Simulation Studies Method to identify Occupancy Schedules from Indoor Climate Measurements

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Current situation

Current calibration procedure:

- Unsystematic adjustment of input parameters
- Results credibility depends on the experts experience

Challenges in the field of building simulation are:

- Various unknown input parameters
- Mutual influence – no unique solution

Guidelines about systematic calibration methods rare (US- American research project by ASHRAE : RP-1051)
ASHRAE Research Project RP-1051

Purpose of this project
- Cull best existing tools, techniques, approaches and procedures
- Develop coherent and systematic calibration methodology

Calibration Methodology suggested by RP-1051

1. Sensitivity analysis to identify most influencing parameters (others are kept as fixed values) by the help of a coarse grid search
2. Identifiability analysis to detect uniquely determinable parameters based on measurement data (others are kept as fixed values)
3. Estimate uncertainty range of detected parameters due to the uncertainty interval of non-determinable parameters by the help of Monte Carlo analysis
Calibration method for schedule detection

**Aim of the presented method**

- detect a various unknown occupancy schedules based on simple indoor climate measurements

**Characteristics of this method**

- Set of unknown parameters for each time step
- Uniqueness is ensured by the time course and influence level of each schedule type
- detection hierarchy needed to identify the schedules
Method description: compilation of schedule versions for each unknown schedule type
Holistic approach

Hierarchical approach

Considered number of combinations (all):

(schedule versions) · (schedule types)

example: 20 versions, 4 types
20^4 = 160,000 combinations

Considered number of combinations:

(schedule versions) · (schedule types)

example: 20 versions, 4 types
20 · 4 = 80 combinations
Version which influences simulation results (fluctuation) the less: **MIN version**

Version which influences simulation results (fluctuation) the most: **MAX version**

Schedule hierarchy = Simulation studies hierarchy
Method application: example building

- Hospital Building, located in Dresden, erected in 2003
- Local outdoor climate measurements
- Only base indoor climate measurements

- Combination of user defined and system controlled ventilation and sunscreen activation
- Missing knowledge about user interaction with building
Method application: base simulation model results (indoor air temperature)
Method application: base simulation model results (indoor air temperature)

Frequency Distribution Characteristics Measurement

Frequency Distribution Characteristics Simulation

Method application: compilation of schedule versions for the example of sunscreen activation
Method application: compilation of schedule versions for the example of sunscreen activation

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<thead>
<tr>
<th>SSA</th>
<th>Outdoor Conditions</th>
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<tbody>
<tr>
<td>none</td>
<td>Min Global Radiation</td>
</tr>
<tr>
<td></td>
<td>500 W/m²</td>
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<tr>
<td>-</td>
<td>26 °C</td>
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</table>

<table>
<thead>
<tr>
<th>Indoor Conditions</th>
<th>Min Air Temperature</th>
<th>Min Sol. Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min Air Temperature</td>
<td>27 °C</td>
<td>26 °C</td>
</tr>
<tr>
<td>Min Sol. Incidence</td>
<td>700 W/m²</td>
<td>600 W/m²</td>
</tr>
<tr>
<td>Qe500</td>
<td>Qe600</td>
<td>Qe700</td>
</tr>
<tr>
<td>Qi700</td>
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</tr>
<tr>
<td>Te26 Qi700</td>
<td>Qi700 Te30</td>
<td>Qi600 Te30</td>
</tr>
</tbody>
</table>

Min version
Max version

TU Dresden, 21.10.2013
Simulation Studies Method Occ. Schedules
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Method application: sensitivity analysis

**Detected simulation order:**

1. **1st level:** SSA
2. **2nd level:** WO
3. **3rd level:** EH
4. **4th level:** PH

**Detected simulation order:**

1. **1st level:** WO
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Method application: schedule det. 1\textsuperscript{st} to 4\textsuperscript{th} lv.
Method application: schedule detection: 1st lv.
Method application: calibration result

Squared Linear Correlation between simulated and measured Air Temperature ($R^2$)

Zone Code

Minimum simulation model
- 1st Simulation Level
- 2nd Simulation Level
- 3rd Simulation Level
- 4th Simulation Level
Method application: calibration results

**BoxPlot- Diagram Measurement**

**BoxPlot- Diagram Final Simulation**
Method application: calibration results

Frequency Distribution Characteristics
Measurement

Frequency Distribution Characteristics
Final Simulation

Calibration method for schedule detection - Summary

- Presented procedure allows detection of unknown occupancy schedules
- Method based on spot tests, theoretical investigations and base indoor climate measurements
- Procedure assumes a unique time course and a hierarchical influence level of each schedule type
- Result depends strongly on the quality of input schedules and remaining uncertainties of the building simulation model
Thank you very much for your attention!