In this work, the problem of detecting radio spectrum opportunities in spectrum-heterogeneous cognitive radio networks is addressed. Spectrum opportunities are the frequency channels that are underutilized by the primary licensed users. Thus, by enabling the unlicensed users to detect and utilize them, we can improve the efficiency, reliability, and the flexibility of the radio spectrum usage. The main objective of this work is to discover the spectrum opportunities in time, space, and frequency domains, by proposing a low-cost and practical framework.

Spectrum-heterogeneous networks are the networks in which different sensors experience different spectrum opportunities. Thus, the sensing data from sensors cannot be combined to reach consensus and to detect the spectrum opportunities. Moreover, unreliable data, caused by noise or malicious attacks, will deteriorate the performance of the decision-making process. The problem becomes even more challenging when the locations of the sensors are unknown.

In this work, a probabilistic model is proposed to cluster the sensors based on their readings, not requiring any knowledge of location of the sensors. The complexity of the model, which is the number of clusters, is automatically inferred from the sensing data. The processing node, also referred to as the base station or the fusion center, infers the probability distributions of cluster memberships, channel availabilities, and devices' reliability in an online manner. After receiving each chunk of sensing data, the probability distributions are updated, without requiring to repeat the computations on previous sensing data. All the update rules are derived mathematically, by employing Bayesian data analysis techniques and variational inference.

Furthermore, the inferred probability distributions are employed to assign unique spectrum opportunities to each of the sensors. To avoid interference among the sensors, physically adjacent devices should not utilize the same channels. However, since the location of the devices is not known, cluster membership information is used as a measure of adjacency. This is based on the assumption that the measurements of the devices are spatially correlated. Thus, adjacent devices, which experience similar spectrum opportunities, belong to the same cluster. Then, the problem is mapped into an energy minimization problem and solved via graph cuts. The goal of the proposed graph-theory-based method is to assign each device an available channel, while avoiding interference among neighboring devices. The numerical simulations illustrate the effectiveness of the proposed methods, compared to the existing frameworks.