系统操作员必须完全了解配电网拓扑，才能执行与监视，控制，优化和计划有关的任何任务[10]，[17]。 例如，如今分布式可再生能源在电网中的渗透率不断提高，可能会导致相当大且频繁的电压波动以及电力线拥塞。在这种情况下，可以重新配置或计划配电网，以减轻过多的电压降，减少线路拥塞或将功率损耗降至最低。 但是，采取这些措施需要完全了解拓扑结构以及节点总线组之间的交互作用。

Full awareness of the distribution grid topology is required for a system operator to perform any tasks related to monitoring, control, optimization, and planning [10], [17]. For instance, the increasing penetration of distributed renewable generation in power grids nowadays can cause sizable and frequent voltage fluctuations, as well as power line congestion. In this case, the distribution grid can be reconfigured or planned to alleviate excessive voltage drops, reduce line congestion, or minimize power losses. Nonetheless, taking these measures entails full knowledge of the topology and the interactions between groups of nodal buses.

高压输电网络通常在固定拓扑下运行（即，在运行过程中无需频繁进行网络重新配置），并且它们的拓扑结构捕获 总线如何通过电线相互连接 通常对于系统运营商来说是可用的[4]。 但是，在低压和中压住宅配电网中，由于信息和通信技术的部署不断增加，通过安装新设备来改造现有的电力基础设施，因此通常不提供实时拓扑信息[4]。在这种情况下，配电网拓扑识别是后续监视，控制和优化任务的先决条件。

High-voltage power transmission networks are typically operated under fixed topology (i.e., there is no frequent network reconfiguration during operation), and their topology capturing how buses are connected with each other through electric lines is typically available to system operators [4]. However, in low- and medium-voltage residential distribution grids, due to the increasing deployment of information and communication technologies, which retrofit the existing power infrastructure by installing new devices, real-time topology information is in general not available [4]. In this context, distribution grid topology identification is a prerequisite for subsequent monitoring, control, and optimization tasks

已经提出了许多方法来识别电力网络中存在的连接。有关最新概述，请参见例如[9]。在[12]中，通过在总线连接点的阻抗估计来重建电网拓扑。但是，由于多个拓扑可以报告相似的阻抗，因此通常无法保证估计正确拓扑的成功。使用线性逼近模型，通过扰动某些总线上的功率注入并观察节点电压响应来执行拓扑处理[16]。文献[4]中提出了一种利用节点电压幅值的逆样本协方差矩阵逆矩阵中元素的符号来提倡一种数据驱动的拓扑识别算法。尽管这些方法相对于基于阻抗的方法有所改进，但它们并未考虑节点电压测量之间的固有非线性依赖性，从而产生了次优的性能。最后，在文献[14]中，利用直流潮流模型，为输电网络开发了一种基于功率注入的盲拓扑识别算法。

A number of methods have been proposed to identify the connections present in a power network; see, for example, [9] for a recent overview. The grid topology was reconstructed by means of impedance estimation at the point of connection of buses in [12]. Nevertheless, since multiple topologies can report similar impedance, the success of estimating the correct topology cannot be guaranteed in general. Using a linear approximation model, topology processing was performed by perturbing power injections at certain buses and observing nodal voltage responses [16]. A data-driven topology identification algorithm was advocated by using the signs of the elements in the inverse sample covariance matrix of nodal voltage magnitudes in [4]. Even though these methods improve with respect to the impedance-based methods, they do not account for the intrinsic nonlinear dependencies between nodal voltage measurements, yielding sub-optimal performance. Finally, leveraging the DC power flow model, a blind topology identification algorithm based on power injections was developed for transmission networks in [14].

为了捕获数据中的非线性连通性和动态性，最近研究了结合部分相关性和内核的拓扑识别方法[19]，[9]，[6]。尽管可以采用这些方法来识别配电网拓扑，但它们在实践中面临两个挑战：首先，选择合适的内核需要交叉验证，或解决计算上涉及的优化任务。其次，用于对数据之间的非线性相互作用进行建模的内核不允许解释子分支中不同总线表现出的相互作用。尽管这种非线性拓扑识别方法可以学习有意义的连接，但它们缺乏解开一组总线之间发生的交互（即高阶交互）的能力。该限制主要是由于它们依赖于著名的结构方程模型（SEM）[11]，[5]。确实，SEM已成功用于识别各种应用中的网络拓扑[9]。但是，由于它们基于成对交互，因此无法捕获一组总线之间的高级交互。

To capture the nonlinear connectivity and dynamics in the data, topology identification methods combining partial correlations and kernels have recently been investigated [19], [9], [6]. While it is possible to adopt these methods to identify the distribution grid topology, they face two challenges in practice: First, selecting proper kernels requires cross-validations, or solving computationally involved optimization tasks. Second, kernels used to model the nonlinear interactions between the data do not allow interpreting the interplay that different buses in children branches exhibit. Although such nonlinear topology identification methods can learn meaningful connections, they lack the ability to unravel interactions occurring among a group of buses, namely higher-order interactions. This limitation is mostly due to their reliance on the celebrated structural equation models (SEMs) [11], [5]. Indeed, SEMs have been successfully used to identify network topology in diverse applications [9]. However, since they build on pair-wise interactions, they cannot capture higher-order interactions among a group of buses