MATLAB EXPO 2018

Progettazione di un sistema di cancellazione attiva del rumore stradale da rotolamento

Alessandro Costalunga
Software Designer
R&D Audio System
Ask Industries S.p.A
ASK Industries S.p.A.

Global Supplier of Acoustic and Communication Technology for OEM customers in the Automotive Industry. Main activities: Design, development and manufacturing of loudspeakers, amplifiers, antennas and cables for the automotive industry.

1965: Foundation
2015: enters in JVC KENWOOD Group
Team

ASK Industries Montecavolo

R&D Audio System Department

Active Noise Management Projects

DUTIES
HW/FW/SW Amplifiers development, Product Innovation, DSP, Audio Tuning...

OBJECTIVES
Increase comfort in car interior
Emphasize/Cancel engine order
Car engine simulation

TEAM
Luca Cattani, Team Leader
Alessandro Costalunga, Software Designer
Carlo Tripodi, Software Designer
Lorenzo Ebri, NVH Engineer
Marco Vizzaccaro, Embedded Software

Active Road Noise Cancellation
Active Noise Cancellation Systems

Noise Source

Resulting Noise
Active Noise Cancellation Systems

Noise Source

Anti-Noise Source

Resulting Noise
Problem: Road Noise

- Structure-borne Road Noise
- Air-borne Road Noise
- Structure-borne Road Noise
- Air-borne Road Noise + Wind Noise
Active Control System Approach

Feedforward System

Reference Signals

Controller

Control Signals

Loudspeakers

Error Signals

Road Noise

Microphones

Noise
Challenges

- Control Algorithm
- Reference Signals Selection
- On-the-field Validation

Diagram:
- Reference Signals
- Controller
- Control Signals
- Loudspeakers
- Microphones
- Error Signals
- Road Noise
- Noise
Control Algorithm

Goal:

\[ C(s) = -\frac{P(s)}{S(s)} \]
Control Algorithm

Multichannel Modified Filtered-x Least Mean Square

1 Environment Simulator
2 Test several ANC algorithms from literature
Algorithm Development

Objectives

1. Environment Simulator
2. Test several ANC algorithms from literature

Constrains

Fast development
Accuracy

Solution

Development of a simulator in Simulink

- Model Based Design
- Graphical Environment
- Rapid Debug
- Code generation
Simulator
Reference Signal Selection

Detecting the structural source of noise in car interior

Typology

Accelerometers

Sensor Placement

Adaptive Algorithm: Linear Filter Estimation of \( \frac{P}{S} \)

Coherence function
Coherence is a function of frequency with values between 0 and 1 which measures the relative linearity between two signals.

Maximum theoretical noise reduction:

\[-10 \log_{10}[1 - C_{xd}(f)]\]
Reference Signal Selection: Process

Position Selection
- NVH analysis of suitable positions
- Accelerometer placement

Measurement
- Recordings on the target car
- Different road asphalts
- Different speeds

Analysis
- Standalone software for analysis of recordings
- Selection of the most reliable positions
Reference Signal Selection: Analysis

Development of a standalone application in MATLAB

Collect and explore large signal dataset

Signal Processing

Easy to use: Graphical User Interface

Fast implementation

- Smart data types
- Wide set of build-in functions
- App Designer API
- Quick debug
- Complete documentation
Reference Signal Selection: Analysis

Coherence Analyzer Tool

Frequency Limit
- Minimum Frequency: 0
- Maximum Frequency: 1000

Select
- References
- Error Mics
- Experiments

References
- 12 eFL S
- Ruvido51.7453
- Ruvido76.7723
- Ruvild0.4661
- Ruvild52.6389
- Ruvild0.777155
- Ruvild08.204

Error Microphones

Experiments

Signals Visualization
- H1 Filtering
- MATLAB Multiple MSC
- Evaluation

View Modes
- Same Figure
- Time
- Frequency
- Signals Domain
- Show Signals
- Close All
- High View

Graph: waterfall

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On-the-field Validation

- Performance Analysis
- Tight Deadlines
- Constant Algorithm improvements

Rapid Prototyping Approach
Rapid Prototyping Approach

- Algorithm Development
- Code Porting
- SW test & debug
- System test
- Algorithm Validation

Expensive in term of time and resources

Algorithm Development → Algorithm Validation

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Page 19
Prototype Car

Alfa Romeo Giulia
2.0 L4 TurboGasoline 200Hp RWD AT8
Prototype Configuration

Cancellation performed on Driver Seat

6 Accelerometers; 2 Loudspeakers; 2 Microphones
Experimental Results

Rough asphalt, 50 km/h

Cancellation on left ear
Average: 3db
Peak: 8db @ 180Hz

Cancellation on right ear
Average: 2.5db
Peak: 9db @ 210Hz
Conclusion

RNC system for automotive applications is feasible and effective.

MATLAB and Simulink are the best options for the development of innovative systems.

Rapid prototyping with MATLAB and Simulink is cost and time effective.
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