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Boosting performance of power quality event identification with KL Divergence measure and standard deviation

Rajiv Kapoor[a], Rashmi Gupta[b], Le Hoang Son[c,d,*], Sudan Jha[e], Raghvendra Kumar[f]

[a] ECE Department, Delhi Technological University, India
[b] ECE Department, AIACT&R, GGSIPU, Delhi, India
[c] Institute of Research and Development, Duy Tan University, Danang, Viet Nam
[d] VNU University of Science, Vietnam National University, Viet Nam
[e] School of Computer Engineering, Kalinga Institute of Industrial Technology, Odisha, India
[f] Computer Science and Engineering Department, LNCT College, MP, India

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ABSTRACT

Power quality event identification is widely recognized as one of the most interesting problems in electric engineering. It consists of two sub-problems: detection and classification. In the first step, a recognition algorithm is used to detect disturbance from power quality events. The next step classifies them into some groups by a machine learning method. In order to enhance the accuracy, a detection technique is required for classifying events in timely manner. In this paper, KL Divergence and Standard deviation are used within Support Vector Machine to detect and classify events. Experimental results with 12 events suggest a specific order of harmonic present in each event. KL Divergence and Standard deviation are obtained for voltage sag of 500 values and for harmonics with swell of 800 values. After calculating KL Divergence and Standard deviation, events are detected with more accuracy. The comparison shows that the new method achieves 94.02% of accuracy which is better than 92.33% of Abdoos et al. (2016), 93.47% of Ma et al. (2017), 89.92% of Li et al. (2016) and 93.87% of Kapoor et al. (2018).

1. Introduction

Power quality, which is also termed as electric power quality, involves voltage, frequency, and waveform [39]. It is defined as good power quality if supplied voltage remains steady within a specified range, and exhibits smooth voltage curve waveform [39]. It is vital to capture characteristics of events like sag, swell, etc. by monitoring power quality [18]. The power quality (PQ) event detection and classification (or identification) is widely recognized as one of the most interesting problems in electric engineering [6,16,51,1].

It consists of two sub-problems: detection and classification. In the first step, a recognition algorithm is used to detect disturbance from power quality events. Next, after successful detection of disturbances, the second step classifies them into some groups by a machine learning method like support vector machine (SVM) [17], Artificial Neural Network (ANN) [38], fuzzy logic [1], etc. It is recalled that good features are necessary for both power quality event detection and classification [29].

Regarding the first step, various methods have been used to detect power quality events such as Fourier transforms (FT) [49]. The power quality disturbances are non-stationary/non-periodic in nature so that they cannot be processed using Fourier transform [40]. The limitation is mainly due to quick variations (transient phenomenon) in incoming signals, which is difficult to observe visually by this method [40]. Short-Time Fourier Transform (STFT) was used for detecting these patterns [49]. This gives information in time domain and frequency domain with two window functions being used to obtain good resolution and increase operations [49]. The major drawback of this method is a fixed short window so that alternative approaches of wavelet change were utilized [9,14,34,40,38].

However, multi resolutions are decayed with the assistance of Low Pass and High Pass channels [17]. Wavelet has few weaknesses, for example, its confounded calculation to commotion level and reliance of exactness on picked wavelet [17]. This prompts the improvement of ST (Stockwell Change) [17] which is an invertible time recurrence unearthly limitation method joining the components of WT and STFT. ST utilizes an investigation window so that thickness is diminished with recurrence; thus giving a recurrence subordinate determination.

* Corresponding author at: 334 Nguyen Trai, Thanh Xuan, Hanoi, Viet Nam. Tel.: +84 904 171 284.
E-mail addresses: rajivkapoor@dce.ac.in (R. Kapoor), rashmig71@yahoo.com (R. Gupta), sonlh@vnu.edu.vn (L.H. Son), jhasudan@hotmail.com (S. Jha), raghvendraagrawal7@gmail.com (R. Kumar).

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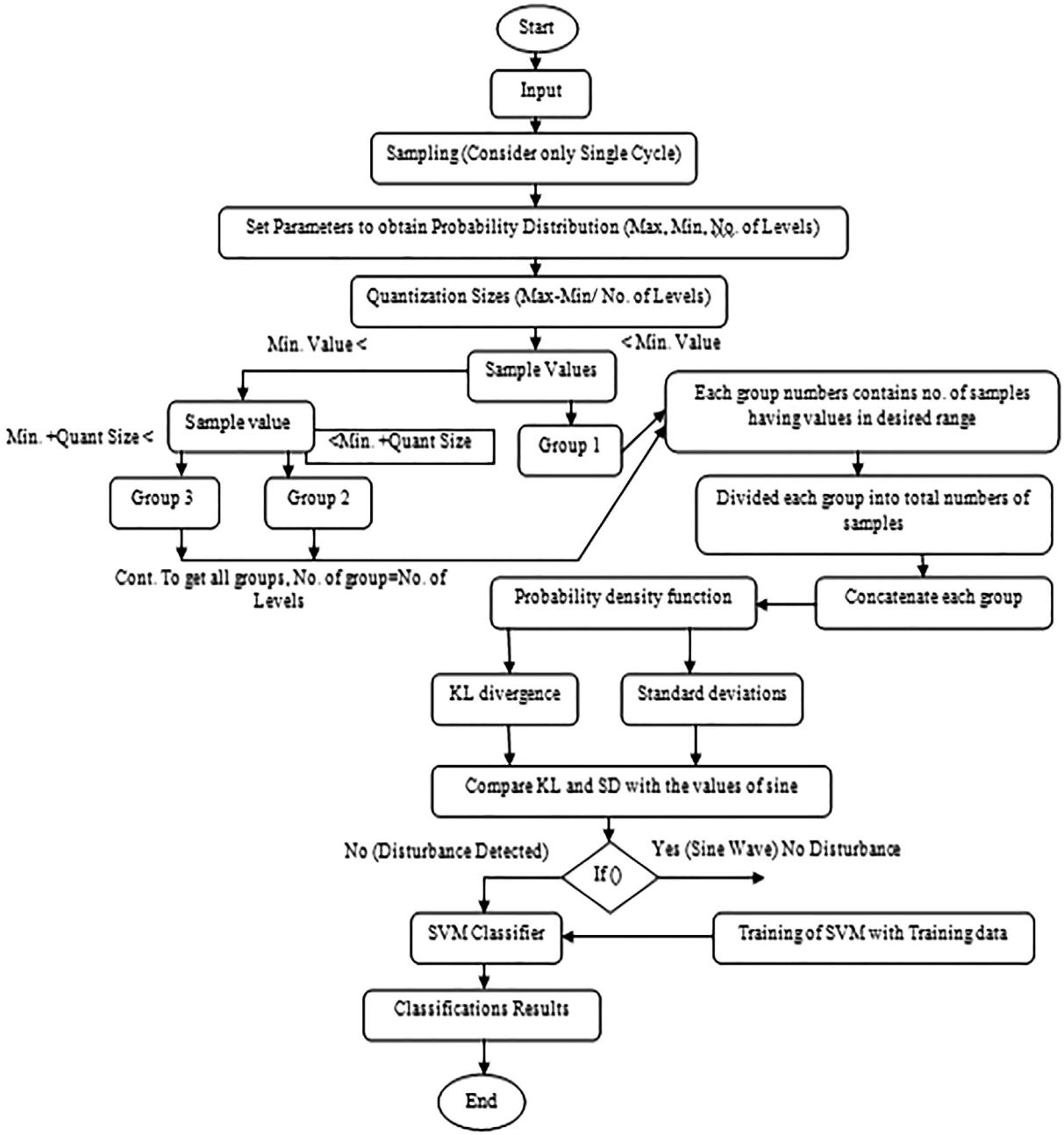

Fig. 1. Flowchart of the proposed method.

More literature review on power event detection can be referred in Section 2. However, we observe that time domain and frequency behaviors are two main approaches from those works [15]. In this paper, KL Divergence and Standard Deviation are used to detect and classify events quickly. KL Divergence acquires less processing time and can be applied to single cycle of the input signal instead of multiple cycles. It reduces the complexity and inefficient time. Standard Deviation is often used for input feature exaction from distorted voltage waveforms. Due to these reasons, KL Divergence and Standard Deviation methods have been more result-oriented approach.

In what follows, related studies and the proposed method are shown in Sections 2 and 3. Section 4 describes experiments. Section 5 delineates conclusions and further works.

2. Literature survey

Gupta and Kumar [10] proposed a straightforward and novel technique in view of symbolic dynamics for discovery of PQ aggravations. Hajian and Foroud [12] introduced a new feature selection method namely Orthogonal Forward Selection by incorporating Gram Schmidt and forward selection for detection of Power Quality Disturbances (PQDs). Kumar et al. [21] introduced the Hilbert – Huang transform for perceiving multiple events. Mohanty et al. [30] examined islanding discovery in a hybrid distributed generation framework by utilization of hyperbolic S-transform, time–time change and morphology techniques. Yong et al. [50] proposed a technique in view of a mix of binary classifiers which are advanced for those extraordinary situations where the genuine signs contain a large number of occasions inside the analyzed temporal window. Khokhar et al. [19] introduced an exhaustive survey on utilization of signal and optimization methods