Framsticks general information

Maciej Komosinski Szymon Ulatowski

www.framsticks.com

General information

- https://youtu.be/CrWj_l-UrN4?t=60
- https://youtu.be/r5RfTmx3S4g

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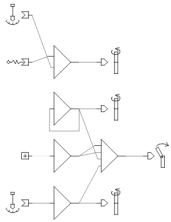
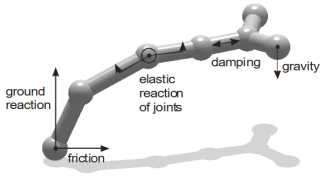
- https://youtu.be/r5RfTmx3S4g

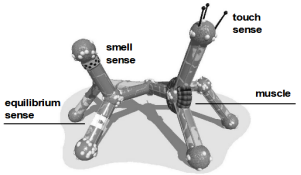
- developed since 1996
- authors and main developers: Maciej Komosinski and Szymon Ulatowski
- volunteers involved in development, experiments, and technical support

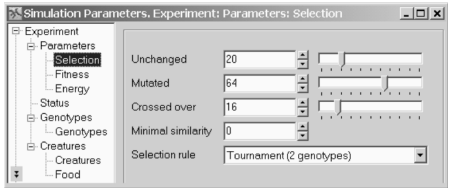
Main points of users' interest

- simulation
- biology, evolution
- robotics
- neuroscience
- cognitive science
- computer science
- visualization
- education and understanding
- simplicity / complexity
- entertainment
- versatility





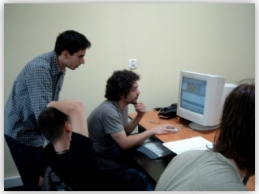


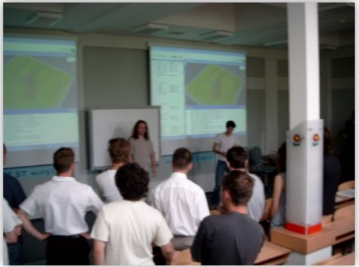


Users

- regular users
- students
- teachers and researchers:
  - Virtual Life laboratory, Utrecht University, Netherlands
  - Bio-inspired Adaptive Machines Course at Autonomous Systems Lab, Lausanne, Switzerland
  - Cognitive Science Lab., Dept. of Philosophy, William Paterson University of New Jersey, USA
  - ...
- advanced users from all over the world

Users





Events

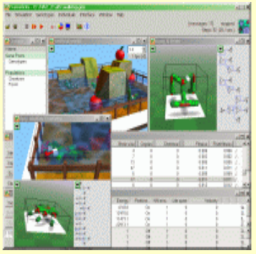
- articles in paper and electronic magazines
- interviews for newspapers, magazines, radio, and TV
- lectures, seminars, presentations, and demonstrations at conferences, workshops, academic institutions and popular shows
- third-party demonstrations (artistic exhibitions, thematic presentations – history of technology, evolution, medicine, etc.)

Presentations invited by

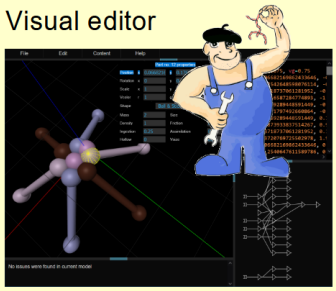
- LEGO Lab, University of Aarhus, DK
- TheoLab, Jena, DE. Friedrich Schiller University. Research Unit for Structure Dynamics and the Evolution of Systems
- University of Dortmund, DE. Chair of Systems Analysis, Department of Computer Science
- Max Planck Institute, Lipsk, DE
- Santa Fe Institute, USA
- European Summer School, PL
- Princeton Institute for Advanced Study, USA. Summer School in Computation and Biology
- University of North Carolina at Charlotte, USA
- Academy of Sciences, PL
- Paris 8 University, FR

Software

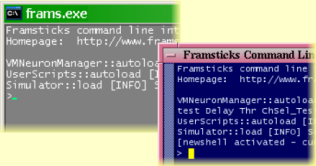
Simulator GUI



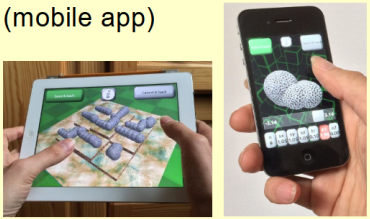
Visual editor



Simulator command-line and network server



Artificial Life (mobile app)

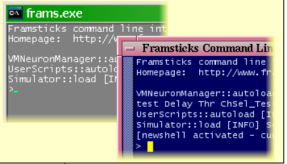


Native library with C++ and Python bindings

```
class FramsticksLib:
    def getSimplest(genetic_format) → str
    def evaluate(genotype_list: list[str]) → list[dict]
    def mutate(genotype_list: list[str]) → list[str]
    def crossOver(geno_parent1: str, geno_parent2: str) → str
    def dissimilarity(genotype_list: list[str]) → np.ndarray
    def isValid(genotype_list: list[str]) → list[bool]
```

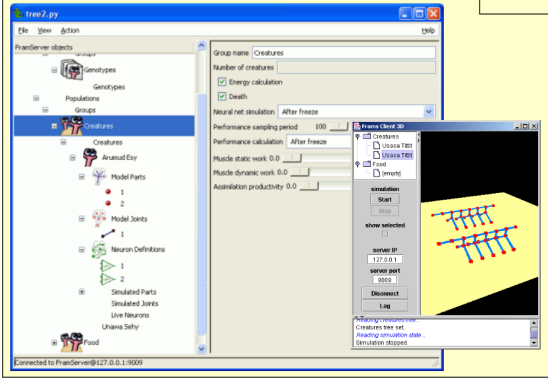
Network software

Command-line server



Experimentation Center

Portable clients



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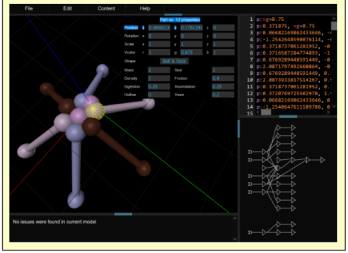
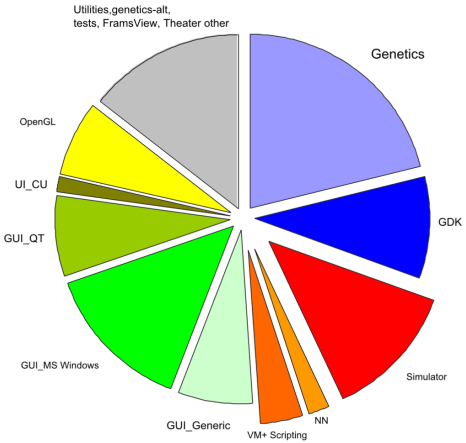


Technical information

- Sources: C++, lex, bison, m4, awk
- Third-party libraries: PLIB, GLPNG
- Sources available in SVN repository – SDK
- Additional apps and modules: Python, JavaScript

Technical information – source size (C++ only)

2003: 78 KLOC, 2 MB



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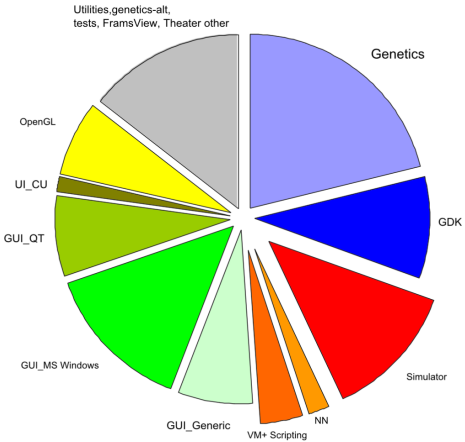
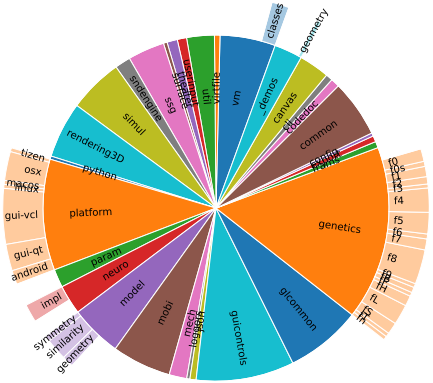


2024: 264 KLOC, 7.7 MB

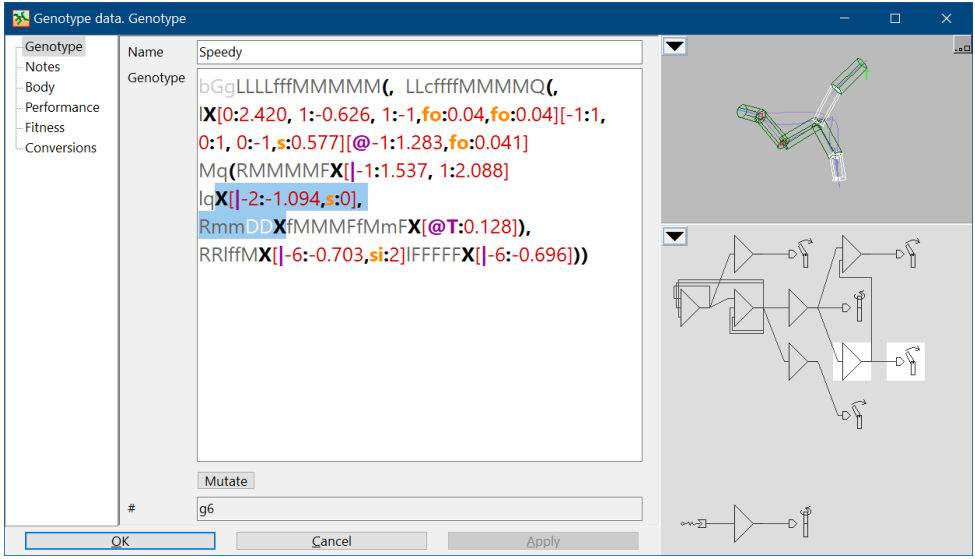


Sample uses and experiments

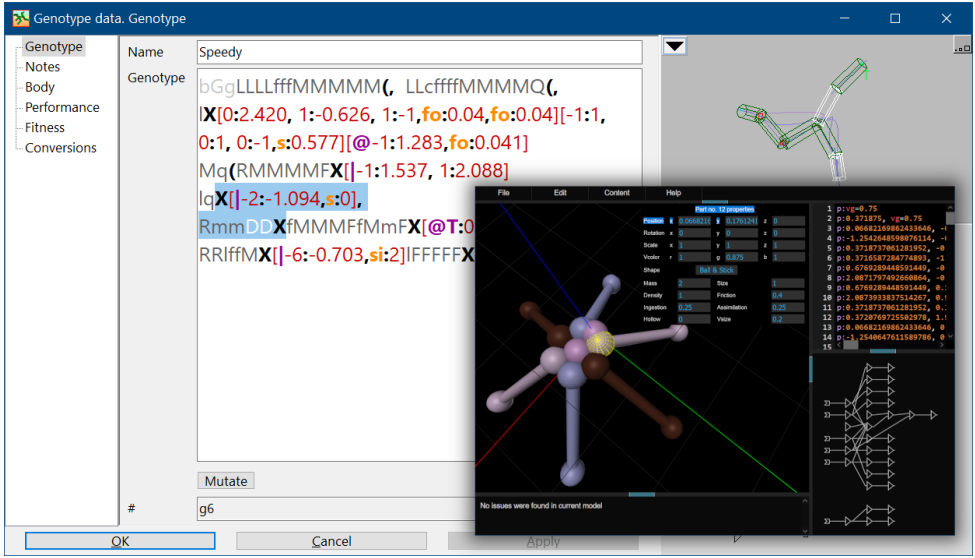
- synthesizing (building) agents
- studying agents' behaviors
- optimizing agents
- designing genetic representations
- studying evolutionary dynamics, coevolution, migration, etc.
- evolving neural and fuzzy controllers
- understanding evolved brains
- evolving communication and cooperation
- designing custom user experiments

- publications available from the web site

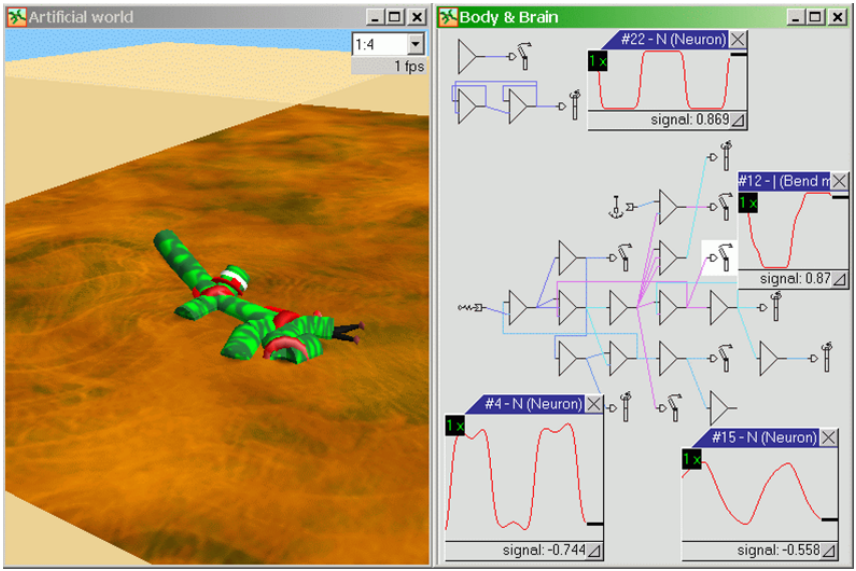
Synthesizing agents



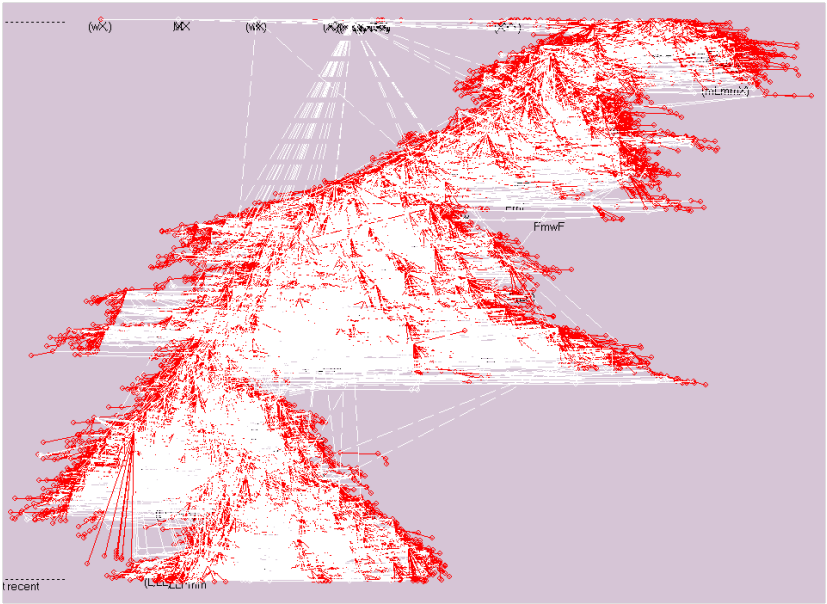
Synthesizing agents



Studying agents' behavior



Investigating evolution (tree, exogenous fitness)



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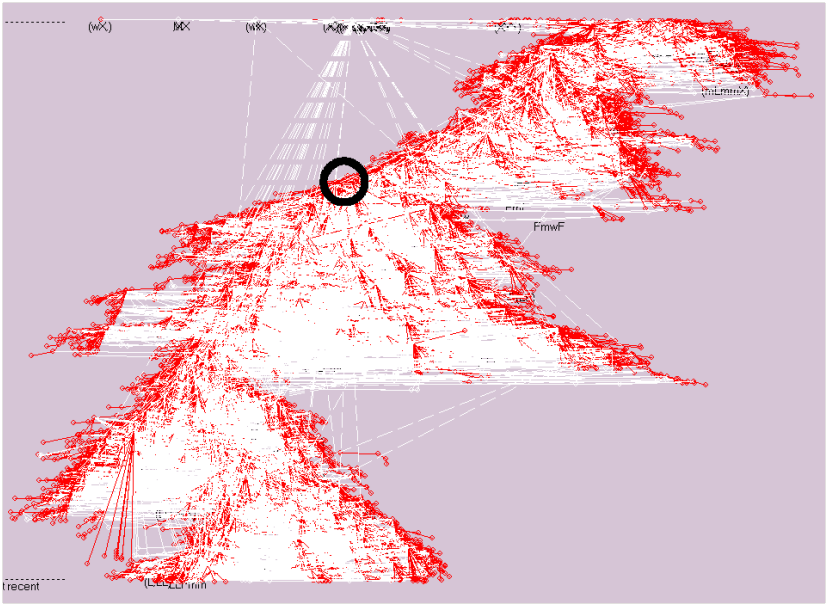

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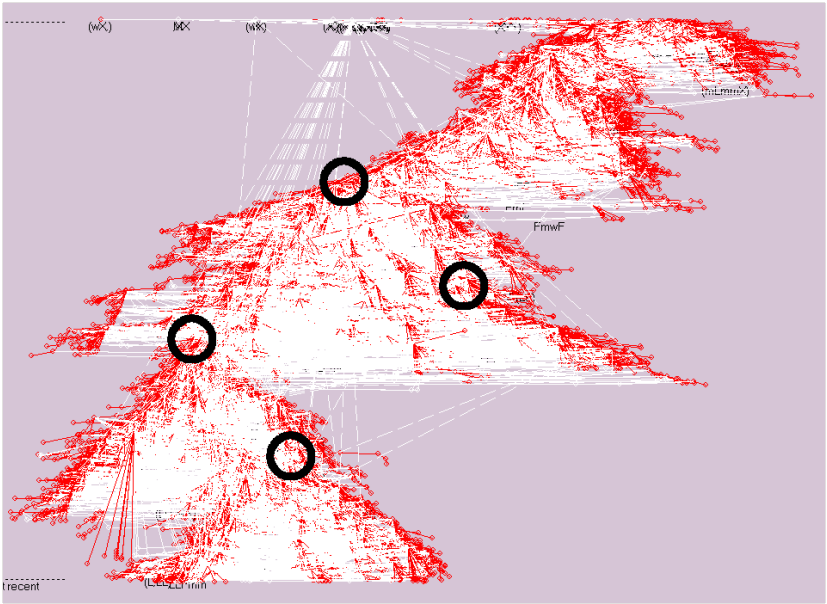

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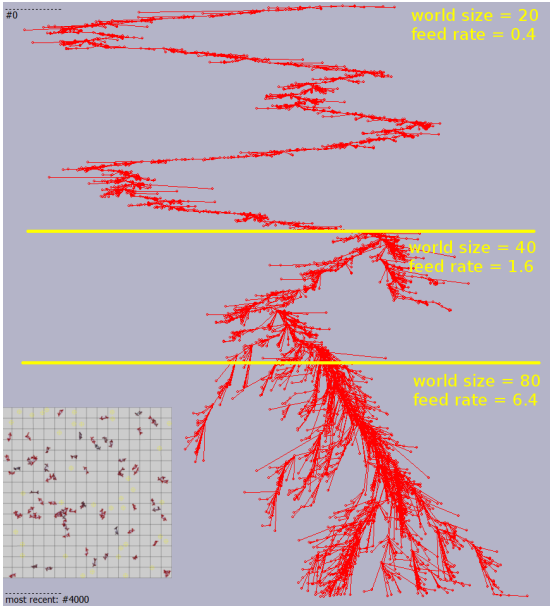

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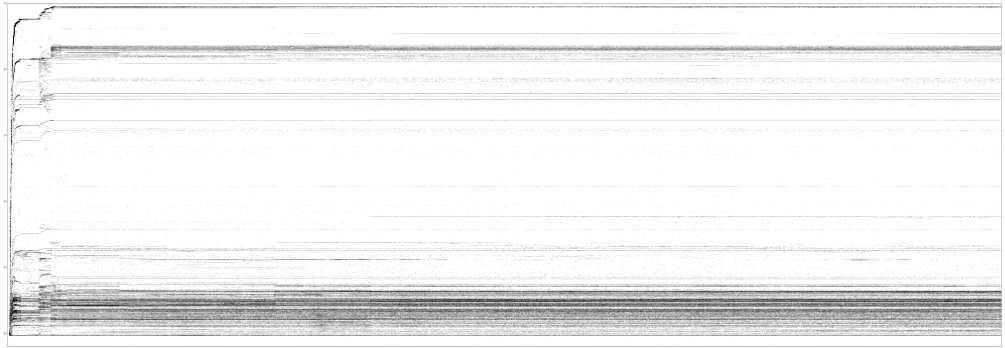

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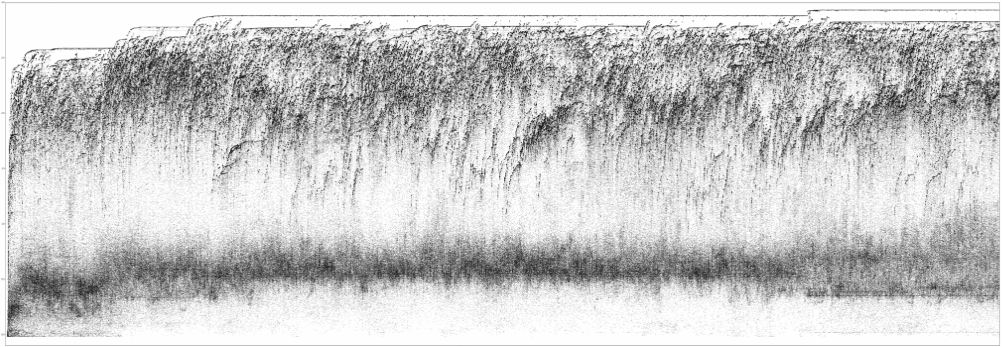

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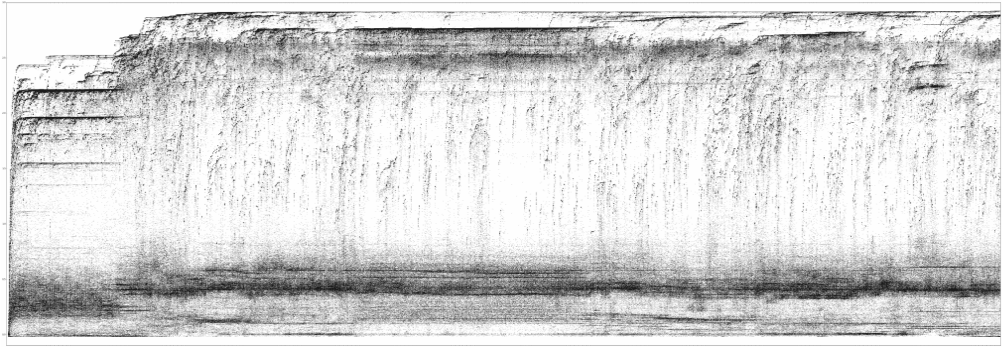
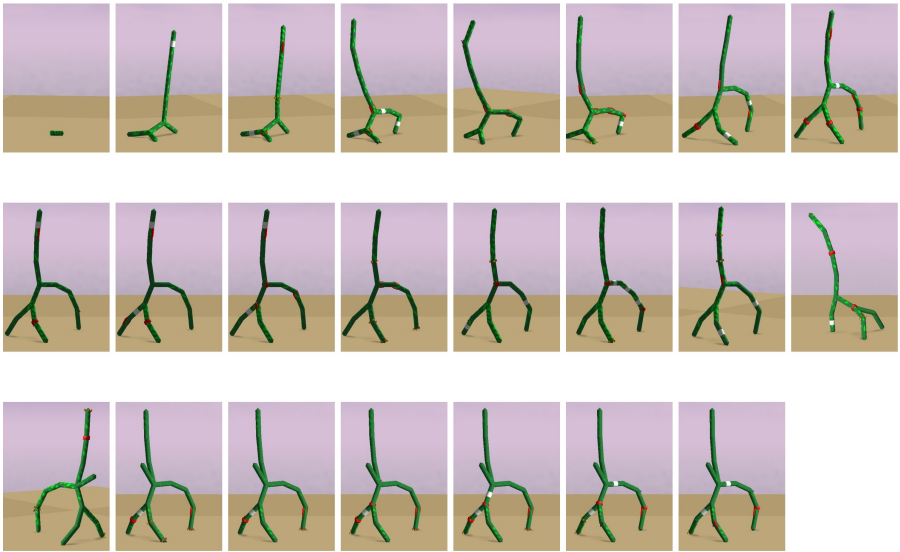


Investigating evolution (individuals)



https://youtu.be/ZRIeOYpTS04

Potential evolved behaviors

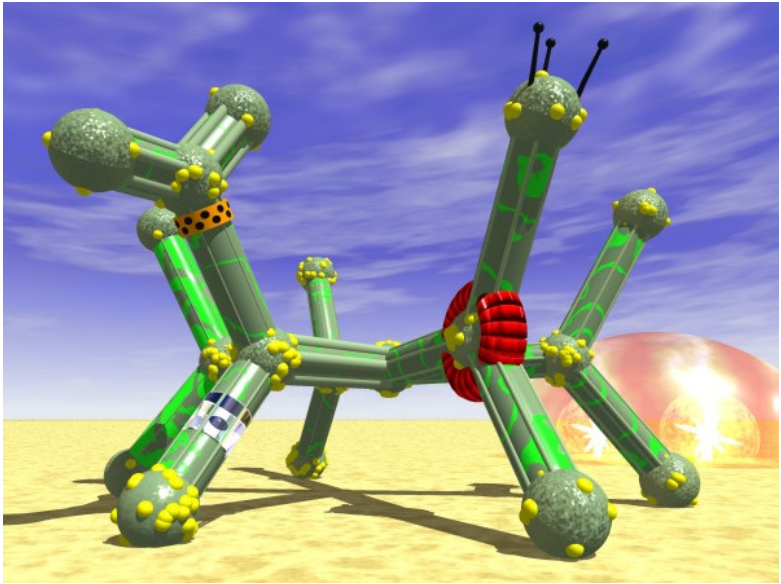
- walking/swimming/jumping/rolling/...
- memory
- predation, prey
- symbiosis, cooperation
- mutual identification and location
- preferences, group/social behaviors
- communication
- feelings, consciousness, ...?

- ...they discover, learn, and exploit simulator imperfections!

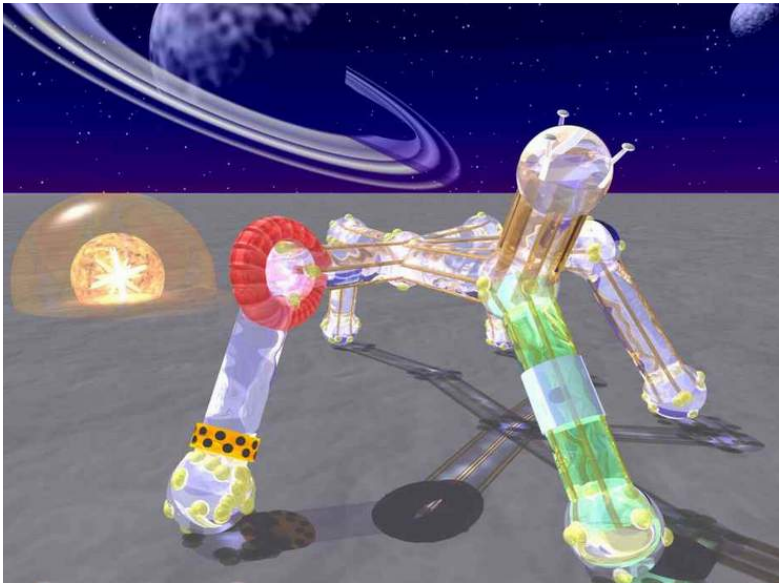
Framsticks as an open system

- custom fitness functions
- experiment definition scripts for custom definition of system framework; user-defined neuron types
- support for various genetic representations
  - conversion to the basic format
  - genetic operators
- network submission of experiment proposals and interesting genotypes; Experimentation Center
- discussion forums for users and developers
- custom definitions of visualization rules (POV-Ray, OpenGL)
- open-source projects

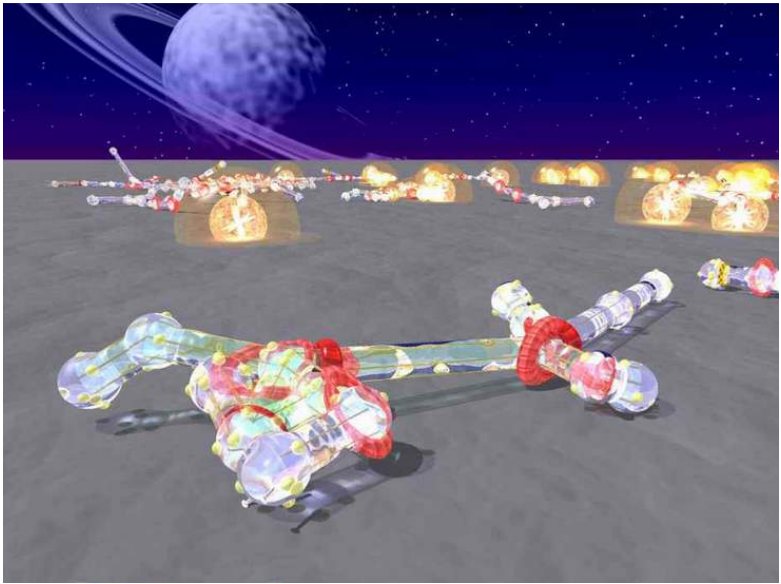
Style: Classic



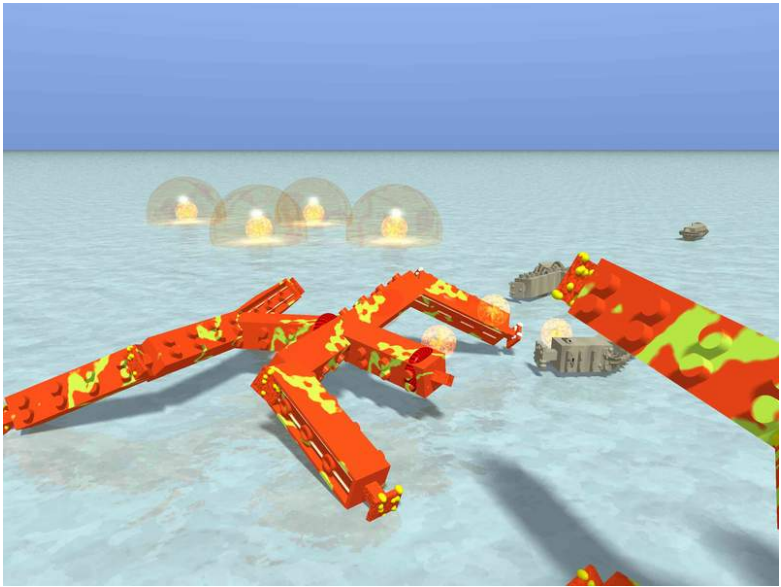
Style: Planet



Style: Planet



Style: Blocks



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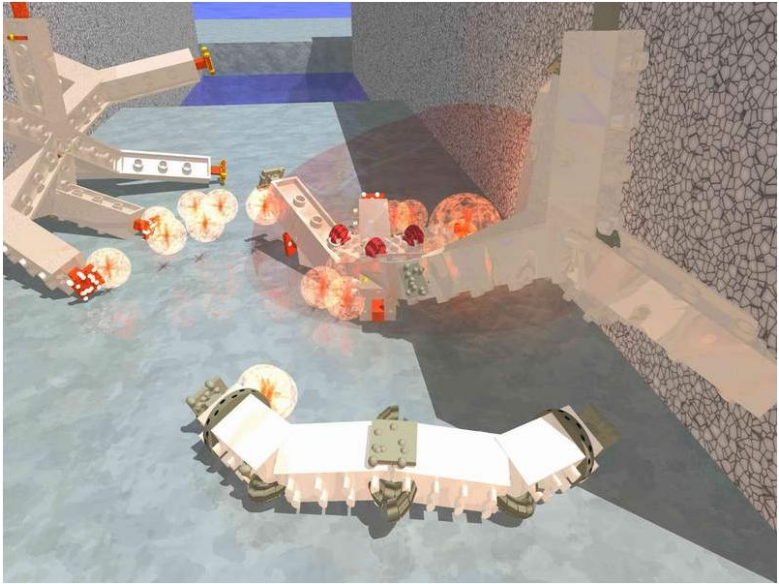
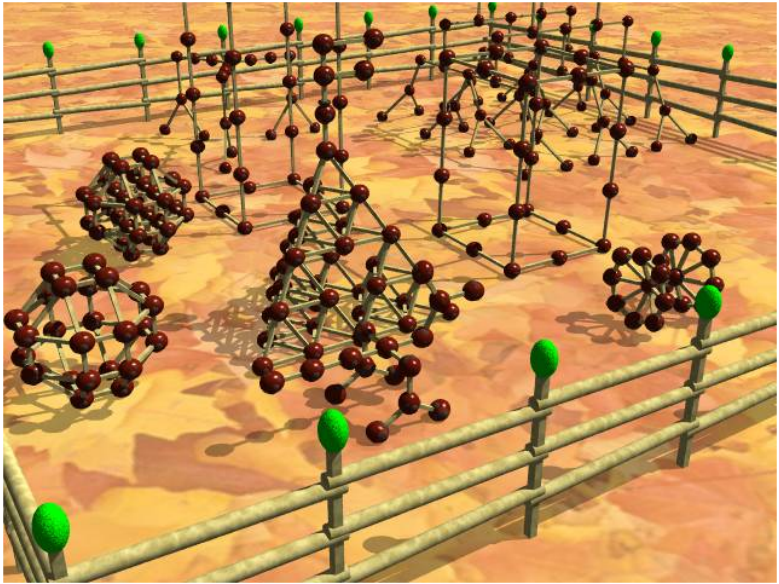


Style: Ghost

Style: Chestnuts



Style: Wookie

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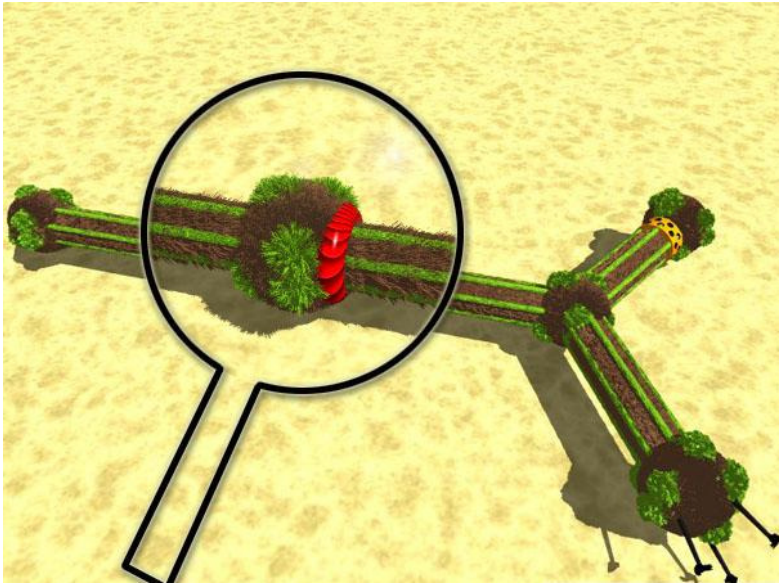

Applications/proposals

- simulating bodies controlled by CAM Brain – PL/JP '98
- LEGO Lab – DK '99
- simulating bodies controlled by wet brains, real neural tissues – USA '00
- HP: Internet, entertainment – USA '00
- UWE, Intelligent Autonomous Systems Engineering Lab., evolving real robots – UK '00
- autonomous/NN agents: games/VR – UK '00
- Max Planck Institute/TheoLab: evolution, phylogeny and methodology – DE '00
- NASA: Space Station robot optimization – USA '04
- structural design – PL '18
- soft robotics, optimization of designs and control – PL '23

Further development and research

- network programs, distributed and parallel evolution
- other genetic representations
- more complex tasks / environments
- tools for analysis of emerged behaviors
- open-ended and spontaneous evolution
- more sensors/effectors (e.g., communication), more fitness criteria
- evolution distributed via mobile apps and Experimentation Center

Inspiration for EC, AL, and KD/ML

- decomposition of hard optimization problems
- hierarchical representation of solutions
- effective crossover operator and speciation
- measures of similarity of complex solutions; global convexity of the search space
- coevolution of solutions and constraints/fitness function
- properties of various solution encodings
- automatic analysis of evolution and agent behaviors
- active perception