Evolvable Filters in Hardware and Software

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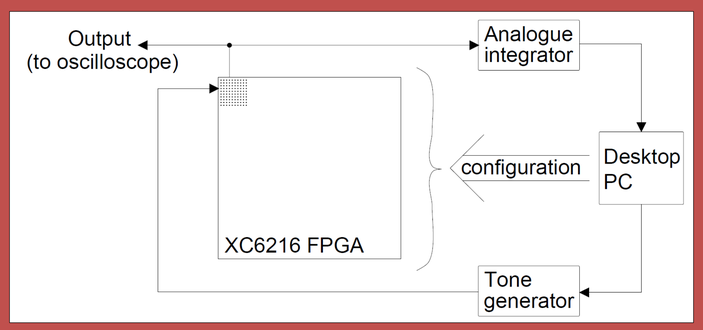
Pitfalls of Conventional Filtering

Many modern applications in electronics require a large amount of digital signal processing (DSP) to maintain accuracy and efficiency. While most conventional signal filters provide fast, accurate results, they suffer from several issues:

- **Requires complex algorithms**
- **Relies on significant info. on signal parameters**
- **Offers little adaptability to signal changes**

Prior Research on Genetic Algorithms

Adrian Thompson at the University of Sussex conducted research on evolvable hardware as a method of assessing genetic algorithms (GAs). In particular, Thompson developed a module on a Field Programmable Gate Array (FPGA) that discriminates between signal tones without using a system clock.



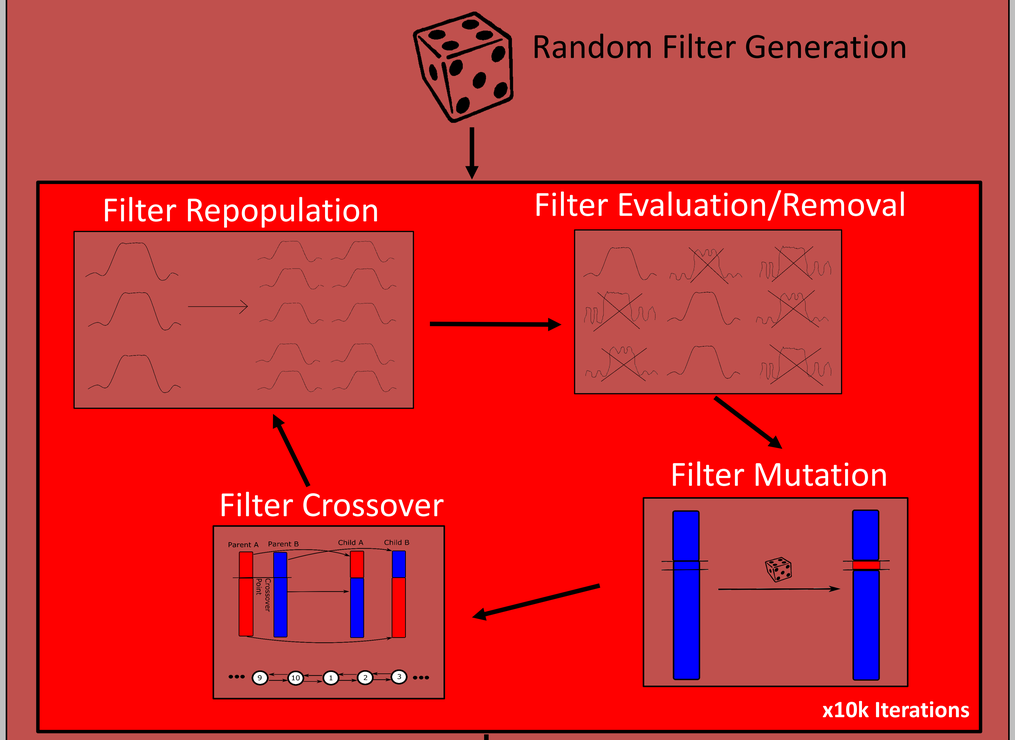
These tests inspired an abundance of projects using GAs for other applications, such as operations optimization and computer-aided Design.

Others, such as Ranjit Chauhan and Sandeep Arya, have developed digital filters based on GAs in hardware, which opens more opportunities for efficient signal processing implementations.

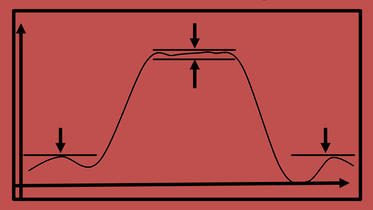
Design of Evolvable Filter Algorithm

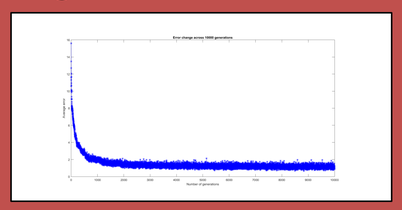
I have developed a software genetic algorithm that performs selective evolution on the filter coefficients featuring:

- Random filter coefficient generation
- Filter mutation that encourages genetic diversity
- Customizable filter performance evaluation modules
- Crossover module for gene sharing



Highest Performing Filter

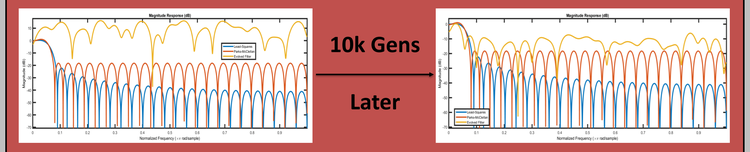




The Evolvable Filter Algorithm provides advantages over conventional filters in several key ways:

- **Greater adaptability** to desired filter parameters
- **Simpler, more intuitive implementation**
- **Multiple unique solutions** across several runs of algorithm

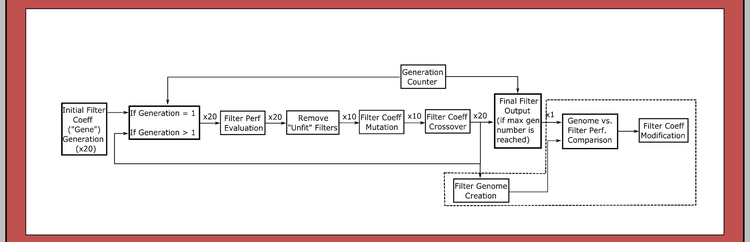
Evolvable Code Provides Effective Filtering



Testing with initial random coefficients shows that the **evolvable filter shows promise against conventional DSP** filter algorithms. While overall accuracy depends on the strength of the evaluation module (AKA "fitness" test), the evolved algorithm can converge from a set of random numbers to a capable filter. In addition, I am currently developing the GA on an **FPGA to provide high computation speeds** competitive to conventional filter designs.

Future Improvements on Evolution

I aim to further the evolvable algorithm's capabilities as a general-purpose digital filtering solution through:



- Testing of of new fitness functions(e.g. phase check)
- Implementation on FPGA for higher speed
- Creation of future gene prediction (e.g. Epigenetics)

References and Acknowledgements

[1] Thompson, Adrian. "An evolved circuit, intrinsic in silicon, entwined with physics". 1st International Conference on Evolvable Systems.

[2] Mostafa et al. "Hardware Implementation of Genetic Algorithm on FPGA". 21st National Radio Science Conference.

[3] Chauhan, R. and Arya, S. "An Optimal Design of FIR Digital Filter Using Genetic Algorithm". Communications in Computer and Information Science, vol. 168.

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