Autoencoder based framework for drone RF signal classification and novelty detection

Sanjoy Basak*†, Sreeraj Rajendran†, Sofie Pollin†, Bart Scheers*

*Department CISS, Royal Military Academy, Belgium

†Department ESAT, KU Leuven, Belgium

Email: {sanjoy.basak, bart.scheers}@rma.ac.be, {sreeraj.rajendran, sofie.pollin}@esat.kuleuven.be

***Abstract*—The increasing use of Unmanned Aerial Vehicles (UAVs) in modern civilian and military applications shows the urgency of having a robust drone detector that detects unseen drone RF signals. Ideally, the system can also classify known RF signals from known drones. This study aims to develop an incremental-learning framework which can classify the known RF signals, and further detect novel RF signals. We propose DEFEND: a Deep residual network-based autoEncoder FramEwork for known drone signal classification, Novelty Detection, and clustering. The known signal classification and novelty detection are performed in a semi-supervised and unsupervised manner, respectively. We used commercial drone RF signals to evaluate the performance of our framework. With our framework, we obtained 100% novelty detection accuracy at 1.04% False Alarm Rate (FAR) and 97.4% classification accuracy with only 10% labelled samples. Furthermore, we show that our framework outperforms the state-of-the-art (SoA) algorithms in terms of novelty detection performance.**

***Keyword*—Deep neural networks, Unsupervised learning, UAV.**

Sanjoy Basak received the M.Sc. degree in electrical engineering and information technology from Karlsruhe Institute of Technology, Karlsruhe, Germany, in 2016. He joined the Royal Military Academy, Belgium as a Researcher in 2016, where he is currently pursuing a joint doctoral study in association with KU Leuven in the Department of Electrical Engineering since 2019. His research interests include deep learning algorithms for wireless signal detection and classification.

Sreeraj Rajendran received the master's degree in communication and signal processing from the Indian Institute of Technology Bombay, India, in 2013, and the Ph.D. degree from KU Leuven, Belgium, in 2019, where he is a Post-Doctoral Researcher with the Networked Systems Group. In 2013, he was a Senior Design Engineer with the Baseband Team, Cadence (Tensilica). He was also an ASIC Verification Engineer with Wipro Technologies from 2007 to 2010. His main research interests include machine learning algorithms for wireless spectrum awareness and low power wireless sensor networks.

Sofie Pollin (Senior Member, IEEE) received the Ph.D. degree (Hons.) from KU Leuven, Leuven, Belgium, in 2006. From 2006 to 2008, she continued her research on wireless communication, energy-efficient networks, cross-layer design, coexistence, and cognitive radio at UC Berkeley. In November 2008, she returned to IMEC, Leuven, to become a Principal Scientist in the Green Radio Team. Since 2012, she has been a tenure track Assistant Professor with the Department of Electrical Engineering, KU Leuven. Her research centers around networked systems that require networks that are ever more dense, heterogeneous, battery-powered, and spectrum constrained. Prof. Pollin is a fellow of the BAEF and Marie Curie.

Bart Scheers was born in Rumst, Belgium, in November 1966. He received the M.S. degree in engineering, with a specialisation in communication from the Royal Military Academy, Brussels, Belgium in 1991 and a joint Ph.D. degree in 2001 from the Université catholique de Louvain, Ottignies-Louvain-la-Neuve, Belgium/Royal Military Academy, where he presented his Ph.D. dissertation on the use of ground penetrating radars in the field of humanitarian demining. After his studies, he was an Officer in a territorial signal unit of the Belgian Army. In 1994, he was an Assistant in the field of signal processing with the Royal Military Academy, where since 2003, he has been a Military Professor with the Communications Information Systems and Sensors (CISS) department, and is also the Director of the research unit on radio networks. His current domains of interest are mobile ad hoc networks (layers 2 and 3), cognitive radio, and internet of things.