

NILMTK: An Open Source Toolkit for Non-intrusive Load Monitoring

Nipun Batra¹, Jack Kelly², Oliver Parson³, Haimonti Dutta⁴, William Knottenbelt²,
Alex Rogers³, Amarjeet Singh¹, Mani Srivastava⁵

¹Indraprastha Institute of Information Technology Delhi, India {nipunb, amarjeet}@iiitd.ac.in

²Imperial College London {jack.kelly, w.knottenbelt}@imperial.ac.uk

³University of Southampton {osp, ar}@ecs.soton.ac.uk

⁴CCLS Columbia {haimonti@ccls.columbia.edu}

⁵UCLA {mbs@ucla.edu}

ABSTRACT

Non-intrusive load monitoring, or energy disaggregation, aims to separate household energy consumption data collected from a single point of measurement into appliance-level consumption data. In recent years, the field has rapidly expanded due to increased interest as national deployments of smart meters have begun in many countries. However, empirically comparing disaggregation algorithms is currently virtually impossible. This is due to the different data sets used, the lack of reference implementations of these algorithms and the variety of accuracy metrics employed. To address this challenge, we present the Non-intrusive Load Monitoring Toolkit (NILMTK): an open source toolkit designed specifically to enable the comparison of energy disaggregation algorithms in a reproducible manner. This work is the first research to compare multiple disaggregation approaches across multiple publicly available data sets. Our toolkit includes parsers for a range of existing data sets, a collection of preprocessing algorithms, a set of statistics for describing data sets, two reference benchmark disaggregation algorithms and a suite of accuracy metrics. We demonstrate the range of reproducible analyses which are made possible by our toolkit, including the analysis of six publicly available data sets and the evaluation of both benchmark disaggregation algorithms across such data sets.

Categories and Subject Descriptors

I.5 [Pattern Recognition]: Applications
: I.2 [Artificial Intelligence]: Learning—Parameter learning

Keywords

energy disaggregation; non-intrusive load monitoring; smart meters

1. INTRODUCTION

Non-intrusive load monitoring (NILM), or energy disaggregation, aims to break down a household's aggregate electricity consumption into individual appliances [1]. The motivations for such a process are threefold. First, informing a household's occupants of how much energy each appliance consumes empowers them to take steps towards reducing their energy consumption [2]. Second, personalised feedback can be provided which quantifies the savings of certain appliance-specific advice, such as the financial savings when an old inefficient appliance is replaced by a new efficient appliance. Third, if the NILM system is able to determine the time of use of each appliance, a recommender system would be able to inform the household's occupants of the savings of deferring appliance use to a time of day when electricity is either cheaper or has a lower carbon footprint.

Such benefits have drawn significant interest in the field since its inception 25 years ago. In recent years, the combination of smart meter deployments [3, 4] and reduced hardware costs of household electricity sensors has led to a rapid expansion of the field. Such rapid growth over the past five years has been evidenced by the wealth of academic papers published, international meetings held (e.g. NILM 2012¹ and EPRI NILM 2013²), startup companies founded (e.g. Bidgely and Neurio) and data sets released (e.g. REED3 [5], BLUED3 [6] and Smart3 [7]).

However, three core obstacles currently prevent the direct comparison of state-of-the-art approaches, and as a result may be impeding progress within the field. To the best of our knowledge, each contribution to date has only been evaluated on a single data set and consequently it is hard to assess whether such approaches generalise to new households. Furthermore, many researchers sub-sample data sets to select specific households, appliances and time periods, making experimental results more difficult to reproduce. Second, newly proposed approaches are rarely compared against the same benchmark algorithms, further increasing the difficulty in empirical comparisons of performance between different publications. Moreover, the lack of reference implementations of these state-of-the-art algorithms often leads to the reimplementation of such approaches. Third, many papers target different use cases for NILM and therefore the accuracy of their proposed approaches are evaluated using a different set of performance metrics. As a result the nu-

¹<http://www.ices.cmu.edu/poil/nilm/>

²<http://goo.gl/dk5tpq>

Nilmtk An Open Source Toolkit For Non Intrusive Load

Reza Arghandeh, Yuxun Zhou



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Table of Contents Nilmtk An Open Source Toolkit For Non Intrusive Load

1. Understanding the eBook Nilmtk An Open Source Toolkit For Non Intrusive Load
 - The Rise of Digital Reading Nilmtk An Open Source Toolkit For Non Intrusive Load
 - Advantages of eBooks Over Traditional Books
2. Identifying Nilmtk An Open Source Toolkit For Non Intrusive Load
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Nilmtk An Open Source Toolkit For Non Intrusive Load
 - User-Friendly Interface
4. Exploring eBook Recommendations from Nilmtk An Open Source Toolkit For Non Intrusive Load
 - Personalized Recommendations
 - Nilmtk An Open Source Toolkit For Non Intrusive Load User Reviews and Ratings
 - Nilmtk An Open Source Toolkit For Non Intrusive Load and Bestseller Lists

5. Accessing Nilmtk An Open Source Toolkit For Non Intrusive Load Free and Paid eBooks
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 - Nilmtk An Open Source Toolkit For Non Intrusive Load eBook Subscription Services
 - Nilmtk An Open Source Toolkit For Non Intrusive Load Budget-Friendly Options
6. Navigating Nilmtk An Open Source Toolkit For Non Intrusive Load eBook Formats
 - ePub, PDF, MOBI, and More
 - Nilmtk An Open Source Toolkit For Non Intrusive Load Compatibility with Devices
 - Nilmtk An Open Source Toolkit For Non Intrusive Load Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Nilmtk An Open Source Toolkit For Non Intrusive Load
 - Highlighting and Note-Taking Nilmtk An Open Source Toolkit For Non Intrusive Load
 - Interactive Elements Nilmtk An Open Source Toolkit For Non Intrusive Load
8. Staying Engaged with Nilmtk An Open Source Toolkit For Non Intrusive Load
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Nilmtk An Open Source Toolkit For Non Intrusive Load
9. Balancing eBooks and Physical Books Nilmtk An Open Source Toolkit For Non Intrusive Load
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Nilmtk An Open Source Toolkit For Non Intrusive Load
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Nilmtk An Open Source Toolkit For Non Intrusive Load
 - Setting Reading Goals Nilmtk An Open Source Toolkit For Non Intrusive Load
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Nilmtk An Open Source Toolkit For Non Intrusive Load
 - Fact-Checking eBook Content of Nilmtk An Open Source Toolkit For Non Intrusive Load
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning

- Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
- Integration of Multimedia Elements
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