Bio-inspired Autonomous Systems

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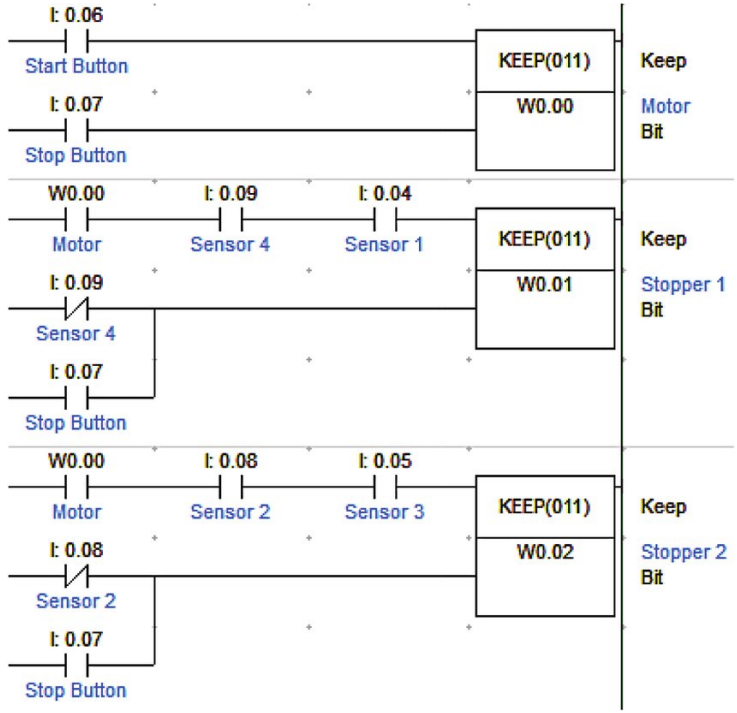
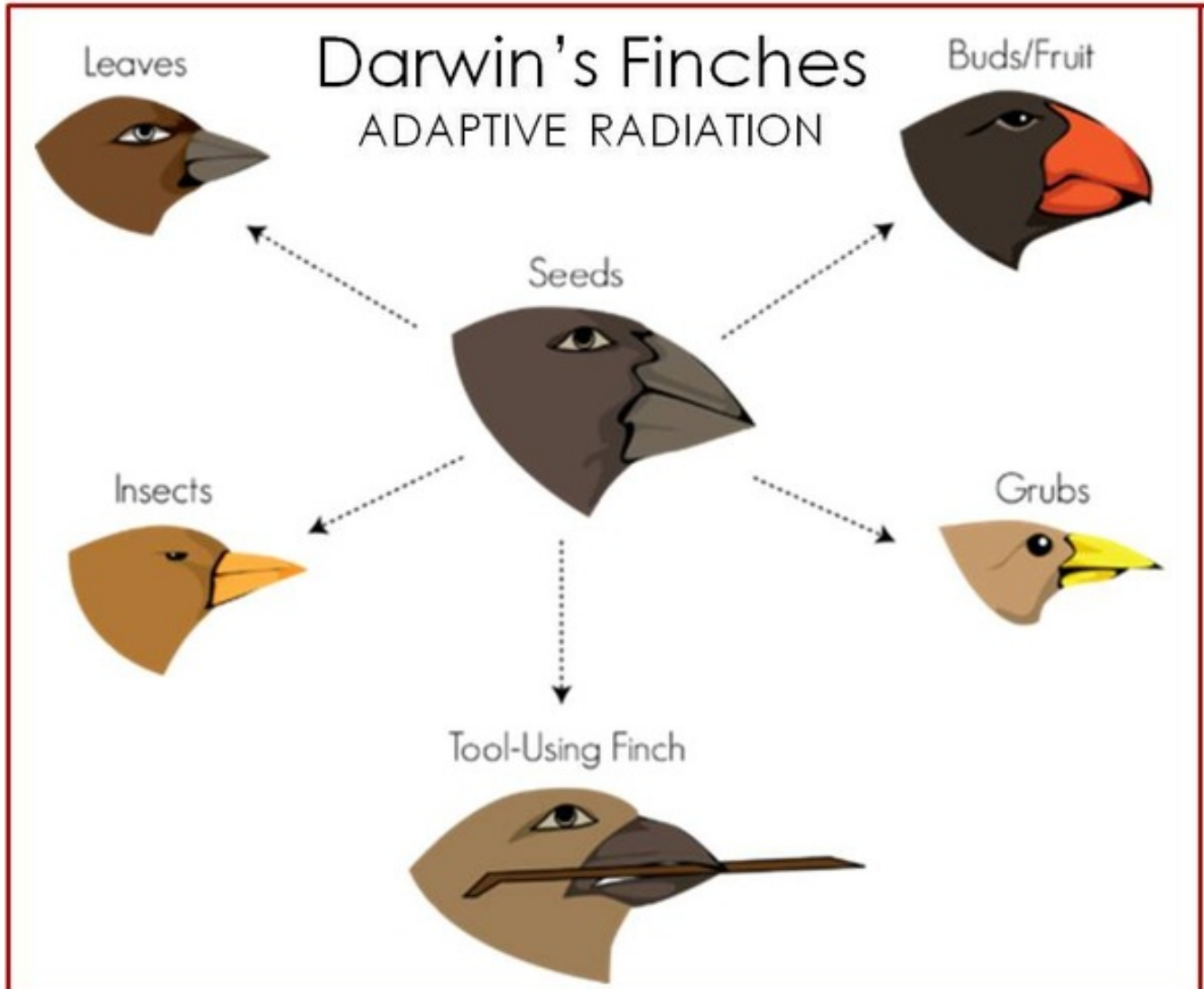
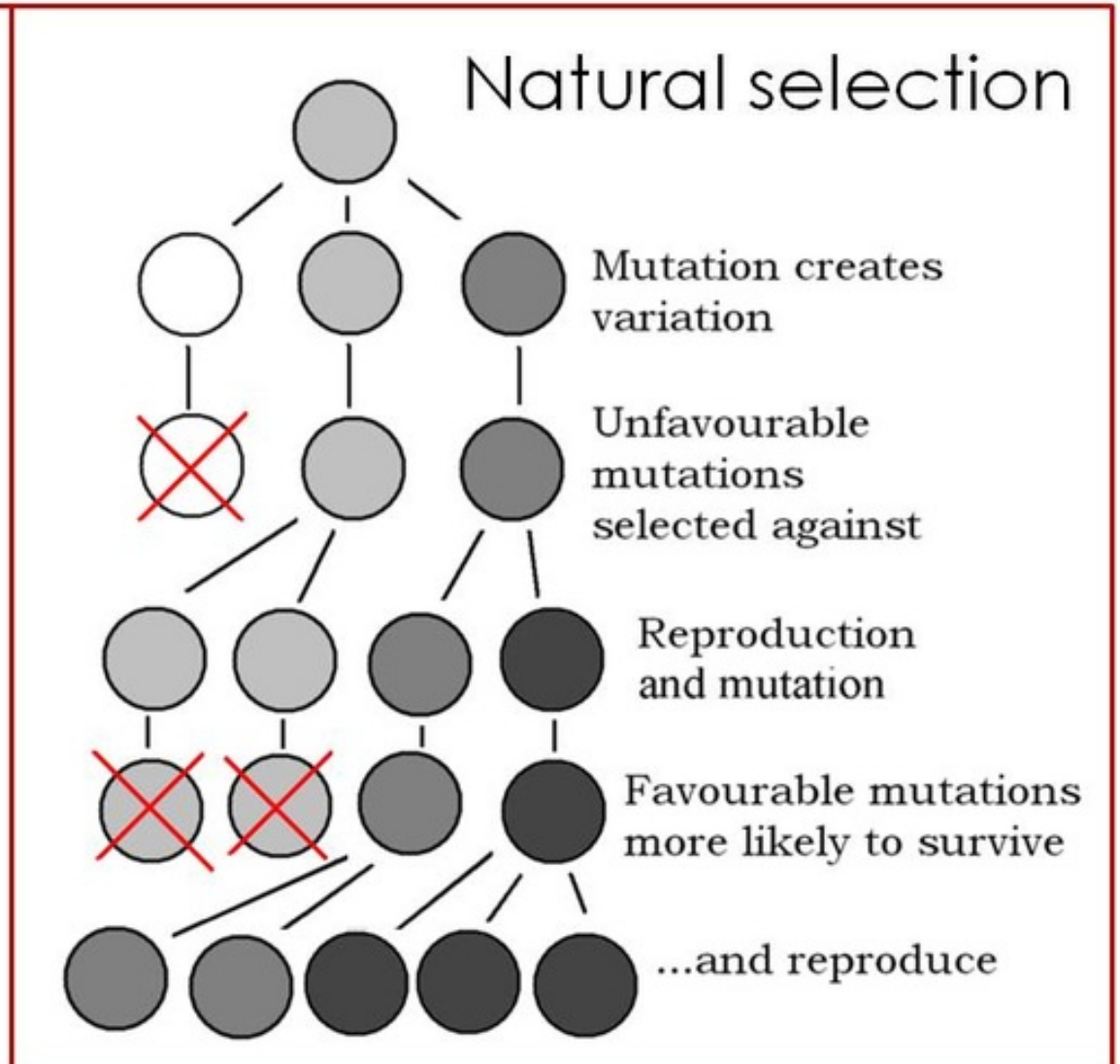
(Very) classic robotics




Darwin's Finches
ADAPTIVE RADIATION
Leaves
Buds/Fruit
Seeds
Insects
Grubs
Tool-Using Finch


Natural selection
Mutation creates variation
Unfavourable mutations selected against
Reproduction and mutation
Favourable mutations more likely to survive
...and reproduce

World’s first biologically-inspired robots (developed late 1940s)

Elmer and Elsie (ELectroMEchanical Robot, Light-Sensitive)

William Grey Walter

From:
https://www.machinedesign.com/mechanical-motion-systems/article/21835853/7-bioinspired-robots-that-mimic-nature
and https://www.sdu.dk/en/forskning/sdu_biorobotics/projects/morf

Bio-inspired robots

Octobot, Harvard

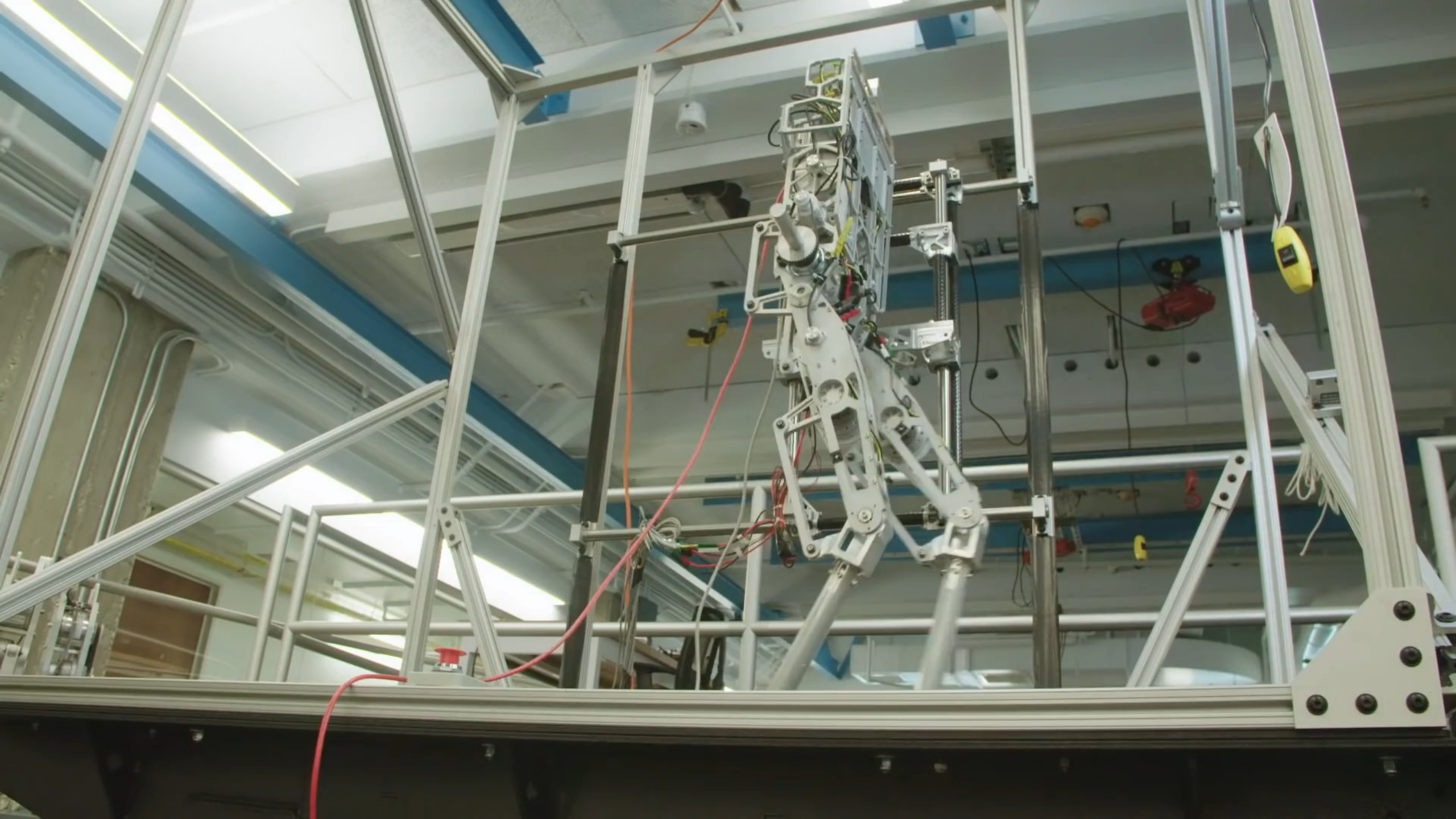
Snakebot, CMU

MORF, SDU

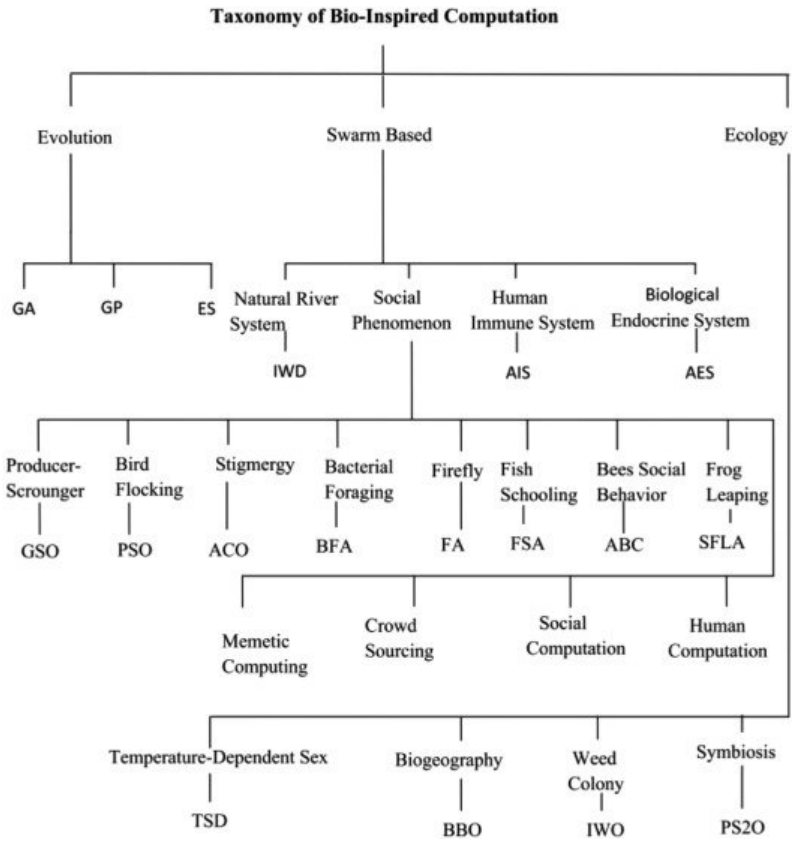
Festo’s Bionic Cobot

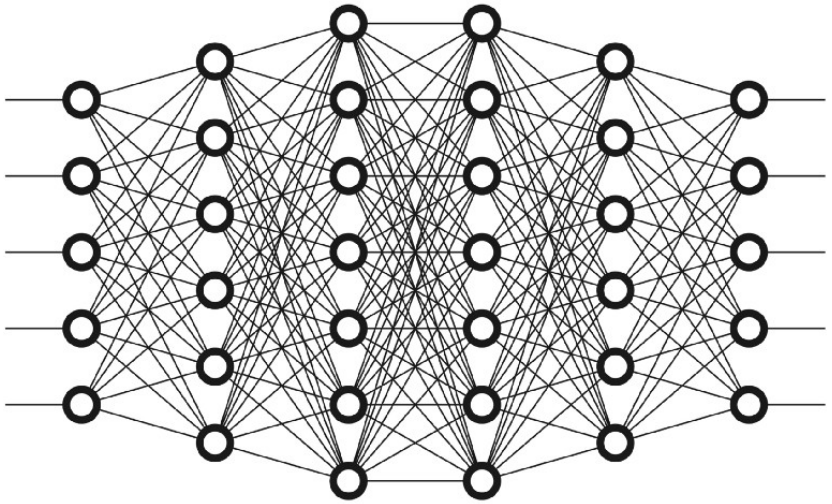
Spot mini, Boston Dynamics

Agility Robotics



Bio-inspired algorithms and models





Neural networks, deep NNs, spiking NNs, …

See: Binitha, S., and S. Siva Sathya. "A survey of bio-inspired optimization algorithms." *International Journal of Soft Computing and Engineering* 2.2 (2012): 137-151.

Structure of the course

Introductory week (this one)

Three weeks:

- Robot swarms and self-organization
- Soft robotics and intelligent materials
- Locomotion and control

Then an assignment in one of the above topics in groups.

Evaluation

- Assignments due: May 17, 2026, 23h59

- Oral exam in June, project and course material:
  - Presentation (prepared slides)
  - Questions to presentation, Bio-inspired Autonomous Systems in general

Grading is on 7-point scale.

Bioinspiration

See course page for paper

we will.

2. Biological systems and bioinspiration

2.1. Bioinspiration, molecules, materials, structures and functions

Because biology offers remarkable examples of new structures and processes at every scale, where should one focus? In biology, at all scales, *function* is the key idea: organisms cannot afford—in the great Darwinian competition—to decorate themselves with functionless features. By trying to mimic the behaviours and properties of living systems, we are therefore automatically engaged in mimicking functional processes and structures. 'Bioinspiration' thus leads—directly or indirectly—to function, some of which is useful to the organism, and some of which *might* be useful to us. Surrounding *function*, however, are other, more conceptual ideas that guide the selection of problems—and the design of appropriate research strategies—in bioinspired investigations.

2.2. Some characteristics of biology and bioinspiration

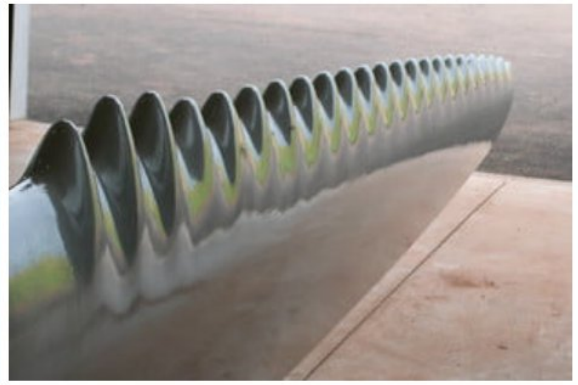
”Bio-inspired” copying, adaptation or derivation from biology

Related terms

- **Biomimetics/biomimicry**: emulation of the models, systems, and elements of nature for the purpose of solving complex human problems.
- **Bionics**: Biology and electronics
- **Cybernetics:** circular causal feedback mechanisms. Norbert Wiener’s definition: “control and communication in the animal and the machine”

Examples of bio-inspired designs


Nose of the Japanese bullet train modelled after the King Fisher's beak to avoid "tunnel boom".

Wind turbines modeled after Humpback whales


Ventilation systems inspired by termites

From: https://www.digitaltrends.com/cool-tech/biomimicry-examples/

Topics covered in the course

- Collective behavior / swarm intelligence
- Materials
- Locomotion

Today

- In groups of three students, find a paper on bio-inspired autonomous systems from 2025. You can use Google Scholar.
- Preferably a conference paper (6-8 pages) on a concrete study (e.g., not a survey paper).
- Read and discuss the paper.
- Prepare a four slides and a 3-minute presentation (see itslearning for template).

Note

- No class next week
- Presentations should be ready for the class Feb. 17
- Class on Feb. 17 starts at 13.00.