

Frequency-Adaptive Dynamic Neurons for Low-Memory FMCW Radar Processing

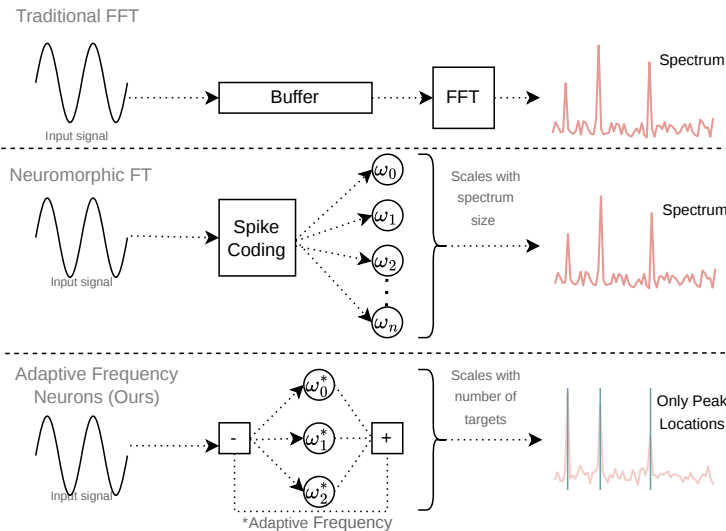
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Frequency Modulated Continuous Wave (FMCW) radar systems typically use Fourier-based methods, such as the Fast Fourier Transform (FFT), to estimate target range and velocity by identifying peaks in the frequency spectrum. Although computationally efficient, these approaches require storing and processing large blocks of data, which can become a bottleneck in memory-constrained applications. Several neuromorphic approaches have been proposed [1, 2, 3, 4] that mimic the computation of a Fourier Transform, however dedicated FFT accelerators remain more efficient [1].

In this work, we propose a neuromorphic-inspired signal processing method based on adaptive frequency oscillators (AFO), derived from a discrete-time resonate-and-fire neuron. Each oscillator dynamically adjusts its internal frequency to match the dominant frequency components of the input signal, eliminating the need to compute the full spectrum. Two layers of adaptive frequency neurons can be chained to estimate both range and velocity of targets.



Method	Memory
FFT	~4 KB
D-FFT [3]	~4 KB
S-FFT [1]	~12 KB
AFOs (5 units)	~140 B

Table 1: Memory requirements for processing a signal of 512 samples (float32).

Figure 1: Processing scheme for different methods.

The proposed model operates sample-by-sample, with each neuron tracking a target, resulting in memory requirements that scale with the number of tracked targets rather than the signal length, as shown in Figure 1. Table 1 shows the memory requirements for different methods. A feedback mechanism is used to enable multiple oscillators to specialize in distinct frequency components. Simulation results on synthetic and recorded FMCW radar data demonstrate that the method can successfully track multiple targets. Compared to conventional FFT-based approaches, the proposed method substantially reduces memory usage, making it well-suited for embedded and edge radar applications.

[1] López-Randulfe, Javier, et al., IEEE Transactions on Computers 71.11: 2792-2802, 2022

[2] S. Chiavazza et al., 2025 22nd European Radar Conference, pp. 335-338, 2025

[3] J. López-Randulfe et al., Front. Neurorobotics, vol. 15, 2021

[4] Frady, E. Paxon, et al., Journal of Signal Processing Systems 94.10: 917-927, 2022