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 compromises 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

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

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

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 processing
- Pattern recognition
- Robot navigation

Classification of Electromyographic Signals:

- Feature extraction
- ECGP-based classifier
- Recognition rate
- Continuous adaptation necessary for high recognition rates

Evolvable Cache Controller:

- Optimizing of memory-to-cache address mapping function
- Cache configuration: level one instruction and data cache, level two unified cache
- Test performance of optimized:
  - level one instruction and data cache
  - level one instruction and data cache, level two unified cache

Recent Publications:


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Multi-objective Intrinsic Evolution of Embedded Systems (MOVES)