

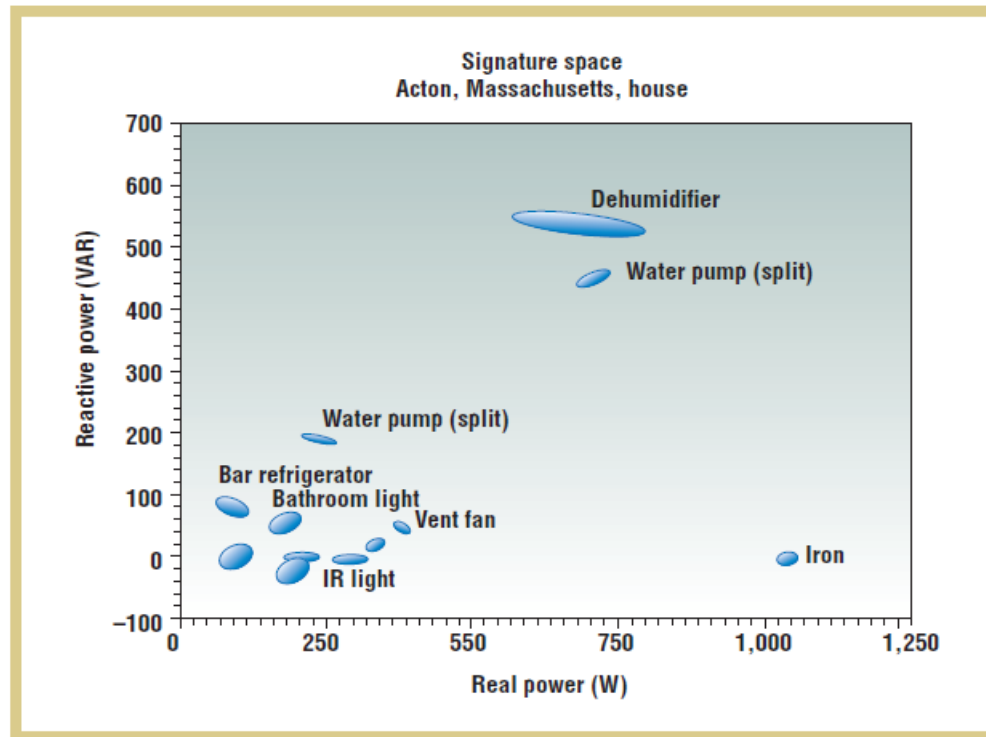
The problem of Energy Disaggregation/ Load Monitoring

Analysis of Kaggle's Belkin Energy
Disaggregation competition

Introduction

- Determine breakdown of power given whole-home consumption (e.g. from smart meter) into component appliances.
- Non-Intrusive and scarce labeling.
 - Sometimes you have sub-metering.
 - Generalization among appliance and homes.
- Usual Signals.
 - Active Power, Reactive Power, Power factor, Apparent Power.
 - Low Frequency and High Frequency

Power based signature of one home



Signatures of diferent appliances [11]



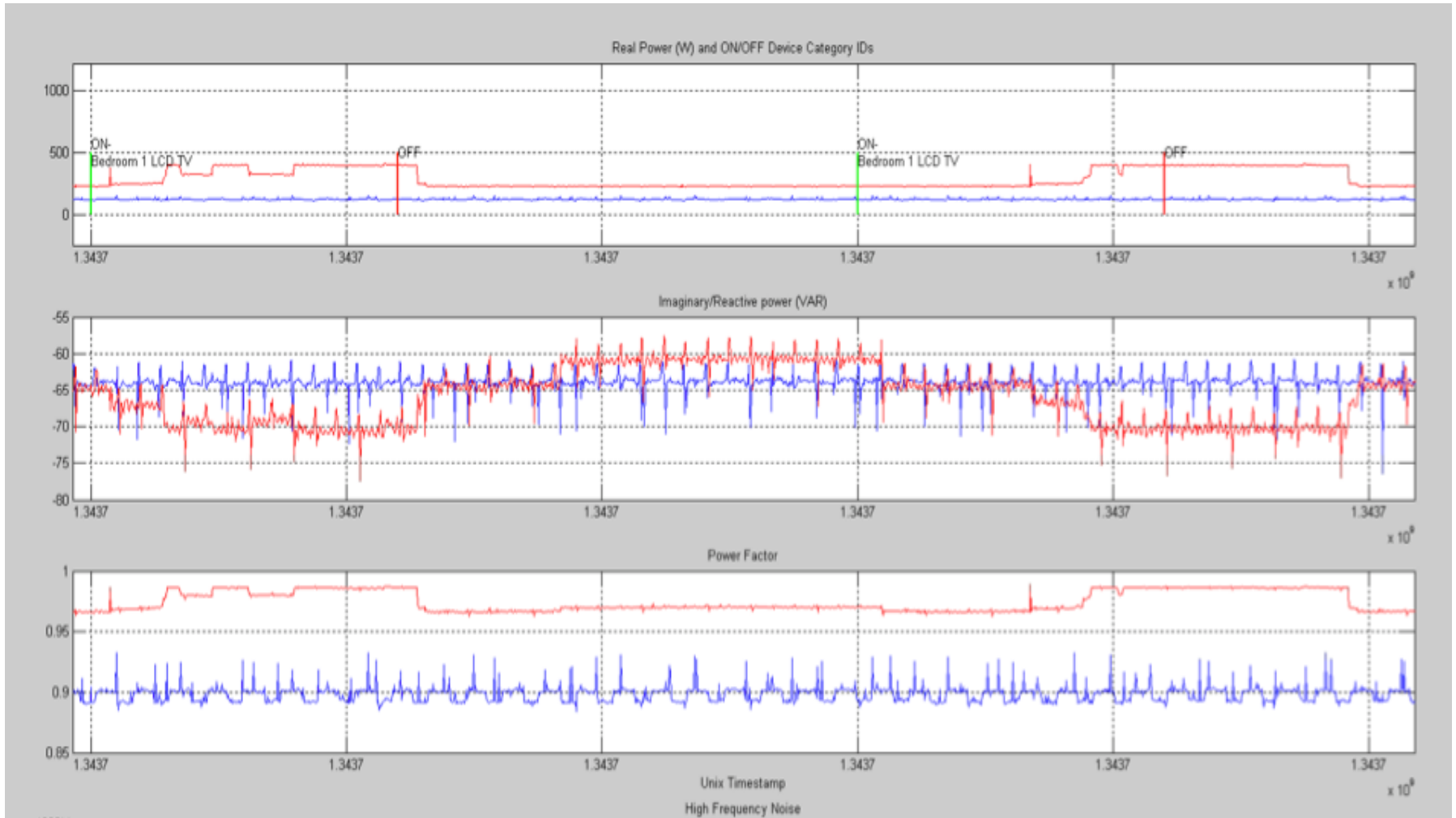
kaggle

Kaggle's Belkin Energy Dissagregation competition

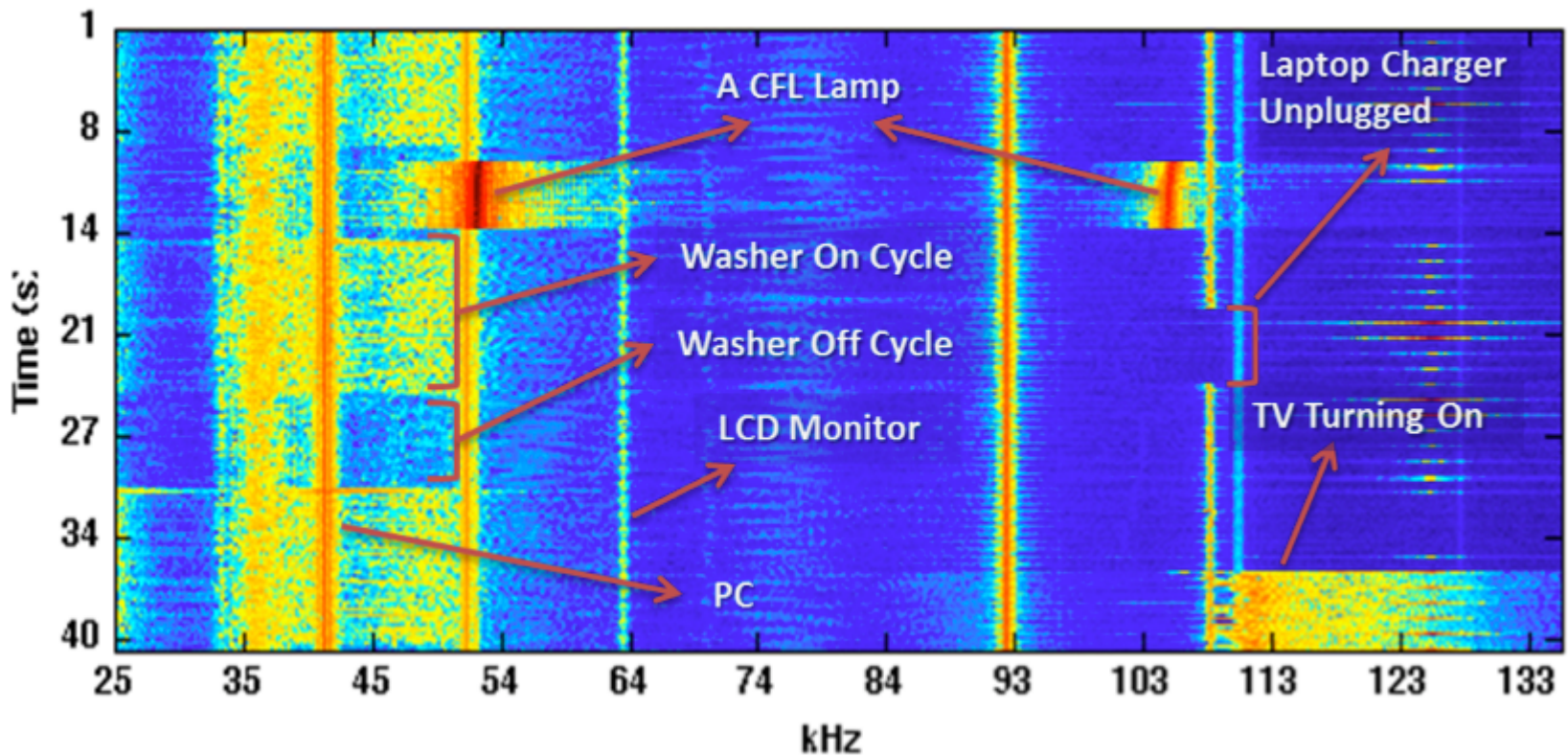
- Data from 4 homes with Train/Test signals capture using Belkin's hardware.
- Signals:
 - LF Signals with 60 Hz and first 5 harmonics of V and I. Software to compute power signals.
 - HF noise.
- Mean Hamming Loss.

$$\text{HammingLoss}(x_i, y_i) = \frac{1}{|D|} \sum_{i=1}^{|D|} \frac{\text{xor}(x_i, y_i)}{|L|},$$

Example of Signals



Example of Signals (2)

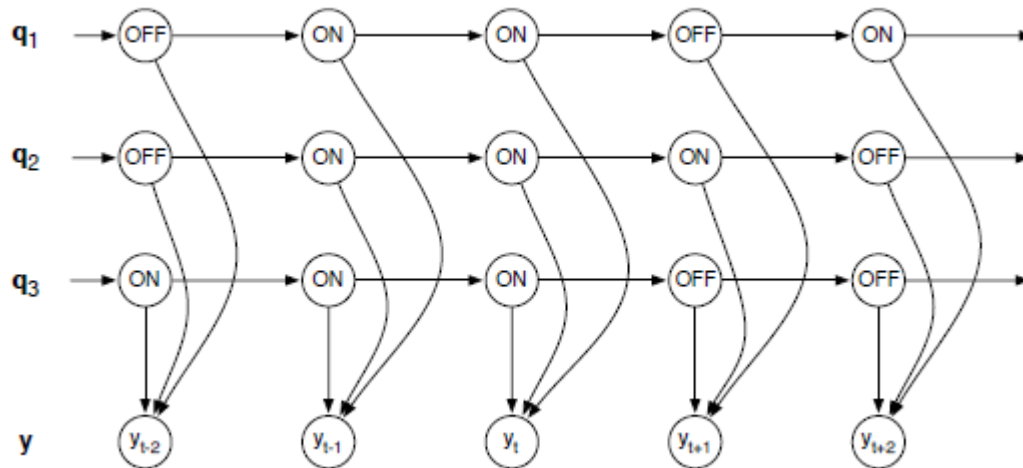


Winner's solutions

- Some information in the forum:
<https://www.kaggle.com/c/belkin-energy-disaggregation-competition/forums/t/6168/congrats-jessica>
- Complains about data quality.
- Common Characteristics:
 - Use mainly resampled LF signal.
 - Detect edges/peaks in derivative.
 - Identifies appliance signature in Train. Model from one home not useful for other.
 - Some kind of Pattern Matching/Correlation with test.
- Best Mean hamming loss = 0.04 (~ 50% Appliances)
- ¿Machine Learning? ¿ Success?

Other solutions in literature

- Clever feature engineering + KNN [11]
- Probabilistic Models. XXX-HMMs [6-9][12][13].



Factorial HMM [12]

- Sparse Coding. [10]

Datasets

See Olivier Parson's Blog: Dissaggregated Homes.

[
<http://blog.oliverparson.co.uk/2012/06/public-data-sets-for-nialm.html>]

- **REDD (Reference Energy Disaggregation Data Set)**

[<http://redd.csail.mit.edu>][4]

- **UCI (Individual household electric power consumption Data Set)**

[
<https://archive.ics.uci.edu/ml/datasets/Individual+household+electric+power+consumption>]

- **AMPds dataset**

[<http://ampds.org>][5]

References: Surveys

1. **Froehlich, J., Larson, E., Gupta, S., Cohn, G., Reynolds, M., & Patel, S.** (2011). Disaggregated end-use energy sensing for the smart grid. *IEEE Pervasive Computing*, 10(1), 28-39.
2. **Zoha, A., Gluhak, A., Imran, M. A., & Rajasegarar, S.** (2012). Non-intrusive load monitoring approaches for disaggregated energy sensing: A survey. *Sensors*, 12(12), 16838-16866.
3. **J. Zico Kolter.** Recent Advances in Algorithms for Energy Disaggregation . J. Zico Kolter. Slides. [<http://web.stanford.edu/group/peec/cgi-bin/docs/events/2011/becc/presentations/4%20%20Recent%20Advances%20in%20Algorithms%20Zico%20Kolter.pdf>]

References: Datasets

4. **Kolter, J. Z., & Johnson, M. J. (2011, August).** REDD: A public data set for energy disaggregation research. In Workshop on Data Mining Applications in Sustainability (SIGKDD), San Diego, CA.
5. **S. Makonin, F. Popowich, L. Bartram, B. Gill, and I. V. Bajic (2013).**
[AMPds: A Public Dataset for Load Disaggregation and Eco-Feedback Research](#). In Proceedings of the 2013 IEEE Electrical Power and Energy Conference (EPEC).

Other References

6. **Parson, O., Ghosh, S., Weal, M., & Rogers, A.** (2012, July). Non-Intrusive Load Monitoring Using Prior Models of General Appliance Types. In *AAAI*.
7. **Batra, N., Parson, O., Berges, M., Singh, A., & Rogers, A.** (2014). A comparison of non-intrusive load monitoring methods for commercial and residential buildings. *arXiv preprint arXiv:1408.6595*.
8. **Parson, O., Ghosh, S., Weal, M., & Rogers, A.** (2014). An unsupervised training method for non-intrusive appliance load monitoring. *Artificial Intelligence*, 217, 1-19.
9. **Kolter, J. Z., & Jaakkola, T.** (2012). Approximate inference in additive factorial hmms with application to energy disaggregation. In *International Conference on Artificial Intelligence and Statistics* (pp. 1472-1482).
10. **Kolter, J. Z., Batra, S., & Ng, A. Y.** (2010). Energy disaggregation via discriminative sparse coding. In *Advances in Neural Information Processing Systems* (pp. 1153-1161).
11. **Gupta, S., Reynolds, M. S., & Patel, S. N.** (2010, September). ElectriSense: single-point sensing using EMI for electrical event detection and classification in the home. In *Proceedings of the 12th ACM international conference on Ubiquitous computing* (pp. 139-148). ACM.
12. **Kim, H., Marwah, M., Arlitt, M. F., Lyon, G., & Han, J.** (2011, April). Unsupervised Disaggregation of Low Frequency Power Measurements. In *SDM*(Vol. 11, pp. 747-758)
13. **I. Valera, F.J.R. Ruiz, F. Perez- Cruz.** To be published