Event Detection and Classification for Fiber Optic Perimeter Intrusion Detection System

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ABSTRACT

A perimeter intrusion detection system (PIDS) is critical for the security of a shale gas field. Among many technologies, the fiber optic sensor-based method is the most widely used, due to its passive, low-cost, long-life, and strong anti-interference ability and strong environmental adaptability. This article proposes an event detection and classification method for a fiber optic PIDS. In general, three types of features are extracted for an improved double-threshold method to improve the probability of detection. Also, the detected intrusion events are distinguished by a support vector machine with wavelet features to reduce the nuisance alarm rate. Experiments on the PIDS in Chongqing Fuling’s shale gas field show that detection algorithms based on the feature of short-time energy and short-time wavelet coefficient energy are much better, and the performance of event classification is satisfactory.

KEYWORDS

Cognitive Signal Processing, Double-threshold Method, Event Classification, Event Detection, FOPIDS, Short-time Energy, Short-time Wavelet Coefficient Energy, Short-time Zero Cross Rate, SVM

INTRODUCTION

Perimeter intrusion detection systems (PIDSs) have been widely used in security protection areas, such as private houses, prisons, and oil-and-gas collection stations. Typical PIDS technologies can be divided into the following categories: Leaky cable detection technology, active infrared detection technology, pulsed electronic detection technology, microwave wall detection technology, electromagnetic induction vibration cable detection technology, and fiber optic sensing technology. Compared with other methods, the fiber optic sensing technology is widely recognized in the PIDS, due to its immunity to electromagnetic interference, high sensitivity, no power required in the field,

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strong environmental adaptability, high reliability, and long-term effectiveness of cost (Kumagai, Sato, & Nakamura, 2012; Mahmoud & Katsifolis, 2010a). However, the implementation of PIDS, often in noisy or harsh environments, needs to overcome some interesting challenges to achieve acceptable performance.

The case the authors studied in this paper is Chongqing Fuling shale gas field. For the rest of this paper, it will be referred to as the Field. The Field is China’s first large-scale shale gas field and the largest shale gas field in the world, except for North America. Since the discovery, the Field has been aiming at intelligent construction, and it is required that the gas gathering station is unattended. This makes the security of the oil and gas station crucial (Stastny, 2010). At present, the Field is equipped with fiber optic perimeter intrusion security systems. However, it is found that the existing PIDS is unsatisfactory, since it is hard to strike a balance between the probability of detection (POD) and nuisance alarm rate. On the one hand, the intrusion detection algorithm of the existing PIDS is relatively simple. It extracts simple features, such as signal amplitude, single packet maximum duration, normalized signal duty cycle, and peak mean value, and then uses thresholds as classification criteria (Allwood, Wild, & Hinckley, 2016; Liu et al., 2016). Indeed, the above features are mainly a simple representation of the signal amplitude, which is not sufficient to express complex and variable intrusion signals. Moreover, the setting of thresholds is usually experienced fixed, which does not allow to easily achieve good results for different types of intrusions (Liu et al., 2014). On the other hand, the existing system does not distinguish between intrusions and nuisances. Nuisance alarms are any alerts which unimportant events generate. Nuisance alarms are usually generated by environmental conditions, such as rain, wind, snow, wildlife, and vegetation, as well as anthropogenic sources, such as traffic intersections, industrial noise, and other sources of environmental noise.

In order to address these issues, advanced signal processing algorithms that can improve POD and eliminate nuisance alarms are critical in PIDSs. Therefore, this paper will focus on these two aspects, and propose a multifeature-based event detection method and an event classification method based on wavelet transform and support vector machine (SVM) to maintain high POD and minimize the nuisance alarms. It consists of two main stages, including an offline training stage and an online application stage. Figure 1 shows the proposed method.

The remaining part of the paper is organized as follows. The second section briefly introduces the basic principle of the fiber optic perimeter system. The third and fourth sections illustrate a multifeatured-based event detection algorithm and a SVM-based event classification algorithm in detail. The fifth section gives the experiments and discussions. The last section is the conclusion.

Figure 1. Overview of the event detection and classification framework
Some Remarks on the Concept of Approximations from the View of Knowledge Engineering
Tsau Young Lin, Rushin Barot and Shusaku Tsumoto (2010). International Journal of Cognitive Informatics and Natural Intelligence (pp. 1-11).
www.igi-global.com/article/some-remarks-concept-approximations-view/43874?camid=4v1a

A Cognitive Informatics Reference Model of Autonomous Agent Systems (AAS)
www.igi-global.com/article/cognitive-informatics-reference-model-autonomous/1578?camid=4v1a