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Quantum-Inspired Features and Parameter Optimization of Spiking Neural Networks for a Case Study from Atmospheric

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Abstract
Identified cluster of atmospheric discharges, sufficiently near from transmissions line, could be an important alarm to support real time decisions. Lightning are important events that affect the electrical power system operation, which are often responsible for transmission lines outages, and can trigger a sequence of events that lead to system collapse. The Brazilian lightning network detection monitors nearly 18 million events monthly and all this data must be processed and analyzed. This paper uses a hybrid model named the Quantum binary-real evolving Spiking Neural Network (QbrSNN) for clustering problem, where the features and parameters of a spiking neural network (SNN) are optimized using the Quantum-Inspired Evolutionary Algorithm with representation Binary-Real (QIEA-BR). The proposed model is applied to atmospheric discharges data, with a significantly higher clustering accuracy than traditional techniques.

Keywords: Atmospheric Discharges, Spiking Neural Network, Clustering, Evolutionary Algorithms

1 Introduction

Early detection of possible occurrences of several whether events is very important to avoid, or at least mitigate, the environmental and social economic damages caused by such events. Atmospheric discharges, responsible for the transmission lines outages, are represented by clustered pattern of behavior associated with thunderstorms, not an isolated incidence of rayon the equipment (Jusevicius, 2007; Lima, 2013). For this reason, the study of algorithms for identifying such groups is important in order to generate alarms with a high degree of reliability, serving to support early real time decisions. Thus, the aim of this study is to identify electrical discharges clusters, which is an important step in the modeling process alarms criteria, using computational techniques named spiking neural networks (Maass, 1997).

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Spiking Neural Networks (SNN) is presented as a new paradigm connectionist creating a third generation of neural network models (Maass, 1997). Are models that are not only biologically inspired, but also biologically plausible, allowing the creation of other types of coding data, new types of neurons and adaptation of existing training methods using the pulses produced by a neuron. The literature contains several proposals that allow treating spatio-temporal data with SNN parameter optimization resources to achieve better precision in classification and forecasting problems (Hamed, 2009; Hamed, 2011).

This neuro-evolutionary model used in this paper is named Quantum binary-real evolving Spiking Neural Networks (QbrSNN) (Silva, 2014), based on the Quantum-Inspired Evolutionary Algorithm with Binary-Real (QIEA-BR) representation (Pinho, 2009). Evolutionary algorithms with quantum inspiration have been used in combinatorial optimization problems, finding good solutions with fast convergence.

The paper is organized as follows. Section II explains presents the concept of atmospheric discharge data and the importance of clustering importance, Section III will present the QbrSNN proposed for clustering, where the input features and parameters that configure the SNN will be optimized. Section IV presents the results, and Section V discusses the conclusions.

2 Atmospheric Discharges Data

Atmospheric discharges (lightning) are electromagnetic phenomenon with an unpredictable and random behavior of great proportions. The Brazilian network lightening detection has capacity to identify intra-clouds and cloud to earth discharges. Brazil has the most cloud-earth lighting incidents in the world, reaching 100 million a year. These problems directly affect the electrical power system, often causing transmission line outages, even leading to a power system collapse scenario (blackouts). These events are associated with a group of discharges and their identification is important for the real-time decisions on power system operation (Jusevicius, 2007).

A reliable identified cluster of atmospheric discharges, sufficiently near to transmissions lines, can be an important alarm to support real time decisions to reschedule generation and energy interchanges, bringing the power system into a secure state. However, the big question for the generation of these alarms is the prior identification of the concentration of these lightning events, close to the transmission lines. Because of unknown frequency and the random characteristics of events, unsupervised learning techniques are advantageous, avoiding the blindness of phenomenologically based modeling for poorly understood systems. Thus, the aim of this study is the identification of lightning clusters, which is an important step in the modeling criteria for process alarms. A group of discharges near to a 500 kV transmission line is shown in Figure 1.

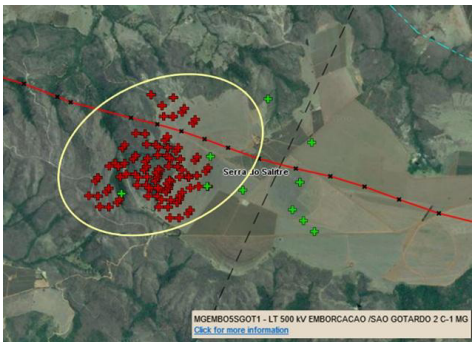

Figure 1: Atmospheric discharge cluster near to transmission line.