SPARK

Spatial-temporal Patterns for Action-oriented perception in Roving robots

CogSys Cognitive Systems

Executive summary and objectives

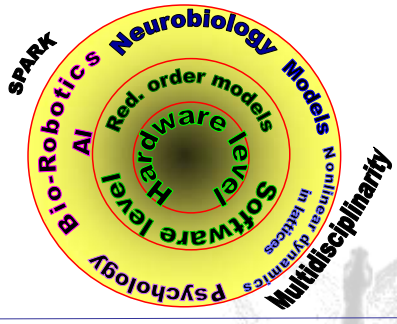
The aim of the SPARK Project is to develop sensing-perceiving-moving artefacts inspired by the basic principles of living systems and based on the concept of "self-organization". Sensors will be treated as devices processing signals distributed in space and also showing non linear time dynamics. Perception will be studied as a result of a spatio-temporal pattern forming process, determined by information deriving from sensors and will directly influence the particular associated motor behaviour. The whole methodology will be implemented in a new architecture, a Spatial-temporal array computer based structure (SPARC), providing a new paradigm for active perception based on principles borrowed from psychology, synergetics, artificial intelligence and nonlinear dynamical systems theory.
The technical objective will be a moving artefact that will actively interact with the environment. It will integrate the sensor stimuli, will create an iconic, abstract and concise representation of the environment under the form of a dynamically emergent pattern in a SPARC based architecture and will generate a sequence of proper motor actions to reach a pre-specified target.

Duration

Start time : September 2004
End-time : August 2007

Objectives

A) Representation and unification of Biological sensory systems under the framework of Spatial-temporal array computing (SPARC) architectures.
B) Introduction of a new paradigm for action-oriented perception, based on SPARC.
C) Implementation of the paradigm into a software/hardware environment with application to robot guidance.



Coordinator:

DIEES – University of Catania – ITALY

Prof. Paolo Arena
Luca Patanè, Ph.D

Prof. Holk Cruse
University of Belefeld – Institute for Biological Cybernetics

Prof. Manuel Velarde
Universidad Complutense de Madrid – Instituto Pluridisciplinar

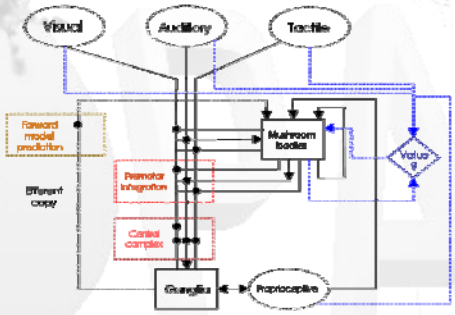
Prof. Barbara Webb
Institute of Perception, Action and Behaviour

Prof. Angel Rodriguez-Vazquez, Prof. Servando Espejo, Dr. Rafael Romay
Innovaciones Microelectronicas s.l. – Seville - Spain

Dr. Gusztav Bartfai
ANALOGIC Computers l.t.d. – Budapest - Hungary

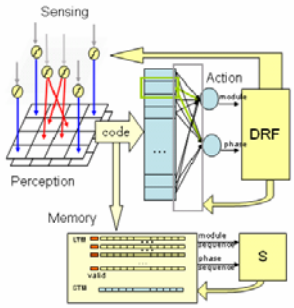
Bio-relevant insect brain model

- **Reflexive sensorimotor loops** (visual, auditory, tactile) using tuned sensory systems, some simple interaction, interfaced to adaptive motor controller that uses proprioception.
- Additional central coordination (**central complex**) for integrating and co-ordinating behaviours, persistance and switching
- Indirect, secondary pathways (**mushroom bodies**) for achieving context generalisation, more complex multimodal interaction
- Recurrent connections – **short-term memory**
- Value systems for learning – **plasticity and long-term memory**
- **Efferent copies and forward models**



Perception as an emerging pattern

• Perception is treated as a dynamical process: similar sets of sensorial inputs are dynamically translated into the same pattern as long as this pattern reflects an action which is really an adequate response to the received stimulus.



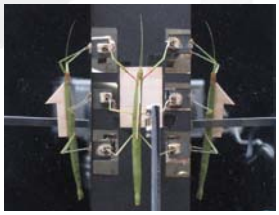
• Framework of the implemented perception system divided in blocks: Sensing, Perception, Action Selection Network and Memory, a block (DRF) with the purpose of evaluating the goodness of performed actions, and a block (S) which manages the memory, reinforcing valid sequences and weakening misleading ones.

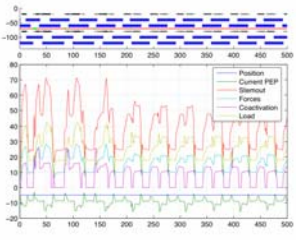
Walknet

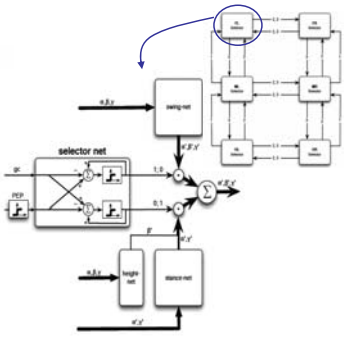
• The locomotion control system is based on biological experiments.

• Characteristic properties of the control system are its decentralized architecture that relies heavily on internal feedback as well as on sensory feedback and that exploits the physics of the body.

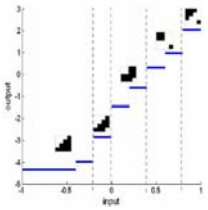
• Locomotion pattern obtained with the reflex-based control system.

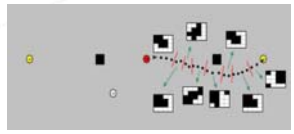






• Activation function of the sensory neuron connected to a distance sensor. The pattern occurring when the considered neuron has an output equal to the height of the step and the other neurons have null output value is reported.

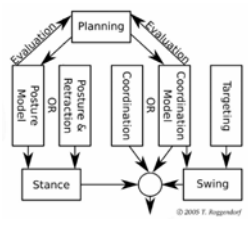




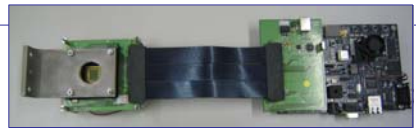
•Trajectory followed by a simulated robot and emerged patterns

Cognitive skills

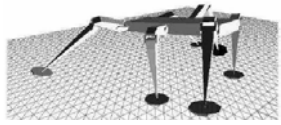
- From reactive to deliberative actions
- Build internal models
- Manage several situation models
- Planning ahead
- Detect possible instabilities
- Detect obstacles
- Circumvent obstacles

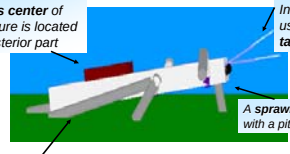


HW implementation SPARC v1.0



SPARC robotic platform





*A new design for the **rear legs** with only two DoF and a linear actuation*

Pro: High stability, avoid overturning
Optimal climbing capabilities
High payload

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