INTERIM PROGRESS REPORT - 2

on

Leaky LMS algorithm based low complexity adaptive noise cancellation

Submitted by

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Under the supervision of

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Abstract:

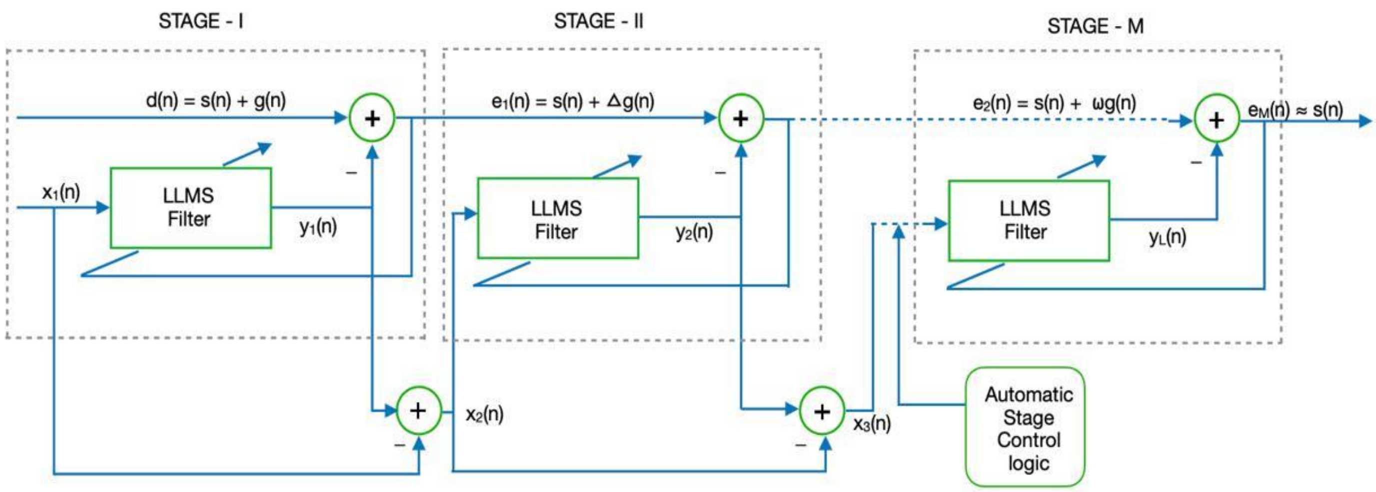
- Parkinson’s disease is a progressive Neurological disease which has a wide range impact on human lives. Over 15 million people around the world suffers from this Neuro degenerative disease. As Parkinson’s disease affects the speech most , it can be diagnosed using acoustic signals like speech, ultrasound and PCG signal. Speech signals are crucial for detecting speech disorders as they hey reveal slight problems in a person’s voice that indicate underlying speech and Neurological disorders . The accuracy of speech signals in medical diagnostics is affected by noise. Speech-processing systems perform worse when speech signals are distorted. Techniques like wavelet transforms, deep learning and EMD work but are computationally expensive and unsuitable for real-time systems. Current approaches are too complicated and computationally demanding for real-time applications.

Literature Survey:

SL No.	YEAR AND PUBLICATION	Topic	Inference
1	Published in 2023 in IEEE.	Hardware Co-Simulation of Adaptive Noise Cancellation System using LMS and Leaky LMS Algorithms ,	This paper discusses the co-simulation approach for implementing adaptive noise cancellation using LMS and Leaky LMS algorithms, showing improved noise cancellation efficiency when implemented in hardware setups like FPGA.
2	International Journal of Electronics and Communications, 2022,	Implementation of Optimized Adaptive LMS Noise Cancellation System to Enhance Signal to Noise Ratio	The paper focuses on optimizing the LMS algorithm to improve the signal-to-noise ratio (SNR) in communication systems, demonstrating significant performance enhancements in various noise environments.

3	Journal of Signal and Information Processing,2023.	A Comparative Study on Characteristics and Properties of Adaptive Algorithms applied to Noise Cancellation Techniques	This study compares various adaptive algorithms like LMS, RLS, and NLMS, analyzing their strengths and weaknesses in noise cancellation applications, providing insights into selecting the most suitable algorithm for specific use cases.
4	Journal of Circuits, Systems, and Signal Processing,2024.	A Switching-Based Variable Step-Size PNLMS Adaptive Filter for Sparse System Identification	A switching-based variable step-size PNLMS algorithm is proposed to improve convergence in sparse system identification, adjusting the step-size dynamically for faster and more stable performance. A sub-band version is also introduced for correlated inputs, showing better convergence than existing methods.

System Model Description:



Proposed Leaky LMS Adaptive Filter:

Algorithm:

1st stage :

- The clean speech signal is denoted as : $s(n)$
- The noise signal added to the clean signal : $v(n)$
- Noise added Input signal: $d_1(n) = s(n) + v(n)$
- Reference noise signal: $x_1(n) = v'(n)$

- Output signal from the 1st stage of the LLMs filter: $y_1(n) = w_1^T(n)x_1(n) = \hat{v}(n)$

- The weights gets updated as follows:

$$w_1(n+1) = (1 - \mu\gamma)w_1(n) + \mu e_1(n)x_1(n)$$
$$= (1 - \mu\gamma)w_1(n) + \mu[d_1(n) - x_T(n)w_1(n)]x(n)$$

- Error signal: $e_1(n) = d_1(n) - y_1(n) = s(n) + v(n) - \hat{v}(n) = s(n) + \Delta v(n)$
- Leakage factor: Where γ is the leakage component in the equation.
  μ is the represents the step-size of Leaky LMS filter.

2nd stage :

- The Input signal to the 2nd stage of the filter is :

$$d_2(n) = e_1(n) = s(n) + v(n) - \hat{v}(n) = s(n) + \Delta v(n)$$

- Reference signal to the 2nd LLMS Filter:

$$x_1(n) - y_1(n) = \Delta v'(n)$$

- Output of the 2nd LLMS filter : $y_2(n) = \mathrm{w}_2^T(n)\Delta v'(n) = \Delta \hat{v}(n)$
-
- The output error signal corresponds to:
- $$e_2(n) = \mathrm{s}(n) + v(n) - \Delta \hat{v}(n) \approx s(n)$$

For M Stage :

$$d_M(n) = e_{\mathrm{M}-1}(n) = s(n) + \rho v(n)$$

Reference signal to the 2nd LLMS Filter:

$$x_{\mathrm{M}}(n) = x_{\mathrm{M}-1}(n) - y_{\mathrm{M}-1}(n) = \rho v'(n)$$

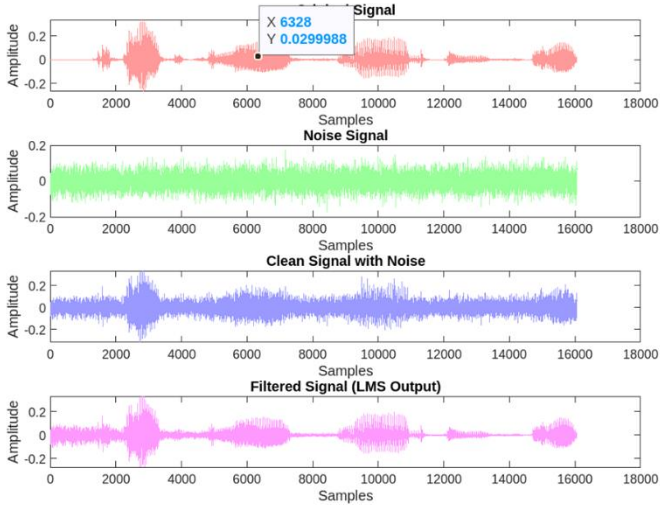
Final Stage Output :

$$y_2(n) = \mathrm{w}_{\mathrm{M}-1}^T(n) x_{\mathrm{M}}(n) = \mathrm{w}_{\mathrm{M}-1}^T(n)\rho v'(n) = \rho \hat{v}(n)$$

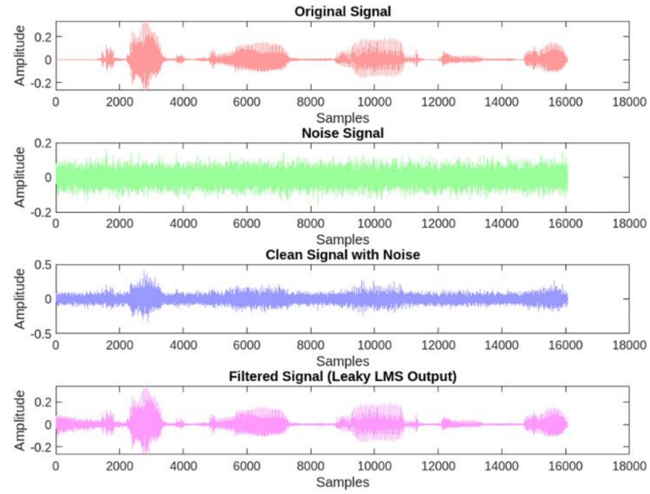
- ➢ Step 1: Load Signals-
- ➢ Load the speech/PCG file (theoretically includes a clean signal for MSE & SNR calculations).
- ➢ Add noise (Gaussian/Uniform/Street) to create the noisy signal.
- ➢ Step 2: Call the Multi-Stage Leaky LMS
- ➢ Specify parameters: input/desired signals, step size, filter order, leakage factor, and number of stage
- ➢ Run the multi-stage leaky LMS function.
- ➢ Step 3: Generate Plots
- ➢ Plot the original signal, noise, noisy signal, and the filtered output. Step 4: Compute Metrics-
- ➢ Calculate MSE & SNR using the clean signal, noisy signal, and the filtered (error) signal.

Results:

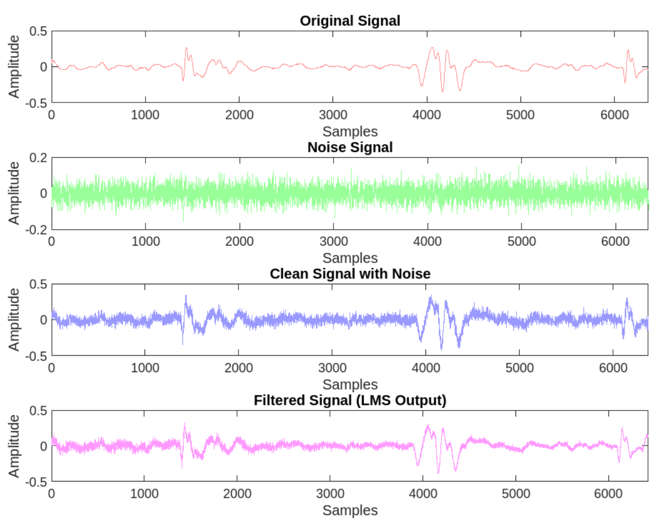
SPEECH SIGNAL WITH GAUSSIAN NOISE USING LMS – Stage 1



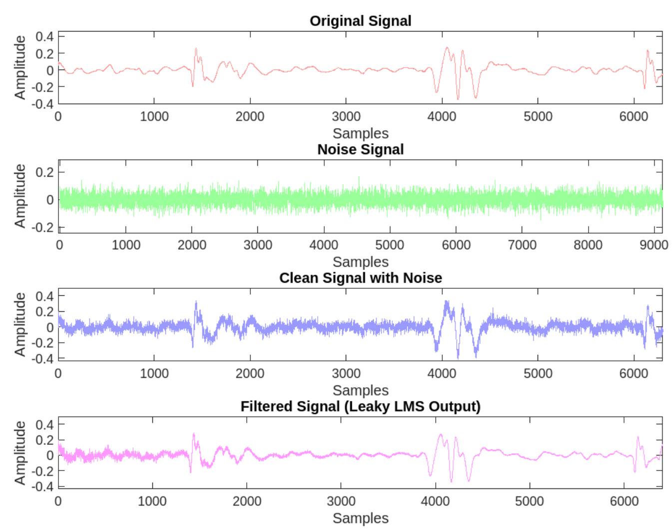
PCG SIGNAL WITH GAUSSIAN NOISE USING LEAKY LMS – Stage 1



PCG SIGNAL WITH GAUSSIAN NOISE USING LMS



PCG SIGNAL WITH GAUSSIAN NOISE USING LEAKY LLMS



Statement of Contribution

This interim progress report, and the activities that it has entailed, has been a collaborative effort amongst the group members.

Swapnil Maiti (RA2111004010283)

- Implementation of base algorithm
- Literature Survey
- Research paper Writing
- Presentation creation

Deekshitha Adusumalli (RA2111004010290)

- Implementation of base code
- Presentation creation
- Comparison graph creation
- System model generation

Kunal Keshan(RA2011004010051)

- Integration of Base code and training algorithm
- Output analysis
- Documentation

Sahil Sharma(RA2011004010252)

- System model integration
- Documentation
- Engineering standard analysis

Declaration

Swapnil Maiti :

Deekshitha Adusumalli :

Sahil Sharma :

Kunal Keshan :

Project Supervisor
Dr. S Hannah Pauline :

INTERIM PROGRESS REPORT EVALUATION RUBRICS
(To be filled by Project Supervisor)

Project Title : Leaky LMS algorithm based low complexity adaptive noise cancellation

Project Code :

Team Member : Swapnil Maiti (RA2111004010283)
Deekshitha Adusumalli (RA2111004010290)
Sahil Sharma(RA2011004010252)
Kunal Keshan(RA2011004010051)

Name of Evaluator :

Rubrics	**Possible Points**	**Assigned Marks**			
		Reg No 283	**Reg No 290**	**Reg No 252**	**Reg No 051**
Aim & Objectives, Abstract ● Objective complete and well-written ● provides all necessary background principles for the experiment	5				
Content-Introduction, Literature review, System model Technically correct; Contain in-depth and complete details of the project	10				
Language (Word Choice, Grammar) ● Sentences are complete and grammatical. They flow together easily ● Words are chosen for their precise meaning. ● Engineering terms and jargon are used correctly; No misspelled words. **Numerical Usage and Illustrations** ● All figures, graphs, charts, and drawings are accurate, consistent with the text, and of good quality. They enhance understanding of the text. ● All items are labelled and referred to in the text. ● All equations are clear, accurate, and labelled. ● All variables are defined and units specified. ● Discussion about the equation development and use is stated.	5				
Total Points	20				

Date: Signature of the Project Guide