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Electrical Decomposition of Time Series of Power Consumption

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Abstract : Load monitoring is a management process for energy consumption towards energy savings and energy efficiency. Non Intrusive Load Monitoring (NILM) is one method of load monitoring used for disaggregation purposes. NILM is a technique for identifying individual appliances based on the analysis of the whole residence data retrieved from the main power meter of the house. Our NILM framework starts with data acquisition, followed by data preprocessing, then event detection, feature extraction, then general appliance modeling and identification at the final stage. The event detection stage is a core component of NILM process since event detection techniques lead to the extraction of appliance features. Appliance features are required for the accurate identification of the household devices. In this research work, we aim at developing a new event detection methodology with accurate load disaggregation to extract appliance features. Time-domain features extracted are used for tuning general appliance models for appliance identification and classification steps. We use unsupervised algorithms such as Dynamic Time Warping (DTW). The proposed method relies on detecting areas of operation of each residential appliance based on the power demand. Then, detecting the time at which each selected appliance changes its states. In order to fit with practical existing smart meters capabilities, we work on low sampling data with a frequency of (1/60) Hz. The data is simulated on Load Profile Generator software (LPG), which was not previously taken into consideration for NILM purposes in the literature. LPG is a numerical software that uses behaviour simulation of people inside the house to generate residential energy consumption data. The proposed event detection method targets low consumption loads that are difficult to detect. Also, it facilitates the extraction of specific features used for general appliance modeling. In addition to this, the identification process includes unsupervised techniques such as DTW. To our best knowledge, there exist few unsupervised techniques employed with low sampling data in comparison to the many supervised techniques used for such cases. We extract a power interval at which falls the operation of the selected appliance along with a time vector for the values delimiting the state transitions of the appliance. After this, appliance signatures are formed from extracted power, geometrical and statistical features. Afterwards, those formed signatures are used to tune general model types for appliances identification using unsupervised algorithms. This method is evaluated using both simulated data on LPG and real-time Reference Energy Disaggregation Dataset (REDD). For that, we compute performance metrics using confusion matrix based metrics, considering accuracy, precision, recall and error-rate. The performance analysis of our methodology is then compared with other detection techniques previously used in the literature review, such as detection techniques based on statistical variations and abrupt changes (Variance Sliding Window and Cumulative Sum).

Keywords : electrical disaggregation, DTW, general appliance modeling, event detection
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