Developing Agents Populations through Ethogenetics

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Some issues related to MAS adaptivity and organization

Problems:

• Explicit prior design for real-world problems
• Coping with necessary reorganizations

We consider organization:

• as an emergent property of the system
• as a permanent process
Metaphors for Adaptive MAS (1)

Organism

- Adaptation of the whole system to its environment
- Emergence of a global behavior
- Possible perception of «!self!» (self-adaptation to perceptions, regulation...)

- Development of the system = ontogenetic process
Ecosystem

- Adaptation of each agent to its own environment
- Emergence of an organization in the system
- Collective learning process relying on the situatedness of the agents in the system

- Evolution of the agents in the system = phylogenetic process
Duality induced by the metaphors

Environmental constraints as selective pressure

Organism that develops (composed of agents) ⇔ Ecosystem Composed of agents that evolve
Purpose of our research

• Phylogenetic and ontogenetic processes = same phenomenon at different scales

• Proposal for self/system adaptation = the organization process of situated agents in the system

• Purpose = studying the evolutionary process that produces the organization, rather than the development process directly = how to have agents behaviors evolve in a situated system? («!Ethogenetics!»)
« Ethogenetics » is our approach to the design of evolvable agent behaviors in a situated system.

It implies the use of a structure for producing the behaviors of the agents, with the following requirements:

1. It should allow for agents behaviors to be of any complexity.

2. It should allow cumulative adaptation in order to allow

3. It should be evolvable through a «!blind!» evolutionary process (e.g. Darwinian selection) which is a kind of unsupervised learning.

4. It should be understandable and manipulable directly by a human designer (for bootstrapping, observation, modifications, explanation, reuse...).
Overview of evolutionary approaches

Genetic Algorithms, Evolutionary Strategies
(Holland, Schwefel)

Genetic Programming, Evolutionary Programming
(Koza, Fogel)

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parameters for a predefined behavior

Executable structure

+ continuity genotype □ phenotype
- poor expressive power

+ automatic behavior design
- strong and hierarchical dependencies between parts of the structure
The ATNoSFERES Model

Existing evolutionary approaches (e.g. Genetic Algorithms, Genetic Programming...) do not meet the 4 requirements simultaneously!

The model we propose as an illustration of Ethogenetics is based on:

• a non-deterministic automaton to represent the behavior of any agent (labeled ATN-like graph; ensures properties 1 & 4)

• a bitstring as hereditary substratum (gene) for building this automaton

• a stack-based gene expression process (to ensure properties 2 &
The ATNoSFERES model Agent architecture

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bitstring
Translation
tokens
Interpretation
Labeled graph
Stack-based Gene Expression

(a) tokens
(b) stack
(c) structure
Biological Gene Expression

a. amino acids → peptidic chain
   → ribosome
   → nucleic acid chain

b. enzymes

c. protein
Properties of the ATNoSFRERES Model

- No specific hypothesis regarding the cognitive abilities of the agents
- Any genotype (bitstring) produces a consistent automaton
- Continuity between genotype (bitstring) and phenotype (ATN)
- Completeness of the ATN-building language

- Validation of the model through simple problems
- Exploitation on various maze problems
- Specific model properties
Conclusions & Perspectives

- Synthesis between evolutionary approaches and agent architectures
- Software engineering considerations (economy, reuse...)
- Adaptive behavior considerations (economy, inner states, structural representation...)

- Next experiments: predators/preys coevolution

- Applications to multi-robot experiments (MICRobES Project)
- Applications to network reliability/security (analogy with immune system)