Chapter 6

Conclusions and Future Scopes

6.1 Conclusions

As discussed in the preceding Chapters 3, 4, and 5, our proposed approaches are well-suited to classify the gases/odors in resource-constrained paradigms. For illustration, we have taken a case of 6G-IoT resource-constrained gas sensing systems to understand the scenario.

- The DTRC is an end-to-end architecture of a hybrid CNN that facilitates the classification of gases/odors even using drifted gas sensor array responses and outperforms its state-of-the-art peers.
- Moreover, DTRC does not require any additional drift correction algorithms, making it computationally efficient.
- The end-to-end architecture of DTRC makes it compatible with real-time classifications of gases/odors. The real-time applications of gas sensing are crucially required in various scenarios.

- ☛ In the research community, our proposed DTRC is the very first application of the hybrid architecture of CNN for gas/odor classification.
- ☛ We have proposed a novel principal component-based non-zero padding that outperforms conventional non-zero padding. The proposed concept of non-zero padding can be used for gas classification and various other padding-based applications.
- ☛ The proposed approach of non-zero padding is generic. Hence, while using non-zero padding, other non-zero features may be alternatives to principal components.
- ☛ Padding also enables CNN to be applied on steady-state responses only. Thus, it reduces computational complexity since the static and dynamic responses have been used simultaneously to classify the gases/odors traditionally.
- ☛ The padded features can also be considered the virtual gas sensor responses that are utilized to artificially augment the data for efficient use of advanced machine learning techniques.
- ☛ For illustration, we have applied the synergy of padding and CNN to optimize the power consumption of gas sensor nodes.
- ☛ Our proposed gas sensor node optimization approach makes the gas sensor nodes compatible to be deployed even in resource-constrained IoT systems.
- ☛ With the upcoming 6G wireless communication technologies, IoT systems are being deployed in miniaturized applications such as healthcare robotics and spy drones that are undoubtedly resource-constrained 6G-IoT paradigms.

- ☛ The wearable sensor technologies are also cutting edge applications requiring miniaturized and optimized sensor networks being resource-constrained applications.

Our proposed approaches are incredibly computationally efficient with all of the above highlights. Moreover, the application of CNN to classify the gases/odors using only steady-state responses, principal component-based non-zero padding, use of 3D CNN for gas classification, and a hybrid CNN-based robust classifier to classify the gases/odors even using drifted datasets are the novelties of this thesis.

6.2 Future Scopes

With the generalized approaches, our works will pave the way for various innovative data processing approaches in the future by the readers of our published articles and the thesis.

- ☞ The application of CNN to steady-state responses for the classification of gases/odors opens the door to applying CNN to limited data applications for researchers of various communities.
- ☞ We have used principal components instead of zero values of conventional zero-padding for the high-performance classification of gases/odors. Hence, this generalized non-zero padding can also use other types of derived features.
- ☞ A straightforward hybrid CNN architecture has been used to classify the gases/odors robustly by surpassing drift's impact. The researchers can propose different CNN architectures with various other end-to-end strategies.

- ☞ A miniaturized integrated gas sensor array can be fabricated by removing the redundant gas sensor elements, keeping insights from gas senor node optimization.

- ☞ All the described approaches in our thesis are well-suited for resource-constrained paradigms. Thus, these can be utilized accordingly for various applications such as micro-robots in healthcare, spy drones, and forensics.