Developing a Non-linear, Passive Sound Filter

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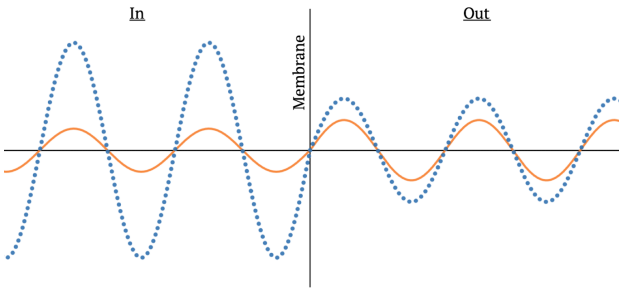
My research utilized mathematical modeling to explore how to create a non-linear, passive sound filter. In a traditional (linear) filter, the larger the amplitude of the signal coming in, the larger the amplitude of the signal going out. I theorized a hypothetical, non-traditional filter that responds differently depending on the input amplitude. The filter is non-linear because when an input signal with large amplitude moves through the membrane, the output amplitude is much smaller. When the amplitude of the input is small, the output amplitude is about the same. In the real world, one could position this sound filter in a window so that when sound waves of the same frequency hit the window, louder sounds (such as a passing truck) would sound quieter than softer sounds (such as chirping birds). What makes this system *passive* is that no additional electrical power is necessary for it to function.

The experimental setup involves a hollow cylinder on its side with a circular membrane (like a drum head) dividing the cylinder in half. A speaker positioned on the left side of the cylinder would emit a sound towards this membrane, and a microphone positioned one the right side of the cylinder would read the resulting sound wave having passed through the membrane. By placing magnets on the left and right side of the membrane, interactions between the magnets would make the system non-linear.

In the figure to the right, two different input signals pass through the membrane. The blue input signal has 5 times the amplitude of the orange one, but after the signals pass through the membrane, the amplitude of the blue output signal is cut in half. Due to the nature of the filter, the orange output signal has a slightly higher amplitude than the input after membrane interaction.



This figure is a product of the mathematical models I have been researching and refining. The field of differential equations enabled me to research this filter from both an analytical (pencil-and-paper) and numerical (MatLab programming) perspective. My goal was to have solutions from the analytical side match the numerical solutions, and vice-versa.

The next step of the project is to continue developing the model, and the longer term goal is to create a physical manifestation of this filter as described in the experimental setup. I plan to work with Dr. Vicent Romero-García, a CNRS Researcher at the Laboratoire d'Acoustique de l'Université du Mans in France. After I share my results with Dr. Romero-García, he and his researchers can test our theory in the physical world. I will be in close contact with him and his team, analyzing their results to build an even stronger mathematical model.

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