UNIVERSITÄT PADERBORN
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Multi-objective Intrinsic Evolution of Embedded Systems (MOVES)

SPP OC Bochum '09

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

Deutsche Forschungsgemeinschaft DFG

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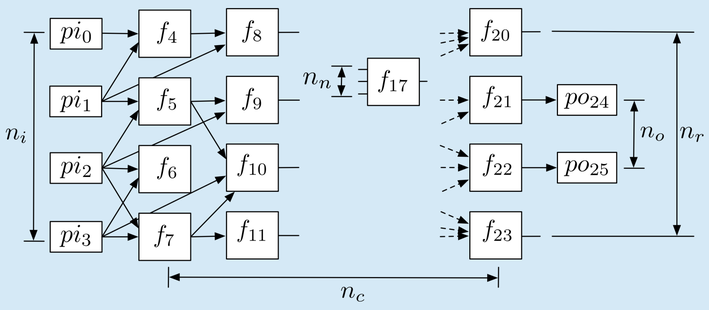
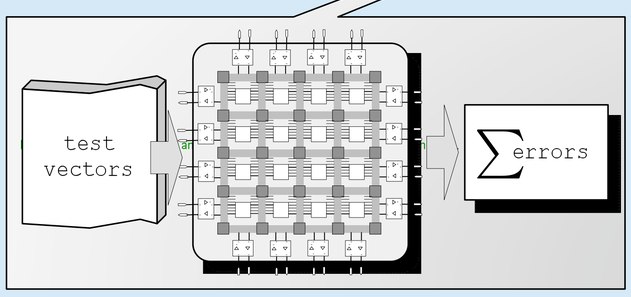
Models

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



Cartesian Genetic Programming model



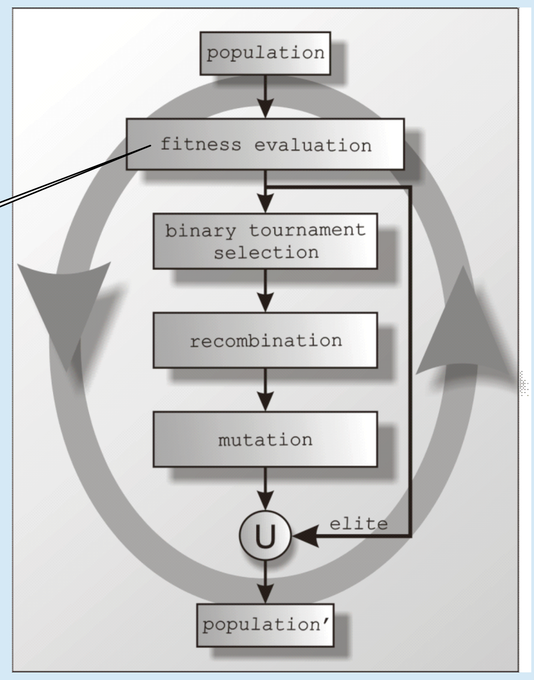
Fitness evaluation

Evolutionary Algorithms

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

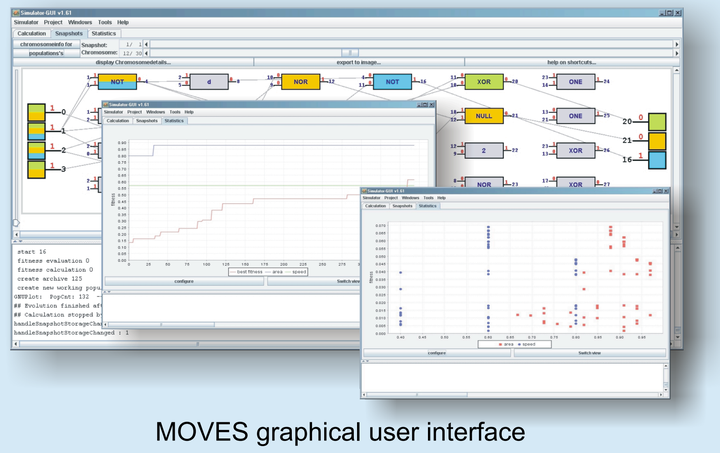
Particularly suitable for applications where ...

- the optimal solution is unknown or too complex to compute
- the functional quality depends on input data



Genetic algorithm

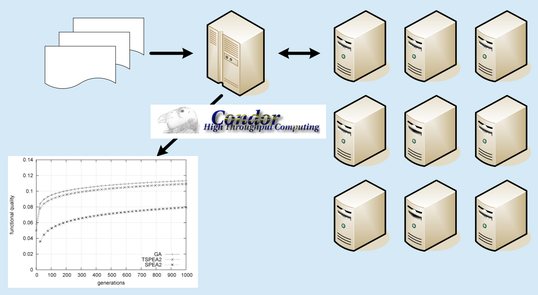
Experimentation Environment



MOVES graphical user interface

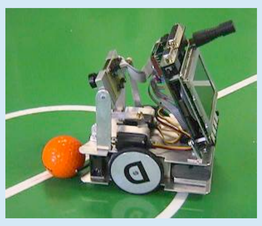
MOVES simulation framework

- 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



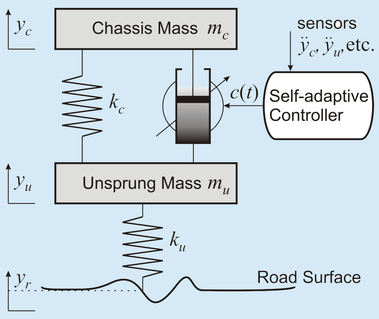
Application Areas:

- Signal processing
- Pattern recognition
- Robot navigation



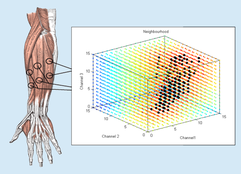
EyeBot robot platform

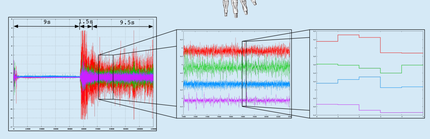
Evolvable hardware robot controller

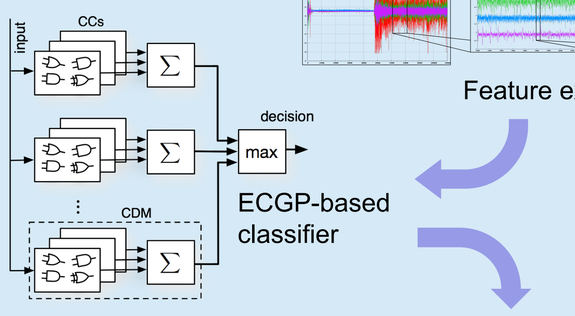


Self-adaptive active suspension

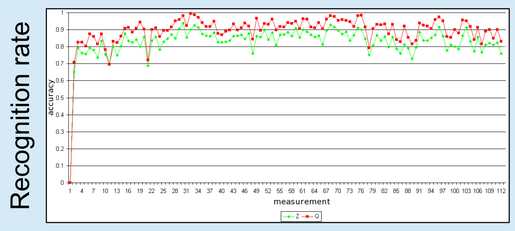
Classification of Electro-myographic Signals:





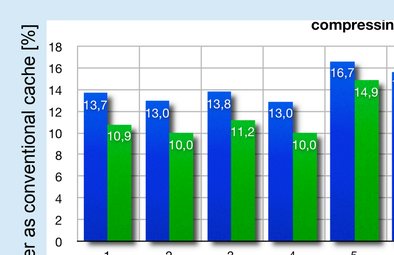


Feature extraction



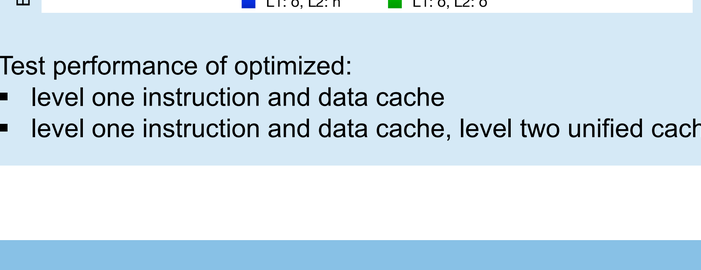
Continuous adaptation necessary for high recognition rates

Evolvable Cache Controller:



Optimizing of memory-to-cache address mapping function

Cache configuration: level one instruction and data cache, level two unifed cache.



Test performance of optimized:

- level one instruction and data cache
- level one instruction and data cache, level two unified cache

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Recent Publications:

Kyrre Glette, Jim Torresen, Paul Kaufmann, and Marco Platzner. **A Comparison of Evolvable Hardware Architectures for Classification Tasks**. In *Proceedings of the 8th International Conference on Evolvable Systems: From Biology to Hardware (ICES), LNCS. Springer, September 2008.*

Paul Kaufmann and Marco Platzner. **Advanced Techniques for the Creation and Propagation of Modules in Cartesian Genetic Programming**. In *Proceedings of the Genetic and Evolutionary Computation Conference (GECCO), Atlanta, Georgia, USA, July 2008. ACM.*

Kyrre Glette, Jim Torresen, Thiemo Gruber, Bernhard Sick, Paul Kaufmann, and Marco Platzner. **Comparing Evolvable Hardware to Conventional Classifiers for Electromyographic Prosthetic Hand Control**. In *Proceedings of the NASA/ESA Conference on Adaptive Hardware and Systems (AHS), Noordwijk, The Netherlands, June 2008.*