Load Disaggregation Using Non-negative Matrix Factorization

Joseph Estrada
Mentor: Alireza Rahimpour
Supervising Professor: Dr. Hairong Qi

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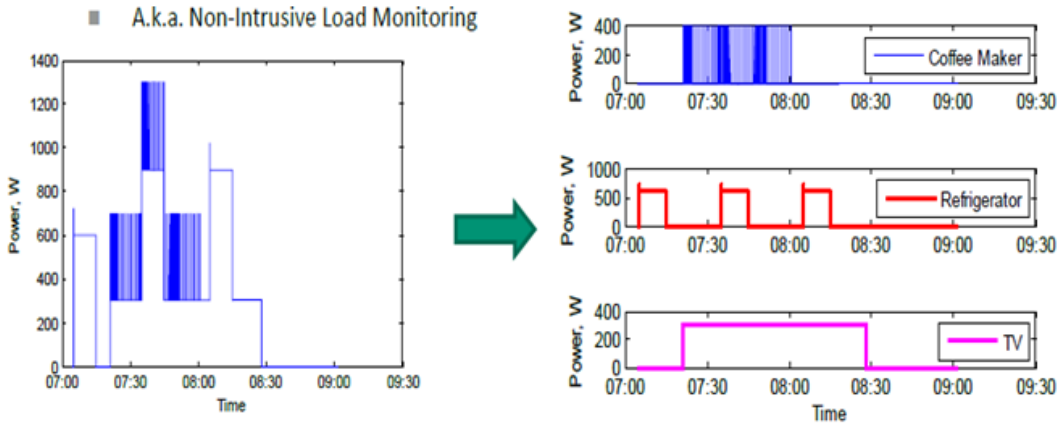
Min H. Kao Building

Introduction

- Energy conservation concerns everyone
  - Energy consumption has grown by 46% in from 1987 to 2007
- Could Load disaggregation provide a means to reduce consumption?
- Self-regulation and monitoring

What is load disaggregation?

- Decomposing aggregate power signal into it's composite appliance signals
- Original Methods formed in 1980s at MIT
- Application will determine algorithmic approach



How can we do this?

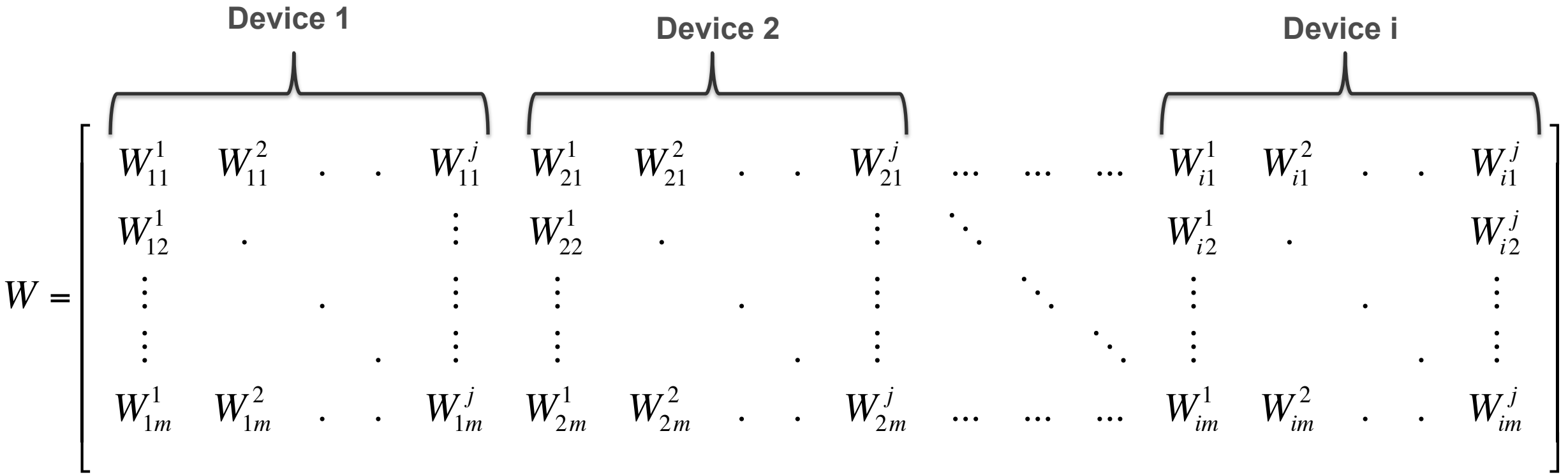
- The matrix factorization technique

$$X = WH$$

- Where X is the aggregate signal and is *mxn* for one day
- W is the basis/dictionary used for training and is *mxk*
- H is the activation matrix that will provide coeffecients and is *kxn*

How can we do this?

- We have a matrix X_i such that the j^{th} column will contain a day of power consumption signal for device *i* to form the basis matrix W that is *mxk*.



How can we do this?

- The aggregate signal which is the summation of all the devices power signals (1,…,k) for a particular time.

$$X = \sum_{i=1}^{k} W_i$$

- In this research the particular time used was one day

How can we do this?

- Using these two matrices we can find the activation matrix H by solving the following optimization problem:

$$H = \underset{H \geq 0}{\arg\min} \left\| X - WH \right\|_2^2$$

Estimated Decomposition

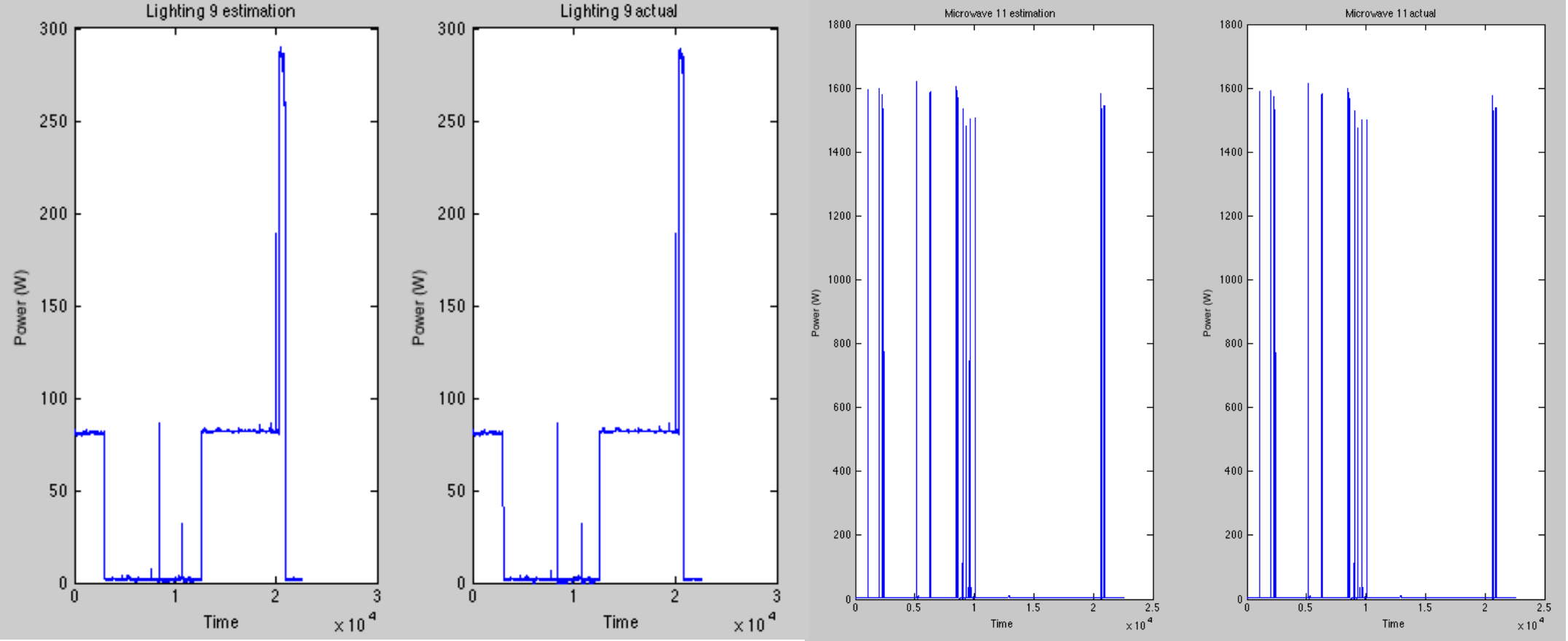
- In order to estimate an appliance signal

$$\hat{X}_i = W_i H_i$$

- This verifies training
- For decomposing next day whole home power
  - Used W from training
  - Found activation matrix H
- Estimations were found and compared to actual data

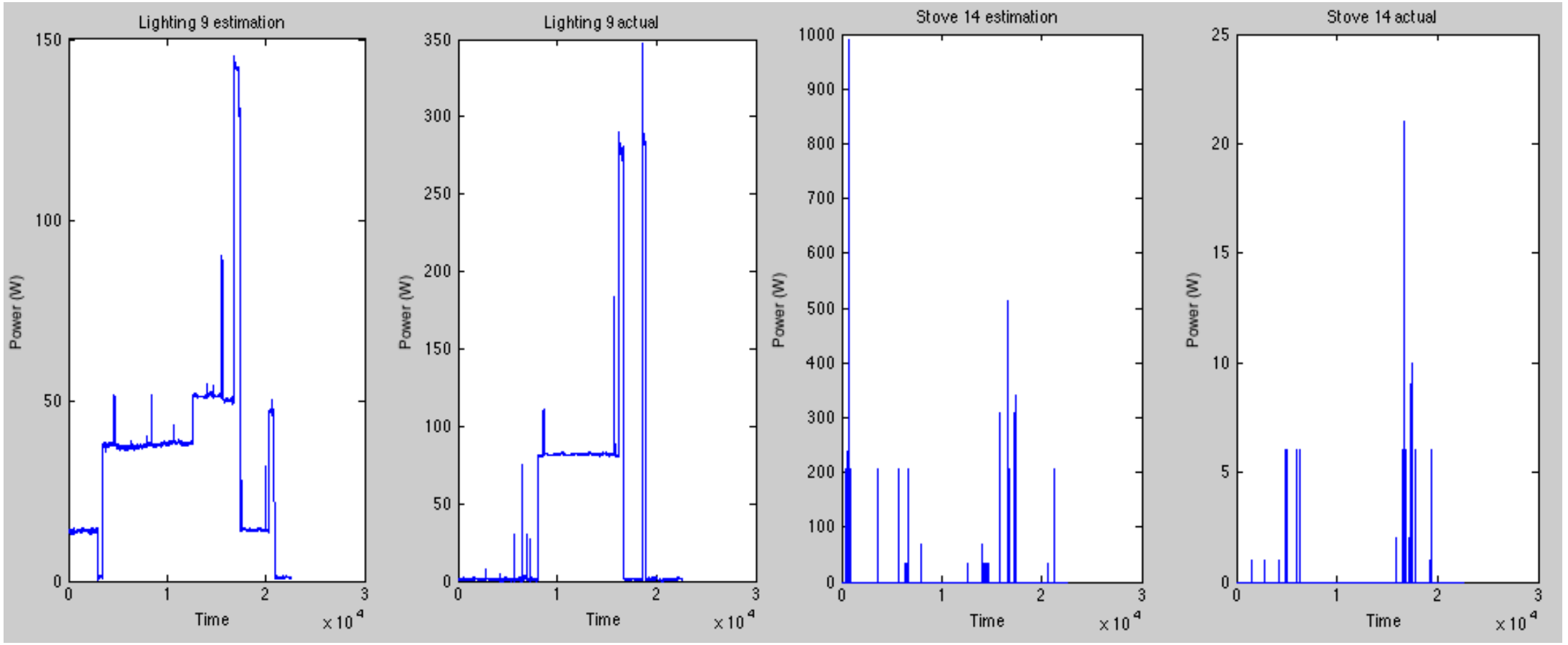
Results

- Training Results:



Results

- Testing Results:



Conclusions

- Although training was successful, testing accuracy was lower.
  - More constraint on the optimization problem
    - Temperature
    - Time of day
    - Etc.
- Generalize the method
  - Train dictionary on several houses and test on different homes

Future Work

- Consider application of constraints to optimization
- Apply the method to several different homes to obtain a generalized method
- Develop an unsupervised technique

Acknowledgements

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Any Questions?