NILMTK v0.2: A Non-intrusive Load Monitoring Toolkit for Large Scale Data Sets

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Abstract

In this demonstration, we present an open source toolkit for evaluating non-intrusive load monitoring research; a field which aims to disaggregate a household’s total electricity consumption into individual appliances. The toolkit contains: a number of importers for existing public data sets, a set of preprocessing and statistics functions, a benchmark disaggregation algorithm and a set of metrics to evaluate the performance of such algorithms. Specifically, this release of the toolkit has been designed to enable the use of large data sets by only loading individual chunks of the whole data set into memory at once for processing, before combining the results of each chunk.

Categories and Subject Descriptors

H.4 [Information Systems Applications]: Miscellaneous

Keywords

energy disaggregation; non-intrusive load monitoring; smart meters

1 Introduction

The field of non-intrusive load monitoring (NILM) was founded by Hart over 30 years ago [4]. In recent years, the field has rapidly expanded due to increased national interest as smart meter deployments in many countries. As a result, many data sets have been released to enable the performance of multiple disaggregation algorithms to be compared using the same data set. However, new approaches have typically preprocessed the existing data sets in different ways, been compared with different benchmark algorithms, and evaluated using different accuracy metrics. Consequently, it was not possible to quantitatively compare the accuracy of any two state-of-the-art disaggregation algorithms.

In April 2014, an open source toolkit for non-intrusive load monitoring (NILM) was released to overcome these limitations [2]. The toolkit contained a number of importers for existing public data sets, a set of preprocessing and statistics functions, two benchmark disaggregation algorithms and a set of metrics to evaluate the performance of such algorithms. However, the toolkit was designed to handle the relatively small data sets (less than 10 households) which were available at the time of release. As such, the toolkit was not suitable for use with larger data sets (hundreds of households) which have been released since (e.g. WikiEnergy data set). As a result, it has not been possible to evaluate energy disaggregation approaches at a sufficient scale so as to investigate the extent of their generality.

To address this shortcoming, we present a new release of the toolkit (NILMTK v0.2) which is able to evaluate energy disaggregation algorithms using arbitrarily large data sets. Rather than loading the entire data set into memory (as in v0.1), the aggregate data is loaded in chunks and the output of the disaggregation algorithm is saved to disk chunk-by-chunk. As a result, we are able to demonstrate data set statistics and disaggregation for the WikiEnergy data set, which contains 239 households of aggregate and individual appliance power data. In addition to scalability improvements, v0.2 also includes support for a rich data set metadata description format, as well as a number of usability improvements and many software design improvements.

2 NILMTK v0.2

NILMTK v0.2 improves on NILMTK v0.1 [2] in several important ways. Indeed, these changes are so fundamental that NILMTK v0.2 is a complete re-write of NILMTK. We now present the changes in NILMTK v0.2.

2.1 Scalability

The most important change is that v0.2 can handle data sets of arbitrary size whilst v0.1 can only handle data sets which fit into system memory. v0.2 achieves this ‘out-of-core’ functionality by lazily loading data in chunks (Fig. 1). When a user first opens a data set, only the metadata is loaded into memory. The user then builds a processing pipeline (e.g. preprocess the data, then calculate some statistics, then train a disaggregation algorithm). NILMTK loads data from disk into the pipeline in chunks and only holds one chunk in memory at any one time. Under the hood, we have two families of statistics classes: Node classes perform calculations on each chunk (e.g. calculating the total energy) and Results classes know how to merge results from multiple chunks (e.g. sum the total energy calculated for each chunk). NILMTK supports both batch and on-line algorithms and, if required, the subsequent data chunk can be ‘peeked’ into by passing the argument n look ahead rows.
2.4 Improved warnings

An experimental feature of NILMTK v0.2 is a framework for performing precondition checks for each statistics function. The motivation is that some statistics functions require the data to be preprocessed in a certain way. In NILMTK v0.1, if a user attempts to run a statistics function on incorrectly preprocessed data then no warning is raised and the wrong answer will be produced. In v0.2, statistics classes declare a set of preconditions. These preconditions are checked against the data set metadata and the previous nodes in the processing pipeline. If any preconditions are not met then the user is warned immediately (before any time series data has been loaded from disk).

2.5 Software engineering improvements

NILMTK v0.2 also includes documentation and over 40 unit tests. Furthermore, we use TravisCI for continuous integration of our code base. Each contribution is evaluated by TravisCI to ensure that all the unit tests pass. We also use Coveralls for coverage testing of our code base, which gets triggered each time a new contribution is made. Finally, we also use Landscape based code health monitoring which automatically warns us of potential bugs in the code base.

2.6 Data set importers

NILMTK v0.2 includes data set converts for REDD [7], iAWE [1], WikiEnergy (wiki-energy.org) and GreenD [8]. COMBED [3] and UK-DALE [6]. The GreenD importer was written by the data set authors and was the first significant code contribution from outside of the core NILMTK contributors.

3 Conclusions

In this demonstration, we presented an open source toolkit for evaluating non-intrusive load monitoring research using large scale data sets. v0.1 of the toolkit was released in April 2014 and v0.2 was released in July 2014.

4 References