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Multi-objective Intrinsic Evolution of Embedded Systems (MOVES)

Motivation and Goals

Investigate intrinsic evolution as a mechanism to achieve self-adaptation and –optimization for autonomous embedded systems.

Develop autonomous embedded systems that are capable to ...

- adapt to slow changes caused by the environment
- adapt to radical changes caused by faults or reassignment of system resources

This is achieved by a combination of biologically-inspired methods, multi-objective optimization and reconfigurable hardware.

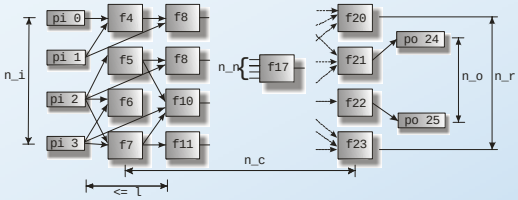
Biologically inspired methods
- adapt to slow changes by simulated evolution
- generate hardware functions by evolutionary design (evolvable hardware)

Multi-objective optimization
- multi-objective evolutionary algorithms compute reasonable comprises in the presence of conflicting optimization criteria
- adapt to radical changes by switching to pre-evolved alternatives

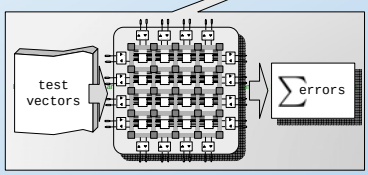
Reconfigurable hardware
- the adaptability of hardware resources requires reconfigurable hardware technology
- autonomous operation requires the evolutionary optimizer to run on the same embedded target as the optimized function

Models and Algorithms

Evolutionary algorithms require a hardware representation model to encode the chromosomes of the candidate solutions. The hardware representation model should be ...
- close to the target technology for a simplified mapping
- application-specific to improve the evolutionary algorithm's convergence behavior



Cartesian Genetic Programming Model

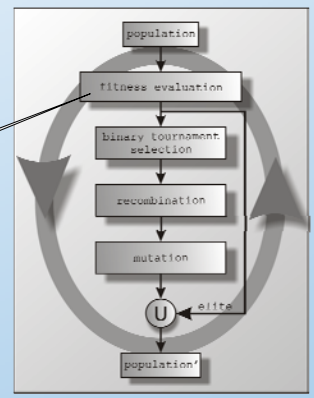


Fitness Evaluation

Evolutionary Algorithms

Stochastic search algorithms using the bio-inspired operators recombination, mutation and selection to steer the search process.

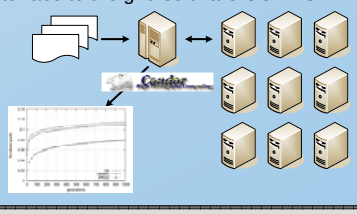
Particularly suitable for applications where ...
- the optimal solution is unknown or too complex to compute
- the functional quality depends on input data



Genetic Algorithm

Experimentation Environment

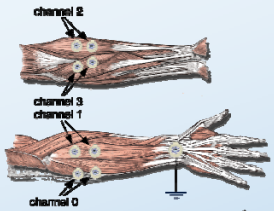
MOVES simulation framework
- modularized framework for evolvable hardware experiments
  - different hardware representation models
  - different optimization objectives
  - different (multi-objective) evolutionary algorithms
- graphical analysis tools
- export of resulting circuits to the Xilinx tool chain
- interface to the grid software CONDOR

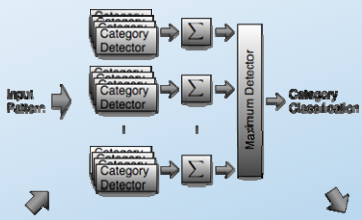


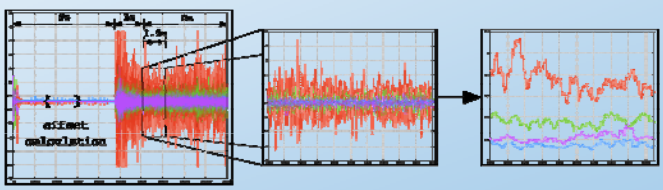
Application Areas

Signal Classification

- image recognition
- muscle contraction recognition
  - wearable system
  - adaptable to changing
    - sensor setup
    - muscle fatigue
    - age of the user







Robot navigation

Testbed for complex systems, where we investigate
- self- and online-adaptation
- modes of fitness evaluation

EyeBot robot platform

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