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Empirical evaluation of the efficiency of Genetic and Particle Swarm algorithms for kinetic mechanism optimization.

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Context and Objective
- Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) are two evolutionary algorithms widely used for optimization
- GA is well known and used for detailed kinetic mechanisms optimization [1] but, so far, PSO is not
- Objective: compare the performances with the open-source tool Brookesia [2]

2. Error computation
- Ignition delay
  \[ Er(\delta) = 1 - \frac{\delta_{opt}}{\delta_{ref}} \]
  \[ Er(i) \approx \frac{|A_{ref} - A_{opt}|}{A_{ref}} \]
  \( Er: \) relative error \( \delta: \) ignition delay time \( A: \) area below the profile with:
  \( ref / opt: \) simulation from reference / optimized mechanism

3. a. Optimization by Genetic Algorithm
- Concept
  1. from randomly modified kinetic mechanisms a series of simulation is performed
  2. based on the result analysis, the best mechanisms (individuals) are retained (Selection operator)
  3. individuals will share parameters (Cross-Over operator) to generate new mechanisms (children)
  4. some individuals will be partially randomly modified (Mutation operator)
  5. a new series of simulation is performed and the cycle is repeated
- Strategies
  

<table>
<thead>
<tr>
<th>Strategies</th>
<th>Selection</th>
<th>Crossover (%)</th>
<th>Mutation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of individuals: 20</td>
<td>x</td>
<td>x</td>
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</tbody>
</table>

- Performances
  each strategies repeated 20 times:
  - Mean error is averaged over the 20 trials
  - the standard deviation measured between trials is shown below

3. b. Optimization by Particle Swarm Algorithm
- Concept
  1. from randomly modified kinetic mechanisms a series of simulation is performed
  2. each kinetic mechanism is a particle, its dynamics is governed by:
    - an inertial component, relative to the speed of the iteration of the previous iteration
    - a cognitive component based on the best solution found by the individual during the optimization process
    - a social component based on the best location the neighbours of the particle found up to the iteration
  3. a new series of simulation is performed and the cycle is repeated
- Strategies
  

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- Performances
  Each strategies repeated 20 times:
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3. c. Simulation results
- CH4/air \( \Phi=0.5 \) \( T = 1500K \)

Conclusions
The comparison of the PSO to GA optimization approach led to the following observations:
- some strategies are more efficient than GA.
- those strategies come along with very high convergence rates
- high sensitivity to the choice of parameters
- lower reliability to the success of an optimization

Given the simplicity of the PSO approach, this work demonstrates the interest in considering PSO optimization as a good alternative to GA.

References