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

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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 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 2012[1] and EPRI NILM 2013[2]), startup companies founded (e.g. Bidgely and Neurio) and data sets released (e.g. REDD [5], BLUED [6] and Smart* [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 mo-

[1] http://www.ices.cmu.edu/ps11/nilm/
[2] http://goo.gl/dr4tpq

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Florian Liebgott

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Big Data Application in Power Systems Reza Arghandeh,Yuxun Zhou,2017-11-27 Big Data Application in Power Systems brings together experts from academia industry and regulatory agencies who share their understanding and discuss the big data analytics applications for power systems diagnostics operation and control Recent developments in monitoring systems and sensor networks dramatically increase the variety volume and velocity of measurement data in electricity transmission and distribution level The book focuses on rapidly modernizing monitoring systems measurement data availability big data handling and machine learning approaches to process high dimensional heterogeneous and spatiotemporal data The book chapters discuss challenges opportunities success stories and pathways for utilizing big data value in smart grids Provides expert analysis of the latest developments by global authorities Contains detailed references for further reading and extended research Provides additional cross disciplinary lessons learned from broad disciplines such as statistics computer science and bioinformatics Focuses on rapidly modernizing monitoring systems measurement data availability big data handling and machine learning approaches to process high dimensional heterogeneous and spatiotemporal data

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were held virtually The 13 revised full papers were carefully reviewed and selected from 28 submissions They present multidisciplinary scientific results toward answering the complex technological problems of emergent Smart Cities The subjects related to sustainable energy framed with the scope of smart cities and addressed along with the SESC 2021 conference are crucial to guarantee an equilibrium among economic growth and environmental sustainability as well as to contribute to reducing the impact of climate change   Sustainability in Energy and Buildings 2024 John R. Littlewood,R. J. Howlett,Lakhmi C. Jain,2025-09-30 This book contains the proceedings of the 16th KES International Conference on Sustainability and Energy in Buildings 2024 SEB2024 held in Madeira Portugal during September 18 20 2024 organized by KES International SEB24 invited contributions on a range of topics related to sustainable buildings and explored innovative themes regarding sustainable energy systems The conference formed an exciting chance to present interact and learn about the latest research and practical developments on the subject The conference attracted submissions from around the world Submissions for the full paper track were subjected to a blind peer reviewed process Only the best of these were selected for presentation at the conference and publication in these proceedings It is intended that this book provides a useful and informative snapshot of recent research developments in the important and vibrant area of sustainability in energy and buildings   *Proceedings of Eighth International Congress on Information and Communication Technology* Xin-She Yang,R. Simon Sherratt,Nilanjan Dey,Amit Joshi,2023-09-14 This book gathers selected high quality research papers presented at the Eighth International Congress on Information and Communication Technology held at Brunel University London on 20 23 February 2023 It discusses emerging topics pertaining to information and communication technology ICT for managerial applications e governance e agriculture e education and computing technologies the Internet of Things IoT and e mining Written by respected experts and researchers working on ICT the book offers a valuable asset for young researchers involved in advanced studies The work is presented in four volumes Chapter Ontology Engineering to Model the European Cultural Heritage The Case of Cultural Gems is available open access under a Creative Commons Attribution 4 0 International License via SpringerLink   *Algorithms for Event-based Non-intrusive Load Monitoring* Florian Liebgott,2024   **Scalable Non-intrusive Load Monitoring** Mengmeng Zhuang,2019

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junk food should be banned debatewise - Sep 19 2023

junk food should be banned many children in america eat large amounts of junk food and this can cause health problems in fact junk food is even sold in the vending machines of many schools this debate is about the good and bad points for how junk food should be banned

should junk food be banned group discussion ideas - Jul 17 2023

mar 18 2021   no junk food should not be banned banning junk food is against the right to choice of food if we eat junk food in limited qualities it won t be much problem health problems arise when we take too much junk food so junk food itself is not the problem but limiting the intake is the key

junk food effects types of junk food junk food and schools - Nov 09 2022

there have been constant debates on this topic from past few years that whether the junk food should be banned in schools or not and there have been arguments from both the sides in favour as well as from those against banning fast food in schools

junk food should be banned createdebate - Jun 04 2022

jan 28 2017   junk food should be banned junk foods should be taken out of school lunch menus because they affect your body and mind in negative ways junk food is a major cause of childhood obesity 32 of youth are overweight and nearly 74 are unfit

why should all the junk foods should be banned createdebate - Apr 02 2022

debate about why should all the junk foods should be banned we shouldnt or we should

should we ban junk food in schools we asked five experts - May 15 2023

feb 18 2020   five experts want to write write an article and join a growing community of more than 172 200 academics and researchers from 4 766 institutions register now we asked five experts if there

pros and cons should junk food be banned or allowed in schools - Aug 18 2023

aug 20 2019   5 reasons junk food should be banned in school cons 1 junk food leads to obesity junk foods usually have a high level of salt fat calories and sugar and offer limited nutritional value consumption of unhealthy foods on a regular basis leads to obesity the amounts of fats and sugar in junk are alarmingly high

should junk food be banned in schools createdebate - Jan 31 2022

should junk food be banned in schools students have been getting more obiese over the years if schools want to follow

through with their health programs they should get the kids to eat healthier and not just exersize more i think it should be banned

18 banning junk food in schools pros and cons connectus - Sep 07 2022

mar 24 2019   junk foods are easier to manage when they are allowed as part of the school policy schools do have the ability to ban the presence of junk food on their grounds parents can limit the access that children have to these items at home

should junk food be banned createdebate - Mar 13 2023

junk food addiction is a worldwide issue that concern every society some agree that junk food that be banned because of its disadvantages such as obesity heartache diabetes and further damages in the future on the other hand others disagree that junk food should be banned due to its advantages which are that junk food are easy to make and

should you be banned from buying junk food scholastic - Apr 14 2023

feb 1 2021   the goal of these bans is to improve kids health research shows that eating too much junk food can lead to obesity that s the condition of being severely overweight people with obesity are at higher risk for health problems such as heart disease and type 2 diabetes but some people argue that a ban on buying junk food won t do very

government wants to ban all junk food ads online bbc newsround - Aug 06 2022

nov 11 2020   the uk government has revealed a plan to ban all junk food adverts online the ban would affect food products that are high in fat salt and sugar in an attempt to solve health problems caused by