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Music and Museums: An Investigation into the Effects Acoustic Noise on Museum Displays and Artwork

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Introduction

- Museums host a variety of events with music genres from classical to dance
- Vibrations from the acoustic noise caused by this music can cause detrimental effects to museum objects
- Many different methods are used to display these artifacts including Plexiglas casing and Komatex display blocks
- In this project, these vibrations were studied using a wireless tri-axial accelerometer
- The interaction between properties of the music being played such as intensity and frequency and display elements were investigated to determine their respective effects on the vibration of art objects
- In order to perform this investigation three experiments were performed, the intensity experiment, the speaker experiment and the wax experiment

Image 1: UC Ballroom speaker set-up for the Speaker Experiment

Experimentation

A. Intensity Experiment

- An experiment was performed to determine if the vibration levels change depending on the intensity of the excitation music.
- Important Procedural Steps:
  1. The experiment was started at a decibel level of 70 and a 10 second sample was taken using Node Commander®. This step was repeated 3 times.
  2. The decibel level was then increased by increments of 5 decibels until 90 decibels and 3 trials were performed for each intensity levels.

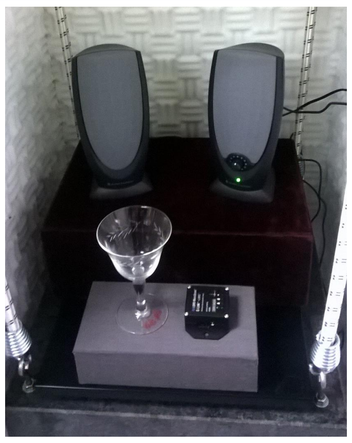

Image 2: Set-Up for the Intensity Experiment

B. Speaker Experiment

- An experiment was performed to determine how different display elements affect the vibration measured by the accelerometer.
- Four different variables were examined in this experiment: the presence or absence of Plexiglas, the display block being placed in a horizontal position or vertical position, the presence of wax, and the position of the display case, either against the wall or freestanding.
- Important Procedural Steps:
  - *Plexiglas, Block Orientation and Display Case Placement*
    1. The display case was placed 42 ft in front of JBL stadium speakers for the Plexiglas and display block experiments and 16 ft in front of the speakers for the against the wall vs. freestanding experiment
    2. A seven second sample was taken at an intensity of 80dB and a frequency of 48.1 Hz. This was repeated at 440 Hz as well
    3. This was repeated for 90dB and 96dB or 98dB depending on the frequency
  - *Presence of Wax*
    1. A glass bowl was placed in the display case that was covered with Plexiglas
    2. A seven second sample was taken at 80 dB at a starting frequency of 50 Hz without wax. This was repeated at 100 Hz,150 Hz, 200 Hz,250 Hz,300 Hz,700 Hz,1000 Hz,3000 Hz,5000 Hz
    3. This was repeated at each frequency with the bowl fixed using wax

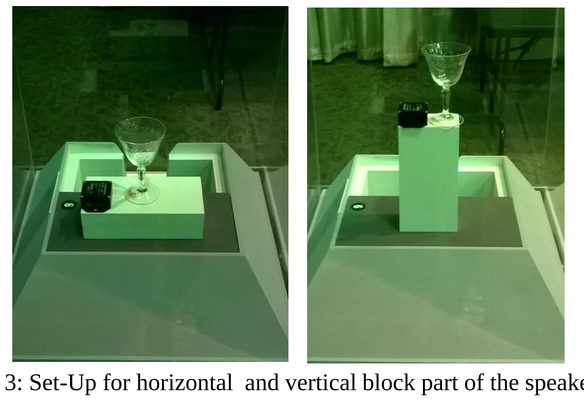

Image 3: Set-Up for horizontal and vertical block part of the speaker experiment

Results

A. Intensity Experiment

- It can be inferred from acceleration plots that around 80 to 90 dB increases the acceleration of the node increases noticeably.
- As pictured in figures 1 and 2 below, while the average acceleration is similar for both the 70 dB and 90 dB signals, the figures have standard deviation values of, 0.0032 and 0.0050 respectively
- This indicates more vibration at 90 dB than at 70 dB

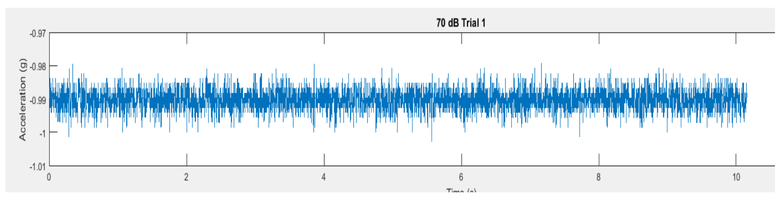

Figure 1: The first trial at 70 dB for the intensity experiment

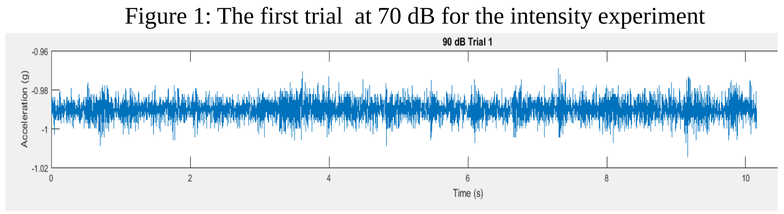

Figure 2: The first trial at 90 dB for the intensity experiment

B. Speaker Experiment

Plexiglas

- Under different museum conditions relative vibrations from various excitations changed considerably. At midrange intensity and midrange frequency the 'no Plexiglas' vibration shows more vibration, with a standard deviation (SD) of 0.0133, than the Plexiglas covered alternative which has a SD of 0.0077 (Figure 3).
- Under a lower frequency at a similar intensity we see that the Plexiglas covered display case showed greater vibration with a SD of 0.0205 while 'no Plexiglas' had a SD of 0.0170(Figure 4).

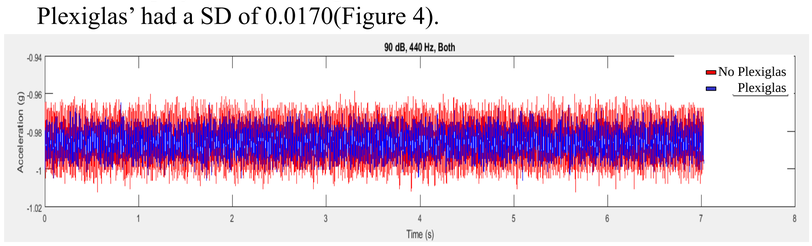

Figure 4: Signal for accelerometer data at 90 dB and 440 Hz with and without Plexiglas

Figure 5: Signals for accelerometer data at 96 dB and 48.1 Hz with and without Plexiglas

Block Placement

- In this experiment, the vertical block orientation results in more vibration at high intensities and midrange frequencies, for example at 98 dB and 440 Hz the SD is 0.0343 for the vertical block and 0.0122 for the horizontal block (Figure 6)
- Conversely, the 96 dB intensity paired with the 48.1 Hz frequency caused substantially more vibration in the horizontal block display orientation yielding a SD of 0.0435 while the vertical block had a SD of 0.0150 (Figure 7)

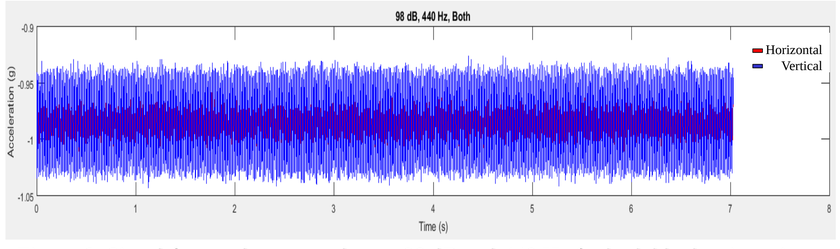

Figure 6: Signal for accelerometer data at 98 dB and 440 Hz for both block orientations

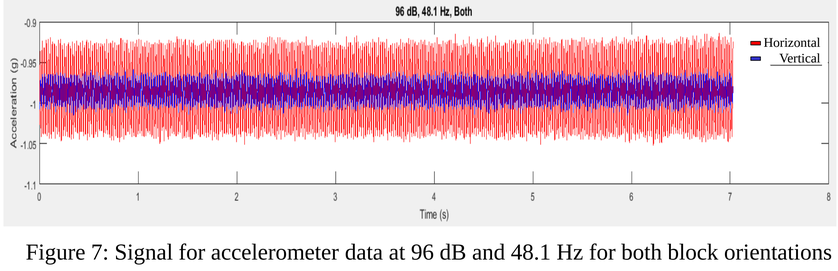

Figure 7: Signal for accelerometer data at 96 dB and 48.1 Hz for both block orientations

Results Continued

B. Speaker Experiment Continued

Placement of Display Case

- At 90 dB 440 Hz only slightly more vibration on the wall was shown in the vibration signals for experiments involving the placement of the display case (Figure 8)
- The same was true for 90 dB and 48.1 Hz but data for 80 dB was not statistically significant (Figure 9)

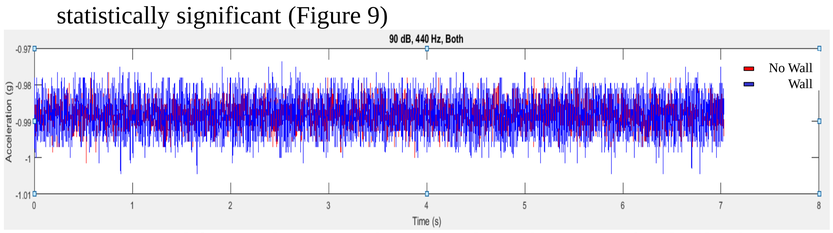

Figure 8: Signal for accelerometer data at 90 dB and 440 Hz for the display case against the wall and freestanding

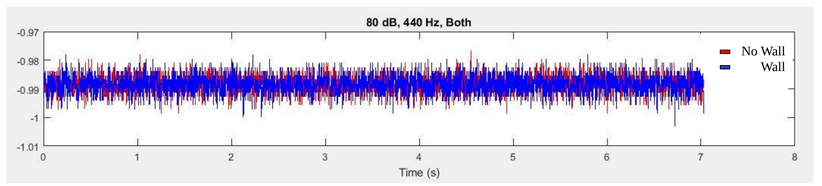

Figure 9: Signal for accelerometer data at 80 dB and 440 Hz for the display case against the wall and freestanding

Presence of Wax

- There is greater vibration at 200 Hz, the resonance frequency, for a glass bowl when fixed to the display block with the wax as shown by the average SD of 0.01124 (Figure 10)
- This pattern is also true for frequencies 50 Hz and 250 Hz
- Any frequencies above 256 Hz yielded inconclusive results due to the limitations of the node

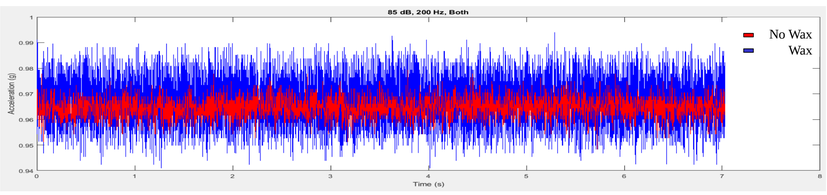

Figure 10: Signal for accelerometer data at 85 dB and 200 Hz for a fixed glass bowl

Further Analysis

T-tests were performed to determine statistical significance of the standard deviation as well as the acceleration for each experiment at a 95% confidence level.

Conclusion

- Throughout the intensity and speaker experiments, the relationship between acoustic properties, display case elements, and vibration on museum objects was examined.
- For the lower intensities, no significant evidence of a relationship between the vibration experienced and the display elements was found
- At higher intensities a correlation was found that indicated the vibration experienced inside the display case relates to the intensity and frequency of the tone being played, along with the variable being studied
  - At high intensities and mid-range frequencies, more vibration was observed without Plexiglas, while at lower frequencies more vibration was observed with Plexiglas.
  - At higher intensities and mid-range frequencies the trials with vertical orientation of the block experienced more vibration, while at lower frequencies objects on the horizontal block experienced more vibration
  - At higher intensities and mid-range frequencies, more vibration was observed when the display case was against the wall as opposed to freestanding but, no conclusions could be made at low intensities
- Museum display elements do affect the vibration observed by the art objects and museums should account for the type of tones the art is exposed to when determining display environments.

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