Abstract

Artificial neural networks (ANNs) have been used for classification, quantification, and drift corrections. While applying ANNs and traditional pattern recognition techniques, additional statistical algorithms are necessary for data pre-processing and compensating for the drift. Due to such multistage off-line statistical procedures, these methods are not suitable for real-time applications. Hence, we have developed an end-to-end hybrid convolutional neural network (CNN) architecture called a “drift tolerant robust classifier (DTRC),” suitable for real-time real-field applications. It can automatically extract salient multidimensional features from the drifted raw sensor array responses capable of efficiently classifying the gases/odors. While classifying with such extracted features, DTRC also curtails the drift impacts and outperforms the various state-of-the-art peers. The DTRC comprises three blocks performing one-, two-, and three-dimensional (1D, 2D, and 3D) operations. DTRC does not use any additional statistical algorithm to compensate for the drift, making it compatible with real-time applications. A publicly available benchmark drifted-dataset has been used to prove the efficacy of DTRC. Moreover, real-time applications requiring high accuracy to detect and estimate hazardous gases/odors are too challenging to implement with traditional approaches. Therefore, researchers have started to use CNNs for developing efficient e-Noses. However, the generalization has not been discussed so far to apply CNNs for gas classification independent of types of gas sensor array responses. Recently, authors have applied CNNs to classify the gases/odors using only dynamic responses without discussing the same for static responses. The popular 2D-CNN performs better when operating on 2D input data of optimal size with suitable kernels. Hence, we have proposed a novel approach by utilizing 2D-CNN for gas classification using steady-state responses of the gas sensor array. In this regard, the operational data vectors are augmented with the synergy of mirror mosaicking and padding of virtual sensor responses, which are obtained from the principal components. The experimental results have been demonstrated on two different datasets that have been upscaled with this approach to provide the desired outcomes. Using such an approach, we are the first to utilize a principal component-based hybrid and upscaled dataset. An e-Nose utilizing our proposed policy has achieved 100 percent correct classification for the considered set of unknown test samples which were not used during training and validation of the networks over the considered gases/odors. Further, the sensor nodes should be ultra-

power-efficient and compatible with Artificial Intelligence (AI) models in 6G-IoT (6G driven Internet of Things) ecosystems. The challenge rises whenever the sensor node is required to be deployed in a resource-constrained environment since AI models require high computational capacity due to inherent complex architecture. We have, hence, discussed how a gas sensor node can be optimized to be power-efficient; and how we can obtain high performance using the synergy of an optimized sensor node and a lightweight CNN. A gas sensor node consists of an array of non-selective gas sensors chosen randomly without intuition about the optimal number of sensors to use, causing redundancy. Consequently, the gas sensor nodes can be optimized by removing the redundant physical gas sensor elements that leads to the reduction in power consumption of the gas sensor node. While the deteriorated performance by this removal is compensated using a CNN incorporating zero-padding and spatial augmentation. The experimentation with this approach has been demonstrated to classify and quantify the four hazardous gases. The performance of the unoptimized gas sensor array has been taken as a “baseline” to compare the performance of the optimized gas sensor array. This approach reduced the power consumption of the gas sensor array to half. At the same time, classification and quantification were achieved with 100 percent accuracy and a very low mean squared error (MSE). Consequently, our power-efficient optimization and lightweight CNN pave the way to deploy gas sensor nodes in the resource-constrained 6G-IoT paradigm. It is also suitable for edge intelligence reducing the computational complexity on edge.