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.

Audio Input Options
Supports both loading external files and direct microphone recording.

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

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.
- **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.

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

Filter Magnitude
Plots 20log10 magnitude response of designed FIR filter.

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.

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

Export to WAV
Saves the filtered audio to disk with standard sampling rate.

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.

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

Audio Engineering Insight
Improved understanding of noise suppression and perceptual audio quality.

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