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ScienceDirect

Energy Procedia 135 (2017) 496–503

Energy Procedia

www.elsevier.com/locate/procedia

11th International Renewable Energy Storage Conference, IRES 2017, 14-16 March 2017, Düsseldorf, Germany

Forecast of Infrequent Wind Power Ramps Based on Data Sampling Strategy

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Abstract

The introduction of wind power generation has been promoted in Japan. However, wind power is an unstable power source because its output varies according to the weather. Particularly, sudden changes in output, which could adversely affect the power system, are called ramps and may cause serious problems in the power system. In this paper, the authors discuss the ramp event forecast by using classifiers. A serious issue in this setup is that classification based forecast tends to be inaccurate since the occurrence of such a ramp is relatively rare. This problem is called the class imbalance problem in the machine learning field. To overcome the class imbalance problem in ramp forecast, several data sampling approaches are implemented. The effectiveness of these sampling approaches is experimentally evaluated by using a real-world wind power generation dataset. The results show that the implemented approaches drastically improved the forecast accuracy.

Peer-review under the responsibility of EUROSOLAR - The European Association for Renewable Energy.

Keywords: wind power; forecast; ramp events; class imbalance problem; data sampling.

1. Introduction

The introduction of wind power generation has been promoted in Japan [1] in terms of preventing global warming, improvement of energy self-sufficiency rate, and economic growth in related industries. The total introduction of wind power generation in Japan has 3,234MW until December in 2016 [2]; and Japan Wind Power Association suggests the introduction target of wind power generation in Japan shall be over 36,200 MW by 2030 [3]. However,

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1876-6102
Peer-review under the responsibility of EUROSOLAR - The European Association for Renewable Energy.
10.1016/j.egypro.2017.09.494

wind power is an unstable power source because its output varies according to the weather. Figure 1 shows the total wind power output in three days observed at Tohoku area in Japan. As shown in the figure, the generated output includes large scale unintended fluctuations. Particularly, sudden changes in output that could adversely affect the power system are called *ramp events* [4]; the sudden rise in output is called *ramp up*, and the sudden drop is called *ramp down*. Figure 1 also shows the occurrences of ramp up (red) and ramp down (blue). When such ramp events occurred, the operation of alternative generation and energy storage systems is necessary to mitigate the impacts on power system. For example, in Japan, a demonstration project utilizing a battery energy storage system has been launched as a new approach to frequency changes caused by weather-dependent power fluctuations resulting from the increasing use of renewable energy sources; this project uses a large-scale battery energy storage system with ratings of 40 MW - 20MWh, which is the world's largest class [5]. In order to determine schedules of alternative generator operation and state-of-charge control of the storage battery system, the information of forth-coming large scale power fluctuation is important.

The study of wind power forecast has been actively discussed in recent years [6]. Most of the wind power forecast methodologies focus on the wind power output, and have been basically evaluated from viewpoints of the root mean squared error (RMSE) or the mean absolute error (MAE). However, these approaches have difficulty in forecasting ramp events accurately because they tend to underestimate the fluctuation and the timing of ramp events. Hence, we particularly focus on forecast of the ramp occurrence from the viewpoint of classification setup [7].

In this paper, we propose a forecast approach of forth-coming ramp events based on the predicted power sequence. In particular, we focus on the difficulty so-called *the class imbalance problem* [8] such that the forecast accuracy of the ramp events tends to be low; the difficulty is mainly caused by infrequency of the ramp events. We adopt several data sampling approaches to overcome the class imbalance problem in ramp forecast. The effectiveness is experimentally evaluated from the viewpoint of *critical success index* (CSI) by using a real-world wind power generation dataset collected at Tohoku area in Japan.

The rest of the paper is organized as follows. The framework of forecast is introduced in Section 2. In Section 3, we explain the class imbalance problem in ramp event forecast and introduce several data sampling methods to overcome the problem. The numerical experiment based on the real-world wind power data is shown in Section 4. The implemented approaches are compared from the viewpoint of ramp forecast accuracy. Finally, the concluding remarks are given in Section 5.

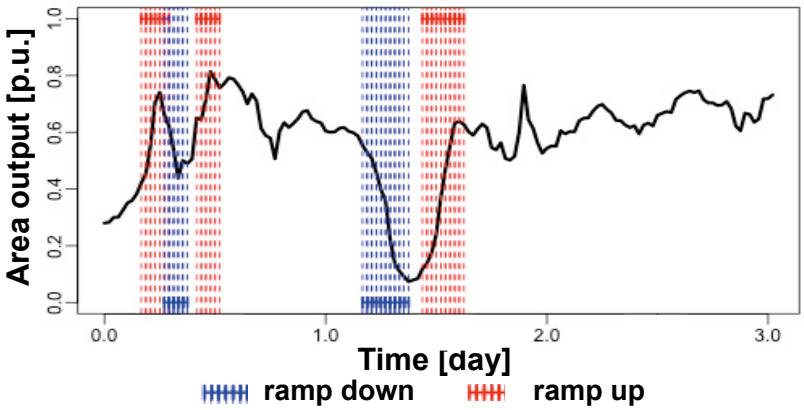

Fig. 1. Example of ramp events