Insect Brain Modeling for Cognitive Robotics

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XXV Cycle

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The goal of the PhD project is to improve and simulate a simplified model of the brain of the *Drosophila melanogaster*, already drafted in my Master Degree Thesis within the European project SPARK II.

Fly has a small brain that shows a wealth of complex behaviors. Genetic techniques allow to remove parts of the *Drosophila* brain and the analysis of mutants behavior can lead to hypotheses about the functions of every single brain part.
A biological sketch about Drosophila

Drosophila Brain:

- 150,000 neurons.
- Central Complex and Mushroom Bodies

Central Complex

Mushroom Bodies

- Ventral Ganglia
- Antennal Lobes
- Selective ablation of neuropils.

- Functional analysis: Mutants vs Wild Type

- **Central Complex:**
  - **Ellipsoid Body:** Visual Short Term Memory, Orientation.
  - **Fan-shaped Body:** Visual Learning.
  - **Protocerebral Bridge:** Object detection.

- **Mushroom Bodies:**
  - Olfactory Learning.
  - Adaptive termination of behaviors.

The Detour Paradigm after Neuser, 2008

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General Architecture

Sensorial Pathways

- Internal States
- Visual Pre-Processing
- Nociception
- Gustation
- Olfactory Pre-Processing

Drives
- PB
- FB
- EB

Behavior Selection
- MB (1)
- MB (2): Behavior Evaluation

Description of Behaviors

Environment

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General Architecture

- Object Detection
- Parallax Motion

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General Architecture

- Color
- Orientation
- Size
- CoG
- Wideness
- Height

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General Architecture

ONGOING: Learning behaviours association via STDP

[Diagram showing the General Architecture with nodes such as Internal States, Drives, and Visual Pre-Processing, along with WTA and Drive 1-4 representations.]
Sequence learning

- GOAL: Extending the capabilities of the model

Example: Solving Simple Mazes

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Neural Architecture for Sequence Learning

Sensing Layer

Self Organizing Spiking Layer (SOSL)

Reward Neuron

- WTA approach
- STDP learning

Pre-motor Area

Environment

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**Courses**

- Tecniche di programmazione avanzata  *(Prof. M. Malgeri, DIIT)*

- Computer Vision  *(Prof. S. Battiato, DMI)*

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