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PASSIVE RADAR FOR UAV DETECTION IN LTE/5G NETWORKS: ANTENNA ARRAY OPTIMIZATION, ECA-B SIGNAL PROCESSING AND AI INTEGRATION

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The progress of unmanned aerial vehicles (UAVs) requires a review of traditional methods of airspace monitoring. Traditional active radar is vulnerable to electronic warfare and consumes significant energy. This is where passive coherent location (PCL) tech comes in as a stealth solution. It uses existing electromagnetic

background signals such as TV, LTE and 5G to spot targets without emitting its own radiation.

The PCL system operates in bistatic geometry, where the reference channel receives the signal directly from the illuminator of opportunity (IoO), and the observation channel receives a weak echo from the target. The main challenge is to identify small UAVs with low radar cross-section (RCS), from -23 to -10 dBsm for LTE frequencies [1]. This requires the use of complex filtering algorithms to extract the useful signal, which is often 30 dB below the noise level.

Detection efficiency depends directly on the geometry of receiver placement, which should be optimized according to the Cramér-Rao lower bound (CRLB) [2]. Phase calibration of antenna arrays is crucial for ensuring accurate direction finding.

Table 1 – Comparison of UAV detection capabilities in different systems

Parameter	Result (DVB-T2)	Result (LTE/5G)	Note
Detection range	750 – 5000 m	250 – 1600 m	It depends on the IoO signal power and the target RCS [3, 4].
Range resolution	18 – 37 m	0.5 – 10 m	5G provides sub-meter accuracy [5, 6].
Direction finding accuracy	2 – 5 deg	1 – 3 deg	When using calibrated antenna arrays [4, 5, 6]
Minimum RCS	~0.01 m^2	~0.005 m^2	DJI Phantom 3 is consistently detected [1].

In terms of data processing, there has been a shift from classic filters to block algorithms using the ECA-B (Extensive Cancellation Algorithm). This allows the signal to be cleaned in real time on embedded platforms (e.g., Raspberry Pi 5) [3].

The role of artificial intelligence is worth mentioning as well. The implementation of neural networks (YOLO, CNN, U-Net) enables UAV classification from RF spectrograms with an accuracy of over 96% [7]. Another promising area is the ISAC (Integrated Sensing and Communication) concept, where 5G/6G networks are initially designed as integrated communication and radar systems. This turns each base station into an active element of a global monitoring network.

In conclusion, effective detection of modern UAVs is greatly enhanced by the synergy of broadband illuminators of opportunity (5G/LTE), adaptive filtering algorithms (such as ECA-B), and intelligent signal analysis. The use of affordable SDR platforms such as KrakenSDR or USRP makes such systems viable for deployment in challenging electromagnetic environments.

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