
Evolving Virtual Creatures

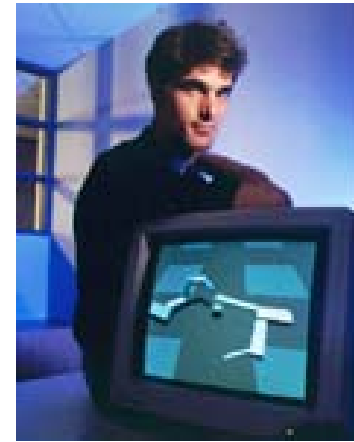
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Presentation for I585 class

Apr. 8, 2009

Author of the paper

- Karl Sims
- Founder of GenArts, Inc.
 - A provider for visual special effects

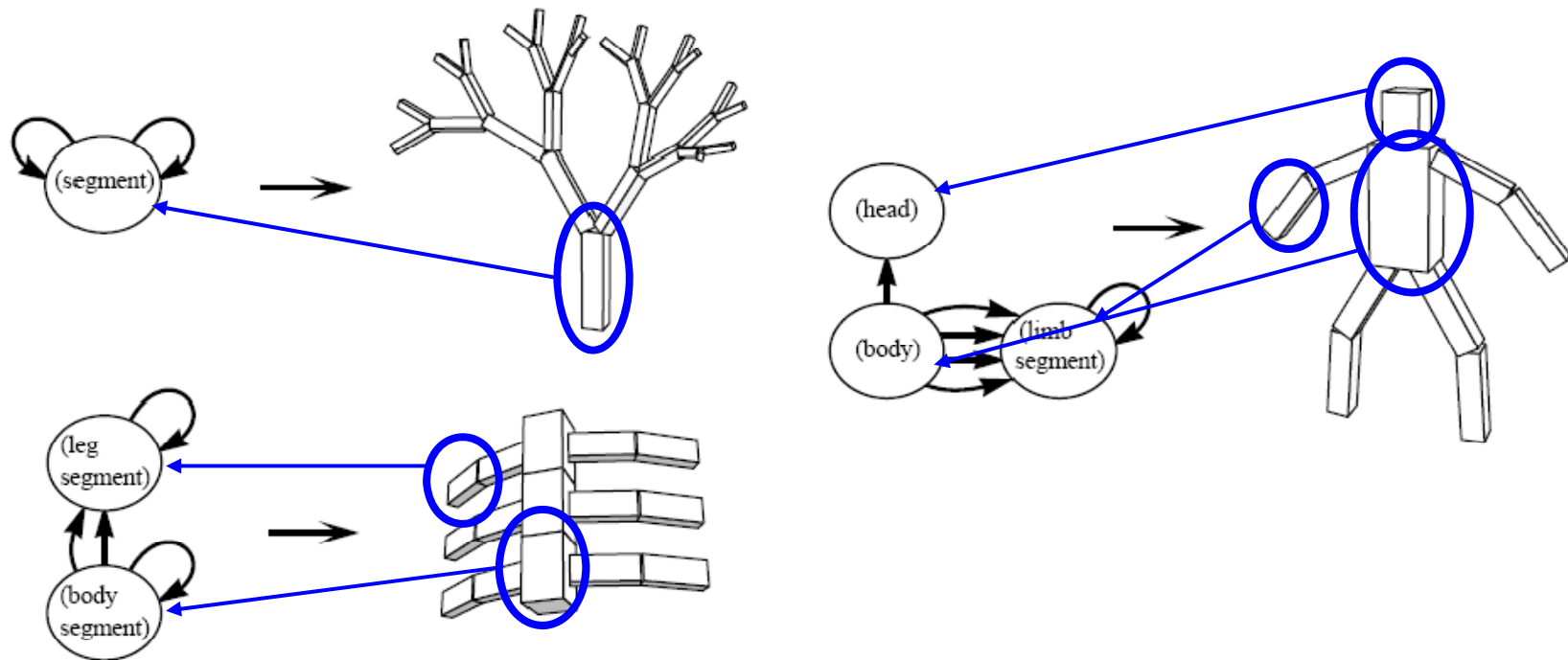


Outline

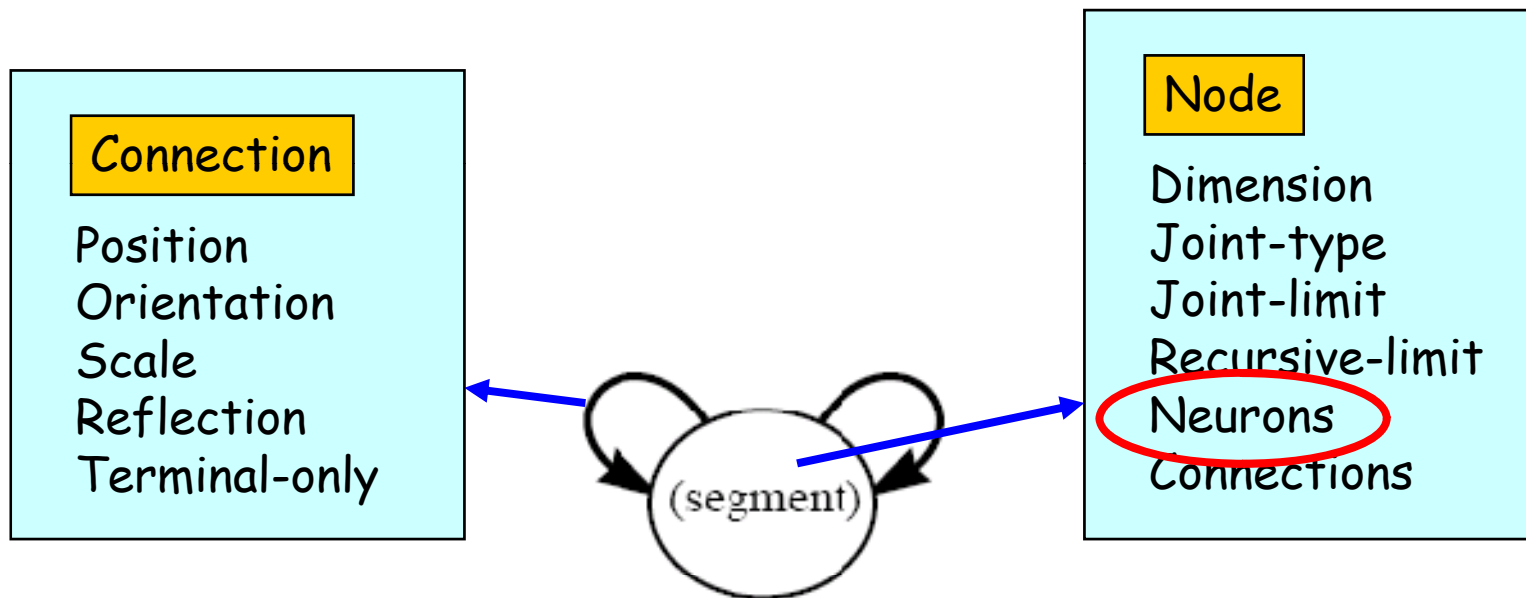
- Virtual Creatures
 - Morphology
 - Creature control
- Creature evolutions
- Evolution results
- Conclusion

Virtual Creature Morphology

- Represented by directed graphs
 - Genotype \rightarrow Phenotype



Virtual Creature Morphology - parameters

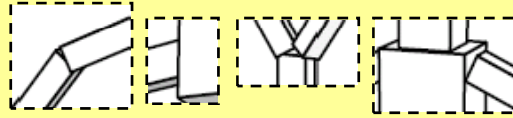


Creature controls

Neurons (functions):

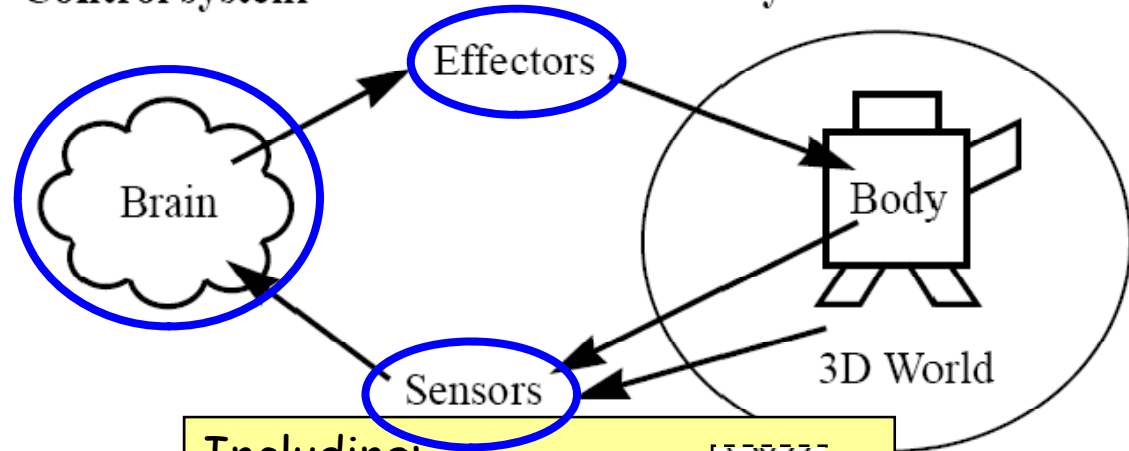
Sum
Product
Divide
Sum-threshold
Greater-than
Min
Max
...

Controls a degree of freedom of a joint



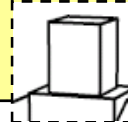
Control system

Physical simulation



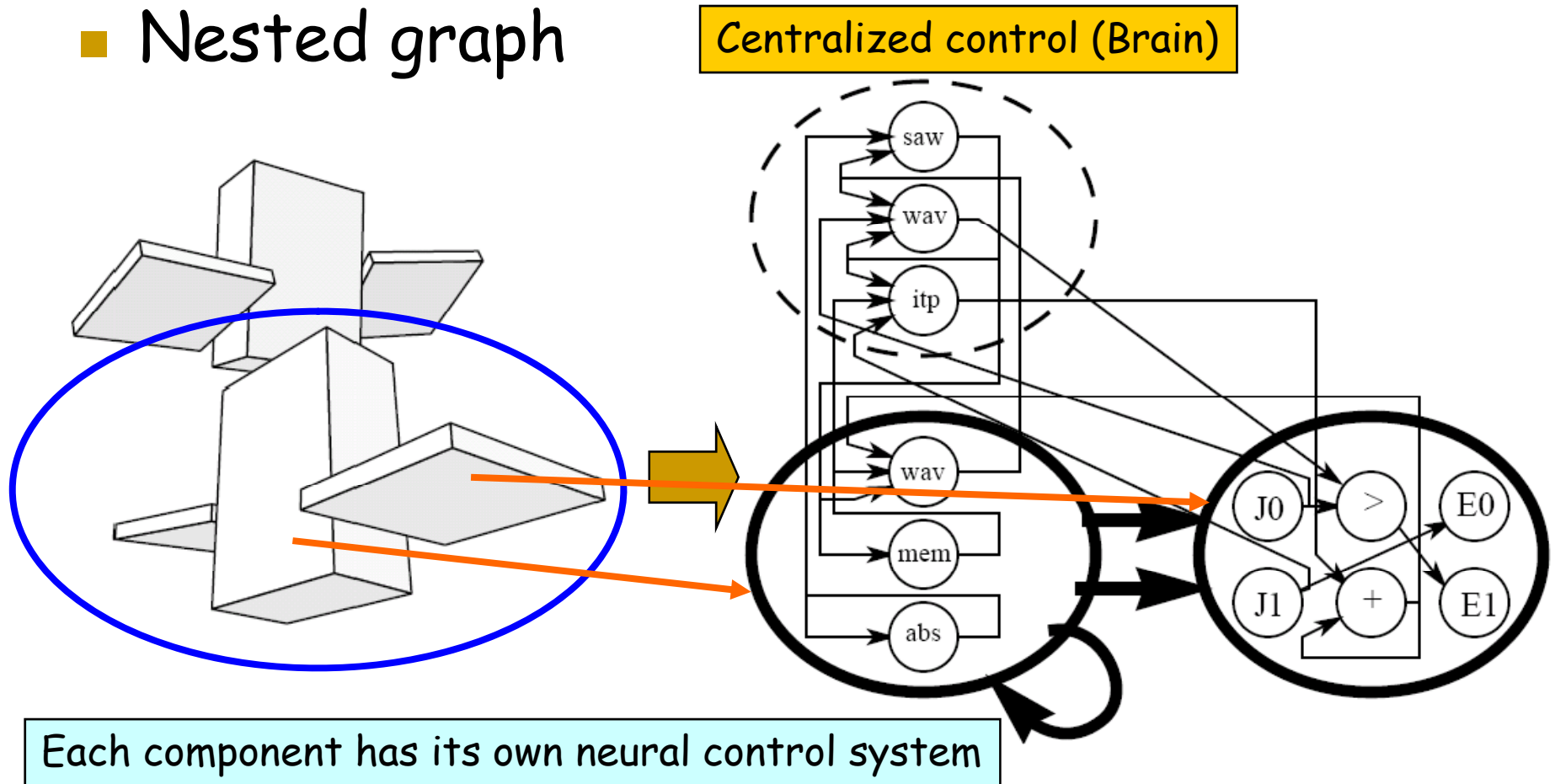
Including:

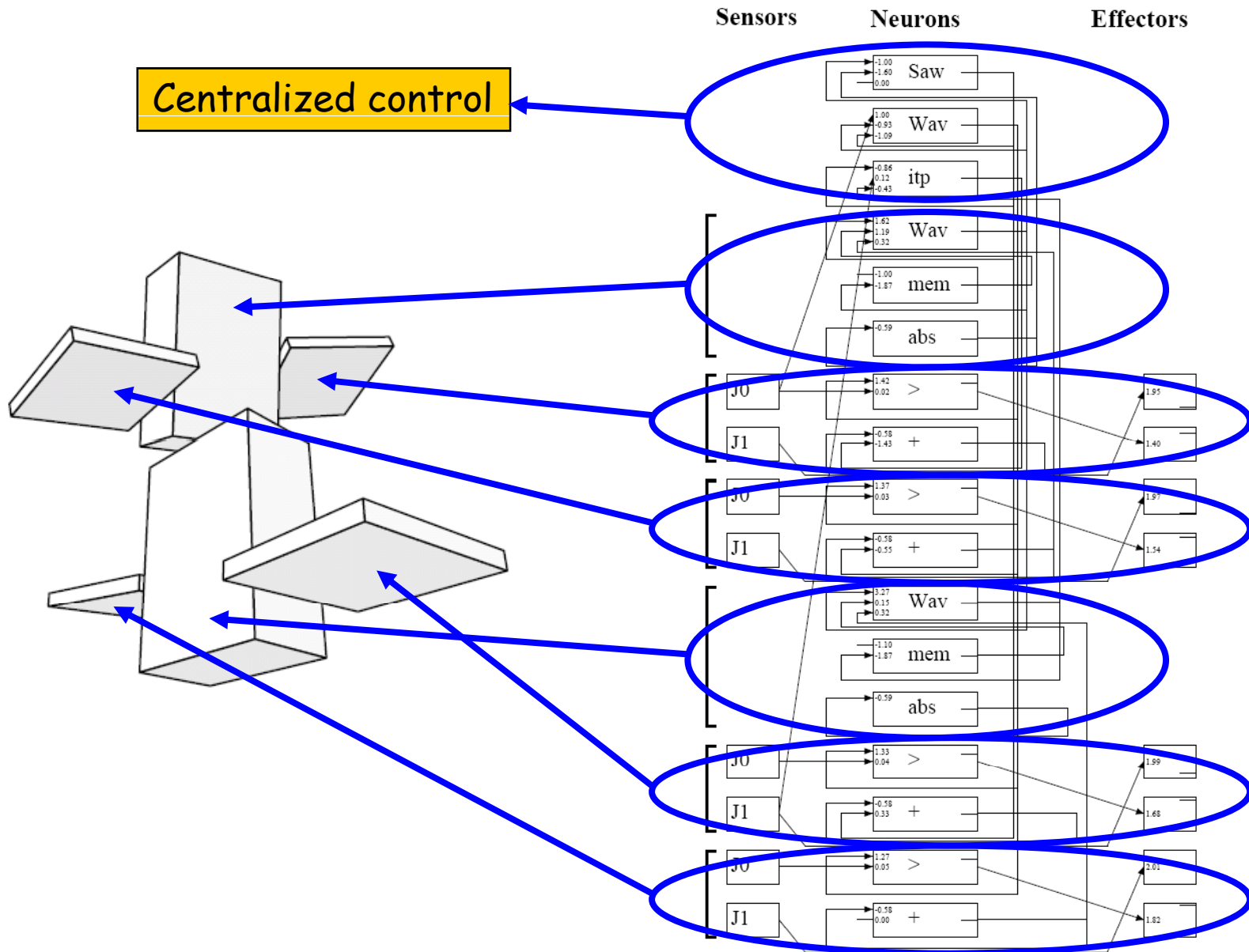
1. Joint angle sensors
2. Contact sensors
3. Photosensors



Combining morphology and control

■ Nested graph

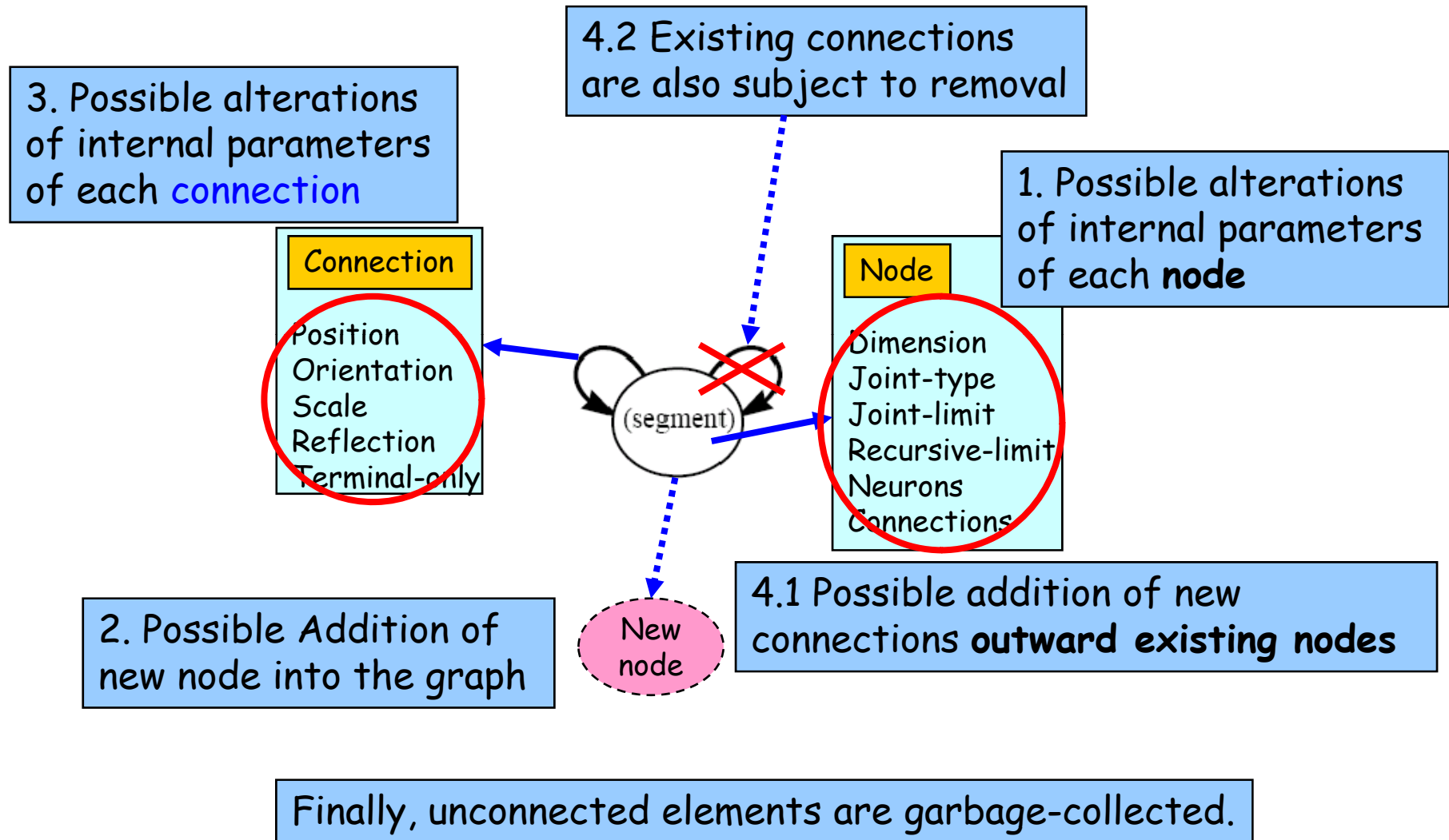




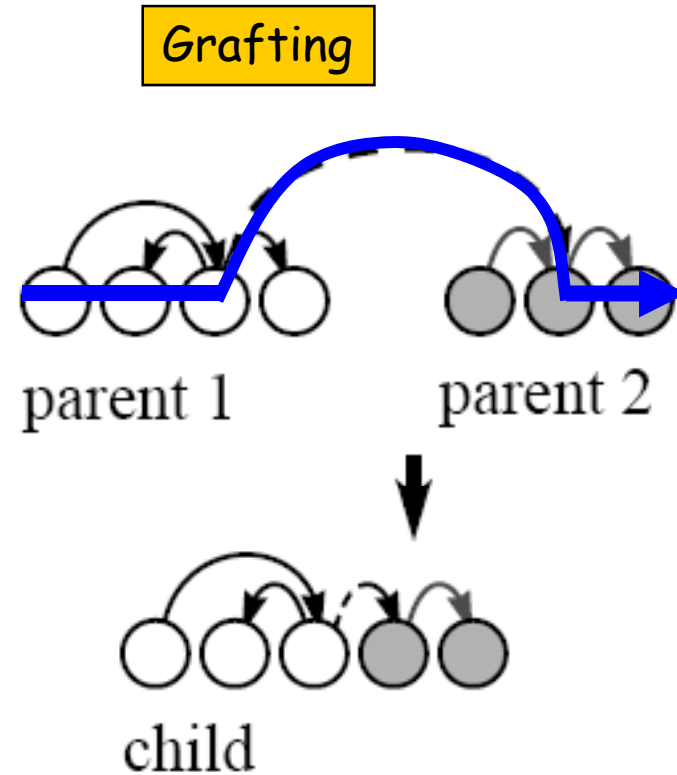
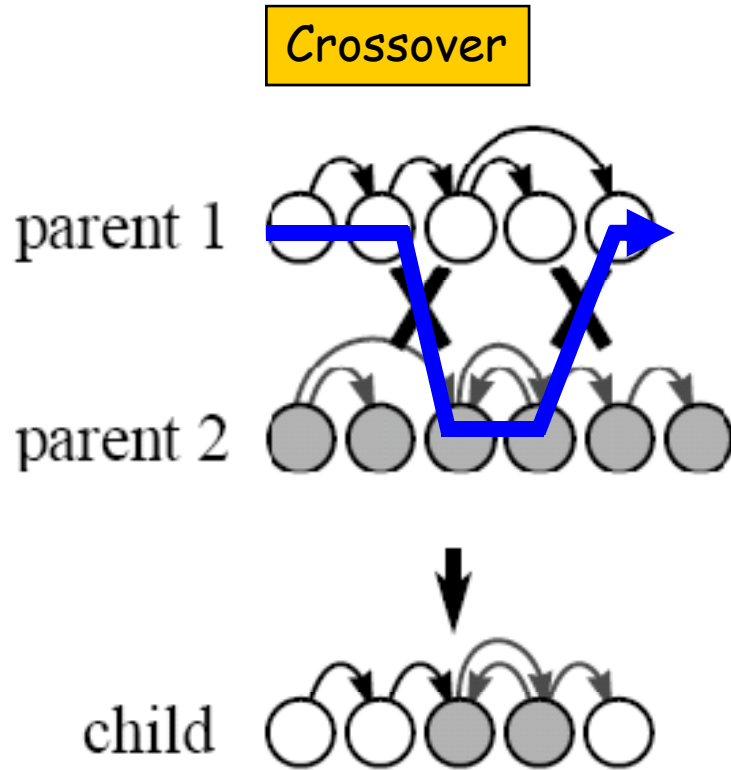
Creature Evolution

- Initialization
 - New genotypes synthesized "from scratch" by random generation of sets of nodes and connections
- Genotype alteration
 - Mutating directed graphs
 - Mating directed graphs

Mutation



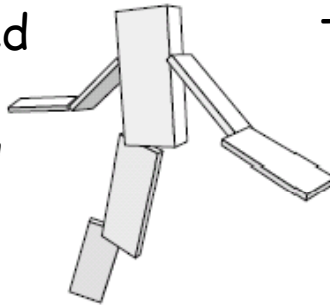
Mating



Behavior fitness selection

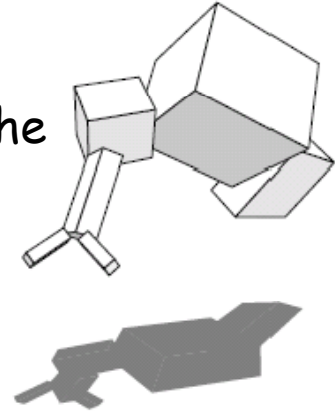
Swimming

- Fastest swimming speed
- Straight swimming is rewarded over circling



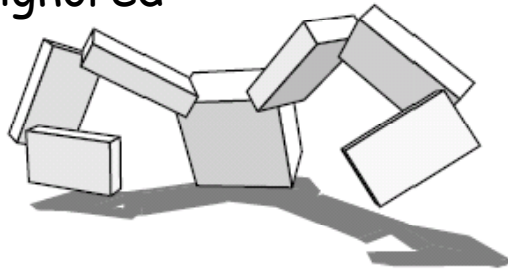
Jumping

- Maximum height of the lowest part



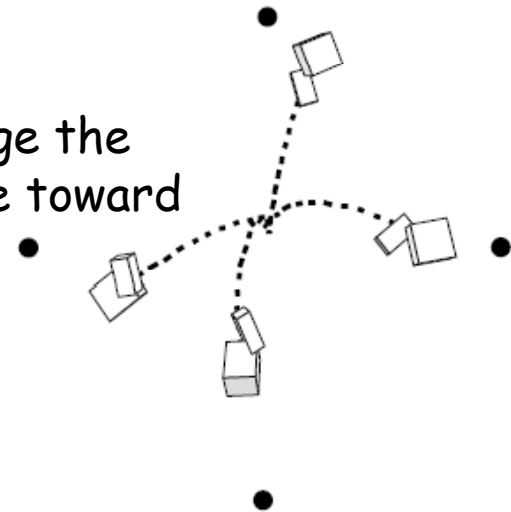
Walking

- Fastest walking speed
- Velocity is ignored

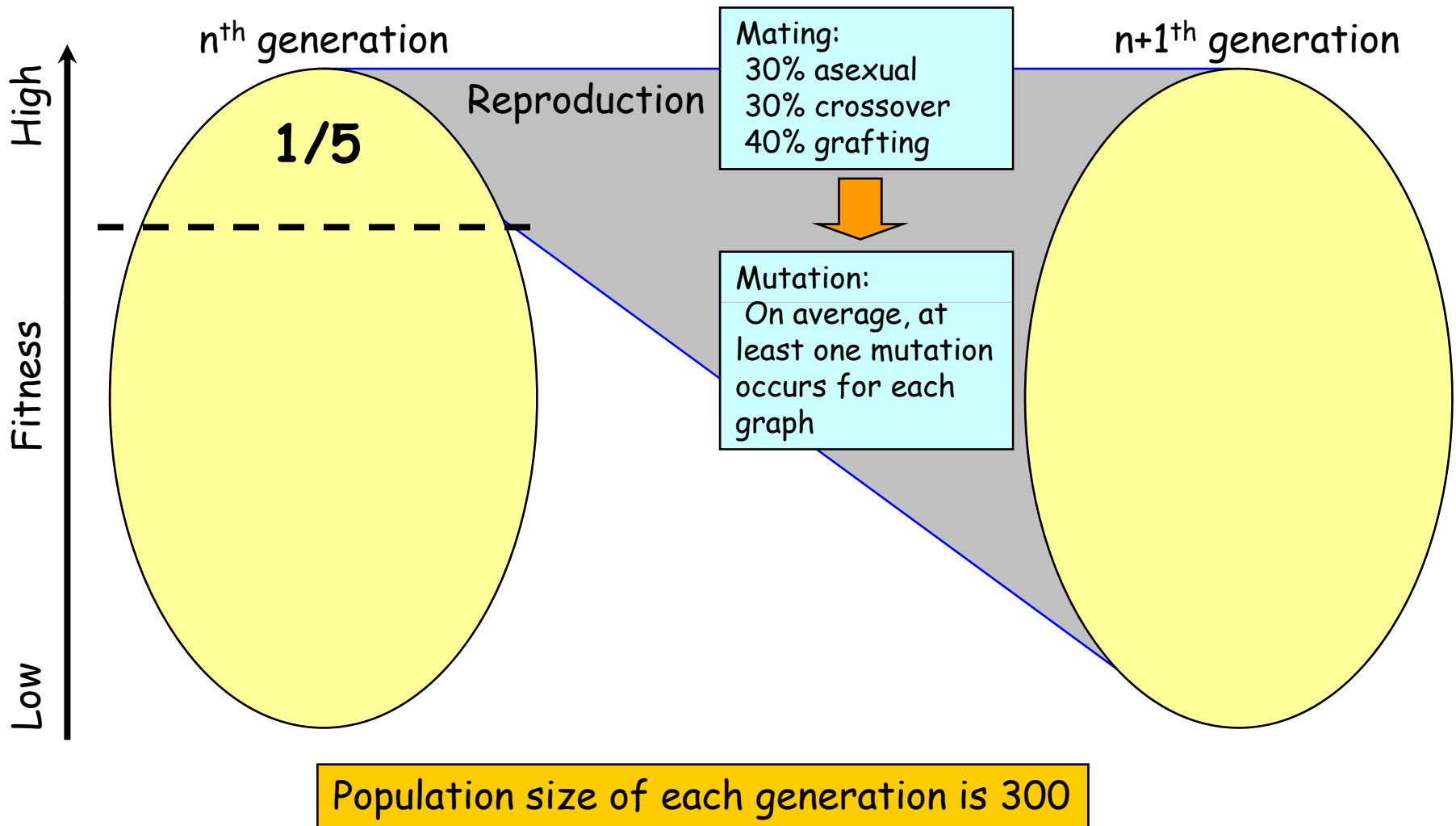


Following

- Fastest average the creature move toward the target



Selection rate



Results after 100 generations - Swimming

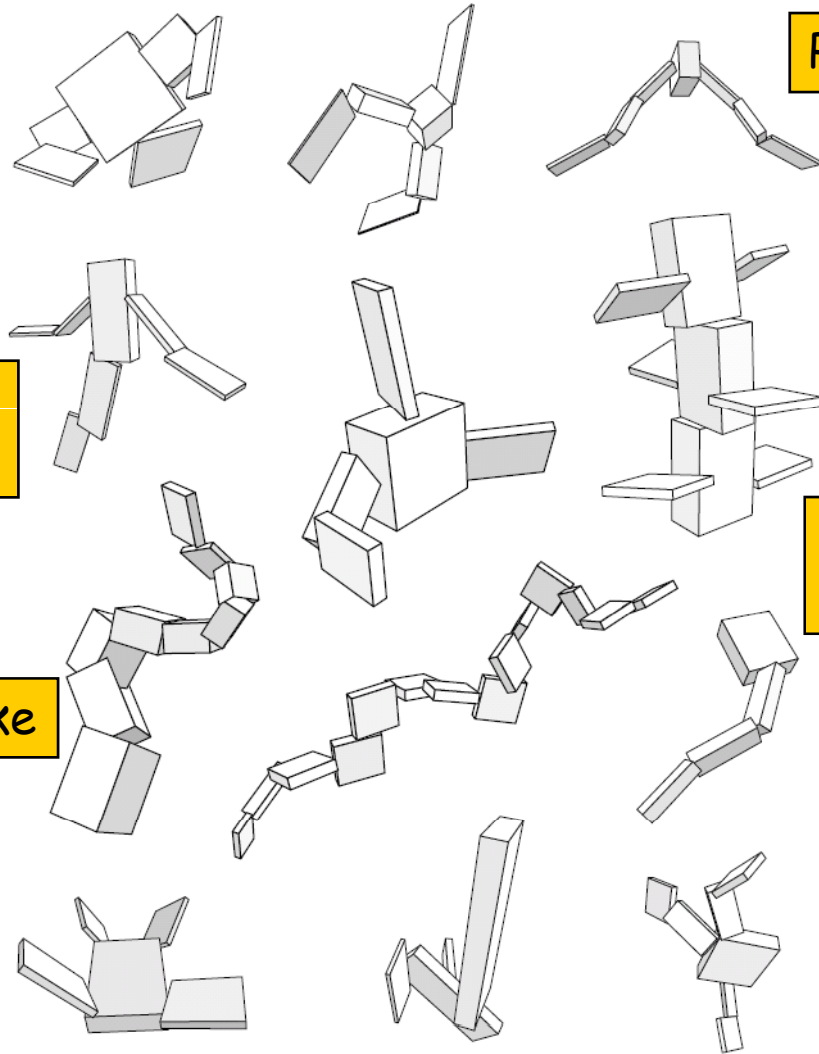
- A large variety of variations

Symmetrical
flippers

Water snake

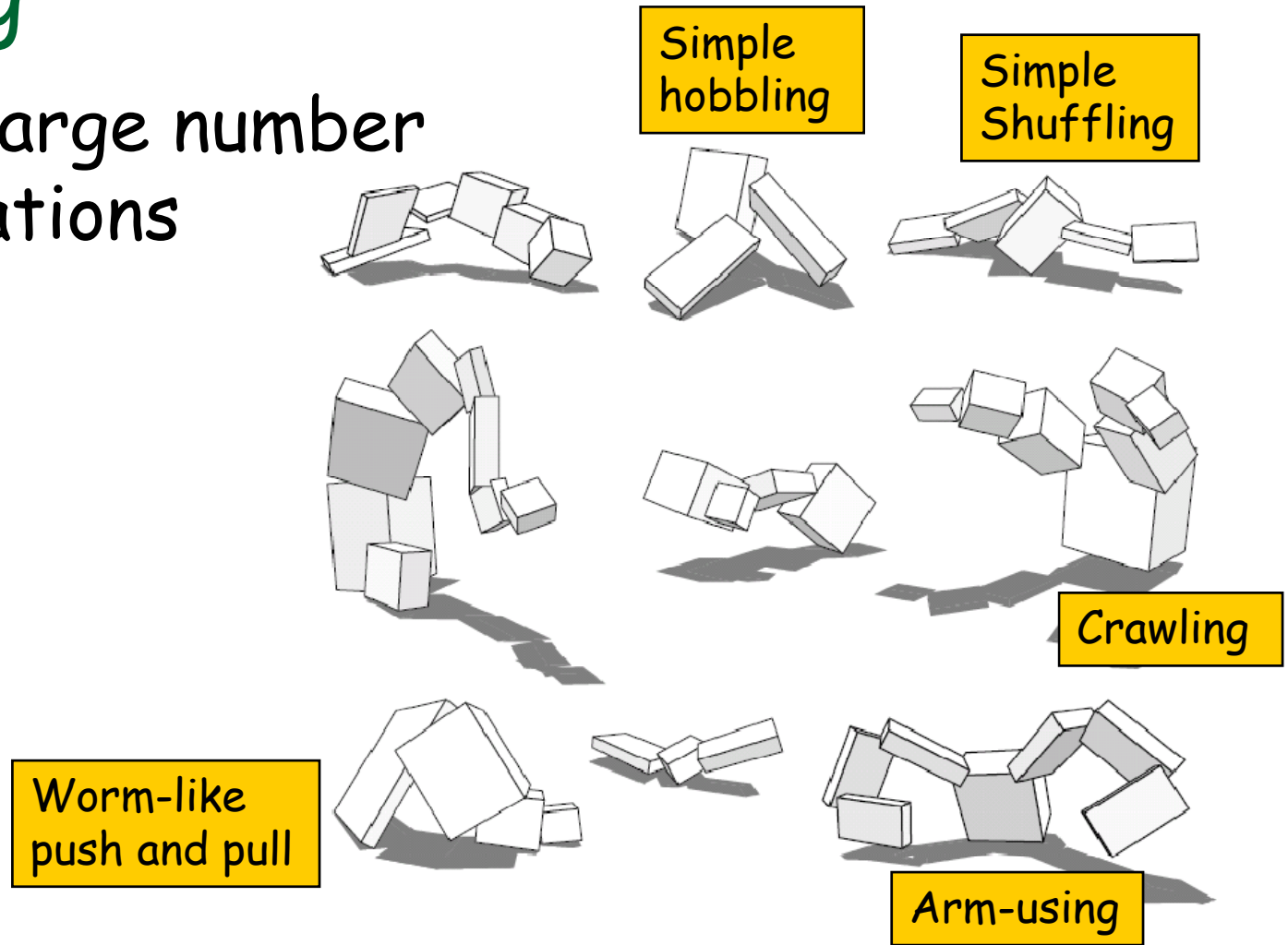
Paddling

Tail
wagging



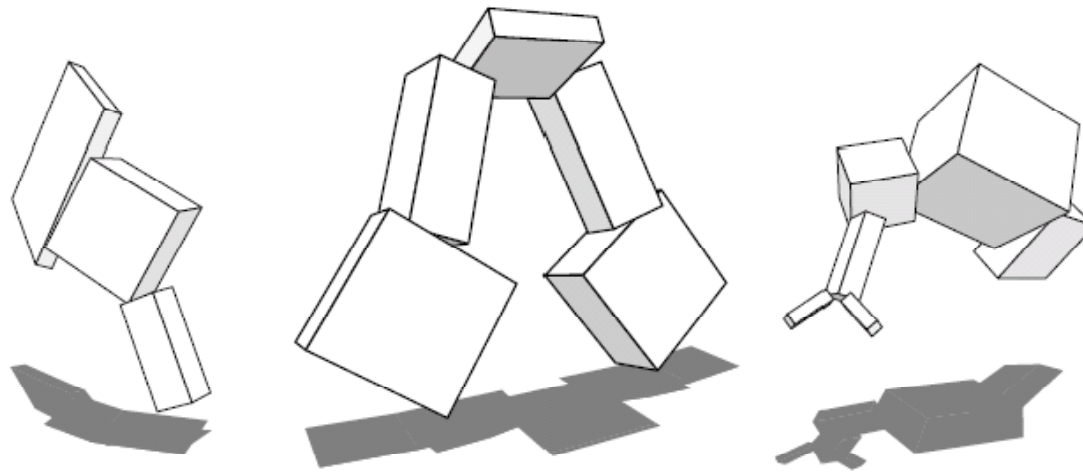
Results after 100 generations - Walking

- Also a large number of variations



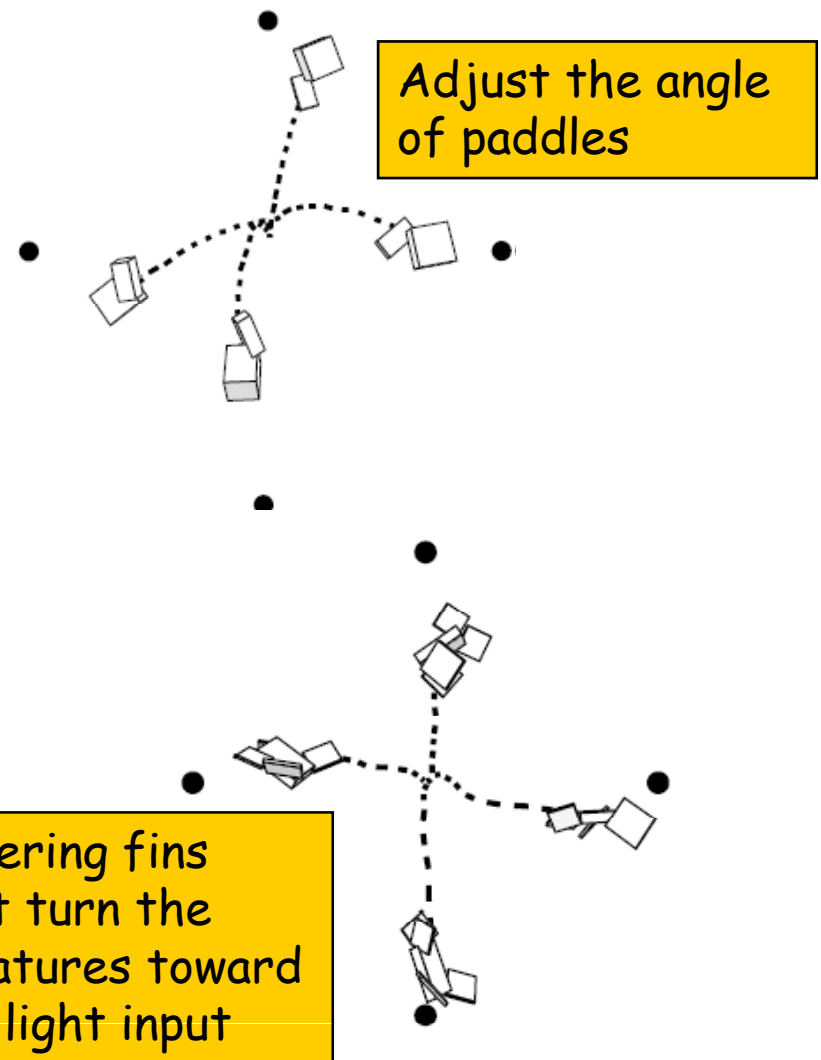
Results after 100 generations - Jumping

- Not many variations



Results after 100 generations - Following

- Both in water and on land
- Some can follow consistently while others fail to follow the light source after some time



Conclusion

- Genetic language used to represent virtual creatures
- Virtual creatures are evolved toward higher fitness
- More fitness estimation could be possible
- Possible adjustment to describe only creatures that could actually be built as real robot?