

FIR Audio Noise Removal Studio

Signals and Systems Project Overview

- **Objective:** Develop a MATLAB GUI for real-time FIR filtering and noise suppression in audio recordings.
- **Platform:** Built entirely in MATLAB using GUI components and DSP toolkits.
- **Functionality:** Supports loading, recording, filtering, and playback with dynamic visualization.
- **Signal Domain Visualization:** Displays time and frequency domain plots, magnitude and phase responses.



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GUI Design & Sidebar Controls

Interactive Features for Audio Workflow



Sidebar Interface

Consolidated control panel with interactive buttons and menus.



Filter Configuration

Selectable filter types with real-time FIR length and cutoff frequency settings.



Audio Input Options

Supports both loading external files and direct microphone recording.



Status Feedback

Dynamic status display provides user guidance and system messages.

FIR Filter Application Logic

Noise Reduction via DSP

- **Preprocessing:** DC removal, pre-emphasis filtering, and noise gating to clean raw signal.
- **Dynamic Filter Design:** FIR filter coefficients generated based on user-specified cutoff and type.
- **Spectral Subtraction:** Post-filtering noise attenuation by subtracting estimated noise spectrum.
- **Normalization & Output:** Audio is centered and amplitude-normalized before playback or saving.

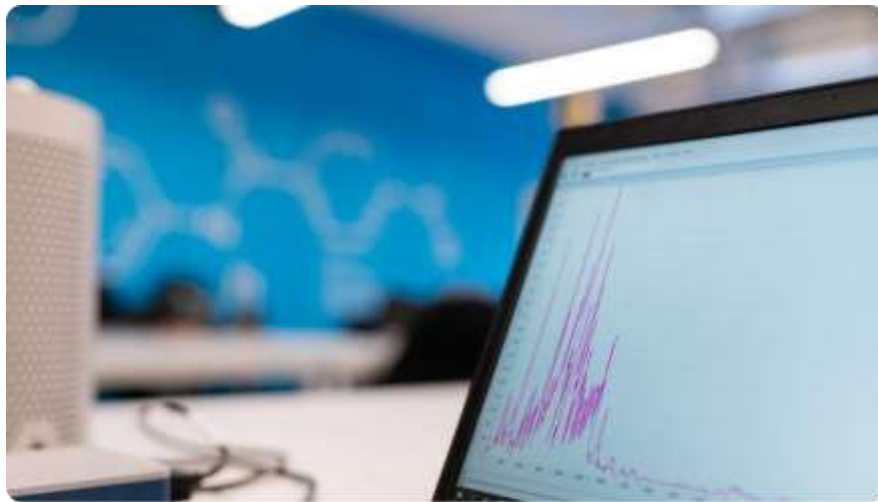


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Procedure

1) Get User Inputs

2) Validate Inputs by applying checks

3 Preprocess Audio

`x = filter(fir1(100,40/(Fs/2),'high'),1,raw_audio);`

`x = filter([1 -0.97],1,x);` **(IIR Filter)**

`x = x / max(abs(x));` **(Maximum Amplitude 1 & -1)**

`x(abs(x)<0.02)=0;` **(Removes Quiet Sounds)**

4) Design FIR Filter

`coeffs = fir1(N-1, ..., ..., kaiser(N,5));` **(Used with fir1 to shape the filter response)**

5) Apply Filter

`y = filter(coeffs,1,x);` **(Filtering the pre filtered signal)**

`y = y - mean(y);` **(Remove DC Offset)**

`y = y / max(abs(y)) * 0.98;` **(Normalize Output)**

Signal Visualization Modules

Multi-Domain Analysis Tools



Time-Domain View

Visualizes raw and filtered waveforms to show temporal noise suppression.



Filter Magnitude

Plots $20\log_{10}$ magnitude response of designed FIR filter.



Frequency Spectrum

FFT-based display of spectral content for pre- and post-filtered signals.



Phase Response

Unwrapped phase plot reveals frequency-dependent delays.

Audio Playback & Export Features

Interactive Output Utilities



Dual Playback

Supports listening to both original and filtered audio for comparison.



Export to WAV

Saves the filtered audio to disk with standard sampling rate.



On-Demand Filtering

Real-time response to user-initiated playback or processing commands.



Status Updates

Live messages guide user actions and system state.

Project Impact & Learning Outcomes

Reflections on DSP Application



Applied Theory

Translates FIR filter and spectral processing concepts into practical use.



Audio Engineering Insight

Improved understanding of noise suppression and perceptual audio quality.



Hands-On DSP

Gained skills in MATLAB programming and GUI-based signal design.



Project Versatility

Usable for education, prototyping, and real-world filtering scenarios.