INVERSE FILTERING OF ROOM ACOUSTICS

Introduction:

Generally signals transmitted in a room suffer distortions due to reflections by the walls, absorption by different objects, etc. So, there is a need to develop an inverse filter to remove distortions and obtain same, i.e. desired output. This can be done by finding the response to a known signal and building a system which inverses (cancels) the distortions. Using only one transmitter and receiver it is not possible to find the exact inverse of the system, as the matrix equation doesn't have exact solutions. We use MINT (Multiple input-output inverse theorem) to overcome this issue by taking multiple transmitters and multiple receivers. This makes the matrix equation into a linear combination with multiple solutions which are exact inverse for cancelling the distortions.

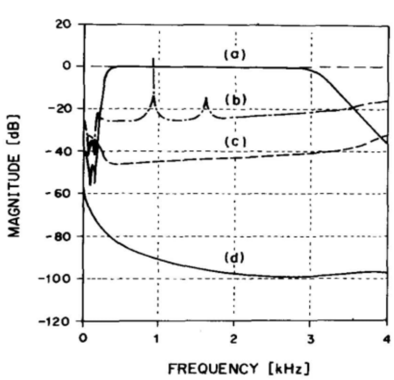
Implementation:

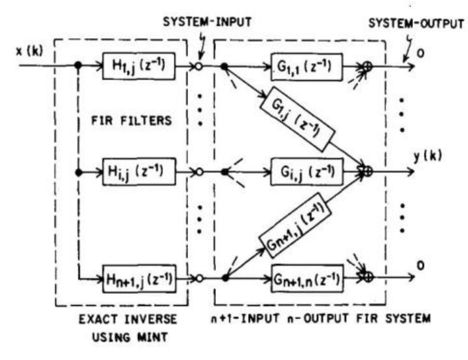
As the conventional method of LSE (least squares error) doesnot have exact solutions for the inverse filter we use MINT method to determine the exact inverse filter. This method can be implemented by simple matrix algebra and computations on matlab.

This method is charaterized by the equation

$$D(z^{-1}) = 1 = G_1(z^{-1})H_1(z^{-1}) + G_2(z^{-1})H_2(z^{-1}).$$

This can be solved on matlab, by inversing matrices and solving the linear combination above. Mathematically we can prove that the above system has exact inverse solutions if and only if $G_1(z^{-1})$ and $G_2(z^{-1})$ are relatively prime, i.e, they have no zeros in common in the z-plane. We can also show that $H_1(z^{-1})$ & $H_2(z^{-1})$ have orders less than those of $G_2(z^{-1})$ & $G_1(z^{-1})$ respectively. In this case the system will have unique solution.





x(k) = y(k)

Plan of Execution :

We plan to simulate the inversing procedure on MATLAB by randomly generating a room response matrix which denotes the transfer function for room acoustics. The solutions to the linear equation of MINT principle can be solved by ~~on~~

1. Gauss-Jordan matrix solution
2. Random checking with progressive changes in the solution matrix.

We plan to simulate the observations on simulink with the room acoustics and its inverse blocks. Device a formal graphical proof to show the power spectra of errors obtained in conventional LSE method and using mint principle. We plan to mathematically prove that using the MINT principle the solutions will be unique for certain restricted dimensions of the matrices and prove that the solutions exist only for co-prime matrices. We also plant to simulate this system setup even for user inputed transfer functions for room acoustics.

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