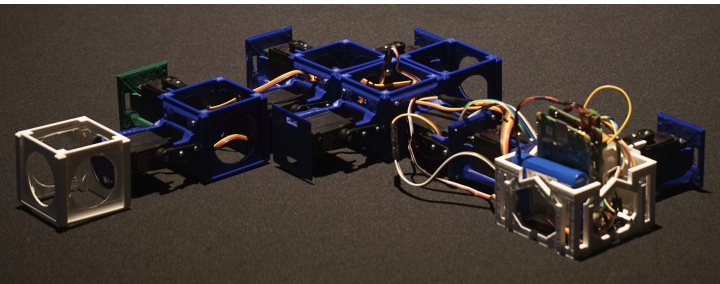


Evolving robots with the Revolve framework

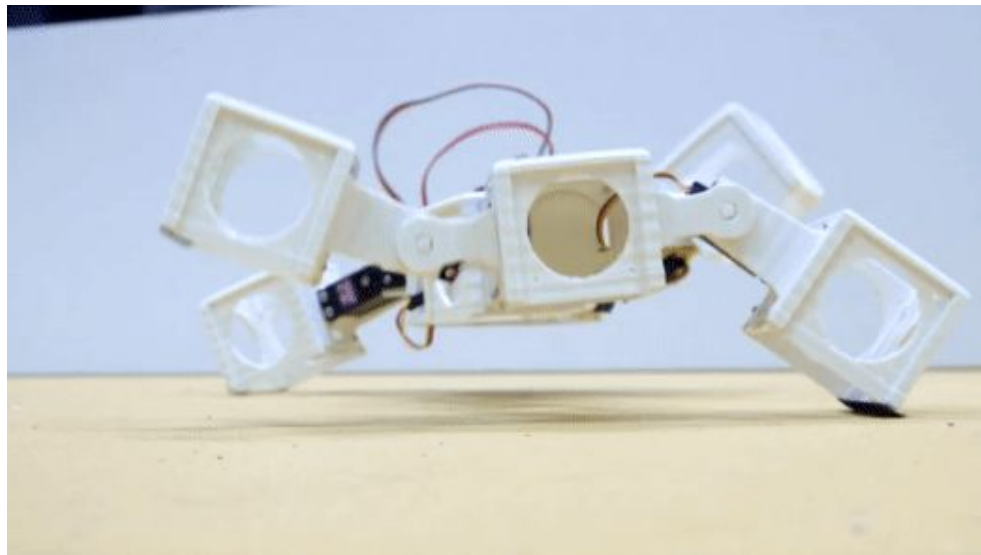
Aart Stuurman
Computational Intelligence Group



Content

- What is Revolve?
 - Hardware: the physical part
 - Software: simulation and optimization
- Example research projects
 - The Effects of Learning in Morphologically Evolving Robot Systems
 - Robots interacting and evolving together in simulation
 - The Influence of Robot Traits and Evolutionary Dynamics on the Reality Gap
- What can you do
 - E.g. use your own novel algorithm
- Experience building software side Revolve

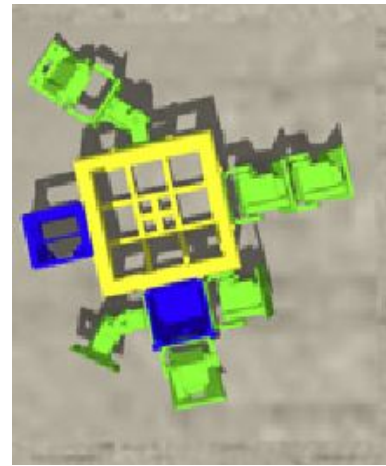
What is Revolve?



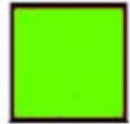
But their gaits are inflexible, desynchronized, and unstable

What is Revolve?

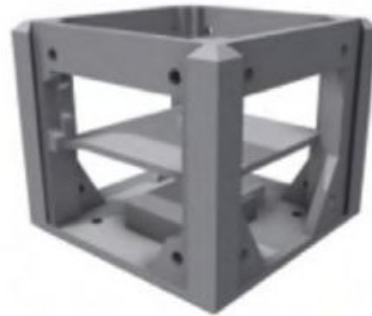
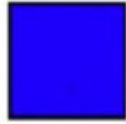
- Core
- Brick
- Active hinge



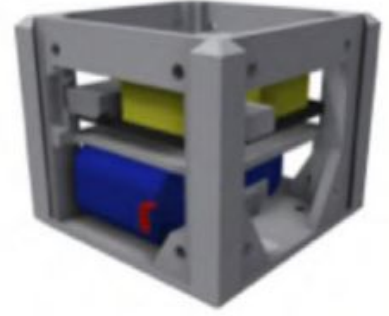
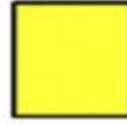
A



B



C



What is Revolve?

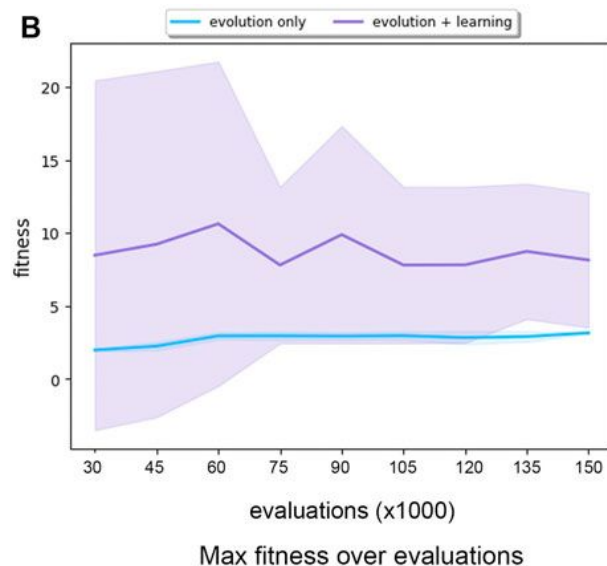
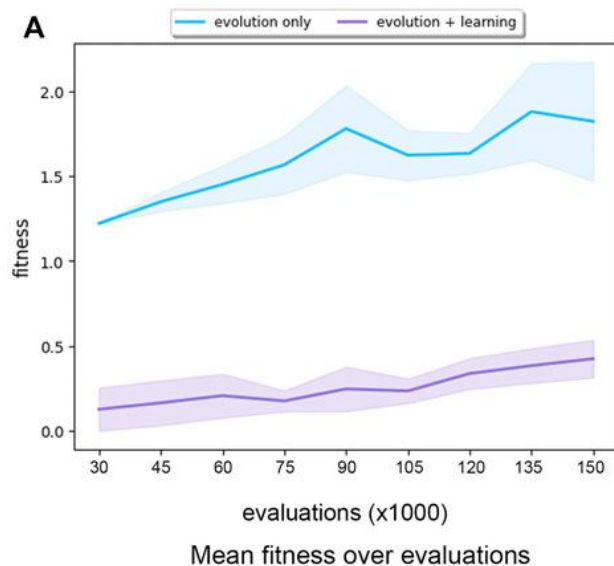
- Research Evolutionary Algorithms
- Brain usually vector based
 - Differential evolution
 - Bayesian optimisation
- Body currently not
 - Tree-based (direct encoding)
 - CPPN (compositional pattern producing network)

Example projects

- *The Effects of Learning in Morphologically Evolving Robot Systems*, J. Luo, A. C. Stuurman
- *Robots interacting and evolving together in simulation*, M. de Carlo
- *The Influence of Robot Traits and Evolutionary Dynamics on the Reality Gap*, F. van Diggelen

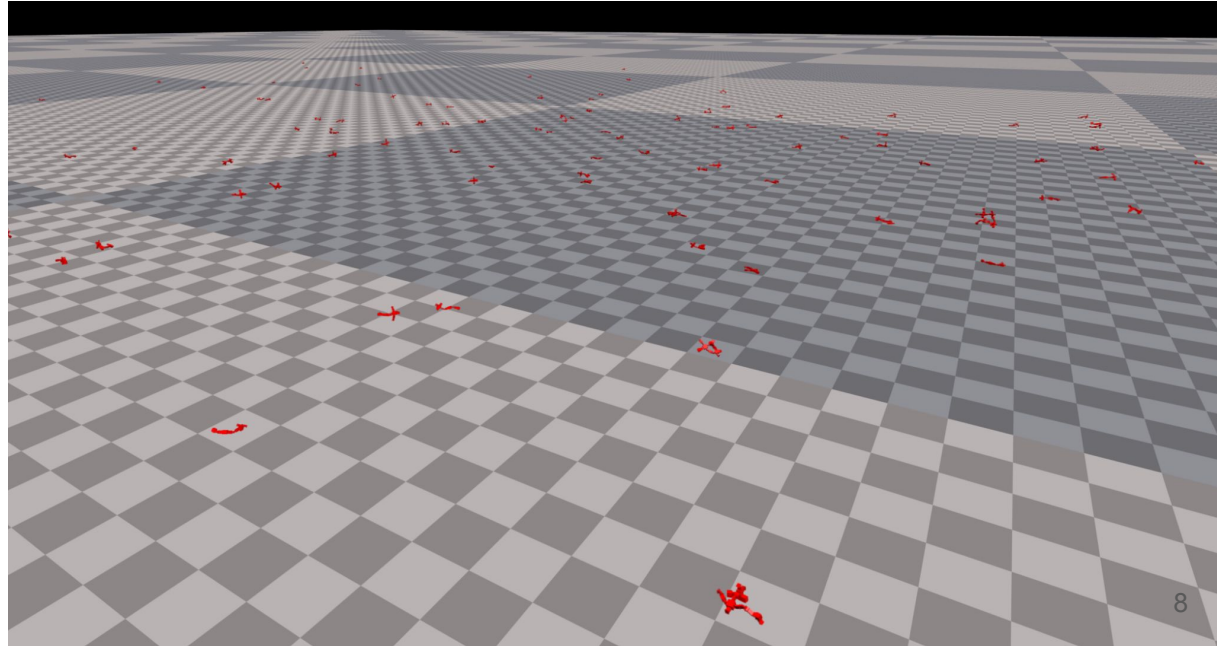
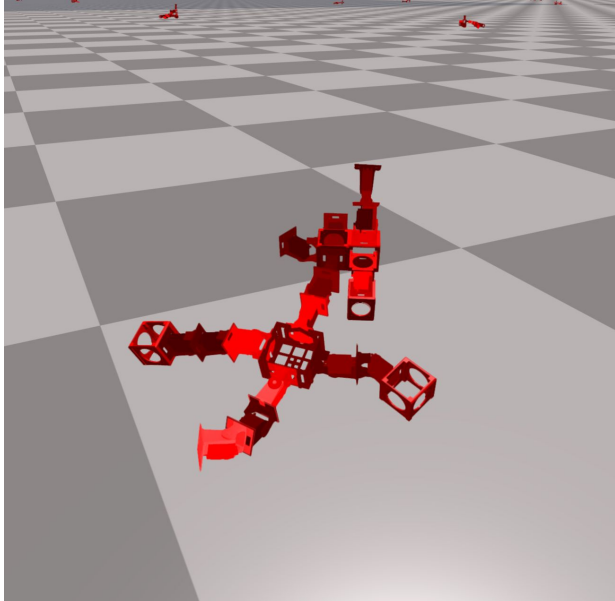
The Effects of Learning in Morphologically Evolving Robot Systems

- By Jie Luo
- www.frontiersin.org/articles/10.3389/frobt.2022.797393/full
- youtu.be/UYCIGJdRhq4?t=9



Robots interacting and evolving together in simulation

- By Matteo de Carlo
- youtu.be/uzUTNuJEg9w?t=207



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

- By Fuda van Diggelen
- ieeexplore.ieee.org/document/9536611
- youtu.be/spetUQIfPdM?t=77

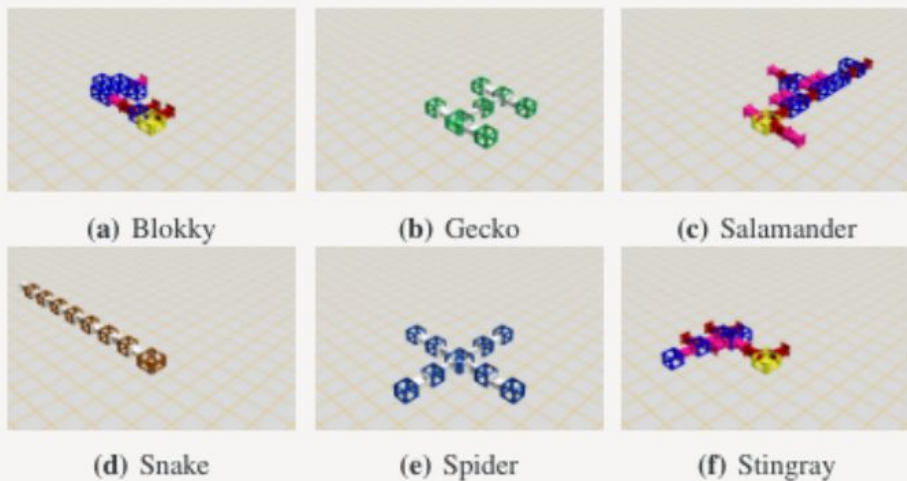


Figure 2: Test suite of six robots as rendered in the simulator.

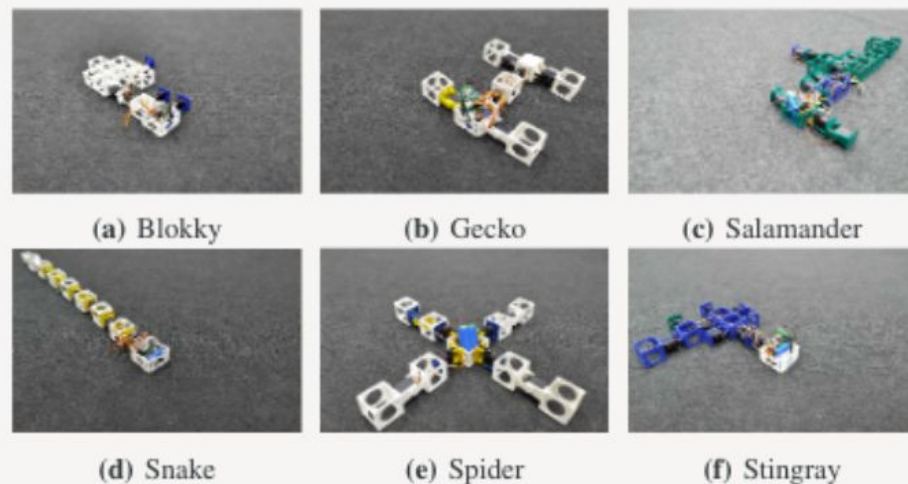


Figure 3: Test suite of six robots in the real world.

What can you do with Revolve?

- github.com/ci-group/revolve2
- Easy access to a difficult black box problem
- Test your own (evolutionary) optimization algorithm
 - Either for brain,
 - Or body
- Compare with physical robot



Building scientific software

Name	Type	Schema
▼ Tables (14)		
▶ environment_name		CREATE TABLE environment
▶ environment_names		CREATE TABLE environment
▶ environment_names_item		CREATE TABLE environment
▶ genotype_with_meta		CREATE TABLE genotype_wi
▶ measures		CREATE TABLE measures (i
▶ parameters		CREATE TABLE parameters (
▶ parameters_item		CREATE TABLE parameters_
▶ population		CREATE TABLE population (
▶ population_individual		CREATE TABLE population_i
▶ program_root		CREATE TABLE program_ro

```
from ._serializable import Serializable

T = TypeVar("T", bound=Union[int, float, str, Serializable])

class SerializableList(List[T], Serializable):
    """A python list that can be serialized to the database."""
    __db_base: type # TODO proper type
    __item_type: Type[T]
    __is_basic_type: bool
    item_table: Any

    @classmethod
    def __init_subclass__(
        cls, /, table_name: str, value_column_name: str, **kwargs: Dict[str, Any]
    ) -> None:
        """
        Initialize this object.

        :param table_name: Prefix of all tables in the database.
        :param value_column_name: Name of the value column in the database table.
        :param kwargs: Other arguments not specific to this class.
        """
        super().__init_subclass__(**kwargs)

        assert len(cls.__orig_bases__) == 1 # type: ignore # TODO
        cls.__item_type = get_args(cls.__orig_bases__[0])[0] # type: ignore # TODO

        dbtype: Union[Type[Integer], Type[Float], Type[String]]

        if cls.__item_type == int:
            cls.__is_basic_type = True
            dbtype = Integer
```

Building scientific software

- Get a dedicated software engineer
 - Domain knowledge is not so relevant
 - Make sure they want to build software

Building scientific software

- Get a dedicated software engineer
 - Domain knowledge is not so relevant
 - Make sure they want to build software
- Spend time on software, not research

Building scientific software

- Get a dedicated software engineer
 - Domain knowledge is not so relevant
 - Make sure they want to build software
- Spend time on software, not research
- Share within your group

Contact me

- Email a.stuurman@vu.nl
- github.com/ci-group/revolve2
- About using Revolve,
- And about building your own software platform