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Editorial

Power Systems Imitate Nature for Improved Performance Use of Nature-Inspired Optimization Techniques

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1. Introduction

Renewable energy transition creates unprecedented issues in power system control, operation and protection. In order to mitigate these challenges, novel solutions are required. One approach is imitating the behavioral patterns of animals such as butterflies, ants, wolves or whales. Their optimized behavior in different stages of life such as hunting, or foraging can be used as a guide for other complex systems. When employed in a suitable way, their natural behavior helps to optimize interactions between different renewable-energy based generators and create a more stable microgrid [1,2].

One of the ways in which these optimization techniques can be implemented is managing the intermittent behavior of renewable resources [3]. There are other implementations of such optimization approaches. For instance, they can be utilized to predict and mitigate electricity theft [4] or develop inverters with higher performances [5–7] or control torque in electrical machines [8]. More sophisticated designs include the control of virtual power plants for deep renewable energy penetration [9], a more efficient energy routing [10] and an optimal power flow [11], as well as the control of frequency control for stability [12–14]. These solutions are not only limited to power system operation. Recently, researchers have been using such optimizations to maximize profits in the competitive energy markets with renewable energy participation, organize demand side response schemes [15] and even to detect and mitigate cyberattacks.

It goes without saying that there are many more such techniques. For instance, one technique is to use an artificial bee colony [16], where a bee's foraging for nectar and subsequent dancing to guide the other bees to the food source is modeled, whereas the particle swarm optimization foraging behavior of birds or fish over a large swath of land can also be utilized to find the optimum solutions points for a specific function [17]. There are more novel approaches such as those that are based on the unique hunting behavior of humpback whales [18] or the internal dynamics of wolf packs during hunting [19]. Regardless of their origin of inspiration, all of these approaches count on the fact that nature always finds the most optimal way of doing something which is desperately required for survival.

2. Conclusions

Modern power systems, when utilized, are pushed closer to their physical limits. This means there are smaller margins for any errors in operation or planning. To operate an efficient system within these tight limits, everything must be optimized as much as possible. Recent studies show that optimization techniques found in nature can help to fill this important knowledge gap. Animals, as well as plants, have developed these optimized operations which have stood the test of time, on the order of thousands or millions of years. When applied to modern power system issues, they can help stabilized system frequency, increase renewable energy penetration and detect cybersecurity vulnerabilities. It is a relatively new research area with many exciting opportunities.

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