Insect inspired unsupervised learning

***SPARK II** Spatial-temporal Patterns for Action-oriented perception in Roving robots*

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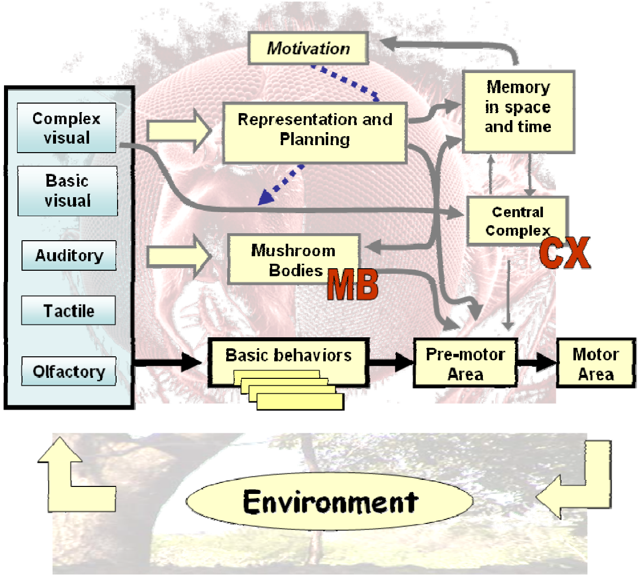
ORAL PRESENTATION

DIEES – University of Catania, Italy

Towards an Insect Brain Model

Here we focus on a simple learning algorithm that can be efficiently implemented into a mobile bio-inspired robot for real time unsupervised learning of new situations in dynamically changing environments. This is based on spiking networks, resembling a correlation-based approach introduced in the mid nineties after experimental observations in neural tissues, the so called **Spike timing dependent plasticity (STDP).** This learning rule was also recently studied in insect olfactory learning, which takes place in relevant centers of the insect brains, the so-called **Mushroom Bodies (MBs).** This strategy was focused to add new details toward the bio-inspired design and realization of an insect brain computational model. The architecture, designed in collaboration with insect Neurogeneticians, is organized in various control levels consisting of functional blocks, acting either at the same level, as competitors, or at distinct hierarchical levels showing the capability to learn more complex, experience-based behaviors. The control architecture consists of series of parallel sensory-motor pathways (i.e. basic behaviours) that are triggered and controlled by specific sensory events in a reflexive way, giving the knowledge baseline to the system. Going up in the hierarchical scheme, we can find besides the MBs, another relevant center for insect perception: the **Central Complex (CX).** Both MBs and CX are not yet well understood from a biological/neurogenetic point of view. However interesting studies underlined how deeply these structures are involved in perceptual processes. In particular MBs are mainly devoted to the enhancement of causal relations arising among the basic behaviours, by exploiting the temporal correlation between sensory events; information storage and retrieval in the case of the olfaction sense; resolving contradictory cues through the visual sense by imposing continuation or adaptive termination of ongoing behaviour.

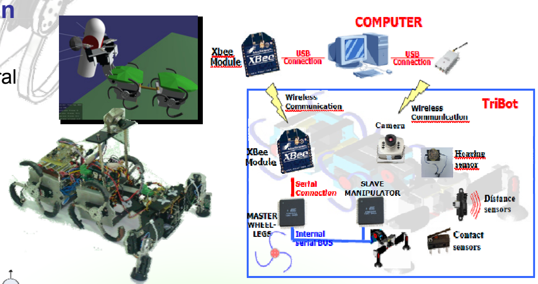


CX is instead responsible for integration and elaboration of visual information, storing and retrieving information on objects and their position in space, controlling the step length in order to approach or avoid such objects; motor control, landmark orientation and navigation, orientation storage and others. In this work we focus our attention to one of the main functionalities of MBs, based on STDP, creating a correlation-based anticipation layer. The higher layers of the brain architecture are even less understood, so we are currently making some hypotheses, with the introduction of a **Representation layer**, which contextualize sensory information, modulating the ongoing behaviors or giving rise to new behaviors that better shape the insect interaction with the environment. This is performed by using lattices of non spiking neurons giving rise to dynamical pattern formation, representing percepts. Patterns are trained, using a **Motivation** input, to learn new more complex behaviors. Although some of the functionalities of this layer are shared with the MBs and CX, in the next future, after experiments in the fly, a new architecture is envisaged, better modeling this perceptual learning

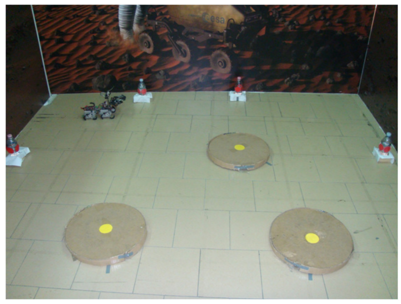
STDP based learning for behaviour selection

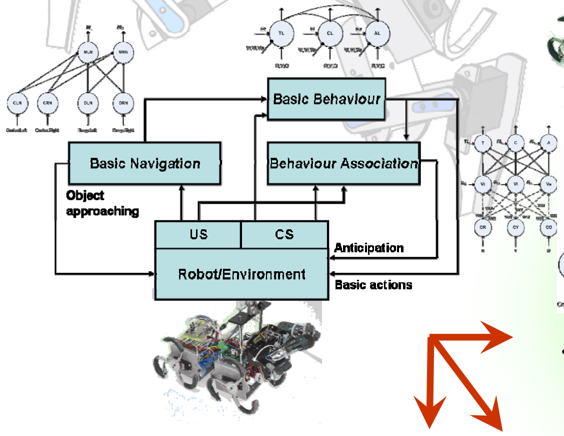
• The learning algorithm was applied to enhance the behavioral capabilities of a new bio-inspired robot called **Tribot**

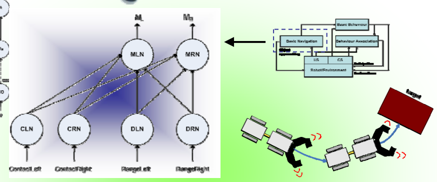
Tribot



Scenario

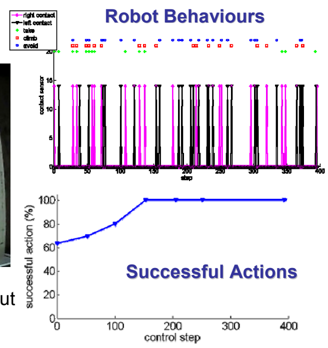




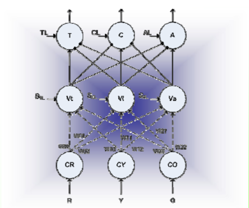


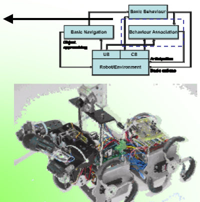
• The **Basic Navigation** block is a pre-defined structure with fixed synapses, used to approach the objects in the scene

Sensory system:
• 4 Distance sensors *(2x 4-30cm)(2x 10-80cm)*
• 4 Contact sensors *(threashold on distance)*



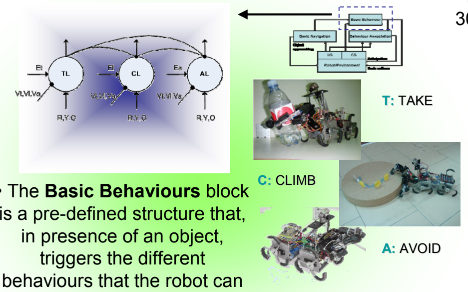
• **Learning phase** (about 30 min)





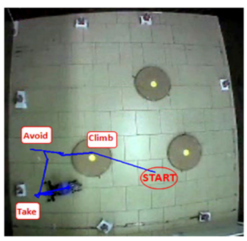
• The **Behaviour Association** block contains plastic synapses that through STDP learns correlation among visual cues and basic behaviours

Sensory system:
• Wireless Color Camera *(Centroid of red and yellow circles)*
• 3 Contact sensors
• Accelerometer



• The **Basic Behaviours** block is a pre-defined structure that, in presence of an object, triggers the different behaviours that the robot can perform in a predefined sequence

Beginning of the learning phase



End of the learning phase

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