Concise Metamodels of Simulated Systems

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Preliminaries

- Simulation model — a mathematical model that is solved by means of experimentation [1]
- Metamodel (a.k.a. surrogate model) — an approximation of the input/output function that is defined by the underlying simulation model [1]

Purposes of metamodels [2]:
- Simulation model approximation (reduce costs)
- Design space exploration (“what if?”)
- Problem formulation (inputs’ significance)
- Optimization support

The Experimental System [3]

- The electrical grid frequency $\omega$ is connected to the electricity price
  $p_\omega = p_\Omega + c(\Omega - \omega)$
- Electrical grid connects $n$ electricity consumers and producers
- Participant $i$ measures frequency $\omega_i$ at his place, averages it over time $T_i$, calculates price and adapts his/her consumption after time $\tau_i$

One uses simulations to ensure the system stability given specific values of inputs ($\tau_i$, $T_i$, and others)

Methodology

- Run many simulations (4-node system)
- Estimate different metamodels
- Compare metamodels according to various criteria

<table>
<thead>
<tr>
<th>Group</th>
<th>Models</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>Most frequent class</td>
</tr>
<tr>
<td>Linear</td>
<td>Logistic, LDA, SVC</td>
</tr>
<tr>
<td>Tree</td>
<td>CART, C5.0, C4.5</td>
</tr>
<tr>
<td>Rules</td>
<td>PRIM, PART, Ripper, C5.0 rules</td>
</tr>
<tr>
<td>Complex</td>
<td>RF, SVM, Boosted trees</td>
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</tbody>
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Some Results

Quality measures: (1) Accuracy (2) Consistency — the similarity of the models produced on different training sets generated by the same phenomenon (3) Comprehensibility — the number of leaves in decision trees or rules

Future Work

- For which input values to run the simulations?
- How many simulations to run?
- How to minimize the number of simulations, still obtaining good metamodel?

References