Synthetic Aggregate Household Consumption Trace Generation with SHoCo

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Motivation

- **Smart meters** have emerged as invaluable tools for utility companies, as they automated collect energy consumption readings and enable multi-tariff billing
- Plug-level power sensors, or **smart plugs**, allow for the automated collection of energy consumption data per device
- Test data including **meta information** to the energy consumption is strongly limited available, so development of new services is blocked
- Collecting energy consumption with a certain characteristic is **expensive** in the field
- SHoCo tackles the challenge to generate semi-synthetic, yet realistic-looking household consumption traces based on the re-combination of snippets of existing device-level consumption traces

Activity Segment Extraction

SHoCo distinguishes four types of appliance with respect to their power consumption:

- first group (a) are on-off devices
- second group (b) consumes constant standby power and spike while in use
- third group (c) have a repetitive pattern over the day
- fourth group (d) operates based on a state machine

Design key benefits

- SHoCo provision **ground truth annotations** as a separate listing describing all device activities and contained events
- The configuration adapts quick and convenient to generate large set of household consumption traces
- **Realism** of generated traces is improved by using extracted parts of actual consumption data instead if fully relying on artificial load signature models
- The traces are therefore semi-synthetic based on 1 Hz sampled input

**Device configuration**

<table>
<thead>
<tr>
<th>Device type</th>
<th>ID</th>
<th>#</th>
<th>Time model</th>
<th>Time</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coffeemaker</td>
<td>3</td>
<td>1</td>
<td></td>
<td>07:00 - 08:00</td>
<td>Breakfast</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>1</td>
<td>1</td>
<td></td>
<td>12:00 - 13:00</td>
<td>Lunch</td>
</tr>
<tr>
<td>Toaster</td>
<td>1</td>
<td>6</td>
<td></td>
<td>18:00 - 20:00</td>
<td>Dinner</td>
</tr>
<tr>
<td>Refrigerator</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Temporal model**

Trace Synthesis

- First, random snippets are chosen from the previously extracted activity segments
- Next, a start point is randomly selected for each segment in accordance with the activity period model and saved for the ground truth annotation
- Last but not least, power values of parallel active segments are summed up for trace generation
- The output trace is **sampled with 1 Hz** which correspond to 86400 entries
- A seed can be used to control the random selections, so **reproducibility is guaranteed**
- Alternating the seed value generates similar traces with totally different characteristics

Conclusion

- Automated creation of large number of semi-synthetic consumption traces with realistic appearance
- Temporal models allow to **controlled device activation**
- Precise control on the number of synthesized appliances to adapt it according to the capabilities of the disaggregation algorithm under evaluation