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Topos 2: Spiking Neural Networks for Bipedal Walking in Humanoid Robots

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This work

- marks the goals to achieve in our ongoing work
- analyses the state of the art in Evolutionary Robotics
- and finally justifies the selected path to follow

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Goals

- to obtain through evolution the neural network that couples with a complex humanoid robot body
- to search for new paths in Autonomous Robotics
- to exploit current computer power and neuroscience-based computational intelligence

Constraints and choices

Constraints and choices:

- Computational Intelligence and Robotics
  - complex humanoid robot
  - embodied and situated robot
  - bottom-up
  - bio-inspired
  - new theories in graphs and networks
- Evolutionary Robotics: neural networks + evolutionary strategies
- non-structured environment (representation is not possible)
  - lack of information
  - changing environment
  - description too complex

Spectrum of Robot Control

Arkin's *Spectrum of Robot Control*:

Classic

- deliberative and symbolic
- classical AI
- High level Cognition
- structured environments

Nouvelle AI (Brooks)

- reactive and sub-symbolic
- conexionist AI
- embodied and situated cognition
- non-structured environments

Embodiment and situatedness

- symbols are the result of the perception of the element
- perception and action are related to the signal processing of the body
- the map of the world is the world itself
- the programmer does not choose which information is important

Problems of Evolutionary Robotics

- morphogenesis
- scalability

If the body (the humanoid robot) is fixed, the evolutionary strategies are applied to sensor and motor hand-made filtering and mainly to the dynamics and connectivity of the neural network.

Small World topology and STDP

To face morphogenesis and scalability:

STDP (a hebbian learning well suited for spiking neural networks) can change the topology of the net from random small world, present in some parts of the brain and with some optimal characteristics.

Simulation

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- Cheaper: lots of computational power
- no damaged robots because of bad controllers

We select SimSpark, used in RoboCup 3D Soccer Simulation League, and its Nao-like humanoid robot. Libbats is a library to ease the programming.

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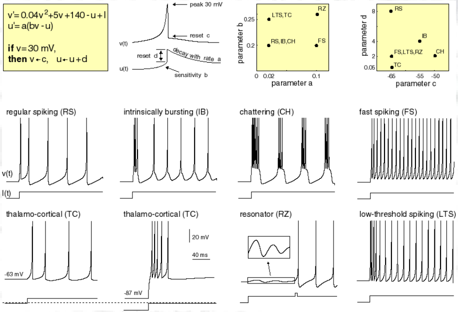
Izhikevich model of Spiking Neural Networks

- Fast but phenomenologically accurate
- Time among spikes codifies information and time-related events
- Polychronization or computation with spikes



The graphics processing units (GPU or graphics cards) are programmed to perform general-purpose computing. CUDA is the system used to program NVidia GPUs.

With the use of general-purpose graphics cards (GPGPUs), the speed of Izhikevich models is increased tens of times, allowing thousands of neurons.

The problem

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The fitness function tries to optimize through the evolutionary strategies the distance: the longer the covered path the better.

Conclusions

We have established a basis for a search of new techniques in Robotics

- Evolutionary Robotics
- bio-inspired bottom-up structure
- new model of neural networks in ER

in order to develop complex robots that could interact with a complex environment and have emerging behaviours.

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