Preface

The potential of edge devices has been significantly enhanced by integrating Machine Learning (ML) with the Internet of Things (IoT). ML algorithms have provided fast data analytics and prediction in IoT applications connected to the Internet for helping the end-users. This integration of edge devices and ML optimizes resource utilization and facilitates fast responsiveness. Smart city management, waste management, traffic management, *etc.*, use intelligent edge devices using ML. Edge device advancement via ML facilitates the Intelligent Transportation System (ITS) to improve transportation facilities. In addition, ML with IoT supports remote patient monitoring systems, which is an advancement of edge devices. The application of Unmanned Aerial Vehicles (UAVs) is increased via edge devices using lightweight Deep Neural Networks (DNNs) to improve battery life and fast responsiveness. The integration of edge devices and ML is transforming industries to become smarter and enhance productivity.

ITS is an emerging area of recent research, where prior literature has indicated several important contributions with integrating federated learning and LoRaWAN in intelligent applications such as transportation systems, smart buildings and UAVs. The critical issues facing the field of ITS and the urgent demand for a workable solution serve as the driving force behind this research. Modern transportation has seen the emergence of ITS as a critical paradigm, offering safer and more effective movement for both products and passengers. However, several serious problems have hampered ITS's potential, necessitating creative fixes. The most important of these concerns is the privacy and security of personal data. The substantial volume of data gathered and processed by ITS includes sensitive data relating to cars, drivers, and passengers. The effectiveness of communication in ITS is a worry in addition to these problems. Vehicle mobility, great separations between them and the processing units, and the erratic nature of wireless connectivity all add complications that must be resolved. We aim to maximise communication efficiency to ensure that data transmission continues to be both dependable and energy-efficient.

In this thesis, we investigated the different challenges encountered during the advancement of edge device applications. This work considers three tasks: 1) a federated learning approach with imperfect labels in LoRa-based transportation systems, 2) machine learning-based interference mitigation in long-range networks for high-ceiling smart buildings, and 3) leveraging augmented intelligence of things to enhance the lifetime of UAV-enabled aerial networks. While considering the task of IoT application, we identify challenges like imperfect labelling problems and interference mitigation problems while transmitting the data and enhancing the lifetime of UAV devices.

First, we proposed a federated learning approach for ITS, which aims to improve data security and communication efficiency while handling the issue of imperfect label data in participant device datasets. In this work, we have estimated class-wise centroids to identify participants with imperfect labels and use data reduction and inclusion mechanisms to enhance their performance. Fed-LoRa employs the LoRaWAN for efficient data transmission, estimates class-wise centroids to identify participants with imperfect labels, and uses data reduction and inclusion mechanisms to improve their performance. The experimental validation proves Fed-LoRa effectiveness in protecting privacy, security, and communication efficiency in the setting of ITS.We conducted experimental results to find out the accuracy of various imperfect labels. We have also shown the class-wise similarity score and performance. We have also conducted experiment on the different similarity thresholds.

We further covered the second problem of identifying the interference nodes in LoRa networks. Our approach utilizes ML techniques, using Signal to Noise Ratio (SNR) and Radio Signal Strength Identifcation (RSSI) values to identify nodes that cause network interference accurately. We conducted experiments in different deployment scenarios, including a high-ceiling smart building, and observed that network parameter-based interference solutions work well in scenarios with few obstacles and static LORa Nodes and LoRa Gateway. Our approach successfully estimates interference from up to five devices on a given SF with high accuracy. We have drawn experimental results to show the accuracy in the prediction of interference nodes. We have created dataset(SQM) on our campus to doing all experiments. We also performed different machine learning techniques to find out the interference nodes.

Finally, we proposed an approach to enhance the lifetime of UAV-enabled aerial networks via augmented IoT (AIoT). The main objective of the approach is to improve the lifetime of aerial networks by replacing DNN on battery-operated UAVs with lighter versions, incurring minimal accuracy compromise. We calculated accuracy, F-score and recall on a publicly available dataset namely River Water Pollution Monitoring (RWPM). We have also shown experimental result of the impact of layer sharing. We considered different performance metrics, including F1-score (F1), precision (P), recall (R), and training time reduction ratio (TTR2). We have used optimal dropout selection followed by weight factorization and reducing gated units to obtain lightweight DNN from given large-size DNN satisfying constraints battery power, memory, and task frequency. We have utilized the concept of knowledge distillation, where we adopted layer sharing among teacher and student, followed by selective back-propagation of shared layers during student training.