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Data-driven behavioural modelling of smart meter data to identify end-use determinants of residential water use

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Residential water consumption data collected at the household level with intelligent meters is being increasingly utilized, on the one hand, to inform utilities' operations and demand management strategies, on the other hand, to communicate transparent and personalized reports on water use to water consumers. Coupling intelligent metering systems with data analytics is a core element driving the transition towards digital water utility service providers. By intelligently mining into high resolution water consumption data, utilities can gain knowledge about heterogeneous water consumption routines, segment their customers into profiles based on behavioural similarities and differences, and ultimately tailor demand-side management interventions for the different groups. In this work, we present a data-driven customer segmentation analysis performed on the water use time series of 327 water consumer accounts from Southeast Queensland and Melbourne, each monitored in 2010 with intelligent meters sampling observation with an interval of 5 seconds. Our customer segmentation analysis is composed of three steps. First, we disaggregate the water consumption time series of each household into eight different end uses (i.e. tap, shower, washing machine, dishwasher, toilet, bathtub, irrigation, evaporative cooler) via Autoflow, a state-of-the-art algorithm for end-use disaggregation which combines Markov Models, Artificial Neural Networks, and Dynamic Time Warping. Second, we identify water end use routines for individual accounts (i.e. recurring hourly patterns of daily water use at the end-use level) by Principal Component Analysis. Finally, we cluster the routines to identify groups of accounts revealing similar water end use behaviours. Numerical results show that the data variance of primary routines is mainly explained by shower, washing machine, and irrigation end uses, thus suggesting three main behavioural classes exist among the considered accounts. Second, behavioural differences based on time-of-use, amount of water used for each end-use, weekday vs weekend routines, and regularity in the occurrence or primary routines emerge within each of the above classes. We thus demonstrate that our proposed data-driven customer segmentation analysis reveals the main end uses and consumption patterns driving heterogeneous types of water use behaviours. This brings a two-fold contribution to demand management: first, our customer segmentation analysis successfully mines high-resolution water consumption time series to provide water utilities with a concise profile characterization of their water consumers; second, our findings support the design of effective portfolios of customized feedback and demand management interventions.