

A Parallel Genetic Algorithms applied to acoustic noise cancellation.

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Abstract: This paper studies the application of genetic algorithm to actively cancel acoustic noise on rectangular ducts. The software was designed to work in a parallel DSP TMS320C44 architecture managing real time interrupts and communication with a shared memory. A UNIX simulator was developed with a simplified model to test the software. The noise reduction obtained in simulations is around 40 dB and the experimental results 20 dB down.

This paper updates last publication on the DINAME 97 ^[1] proceedings and shows recent acoustic developments of the Dynamic and Control Laboratory- University of São Paulo.

The genetic algorithm.

The evolution and improvement of life occurs through the reproduction, when each individual contributes with its own genetic information building a new one ^[2] with fitness to the environment and more surviving chances. With the objective of obtaining the sound components to be used for the cancellation of undesirable noise in the interior of ducts, a computer software which mimics the genetic process ^[3] was developed. Each 'individual' of the generation represents a signal component with a different frequency, phase, and amplitude. It creates a population randomly distributed and evaluates the fitness of each individual. The best individuals are selected, and crossover and mutation take place. Following few generations, the population converges to the mix of components that better reduce the acoustic noise.

Two different approaches based on genetic algorithms (GA) were studied. In the Simple Genetic Algorithm (SGA) each individual of a generation represents a specific frequency, phase and amplitude used in cancellation of noise, and the fitness function is the average energy of the signal (Fig. 1). The Successive Approach Genetic Algorithm (SAGA) is a modification of SGA, where a first level search the best frequencies and a second level improves them between fixed limits (Fig.2).

The experimental result analysis.

The experimental setup consists of a rectangular duct of 18' long, with speakers to generate the noise and the cancellation signal.

The SGA parameters and variables are shown in Fig. 1 (table) for simulation and experimental values. The experimental setup needs less individuals than the simulator due to the actual signal fluctuations, resulting in the increase of the convergence rate in the neighbour of destructive interference region. The reduction of 20 dB is an experimental observed limit where the duct resonance begins to interfere with feedback control system.

Fig. 1 (bottom) shows the distribution of each individual value of frequency and fitness. Until the seventh generation the individuals displays a randomly frequency value, and a decreasing fitness. Then, the algorithm converges to the destructive value and maintains itself stable.

The Fig. 2 shows the results of SAGA implementation. The first level converges very fast to the desirable frequency, defining the limits to the second level. The destructive region decreases and the second level algorithm finds the final result after 5 generations. The distribution graphics of each individual are locate below the table of parameters and variables, and they display the perspective of a good result with variable frequencies.

Conclusions

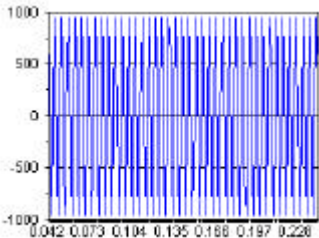
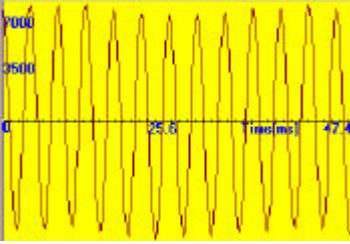
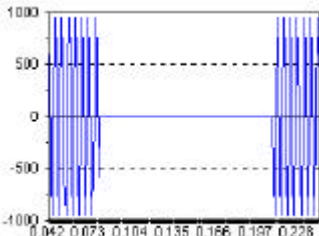
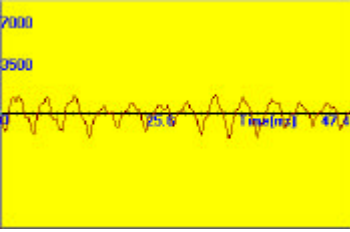
The two implementations are running very well under controlled environment. The next step is the development of an operational version, where the fitness evaluation time will be reduced to permit the application to control acoustic noise in an air conditioning system and a real land or airborne vehicle.

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BIBLIOGRAPHY.

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- [2] Renato Basile & Luis Edmundo de Magalhães ; Citologia e genética; Editora Cultrix (1976)
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Chromosome codes the frequency, amplitude and phase.
Fitness calculates through the signal energy.

Parameters & variables	Simulator	Experimental duct
Frequency	16 bits (100 to 500Hz)	16 bits (100 to 500 Hz)
Phase	16 bits (0 to 2 Pi)	16 bits (0 to 2 Pi)
Amplitude	16 bits (0 to 10000)	16 bits (80 to 120)
Populations	500	200
Generations	100	20
Crossover	0.5	0.5
Mutation	0.05	0.05
Noise		
Noise+signal		
Reduction	40 dB	20 dB

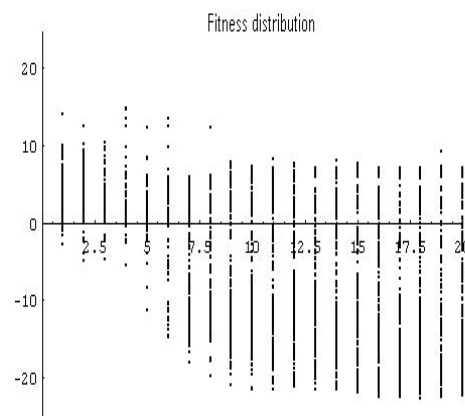
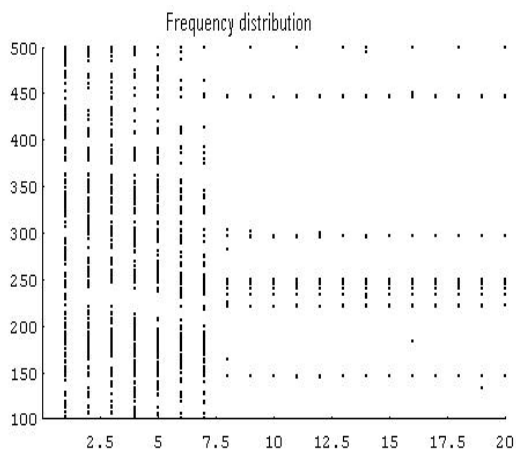
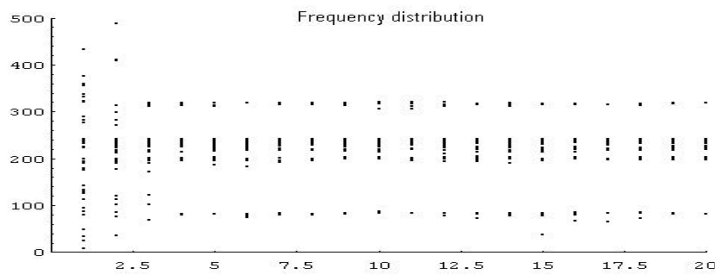


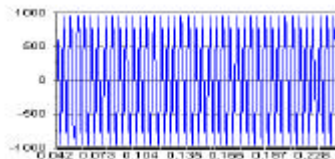
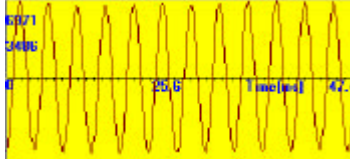
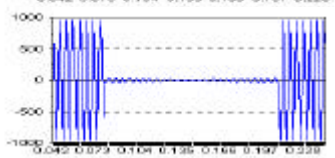
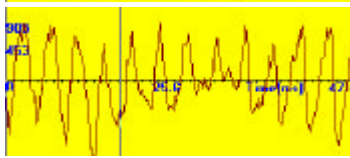
Fig.1 SGA results of the simulator and experimental rectangular duct.

Level 0: chromosome codes the frequency. **Fitness** through the signal FFT.

Parameters & variables	Simulator	Experimental duct
Frequency	24 bits (100 to 500Hz)	16 bits (100 to 500 Hz)
Population	300	100
Generations	20	20
Crossover	0.5	0.5
Mutation	0.05	0.05



Level 1: chromosome codes the frequency, phase and amplitude between defined limits into level 0. **Fitness** calculates the signal energy.

Parameters & variables	Simulator	Experimental duct
Frequency	8 bits	16 bits
Phase	8 bits (0 to 2 Pi)	16 bits (0 to 2 Pi)
Amplitude	8 bits (0 to 10000)	16 bits (100 to 30000)
Population	300	100
Generations	20	20
Crossover	0.5	0.5
Mutation	0.05	0.05
Noise		
Noise+signal		
Reduction	40 dB	18 dB

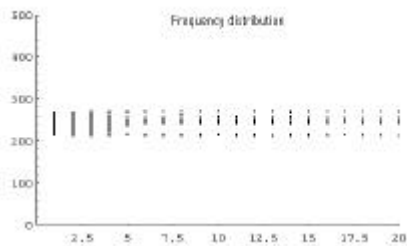


Fig.2 SAGA results of the simulator and experimental rectangular duct.