DSP Project: Adaptive Noise Cancellation

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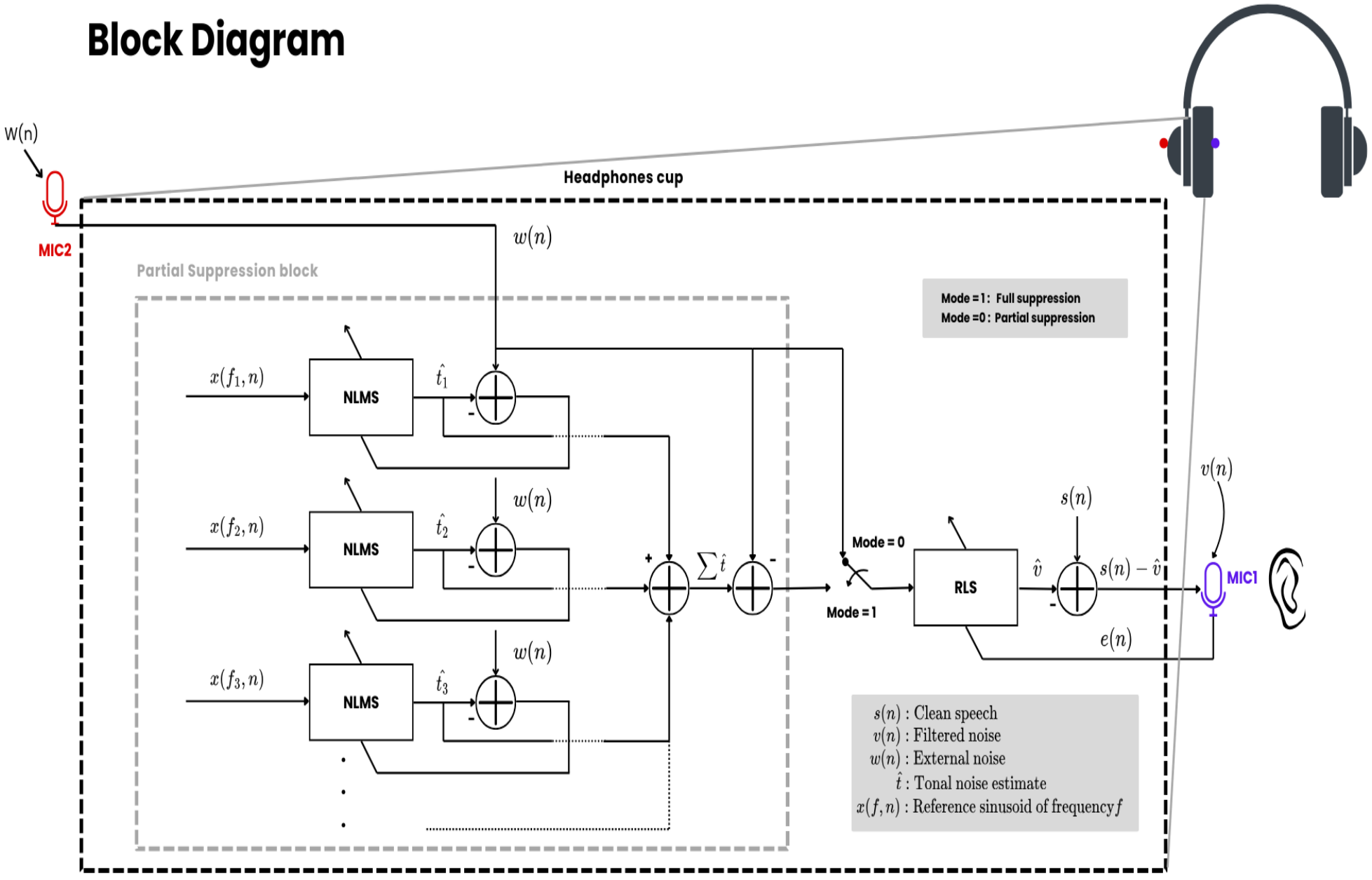
Block Diagram



Design Overview

Full Suppression (Mode = 0):

1. Uses an RLS (Recursive Least Squares) filter to update coefficients.
2. Filter order (L): Lower taps for lower latency.
3. RLS has a higher computational complexity, $O(L^2)$, than LMS ($O(L)$), but offers a faster convergence rate.[1]
4. Metric used to determine: SNR Gain.

Partial Suppression (Mode = 1):

1. Uses a reference sinusoid and an NLMS filter to adaptively estimate tonal noise from external noise ($w(n)$).
2. The reference includes both sine and cosine components to track phase shifts relative to $w(n)$ and also time-varying amplitudes.
3. Using RLS to estimate tones would drastically increase complexity (up to $O(L^3)$) if programmable frequencies exceed filter length.
4. Metric: Normalized TNR (Tone to Noise ratio) gain using FFT.[2]

Design: Pros and Cons

Pros :

1. RLS filter offers better tracking of non-stationary noise.[3]
2. Performs well when the noise is locally stationary and the filter order is low.
3. Adaptive filters (such as NLMS) provide more effective tonal noise estimation compared to low-Q notch filters, which offer limited frequency selectivity.

Limitations :

1. The computational complexity increases as the filter order is increased, hence may fail to capture lower frequency noise.
2. NLMS struggles to estimate the tonal noise if it is much weaker than the non-tonal noise.

Assumptions :

1. The noise and the speech are uncorrelated.
2. The time of computation is very low; noise can be subtracted instantaneously at each time step.

References

[1] Monson H. Hayes: Statistical Digital Signal Processing and Modeling, Wiley, 1996, ISBN 0-471-59431-8 (Chapter 9, Page 546)

[2] ECMA TR/108: Proposal of New Parameters, T-TNR and T-PR for Total Evaluation of Multiple Tones

[3] Paulo S.R. Diniz: Adaptive Filtering: Algorithms and Practical Implementation, Kluwer Academic Publishers, 1997, ISBN 0-7923-9912-9