Internet-of-Things-Assisted Smart Grid Applications in Industry 4.0

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Abstract. This paper studies some recent advances in the field of Smart Grid, including the application of some intelligent algorithms to optimize energy efficiency and energy collection, in order to have some impact on the green theme of Smart Grid under the intelligent system of the Internet of Things. For optimization in SG, evolutionary or heuristic algorithms play an important role. Cat Swarm Optimization (CSO), Emperor Penguin Optimization (EPO), Butterfly Mating Optimization (BMO), Honey Bee Mating Optimization (HBMO) and many other algorithms have been applied to SG optimization, and more and more flexible, skilled and robust algorithms will be added to contribute to SG optimization in the future.

1. Introduction

The framework of Industry 4.0 requires more interactions and connections among machines, products, components and operators. Therefore, for all manufacturers, strengthening autonomous interactions and maintaining the stability of connections are the top priorities [1]. The goal of Internet of Things (IoT) is to enable manufacturers to collect and share data in real time, and it is regarded as the real game changer of industrial networks in I 4.0. This study focuses on the field of SG and explores the optimization of energy efficiency and energy collection by some evolutionary or heuristic algorithms.

Traditional power grids are facing problems such as low power generation efficiency, lack of automation, insufficient distribution and power supply, and blind monitoring [2]. These problems not only limit the supply and demand of the grid and lead to the gap between supply and demand, but also lead to the rise of electricity prices and harm to the ecological environment. Hence SG has emerged. SG is a transformation of the traditional power grid that allows distributed generation and integrated renewable energy. The great progress of SG is undeniable. However, SG has its own problems. Recent studies have shown that in SG, wireless channels present some obvious challenges due to fading, multipath effects, device noise, heat, electromagnetic interference, and dust environments that do not normally exist in other environments [1].
Evolutionary or heuristic algorithms are biologically inspired solutions that have been widely used in a lot of fields because of its strong flexibility, proficiency and robustness in the optimization of constraint and search space. These algorithms also make a great contribution to the optimization of SG.

2. Literature Review and Bio-Inspired Routing Protocol
Considering the practical limitations in SG environment, Alam et al. [2] proposed a new network structure based on authorized spectrum and Cognitive Radio technology, namely a channel allocation cluster-based Approach (CBA), and optimized the network with Clustering method. CBA algorithm can make full use of cluster management to reduce interference and network utilization when applied to SG scenario. CBA algorithm, based on cat swarm optimization, can deal with two completely opposite allocation targets, namely, allocation target bundle based on fairness and priority. The simulation results show that the proposed algorithm achieves ideal results on multi-constraint problems.

Preeth et al. [3] proposed a Neuro Fuzzy Emperor Penguin Optimization (NP-EPO) method based on WSN energy saving track design supported by mobile Convergence IoT. An adaptive neurofuzzy reasoning system (ANFIS) is proposed for optimal selection of cluster heads. They considered the input parameters of residual energy, neighbor node sharing and node behavior history to select the optimal sink point. Finally, an effective Emperor Penguin Optimal Routing algorithm (EPO) is used to find the moving convergence points and travel paths. The simulation results show that this method has better performance than the existing routing schemes.

Faheem et al. [1] proposed a new self-optimized butterfly mating optimization data collection routing scheme based on biological excitation. The highly dynamic nature of the SG environment poses some challenges to the system and operating equipment, which will hinder the service communication quality requirements for WSN-based SG applications. By considering the natural behavior of butterflies and the evolution of genetic variation during mating, the bionic routing protocol proposed by them seeks for the shortest loop-free routing solution that is close to the optimal in the sparse and densely deployed network. The proposed routing protocol avoids too many routing faults and solves the problem of routing faults within bounded time interval in the network with an intelligent mechanism based on self-learning. In addition, the key idea of greedy packet forwarding along the narrow routing path with double sinks and each sub-region is utilized to significantly disperse the data traffic load and minimize the memory overflow of sensor nodes and network hot spots. A large number of simulations show that compared with the existing WSN-based routing schemes, the proposed scheme achieves the established goals.

Fadel et al. [4] proposed Cognitive Radio Sensor Networks (CRSN). They wanted to find a low-power clustering solution to deal with the complexity of the network. Therefore, routing and cooperative channel allocation algorithms based on bee mating optimization are proposed. In the harsh smart grid spectrum environment, the framework significantly reduces the probability of packet loss and maintains the high link quality between sensor nodes. The performance of the proposed method has been evaluated in terms of packet transfer ratio, latency and energy consumption, and it is proved that it has successfully solved the QoS requirements of most SG applications.

3. Inspired Bio-Computing Model in Smart Grid Applications
The Inspired Biological Computing Model (IBC) has a big impact on new scientific and technological algorithms. It is helpful to solve complex problems problems. So IBC algorithm makes use of complex problems in SG structure.

Cat Swarm Optimization (CSO) was proposed by Shu-an Chu et al. [5]. It is a kind of global Optimization algorithm based on Cat behavior. It has the characteristics of fast convergence and strong optimization ability. CSO randomly distributes the cats throughout the search space and then subdivides the cats into two modes. The first is called search mode, in which the cat is at rest, paying close attention to its surroundings. The second mode, called tracking mode, is what cats do when they're tracking and chasing dynamic prey. The two modes interact through the Mixture Ratio. MR represents the proportion of the population of cats in the run tracking mode, and MR should be a small value in the program.
Emperor Penguin Optimization (EPO) was proposed by Dhiman and Kumar [6] in 2018 to simulate the behavior of emperor penguins in searching for the highest temperature in the colony for optimization. The basic idea is the emperor penguin convergence integration a group in the winter, the heat group has produced, and in the group must be within the scope of the penguin individual movement towards the direction of the higher temperature, temperature of the top of the individual is the best individual, in determining each after the distance between the individual and the best individual, each penguin experience to the optimal individual motion and to determine the optimal individual position. The emperor penguin individual is guided by the optimal individual to constantly change their position and move to the optimal point, which realizes the optimization process.

Butterfly mating optimization (BMO) was proposed by Jada et al. [7] in 2016. Since the butterfly's life expectancy is very short, usually about 1 to 2 weeks, the mating system of butterflies is of great significance for increasing the butterfly population. Generally speaking, there are two positioning methods for male butterflies to find females, namely patrol and habitat. The males fly over the area where the females are on patrol, and when they spot insects the same size and color as the females, the males fly over to take a closer look. Males use more color, and when patrolling males approach females, some females are spotted using female pheromones. Species that patrol the entire habitat mate at any time of day, even in cold habitats, because flying can increase heat. In roosting mode, on the other hand, males can investigate and intercept passing females by sitting on a protruding leaf or in a particular location for a long period of time.

Honey Bee Mating optimization (HBMO) was proposed by Afshar [8] in 2001. HBMO based clustering algorithm is the biological inspiration obtained from the mating process of real bees. A colony is mainly composed of the queen, some drones, and worker bees, each cell can contain one or more of the queen, the queen in mating season left honeycomb, by attracting drones mating flight, but with the queen and the queen bee drone does not necessarily fall into the same cell, that is to say, the queen can drone mated with other cellular. If there are two or more queens in a hive, one or more queens migrate to the new hive to mate with the drones, causing the bees to replace each other's genes. Drones, which can be thought of as the fathers of a colony, act only as amplifiers for the queen's genome and do not alter its genetic inheritance unless mutated.

4. Discussion and Conclusion

The traditional power grid is becoming less and less suitable for the fourth Industrial Revolution and the increasing daily energy demand. Therefore, the transformation of traditional power grid to SG is an inevitable trend. However, the popularization of new technologies is full of difficulties and challenges still need to be paid continuous attention and overcome. For optimization in SG domain, evolutionary or heuristic algorithms play an important role. Cat Swarm Optimization (CSO), Emperor Penguin Optimization (EPO), Butterfly Mating Optimization (BMO), Honey Bee Mating Optimization (HBMO) and many other algorithms have been applied to SG optimization, and more and more flexible, skilled and robust algorithms will be added to contribute to SG optimization in the future.

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