# Neurorobotics

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# Outlines

- Introduction to Neurorobotics
- Models of Neurorobotics
- Implications
- Darwin Robot Series
- Role of Artificial Neural Network

# Simple Definition

- Neurorobots are robots whose control has been inspired/modeled similar to some aspect of the Brain.

# Introduction

- **Neurorobotics**, is a combined study of neuroscience, robotics, and artificial intelligence.
- It is the science and technology of embodied autonomous neural systems.
- Neural systems include brain-inspired algorithms and computational models of biological neural networks.
- Such neural systems can be embodied in machines with mechanic or any other forms of physical actuation.
- This includes robots, prosthetic or wearable systems.

# Two main approach

**Neuroscience**

- Neuroscience attempts to recognize what intelligence consists of and how it works by investigating intelligent biological systems.

**Artificial Intelligence**

- The study of Artificial Intelligence attempts to recreate Intelligence through non-biological, or artificial means.

# Neurorobotic Models

**Locomotion and Motor Control**

**Learning and Memory Systems**

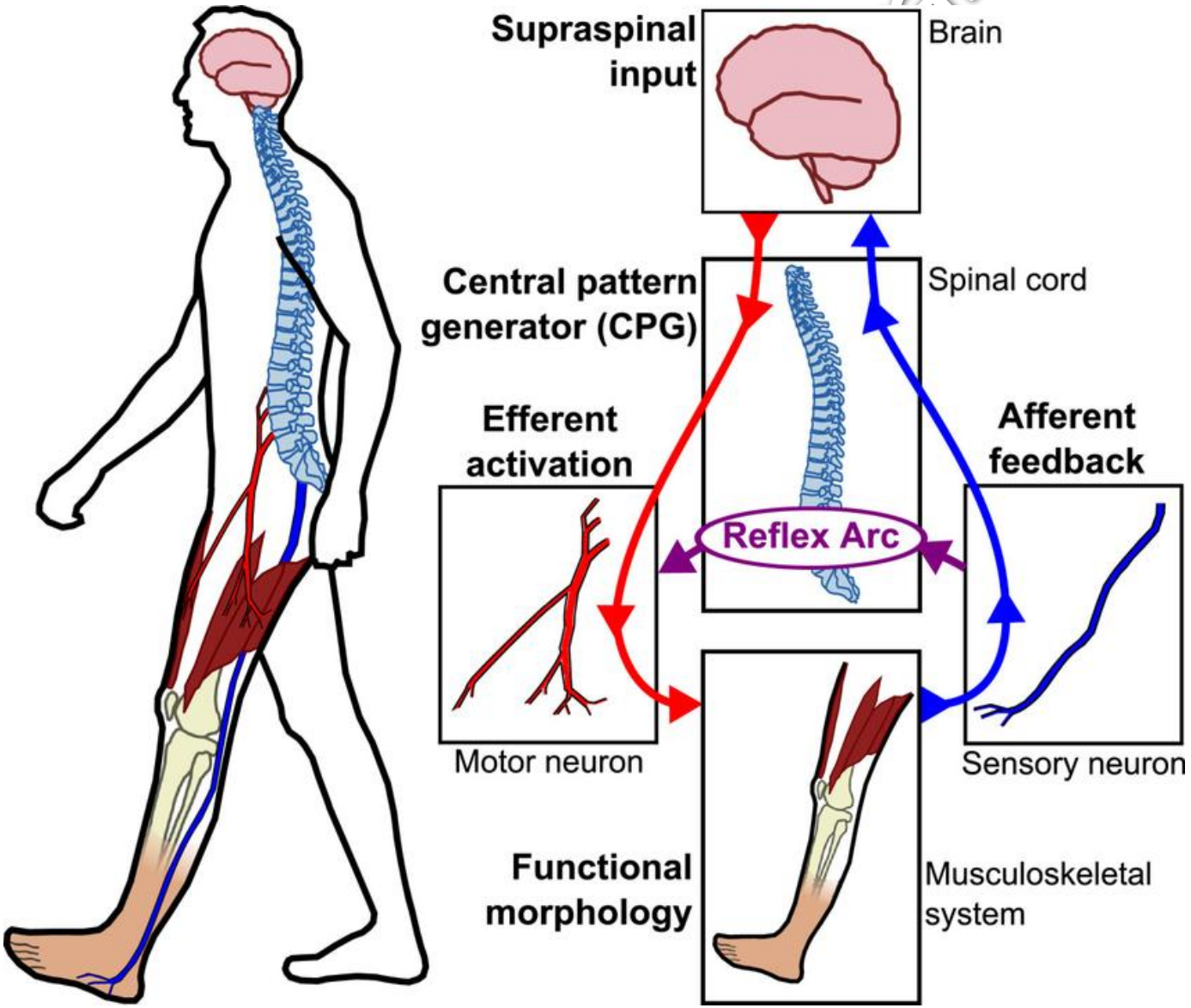
**Action Selection and Value Systems**

**Sensory Perception**

# 1. Locomotion and motor control

- Mimicked from locomotion of humans or animals.
- Models for Central Pattern Generators.
- Bunch of neurons capable of driving repetitive behavior like walking for robots

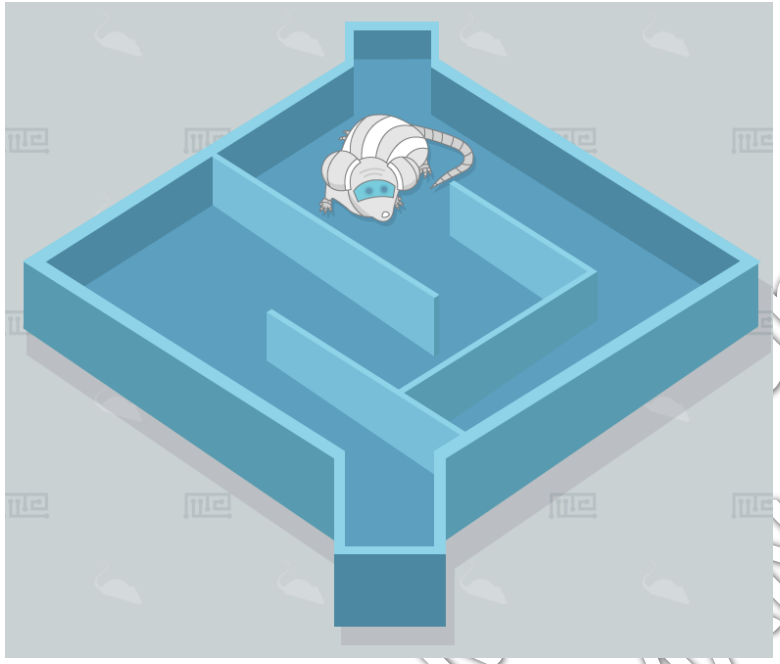
# Locomotion and motor control

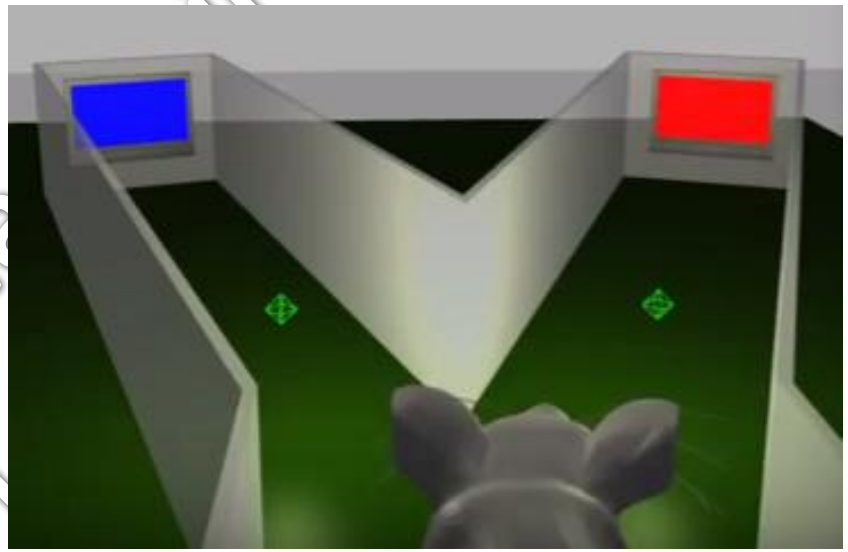


# 2. Learning and memory systems

- Modeling of Hippocampus (part of brain), this remembers locations and visited places.
- Particularly the rat hippocampus, for a specific location that has been learned.
- Systems modeled from rat hippocampus are generally able to learn mental maps of the environment.
- Also includes reorganization of landmarks and associating behaviors with them.
- This helps to predict the upcoming obstacles and other landmarks.

# Learning and memory systems







https://conductscience.com/maze/neurorobotics/
https://www.information-book.com/neurosciences/brain-projects/

# 3. Action selection and value systems

- In biological systems, neurotransmitters such as dopamine, positively reinforce neural signals that are beneficial.

- In robots, positive reward is used neural signals having beneficial outputs/ results.

# Action selection and value systems

- The robot working on this model have visual, auditory, and a simulated taste as input.

- To simulate taste, metal block is use as food. The taste is simulated by conductivity.
  - Good conductive metal block: good taste
  - Bad conductive metal block: bad taste

- The robot had positive/negative feedbacks to the taste based on its level of conductivity.

- Robot learns action selection behaviors based on the inputs it had.

# Action selection and value systems

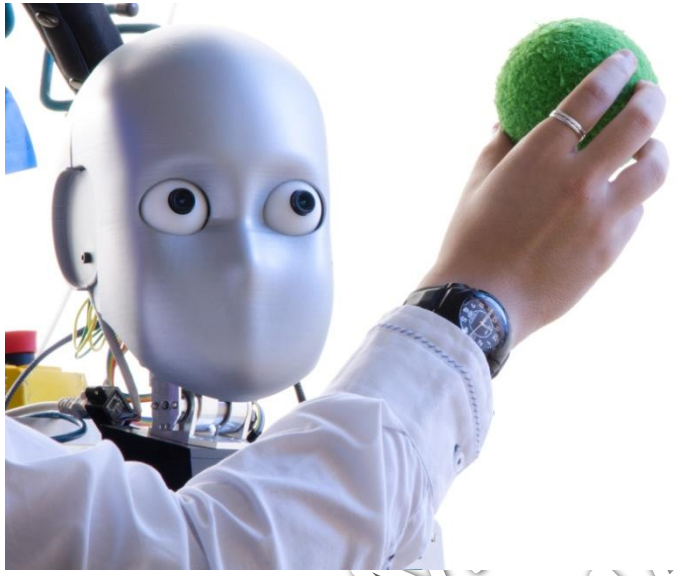
- Neurorobots can also be learned on simple ethical interactions

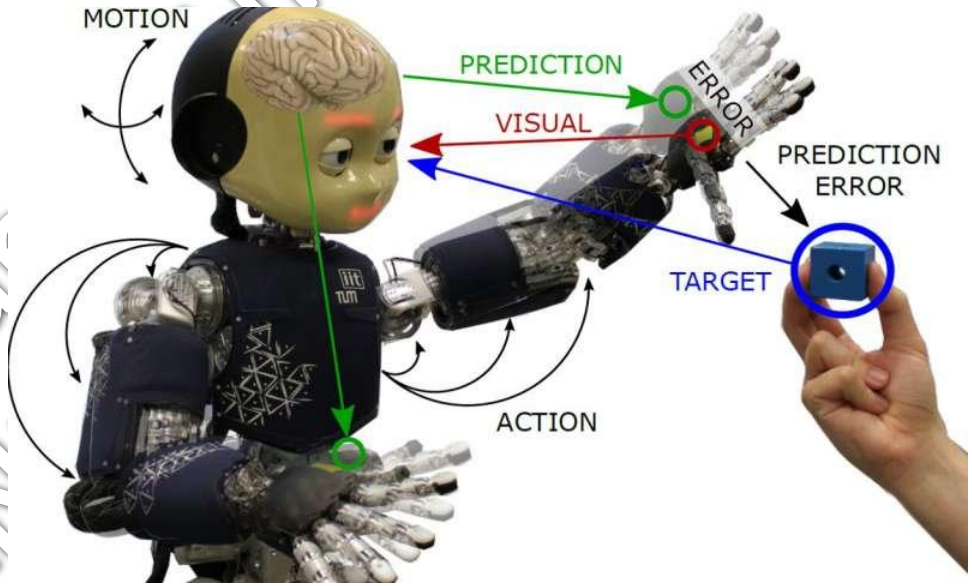
- Such as the classical thought experiment where there are more people than a life raft can hold, and someone must leave the boat to save the rest.

# 4. Sensory perception

- Sense of depth or distance and speed
- For example, depth information may change due to human head or eye movements.
- To establish robust representations of the visual scene
- Neurorobots are also trained for such sensory perception, particularly vision.

# Sensory perception








https://iopscience.iop.org/journal/1748-3190/page/NeuroRobotics
https://techxplore.com/news/2019-06-inference-body-perception-humanoid-robot.html

# Implications for neuroscience

- Neurorobotics is beneficial for neuroscientists, because it provides a platform to test various methods of brain function in a controlled and testable environment.

- Robots are simplified versions of the systems they emulate, they are more specific, allowing more direct testing of the issues.

- They also have the benefit of being accessible at all times.

# Implications for neuroscience

## Neural Rehabilitation

- Progress is dependent on an elaborate understanding of the brain and how exactly it works.
- It is difficult to study the human brain, due to the danger associated with surgeries.
- The use of Neurorobotics technology is filling the gap up-to some extend.

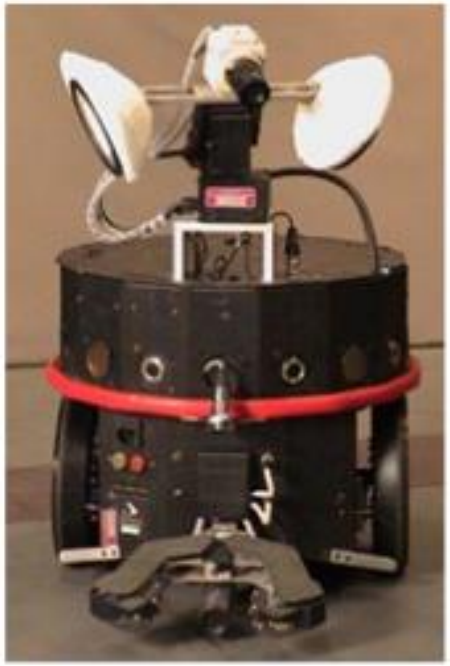
# Darwin Robot Series

- Darwin robot is series of Brain-Based Devices
- These Brain-Based Devices were robots with large-scale neural networks controlling their behavior.

# Darwin Robot Series

Darwin IV-VI
1992 - 1998

Darwin VII-VIII
1999 - 2002



Darwin IX-X
2003 - present

BrainWorks
2004 - present

https://slideplayer.com/slide/793907/

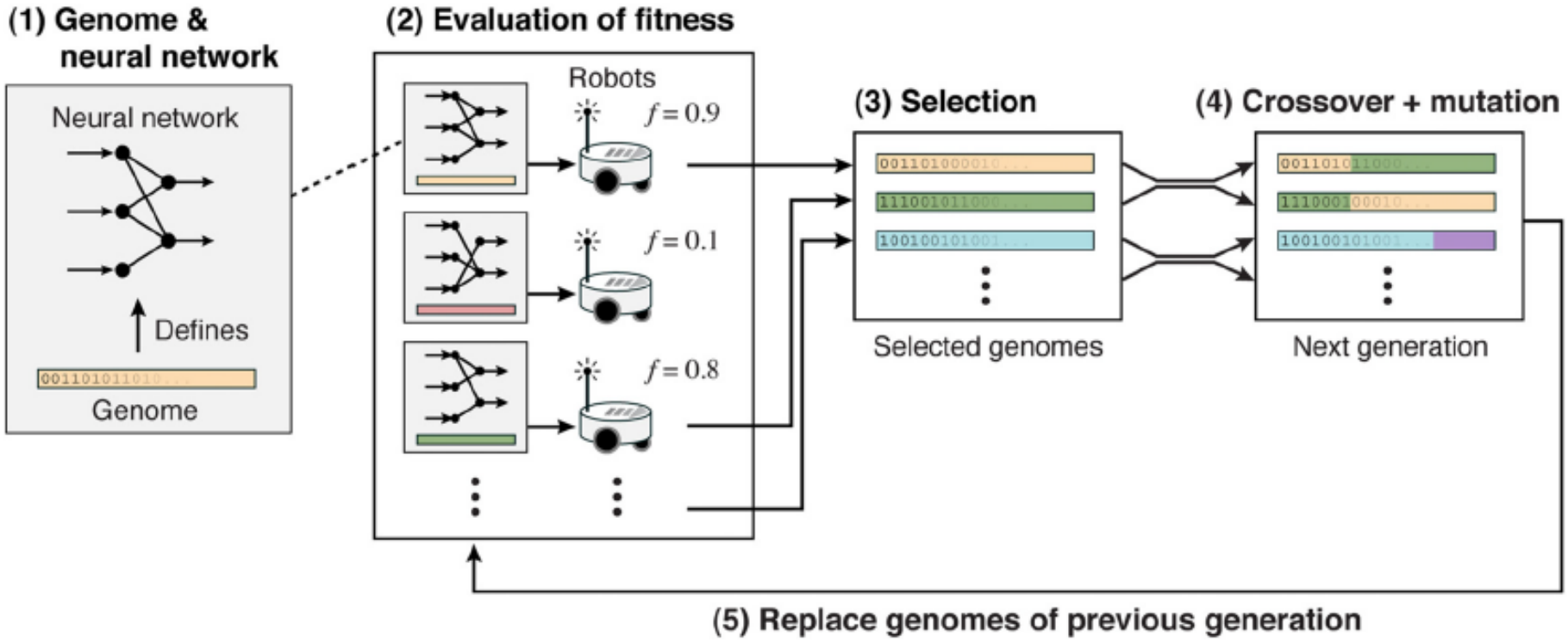
# Darwin VII Robot

- The neural network used in Darwin for behavior control is approximately
  - 20,000 neurons
  - 5,00,000 synaptic connections
- All of which had to updated in real-time to keep up with the active vision and sensors.

# Darwin X

- A highly detailed model of
- Hippocampus and surrounding areas that supported spatial and episodic memory.
- Size of the neural network used
  - 100,000 neurons
  - 1.5 million synapses

# Evolutionary ANN controllers for Robots




Genome defines the neural network controller, which has input neurons receiving inputs from sensors, and output neurons that control actuators.

# Use of ANN in Neurorobotics

- Deep neural networks have been used for robotic applications.

- For example, an incremental deep model that extends Restricted Boltzmann Machines was developed to recognize the context of scenes.

- Identification of objects typically found in an office, kitchen, restroom. So that the robot can respond appropriately.

# Use of ANN in Neurorobotics

- Deep Belief Neural Network was trained for object recognition and robot grasping.
- The DBNN was able to recognize objects in different positions and orientations by extracting object features.
- Use this information to grasp objects in real time.

# Properties of Neurorobotic Device

(1) It engages in a behavioral task.

(2) It is situated in a structured environment.

(3) Its behavior is controlled by a simulated nervous system having a design that reflects, at some level, the brain's architecture and dynamics.

# Key features of the Brain

(1) Learning by rewiring: we learn quickly, incrementally, and over a lifetime.

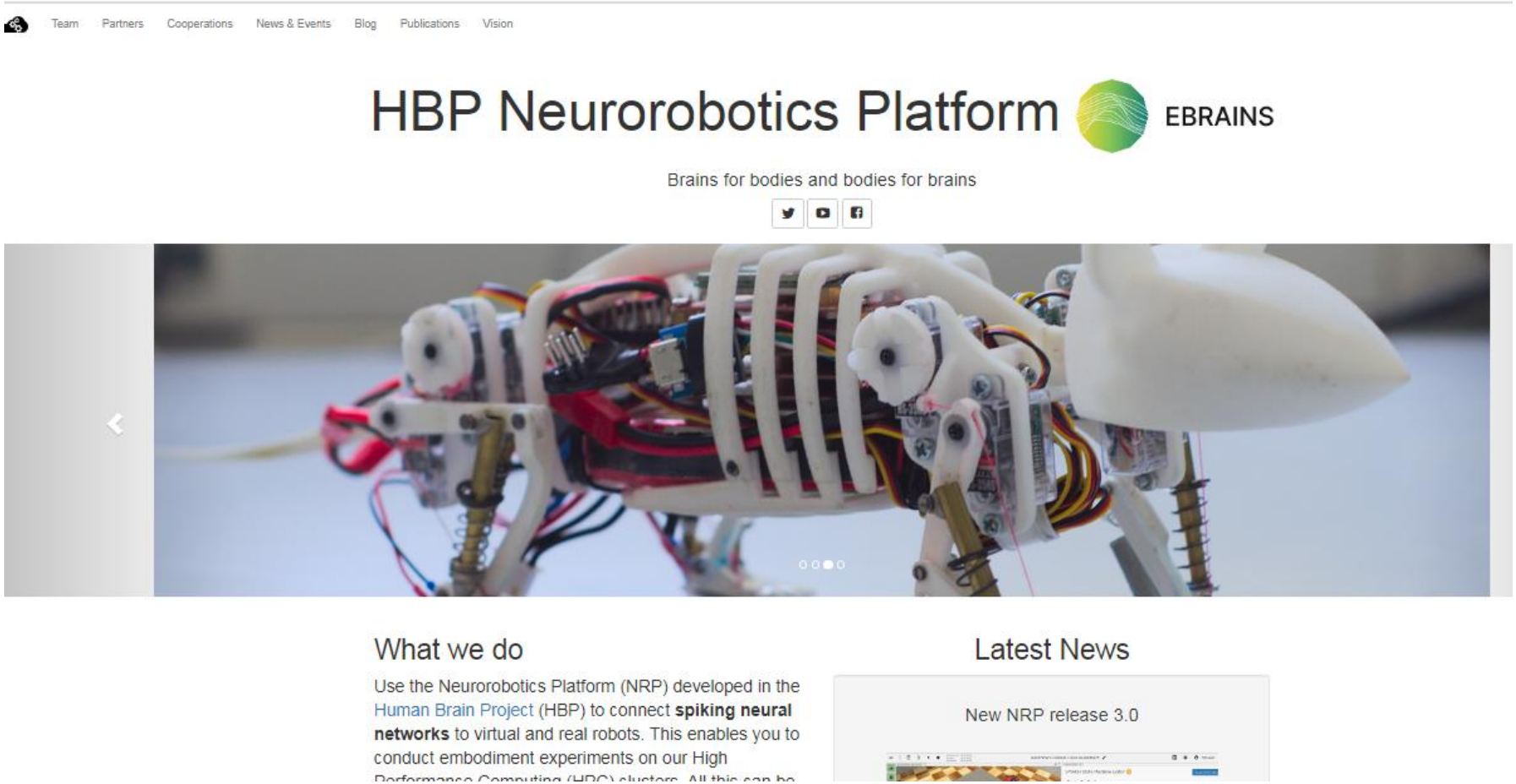
(2) Embodiment: sensorimotor integration is observed throughout an intelligent system.

(3) Value systems: extracting noticeable or important thing from the environment and responding appropriately

(4) Prediction: using past experience to be more successful in the future

# https://www.neurorobotics.net/





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