AUTOMATIC IDENTIFICATION OF ELECTRIC LOADS USING SWITCHING TRANSIENT CURRENT SIGNALS

Tharmarajah Thiruvaran, Toan Phung, Eliathamby Ambikairajah

School of Electrical Engineering and Telecommunications,
The University of New South Wales, Sydney NSW 2052 Australia.

t.thiruvaran@unsw.edu.au, toan.phung@unsw.edu.au, ambi@ee.unsw.edu.au

ABSTRACT

The automatic identification of different electric loads using the current waveform at the time of switching, is analysed in this paper. The time variation of the harmonics at the time of switching is modelled using the Hidden Markov Model with Gaussian Mixture Models representing the probabilities. Short Time Fourier Transform (STFT) and Wavelet Transform (WT) based features are compared at their optimum configurations. The STFT based feature gave an accuracy of 97.9% while the WT features provided an accuracy of 93.75% in a cross fold validation experiment.

Index Terms— Electric load identification, harmonic analysis, Hidden Markov Model, Wavelet Transform.

1. INTRODUCTION

The automatic identification of electric loads is important in several applications such as high efficiency buildings to control the energy consumption [1], and to effectively manage loads in self-configuring microgrids [2]. For example, in the case of an overload condition in microgrids, an automated demand side management system can selectively switch off loads. A proper load identification system can help increase system efficiency by reducing the energy consumption and thus minimising carbon emission [3]. Identifying loads by installing sensors in each load is an expensive and intrusive way of load identification, while identification using electric parameters that can be estimated at the power meter outlet is a non-intrusive and inexpensive method [1]. This non-intrusive method of identification can use current, voltage, active or reactive power, current harmonics and phase angle. A detailed review of methods of load identification can be found in [3, 4]. Though several methods are available, this problem of load monitoring is classified as a subject of high difficulty and requires even more investigation [4]. Loads can be identified using their steady-state waveforms [5] or transient waveforms [6]. Though challenging, methods based on transient waveforms aim to identify those loads as soon as they are switched on and this is very useful for an effective load management.

Generally load identification involves two stages: extracting useful features and then doing a pattern matching using a classifier. For an effective load management system, the event of switching on a load needs to be detected and then the load should be identified. This paper deals with the problem of identifying the load using their transient, in particular when switching on, waveforms using hidden Markov models as a classifier for non-intrusive load monitoring (NILM) systems, given the switching instances. Furthermore, this paper compares features extracted using the Short Time Fourier Transform (STFT) and Wavelet Transform (WT) at their individual optimum configuration.

For transient based load identification at the feature extraction stage, the spectral envelope of a current waveform is used in [6] and instantaneous power of a switching transient waveform is used in [7, 8]. As the authors aimed to identify using the switching waveform only, the switching current waveform is exploited in detail and harmonics are extracted as features using time-frequency analysis. Furthermore, wavelets and STFT are used and compared for load recognition in [9] where the WT and STFT coefficients are directly used as signatures and WT is used with a neural network in [10] for load recognition, but those are not for switching signal based recognition as in the authors' work.

2. DATA COLLECTION AND FEATURE EXTRACTION

2.1. Data Collection

For this paper, a database is collected by measuring the current and voltage waveforms of four loads as in Figure 1 using a LeCroy digital oscilloscope at 10 kHz sampling frequency and the time of switch-on of each load is also recorded. Fluorescent light, incandescent light, computer monitor and motor are the four loads used. Waveforms corresponding to all 24 different sequences of switching on the loads such as S1S2S3S4 (first switching on fluorescent light, then incandescent light, then the monitor and finally the motor), S1S2S4S3, etc are collected. Thus, for each load there are 24 switching waveforms available in the database.

978-1-4673-6349-5/13/$31.00 ©2013 IEEE