Residential Load Pattern Analysis for Smart Grid Applications Based on Audio Feature EEUPC

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ABSTRACT

The smart grid is an important application field of the Internet of Things. This paper presents a method of user electricity consumption pattern analysis for smart grid applications based on the audio feature EEUPC. A novel similarity function based on EEUPC is adapted to support clustering analysis of residential load patterns. The EEUPC similarity exploits features of peaks and valleys on curves instead of directly comparing values and obtains better performance for clustering analysis. Moreover, the proposed approach performs load pattern clustering, extracts a typical pattern for each cluster, and gives suggestions toward better power consumption for each typical pattern. Experimental results demonstrate that the EEUPC similarity is more consistent with human judgment than the Euclidean distance and higher clustering performance can be achieved for residential electric load data.

Keywords: Electric Load Pattern Analysis, EEUPC, EEUPC Similarity, Internet of Things, Smart Grid

1. INTRODUCTION

The smart grid is an intelligent electrical power management system inherited from the conception of the Internet of Things. It is based on the physical electricity network, and benefits humanity by advanced technologies highly integrated, such as sensors, automation control and decision support. In the field of smart grid, electric load analysis has attracted
considerable attention of researchers in recent years. According to the result of electric load analysis, electricity suppliers are able to improve power energy supply and distribution. What’s more, electric load analysis is closely linked with consumers, helping them understand their own needs and make an arrangement of power energy consuming more wisely.

Current work on electric load analysis mainly includes two aspects. On one hand, many researchers analyze the impact of various factors on the electric load in order to facilitate load forecasting. Numerous methods have been proposed, such as Kalman filtering analysis, regression analysis, exponential smoothing forecasting, expert systems, fuzzy prediction, gray model, optimal combination forecasting, artificial neural networks, rough sets algorithm, fuzzy clustering, particle swarm optimization, and genetic algorithm. Based on these algorithms, researchers intend to figure out the relationships between the electric load and factors such as weather, economic growth and so on, and using the factors with high relevance, higher accuracy can be achieved in load forecasting.

On the other hand, there is also much research effort on user electric load pattern analysis, of which current research mainly focuses on clustering and classification of load patterns (daily or monthly load curves in practice). The purpose of load pattern clustering analysis is to group users’ load patterns into several typical classes and thus help electricity suppliers get better knowledge of their customers and customize their supply strategies. For example, many researchers perform clustering analysis on load patterns of industrial electricity customers such as companies and factories (Ding & Wang, 2008). They compare clustering results with economic type codes of customers, indicating that electric power load patterns can be effectively distinguished by pattern modes and the results are approximately consistent with industry types. The limitation of this sort of research lies in three aspects: First, most current research work focuses on clustering of load data of industrial customers other than ordinary residential customers, and conclusions of this type of research cannot suit residential customers as consumption habits of industrial customers and residential customers are of considerable difference. However, clustering analysis of residential customers is of great significance, since the domestic load occupies a large part of total electricity consumption, and is usually not as stable as industrial consumption. Secondly, current methods only yield the result of clustering analysis and support of decision-making is not provided. To make decisions, users have to analyze the clusters of patterns manually to extract useful information. Thirdly, most current methods which deal with industrial load data use the Euclidean distance as the distance measurement of load patterns. However, for residential load data which are more unstable, similar patterns with consistent peaks and valleys may yield low similarity due to the difference in value, thus making results of clustering not satisfactory. Therefore, a different distance metric is needed, which measures the similarity in terms of the shape of the load curve (e.g., peaks and valleys on the curve) instead of simply comparing the values.

In this paper, an approach for residential electric load pattern analysis is proposed. The method focuses on analysis of residential electric load patterns and proposes a novel similarity function based on the audio feature EEUPC (which is named EEUPC similarity). The EEUPC distance exploits features of peaks and valleys on curves instead of directly comparing values as Euclidean distance does, and can obtain better performance for clustering analysis. Moreover, the approach proposed in this paper not only performs load pattern clustering, but also extracts a typical pattern for each cluster and gives suggestions of wiser consumptions with lower cost for each typical pattern.

The rest of this paper is organized as follows. In Section 2, related work on electric load analysis is presented. In Section 3, the electric load pattern clustering method based on the audio feature EEUPC is described in detail. And Section 4 presents the method for typical load pattern analysis after clustering.
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