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Detection and Identification of UAVs based on Spectrum Monitoring and Deep Learning in Negative SNR Conditions

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The democratization of Unmanned Aerial Vehicles (UAVs) is creating an unprecedented need to monitor any misuse of this new technology. Privacy breaching, espionage attacks, drug smuggling, are some notorious examples of illegal use of UAVs that have been reported [1]. Despite the potential threats, UAVs provide practical and cost-effective solutions for several beneficial applications ranging from package deliveries, maintenance, agricultural management, to rescue missions [2]. Consequently, accurate real-time detection, classification and identification of UAVs are primordial to guarantee the safe use of this technology and to protect critical infrastructures.

Multiple techniques have been proposed: Radio Frequency (RF) analysis both in time and in frequency domains, MAC addresses identification, acoustic signatures and radar-based techniques, as well as direct visual detection with high-resolution cameras [2, 3]. In practice, the small cross-section of most UAVs and their ability to fly at low heights hinders their detection. Despite these limitations, real-time spectrum monitoring using a combination of passive radio surveillance with Convolutional Neural Networks (CNN), revealed to be a suitable method to classify UAVs with acceptable accuracy even in the presence of moderately strong random noise [4]. For low and negative Signal to Noise Ratio (SNR), preserving the accuracy of CNN fingerprinting in real-time comes with the cost of the non-trivial knowledge of the apriori SNR and also training different networks for each specific level of noise [4].

The present work tackles the challenge of classification of very weak RF signals which corresponds to negative SNRs ranging from 0 to -15 dB (positive SNRs have also been studied from 30 dB to 0 dB giving equivalent reported results of [4]) and explores different strategies to enhance the accuracy of CNNs while avoiding the common practice of training for noise with different SNRs [4]. This work showcases the advantages of performing spectral equalization and time resolution adjustment in conjunction with CNN classification. These additional cost-effective techniques can boost the classification accuracy without explicitly training for noisy RF fingerprints, and hence are particularly suitable for real-time monitoring systems. The proposed approaches have been tested against a publicly available dataset [5] composed of 17 UAVs models.

During the presentation, the different tools and techniques applied to detect, classify and identify UAVs through the emitted RF signals will be detailed. The detection accuracy will be discussed considering the simulated realistic environment with low SNR and complex channel effects such as inter-symbol interference and fading.

References

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