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Estimating Power Loads from Partial Appliance States

General scope

Knowing the plug-level power consumption of each appliance in a building can lead to significant savings in energy consumption, as well as giving a deep insight of a building power consumption. A critical information is the knowledge of the characteristic power consumptions of an appliance. The problem can be stated as an optimization problem as follows:

$$\min \|\mathbf{x}_{tot}(t) - \sum_{i=1}^{N} \sum_{j=1}^{M_i} w_{i,j} x_{i,j}(t)\|_d$$

- $w_{i,j}$ the steady state power value $j$ for appliance $i$
- $x_{i,j}$ the main aggregated power of all appliances
- $N$ the total number of monitored appliances
- $M_i$ the states count for appliance $i$
- $s_{i,j}$ a boolean which indicates if appliance $i$ is in state $j$
- $d$ a given norm.

Non-Intrusive Load Monitoring (NILM)

An example of NILM on the REDD public dataset House 1

Main power of a building is disaggregated to isolate single appliance power consumptions. This ensures a better understanding of the energy consumption in a building. Most of the current NILM methods have an a priori knowledge of the individual signatures or are trained on single appliances.

SmartSense

- We believe that additional info can help in improving disaggregation algorithms
- Basic computations made directly on sensor node
- Ensures low network usage and user privacy
- Environment is an electronic lab
- 156 nodes are deployed
- More info and data download at smartsense.inria.fr

Dataflow

Electric Smart Meter

Environmental Raw Data

Workplace environment
- Offices
- Breakroom
- Labs

SmartSense Network

Disaggregation Algorithm

$\hat{s}_{i,j}$ = Appliances states rough estimation
$\hat{s}_{i,j}$ = Appliances states fine estimation
$\hat{w}_{i,j}$ = Steady states values estimation

Power Load Estimation

This consists in solving (1) with a linear optimization tool.

We used GNU Math Programming Language.

Comparison with “blind” algorithms

- An estimation algorithm based on environmental sensing has been proposed.
- SmartSense, a sensor network with a wide range of sensors is introduced.
- Promising results are displayed in terms of complexity and prediction error, but the algorithm showed significant variations according to the nature of the appliance power time series.

Conclusion

- Smartsense deployment and data collection are imminent.
- SmartSense expected to yield accurate environmental data but inaccurate appliance states matrix.
- Next challenges to address are the algorithm robustness to this kind of errors, and association between NILM algorithms and environmental data instead of electrical data.