7-2023

An Open-Source, Semisupervised Water End-Use Disaggregation and Classification Tool

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RESEARCH BRIEF
from the **Utah Water Research Laboratory**

An Open-Source, Semisupervised Water End-Use Disaggregation and Classification Tool

Issued
July 2023

Audience
Water resource engineers
civil engineers
professors and students

Research Objective/Summary: Research on individual household water consumption is vital to water management and conservation approaches. Despite a significant number of papers published on end-use disaggregation tools, reproduction and further study of results on water-use behavior is difficult because the data and code are not easily accessible. In order to fulfill this need for open and reproducible tools, we present a new, semisupervised, non-intrusive water end-use disaggregation and classification tool.

Why this research?

Residential water use metering is widespread in the US, but most meters are only read monthly or quarterly, which is too infrequent to see understand how and when water is used. Without more frequent data, it is difficult to draw conclusions about water management, conservation, and efficiency in residential homes.

Several studies have been conducted using smart metering technology and high-resolution data to create water end-use disaggregation tools and models; however, due to unavailability of code and data, and time-intensive human analysis required to use the tools, results from these studies are not easily replicated.

In order to enable further research and replication, we developed a new, fully automated, semisupervised tool for collecting and separating high-resolution water-use data into individual uses. The code for this tool and the data used to develop it are openly available to encourage reuse.

What we did

The tool, a single script developed in Python, can separate and classify water data into individual end-use events, such as a shower or a load of laundry. The process consists of four phases:

1. **Data gathering—**data is gathered on smart meters by recording a magnetic pulse when a certain amount of water is used
2. **Data cleansing—**individual pulses are grouped into events, and noise in the data is filtered out to accentutate event start and end times
3. **Disaggregation—**using volume, duration, and flow rate, overlapping events are broken down into single events
4. **Classification—**outliers are identified and excluded, followed by classification of all other events using a random forest model

The tool was tested on manually labeled data from a single home and then applied to four more homes from a larger data set of 31 homes in Logan and Providence, UT. The tool's self-learning procedure trains the model to identify water end-use events at a particular home. Events classified by the tool were compared to events manually labeled by the home's resident to evaluate the accuracy of the classification procedure.

Key Points

- This tool is open source, so results can be replicated and further research can be conducted.
- The tool has been verified as reliable across meter sizes and types and water-use characteristics, so it is adaptable to specific research needs.
- The semi-supervised technique employed has a 98.2% accuracy in classifying single water end-use events, such as a toilet flush or a shower.
- Information gathered from this tool can aid in homeowner water use awareness, management, and conservation.

READ MORE: *Attallah, N.A, Horsburgh, J.S, Bastidas Pacheco, C.J, (2023). An Open-source, Semi-supervised Water End Use Disaggregation and Classification Tool. Journal of Water Resources Planning and Management, 149:7, https://doi.or/10.1061/JWRMD5.WRENG-5444*

> "There is a clear need for open and reproducible approaches that enable other researchers to test, replicate, reuse, and build on existing work."

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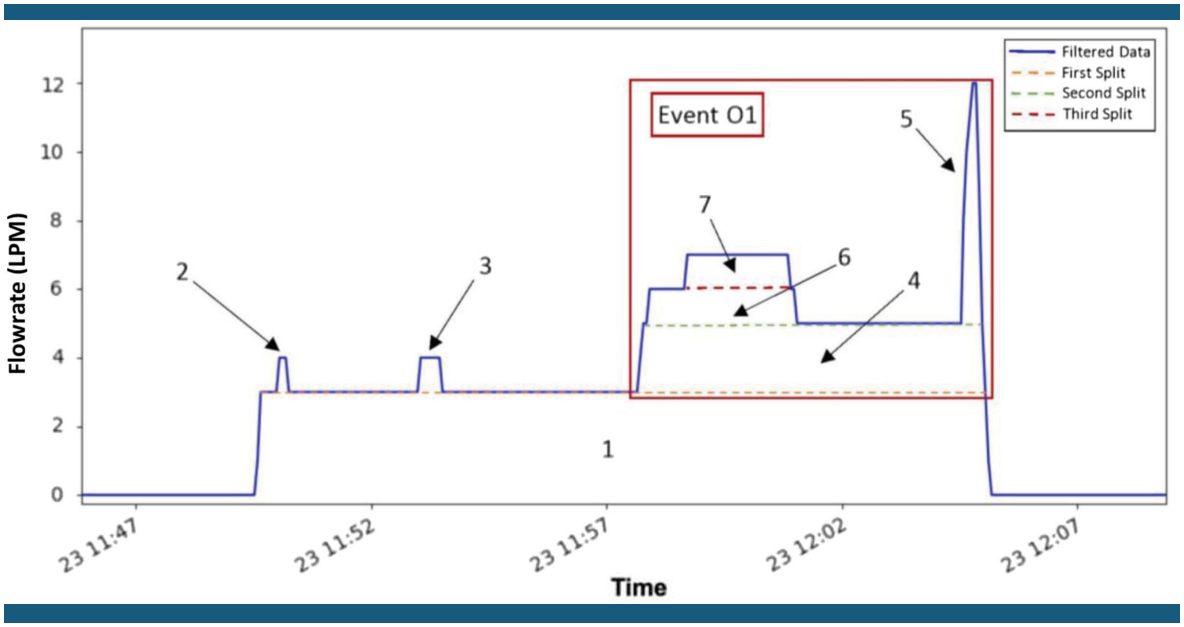

Procedure for splitting overlapping events into single-event components.

What we found

The tool identified a total of 18,491 water end-use events from the five households. The average total processing time of data cleansing, disaggregation, and classifcation per day for one home was approximately 50 seconds with 98.2% accuracy in classification.

Shower and clothes washer classifications were the highest accuracy at 100%, and bathtub classification was the lowest at 66.7%.

Why it matters

This tool uses non-intrusive monitoring data collected from residential home meters to break down total water use at the household level, separating overlapping events into single events prior to classification.

Our results represent an accessible platform for advancing the availability and functionality of end-use disaggregation tools. Because of its openly available code and data, this tool can be adapted to further research in quantifying residential water usage and implementing conservation methods. It can also provide homeowners and water managers valuable information about how and when they use water. This can impact water-use behavior in residential areas.

It is our hope that the code and anonymized data we have openly shared can be a platform for advancing the availability and functionality of open tools for water end-use disaggregation studies.

For more information on the results of this study and the water conservation implications, see https://doi.org/10.26077/A060-2943.

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