An Approach to the Calibration of Modelica Models

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Outline:

-Motivations of *GAPI*Lib
-Why GAs?
-Structure of GAs
-*GAPI*Lib architecture
-New capabilities of *GAPI*Lib
-Some results
-Conclusions
-Future work

- Motivations of *GAPI*Lib

Fitness of parameters

- A model has usually some parameters with unknown values.
- The validation process requires to estimate this group of parameters.
- *GAPI*Lib is a tool to fit the parameters from experimental data.

Optimization

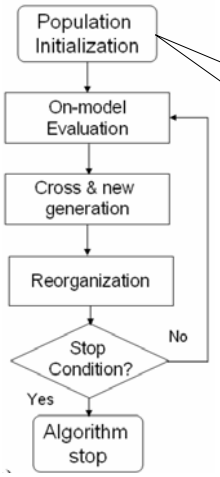
-To fit some parameters of a model to improve the behavior of the real plant.

A free-availiable optimization tool for Modelica models

- Why GAs?

- Robustness and simplicity: without needing to modify the model.
- Finding solutions in high-dimensional search spaces.
- The search range of the parameters can be changed during the algorithm run.
- Parallel implementations of GAs, intended to reduce the computation time.

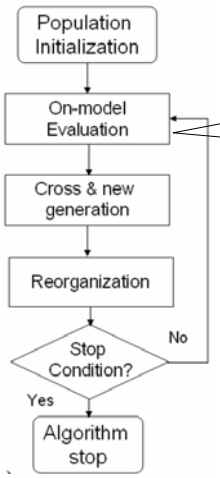
- Structure of GAs



The GA starts with an initial population, which is randomly selected from the search space.

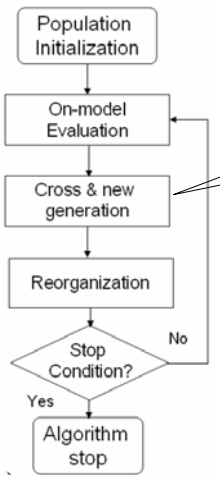
Each individual of the population is formed by a group of chromosomes, which represents a solution to the problem.

- Structure of GAs (II)

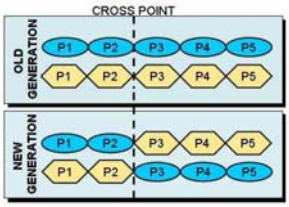


This population is evaluated by using a cost function.
This function is used to calculate the validity of the population members, which are ordered according to this criterion.

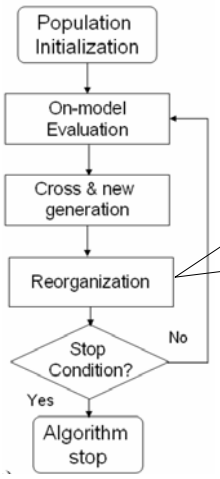
- Structure of GAs (III)



The most valid members are selected for the crossover process, which generates a new population.



- Structure of GAs (IV)

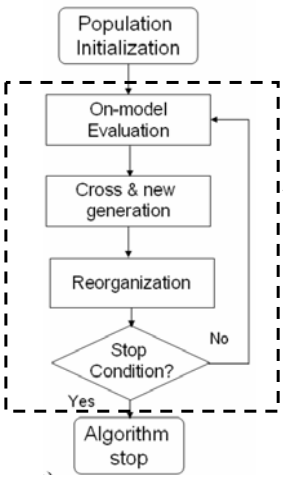


The GA supported by *GAPI*Lib includes several processes intended to improve the algorithm performance:

+ **Elitism** ensures that the most valid individuals pass on to the next generation.

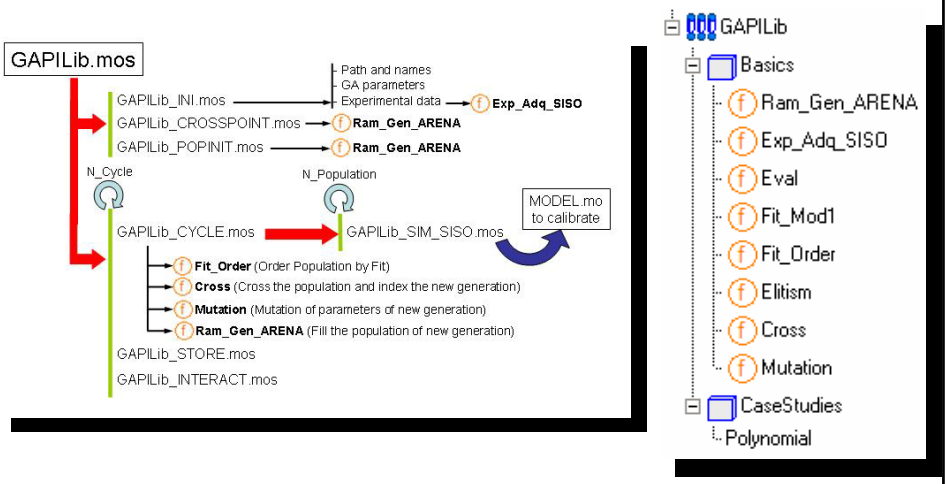
+ **Mutation** introduces random changes on the individuals. The purpose of mutation is to allow the algorithm to avoid local minima.

- Structure of GAs (V)

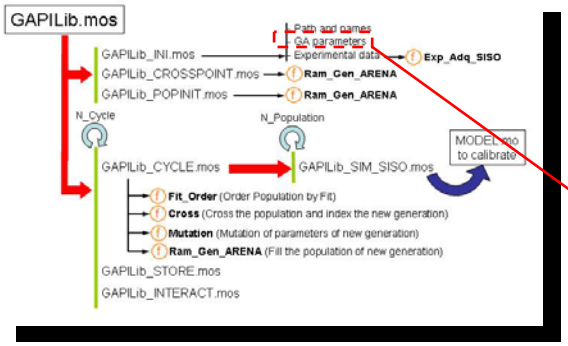


The stop condition is not satisfied, the algorithm goes on.
The new generation completes a new cycle of the algorithm.

- *GAPI*Lib architecture



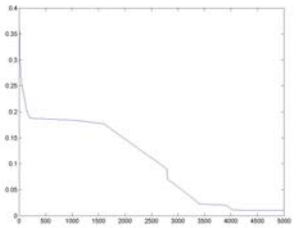
- *GAPI*Lib architecture (II)



N_Population	Number of individuals in the population.
N_Parameters	Number of parameters to identify in the model (i.e., in Model.mo).
N_Parents	Number of parents of the population selected to cross.
N_Elitism	Number of elite individuals. If N_Elitism=0, then the Elitism function is no applied.
N_Cross_Point	Number of crossing points.
N_Cycle	Number of generations calculated. This value sets the stop condition.
F_Mut	Probability of random modification of an individual due to mutation.

- New capabilities of *GAPI*Lib

Runtime monitoring of the algorithm convergence

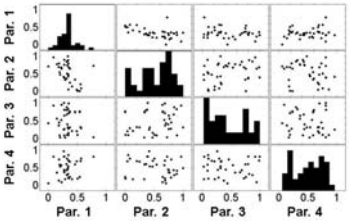


Interactivity of the GA parameters

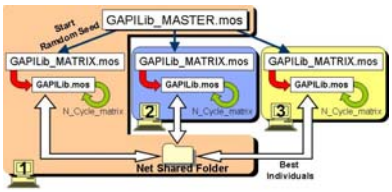
- Range of parameters (Auto-Interactivity-Fixed)
- Elitism factor
- Mutation factor
- Cross point

- New capabilities of *GAPI*Lib (II)

Parameter sensitivity

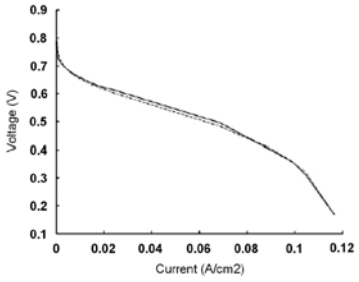


Parallel computing of the GA



- Some results

Polarization curves of PEMFCs

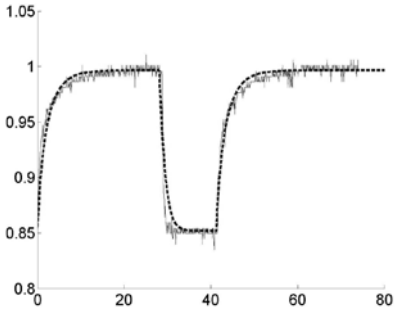


Parameter		Value	Unit
A	Tafel Slope	0.0390	V
I_n	Internal current density	$1.4 \cdot 10^{-3}$	$A \cdot cm^{-2}$
I_0	Exchange current density	$1.5856 \cdot 10^{-6}$	$A \cdot cm^{-2}$
B	Mass Transfer slope	0.0918	V
R	Internal specific resistance	$7.2860 \cdot 10^{-4}$	$\Omega \cdot cm^{-2}$
I_{lim}	Limiting internal current density	0.2265	$A \cdot cm^{-2}$

$N_{Parameters}$ =7
N_{Cycle} = 5000
$N_{Population}$ =100
F_{mut} =0.25
$N_{Parents}$ =70
$N_{Elitism}$ =1

- Some results (II)

Fuel cell voltage in response to step changes in the load

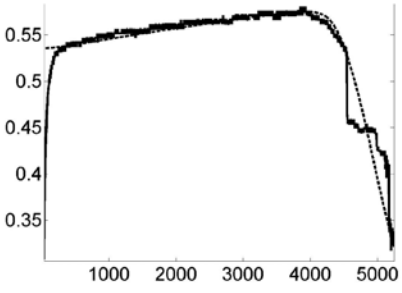


Parameter		Value	Unit
R_{inf}	Low value of the load	0.03315	$\Omega \cdot m^{-2}$
R_{sup}	High value of the load	5.1	$\Omega \cdot m^{-2}$
C_{dl}	Double layer capacitance	10.12	$F \cdot m^{-2}$
k_s	Electrical conductivity of the solid	0.01	$S \cdot m^{-1}$

$N_{Parameters}$ =4
N_{Cycle} =200
$N_{Population}$ =150
F_{mut} =0.25
$N_{Parents}$ =100
$N_{Elitism}$ =1

- Some results (III)

Effect of water on the fuel cell voltage with constant resistance load



Parameter		Value	Unit
$d_{a(Act)}$	Width of active layer	$6 \cdot 10^{-8}$	m
ϵ_g	Volume fraction of pore	0.05	
D_{12}	Binary diffusion coefficient	$5 \cdot 10^{-9}$	$m^2 \cdot s^{-1}$
$d_{a(Mem)}$	Width of membrane layer	$1.6 \cdot 10^{-5}$	m
R_{mem}	Resistance of membrane layer	$1.42 \cdot 10^{-3}$	$\Omega \cdot m^{-2}$

$N_{Parameters}$ =5
N_{Cycle} =700
$N_{Population}$ =70
F_{mut} =0.15
$N_{Parents}$ =50
$N_{Elitism}$ =1

- Conclusions

- *GAPI*Lib is an effective tool for parameter identification in Modelica models using GA.

- It is completely written in the Modelica language, which facilitates its use, modification and extension.

- *GAPI*Lib is a free library.

- Future Work

- Implementation of parallel structure.
- Theoretical study of the parameters´ sensibility.
- Improvement of its capability for optimization.

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THE END

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