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# A lightweight clutter suppression algorithm for passive bistatic radar

**Key words:** Passive bistatic radar; Clutter suppression; Extensive cancellation algorithm; Computational complexity; Space complexity

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# Motivation

In passive bistatic radar, the computational efficiency of clutter suppression algorithms remains low, due to continuous increases in bandwidth for potential illuminators of opportunity and the use of multi-source detection frameworks.

# Main idea

1. The construction of the reference signal subspace matrix within the ECA framework is adjusted to simplify the computational aspects.
2. A dimension-expanding technique is introduced to streamline the clutter estimation.
3. Overall, the proposed method replaces the computation-intensive aspects of the original ECA with fast Fourier transform (FFT) and inverse FFT operations, and eliminates the construction of the memory-intensive signal subspace.

# Method

We introduce a lightweight ECA called ECA-L. ECA-L works through circular convolutions and circular matrix processing, leveraging fast Fourier transforms (FFTs) and inverse FFTs (IFFTs) to fundamentally reshape the construction of reference subspaces and large-scale matrix computations. This transformation yields an order-of-magnitude reduction in both computational workload and storage space requirement compared to the traditional ECA, while retaining high performance.

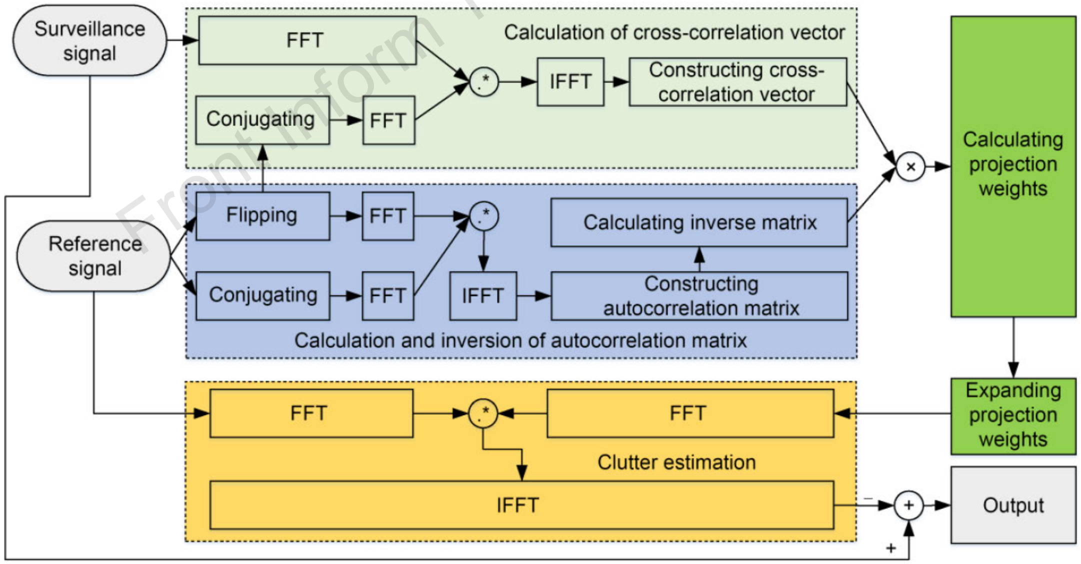


**Fig. 2 Flowchart of the proposed ECA-L (FFT: fast Fourier transform; IFFT: inverse FFT)**

# Major results

- Comparison of clutter suppression performance of ECA, ECA-B (across different batches), and ECA-L based on simulation data

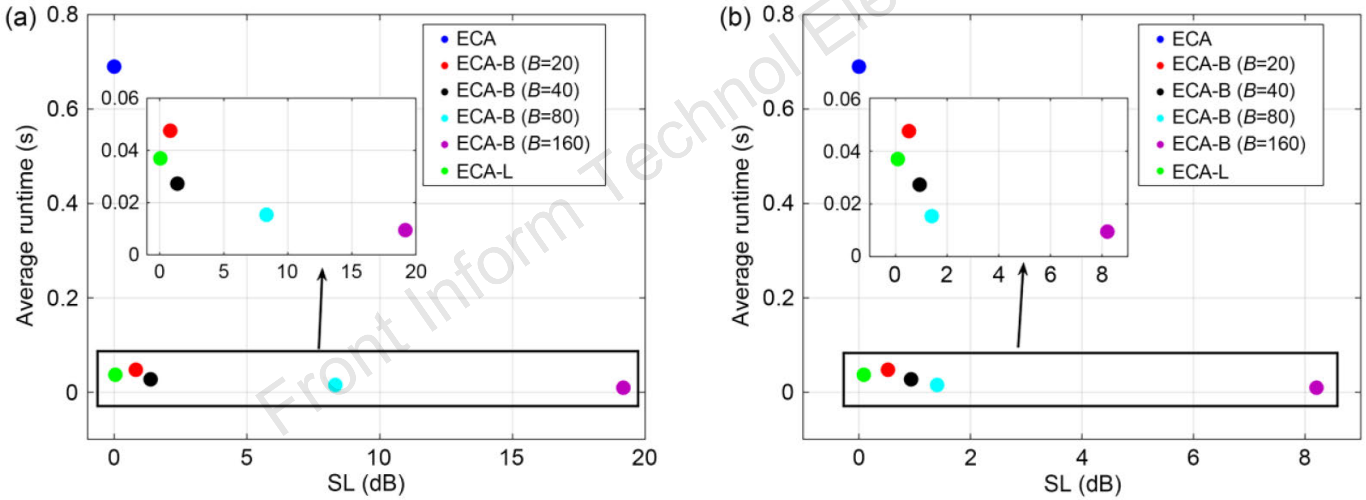


**Fig. 4 Comparison of the signal-to-noise ratio loss (SL) of the two targets and average runtime for ECA, ECA-B, and ECA-L: (a) SLs of target A and average runtime for the three methods; (b) SLs of target B and average runtime for the three methods**

# Major results (Cont'd)

- Comparison of clutter suppression performance of ECA, ECA-B (across different batches), and ECA-L based on real data

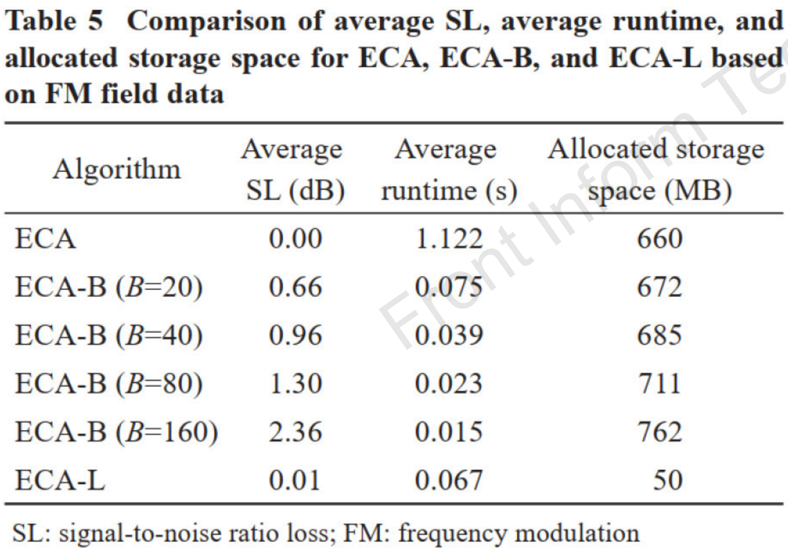


**Table 5 Comparison of average SL, average runtime, and allocated storage space for ECA, ECA-B, and ECA-L based on FM field data**

| Algorithm | Average SL (dB) | Average runtime (s) | Allocated storage space (MB) |
|---|---|---|---|
| ECA | 0.00 | 1.122 | 660 |
| ECA-B (*B*=20) | 0.66 | 0.075 | 672 |
| ECA-B (*B*=40) | 0.96 | 0.039 | 685 |
| ECA-B (*B*=80) | 1.30 | 0.023 | 711 |
| ECA-B (*B*=160) | 2.36 | 0.015 | 762 |
| ECA-L | 0.01 | 0.067 | 50 |

SL: signal-to-noise ratio loss; FM: frequency modulation

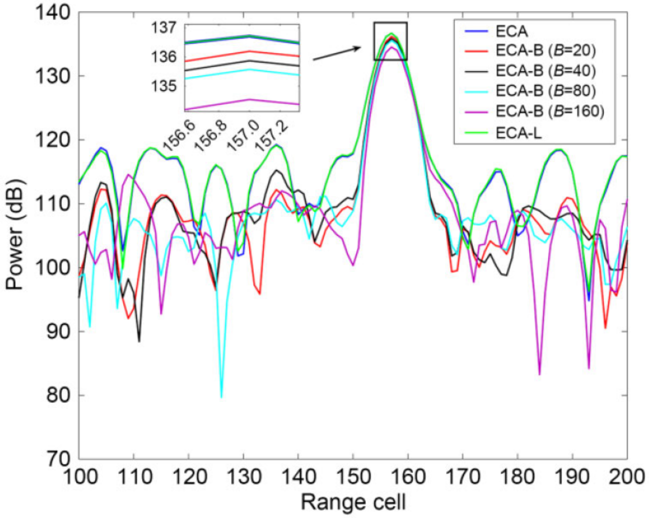


**Fig. 7 Doppler dimensional profiles of the range-Doppler (RD) results of the strongest target for ECA, ECA-B, and ECA-L**

# Major results (Cont’d)

- Comparison of clutter suppression performance of ECA, ECA-B (across different batches), and ECA-L based on real data

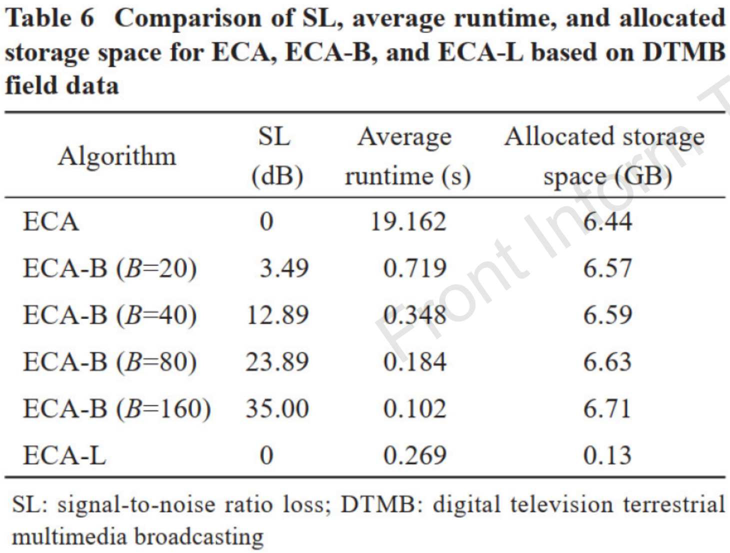


**Table 6 Comparison of SL, average runtime, and allocated storage space for ECA, ECA-B, and ECA-L based on DTMB field data**

| Algorithm | SL (dB) | Average runtime (s) | Allocated storage space (GB) |
|---|---|---|---|
| ECA | 0 | 19.162 | 6.44 |
| ECA-B (*B*=20) | 3.49 | 0.719 | 6.57 |
| ECA-B (*B*=40) | 12.89 | 0.348 | 6.59 |
| ECA-B (*B*=80) | 23.89 | 0.184 | 6.63 |
| ECA-B (*B*=160) | 35.00 | 0.102 | 6.71 |
| ECA-L | 0 | 0.269 | 0.13 |

SL: signal-to-noise ratio loss; DTMB: digital television terrestrial multimedia broadcasting

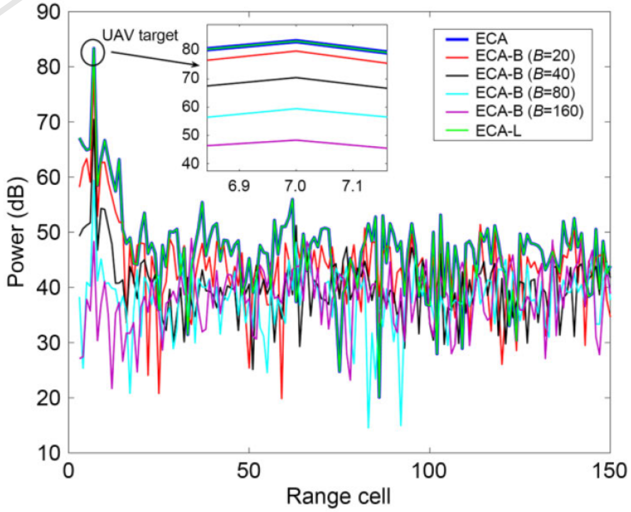


**Fig. 8 Doppler dimensional profiles of the range-Doppler (RD) results of the UAV target for ECA, ECA-B, and ECA-L**

# Major results (Cont’d)

- Comparison of clutter suppression performance of ECA, ECA-B (across different batches), and ECA-L based on real data

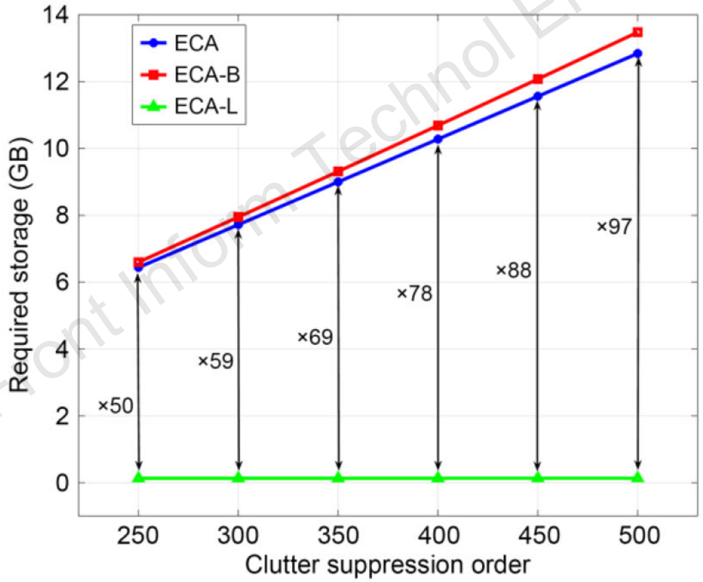
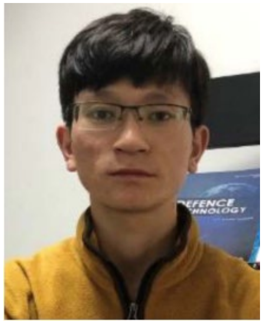


**Fig. 9 Variations in storage resource requirements with clutter suppression order for ECA, ECA-B, and ECA-L**

# Conclusions

1. Differing from mainstream batch processing methods like ECA-B and its variants (which necessitate dividing the signal and reduce the accuracy), the proposed ECA-L streamlines computations through FFT and IFFT operations and eliminates the need to divide the signal. Additionally, it dispenses with the requirement for constructing the reference subspace.
2. ECA-L markedly improves computational efficiency compared to the traditional ECA, while maintaining comparable clutter suppression performance to ECA.
3. The effectiveness of the proposed method was validated through both simulation and field data results, providing a valuable demonstration of its utility for PBR applications.

Yong WU received his Ph.D. degree in signal and information processing from Xidian University, Xi'an, China, in 2016. Currently, he is a lecturer in the Zhejiang Institute of Communications, Hangzhou, China. His research interests include radar signal processing and parallel computing.



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