An Additive Autoregressive Hidden Markov Model for Energy Disaggregation

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Abstract

We motivate and develop an additive autoregressive hidden Markov model specifically designed to work on the task of energy disaggregation; that is, separating a whole-building electricity signal into its component device signals whose sum is the aggregate signal observed by a smart meter. This model assumes each device in the building operates as an individual autoregressive HMM, where hidden states represent the underlying power mode of the device and Gaussian emissions correspond to that device's power consumption. The additive property models the observed output (whole-building power signal) as the sum of the emissions of multiple hidden states (i.e., as the sum of individual consumptions of multiple devices in the building). The autoregressive property realistically models how many appliances consume energy and is a new extension to previous work using factorial HMMs for energy disaggregation. Finally, our model also includes a robust mixture component, via an L1-regularized noise term, that can absorb outliers arising in this setting from unknown or rarely-used devices. We extract the power signals and underlying state sequences of single devices in a stage-wise fashion and illustrate the results of this process on the Reference Energy Disaggregation Dataset (REDD).