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Title: Acoustics in Action; Differentiating Between Shoebox, Surround and Horseshoe Shaped Concert Halls and Simulating Sound Levels
Description: There are different shapes of concert halls, each with varying characteristics. The sound levels of the shoebox hall (most optimal) are visualized through heat maps.
Word Count: 344

Abstract

Excellent acoustics in a concert hall are essential to an optimal listening experience, regardless of how the musicians play. In general, there are three different shapes of concert halls — horseshoe, surround and shoebox. The first part of my research aims to distinguish the acoustical characteristics between each shape and determine their benefits. The second part of my research focuses on the shoebox hall and whether the distribution of sound varies with size and sound absorption coefficients.

The qualitative comparisons were found through informational research. Then, to visualize how sound varied in a specific shoebox hall, a heat map simulation is employed. This simulation is developed using Python's NumPy and matplotlib libraries, and simulates different source strengths, dimensions of the hall, and sound absorption coefficients. In this simulation, I apply the physics of sound waves to acoustics, prominently for reverberation and sound levels. For reverberation, I used phasors to find the amplitude of each sound wave. I then used vector addition to sum the components of the one direct sound wave and the reverberated sound waves. And, to determine the sound levels, I combined various equations.

It was found through informational research that when compared to the horseshoe and surround halls, the shoebox hall has the best acoustics because of its superior reverberation, consistency in sound levels, envelopment, and strength of sound (Hidaka *et al*, 2015). The main reason the acoustics are worse in the horseshoe and surround halls is because of the lack of open space in their upper walls. Open space of the upper walls of a concert hall allows the sound to reflect with around-the-hall reverberation (Beranek, 2010). With the simulation, it was found that the sound interference patterns were symmetric and varied with the size of the hall and sound absorption coefficient. A low sound absorption coefficient produced the most extreme interference patterns due to more sound being reflected off the side walls. Whereas, increasing the absorption coefficient displayed a more uniform sound distribution. Overall, the simulation gives a clear visualization of how sound is heard in a shoebox hall.

Beranek, L.L. (2010). Listener Envelopment LEV, Strength G and Reverberation Time RT in Concert Halls.

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