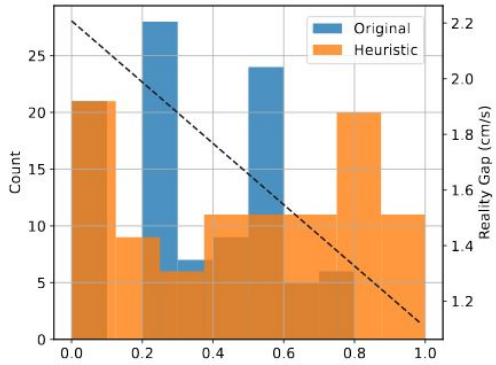


(a) Vertical speed

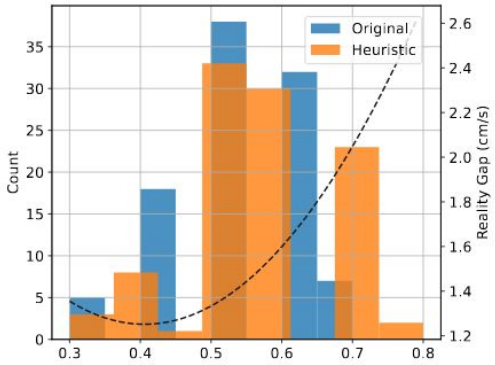


Application of results

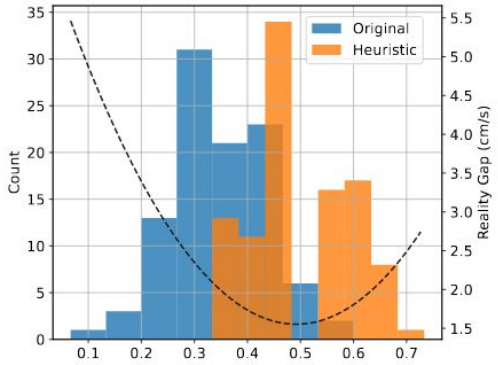
We re-run an evolutionary experiment with the use of a heuristics based on our results



(a) Symmetry



(b) Limb ratio

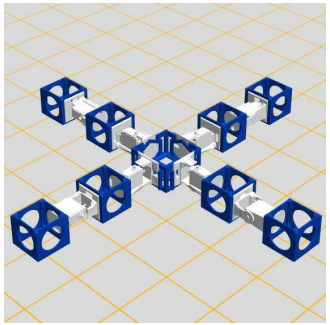


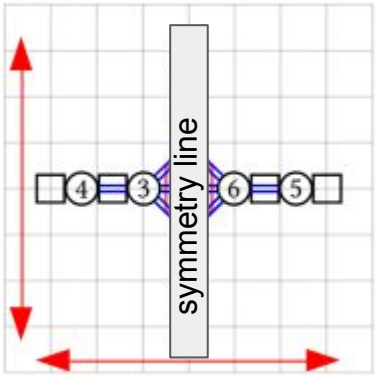
(c) Block ratio

Questions?

Morphological descriptors

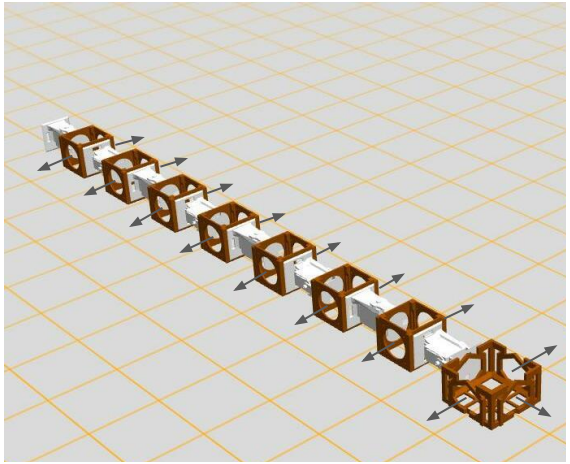
Symmetry: a ratio of modules that match on the opposite side of a line of symmetry, divided by the total number of possible module matches.





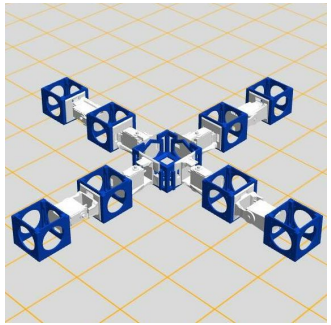
Morphological descriptors

Limb ratio: the number of actual limbs divided by how many limbs a specific morphology could have had.



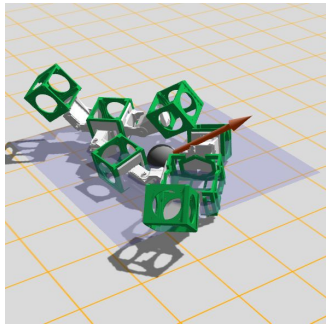
Morphological descriptors

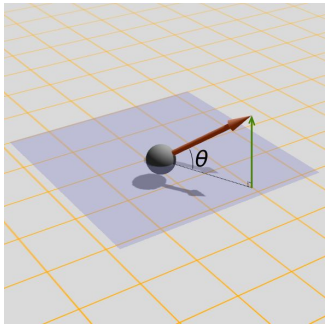
Block ratio: the total number of block components divided by the total number of modules present in the body.



Behavioural measures

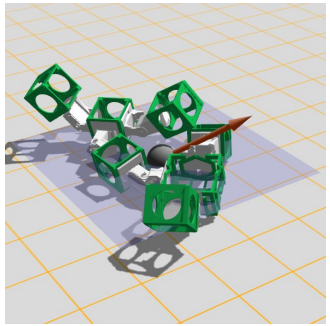
Vertical speed: the sum of the absolute velocity in the Z-direction of the center of mass during a run

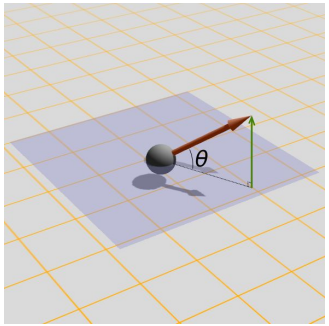




Behavioural measures

Velocity direction: the sum of the absolute angle of the center of mass velocity with respect to the horizontal plane





Behavioural measures

Balance: the total absolute roll and pitch angle of the robot head component relative to the horizontal plane.