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Title: Measurement Human Cognitive Working Memory Capacity under Vibro-Tactile Stimulation

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Intended for: Final presentation by student intern at Engineering Institute

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Measurement Human Cognitive Working Memory Capacity under Vibro-Tactile Stimulation

LANL – CBNU

Engineering Institute Korea

Smart Structure Laboratory

Yunshil CHOI, David Mascareñas

01.29.2013

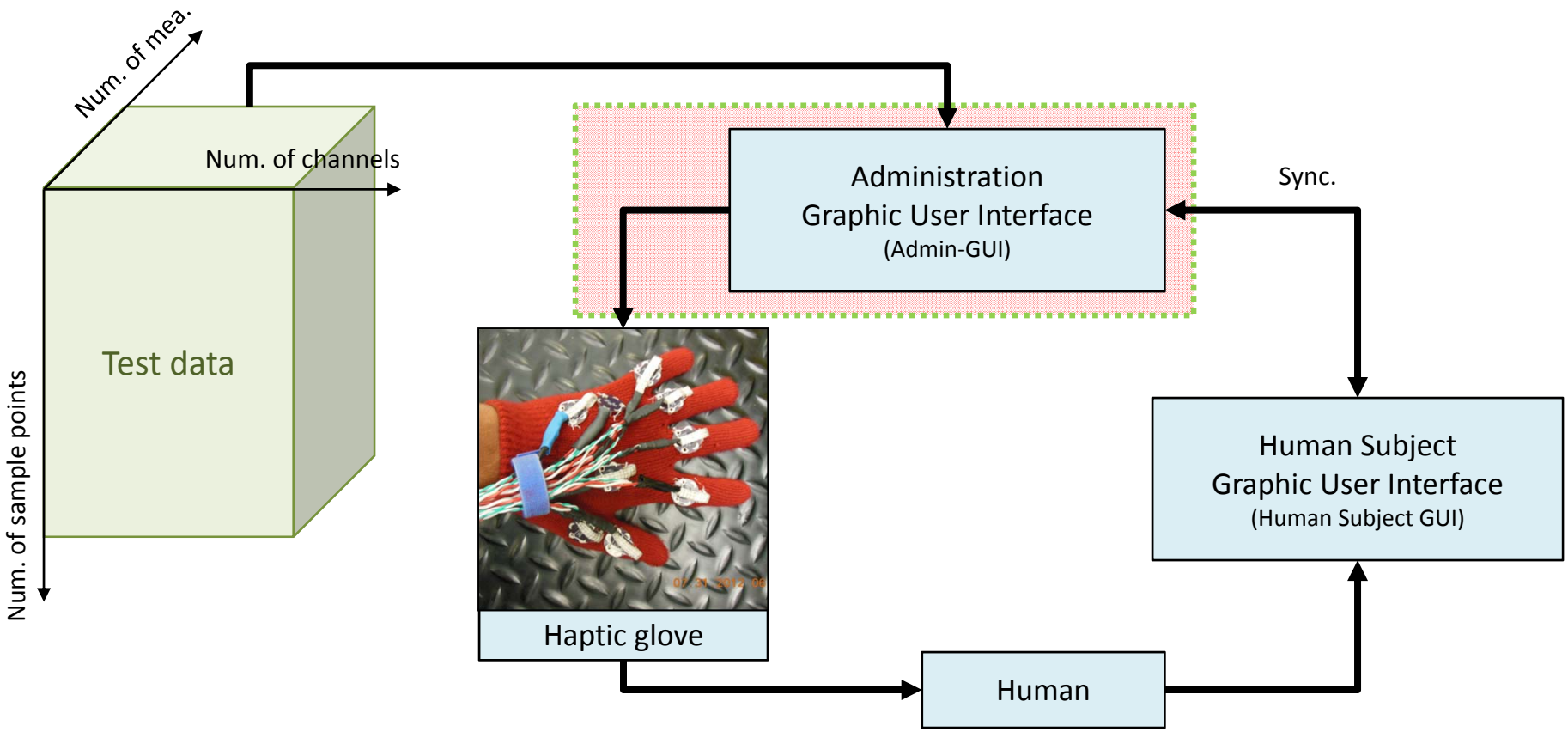
Introduction

Haptic Vibrating Belts Guide U.S. Soldiers Through the Darkness

Tasting the Light : Device Lets the Blind "See" with Their Tongues

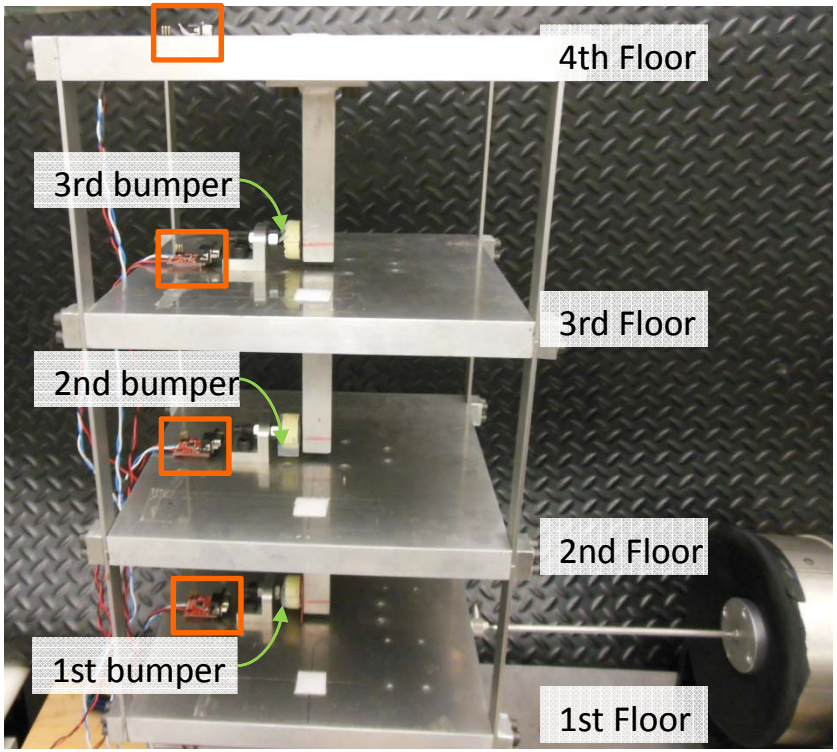
To make sure that human user can determine characteristics of non-linear responses with haptic device.

Configuration of system

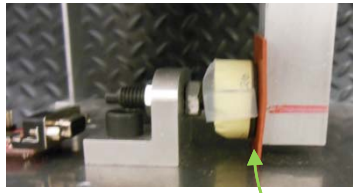


Experiments setup

Three Story Structure



Accelerometer



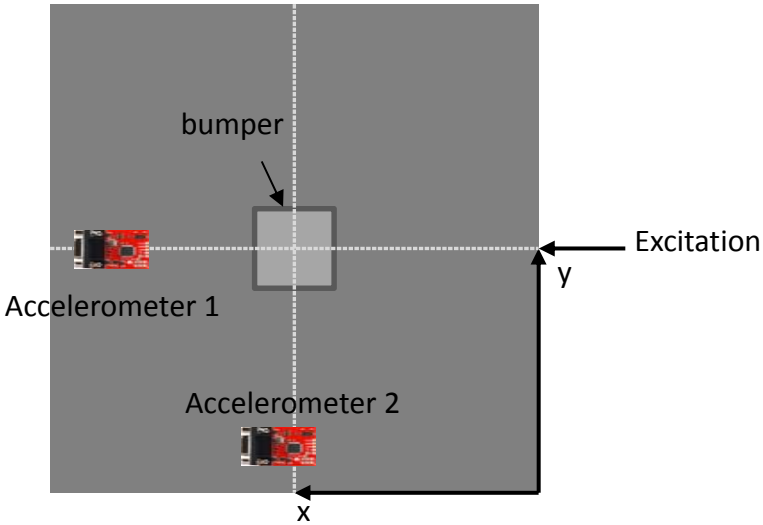
Rubber pad

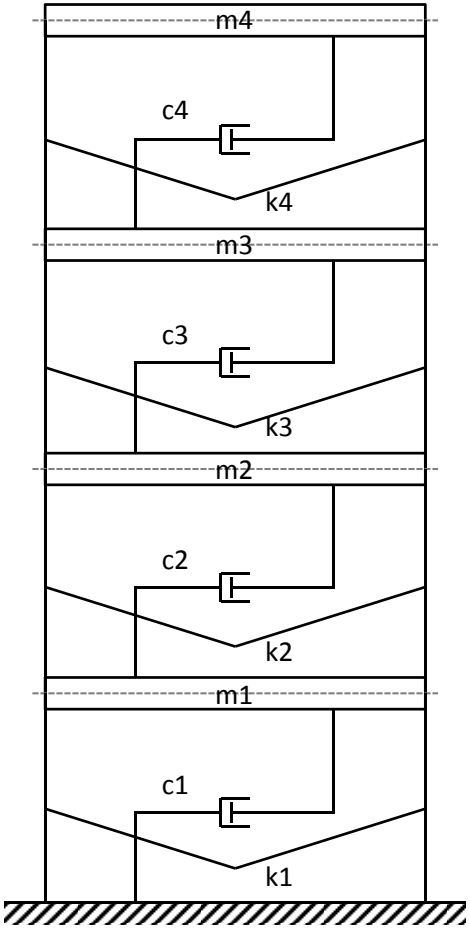
O : Damaged

Bumper	Case							
	0	1	2	3	4	5	6	7
3rd	-	-	-	O	-	O	O	O
2nd	-	-	O	-	O	-	O	O
1st	-	O	-	-	O	O	-	O

- 4 accelerometers
- 10k sampling points
- 100kSa/sec sampling rate
- 8 times measurements for each cases
- Rubber pads between the bumper and columns for stability

Experiments setup

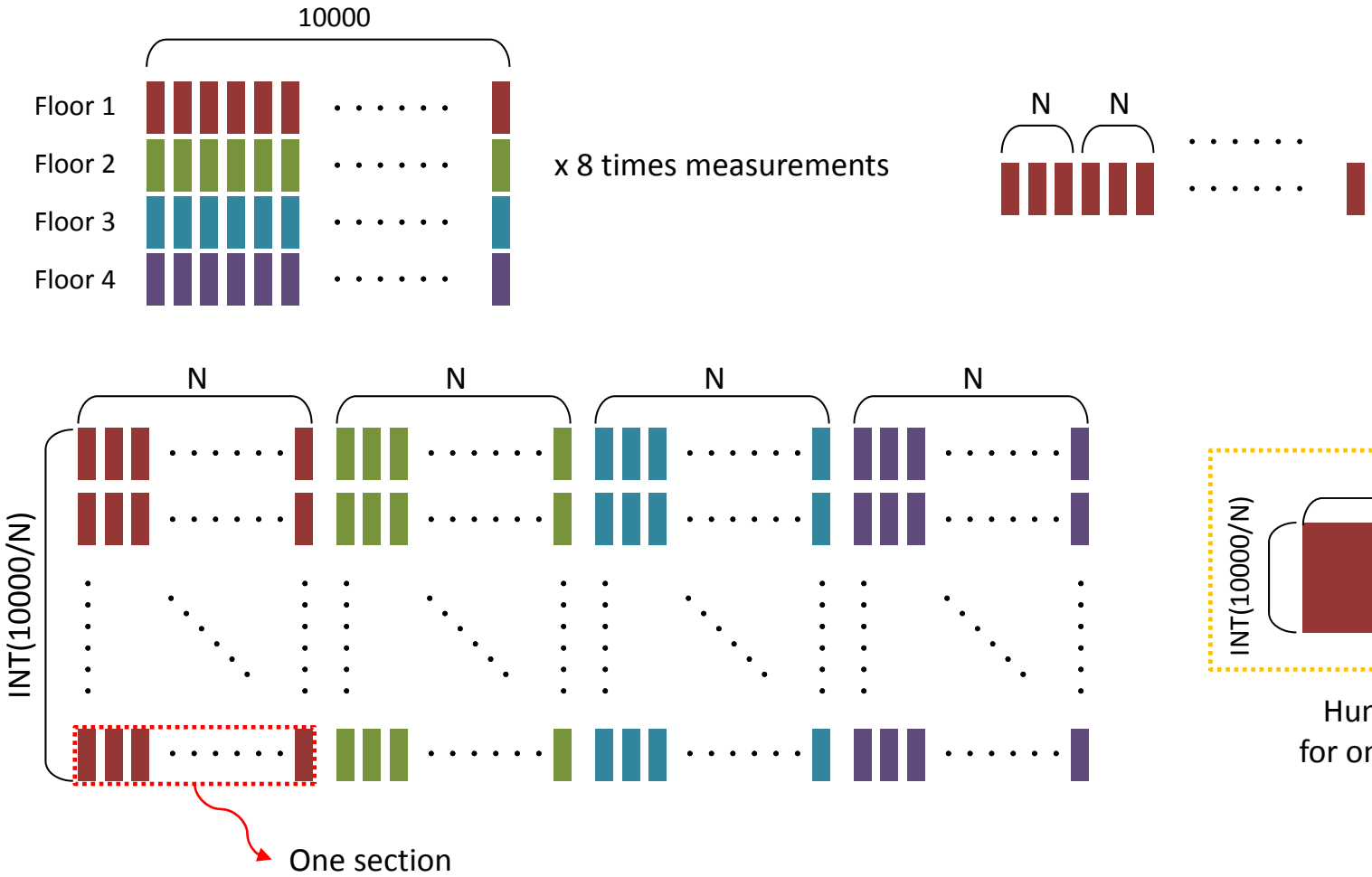


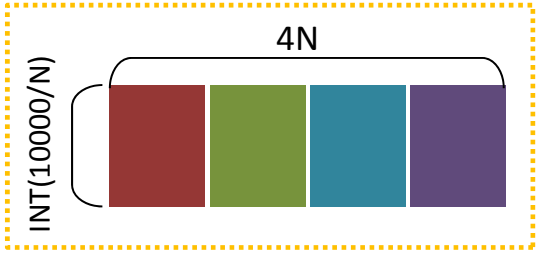


Shear-building structure

The structure was designed for being considered as shear-building structure.
It is reasonable that the accelerometers are placed on same axis (as the accelerometer 1 shown in figure) with excitation axis.

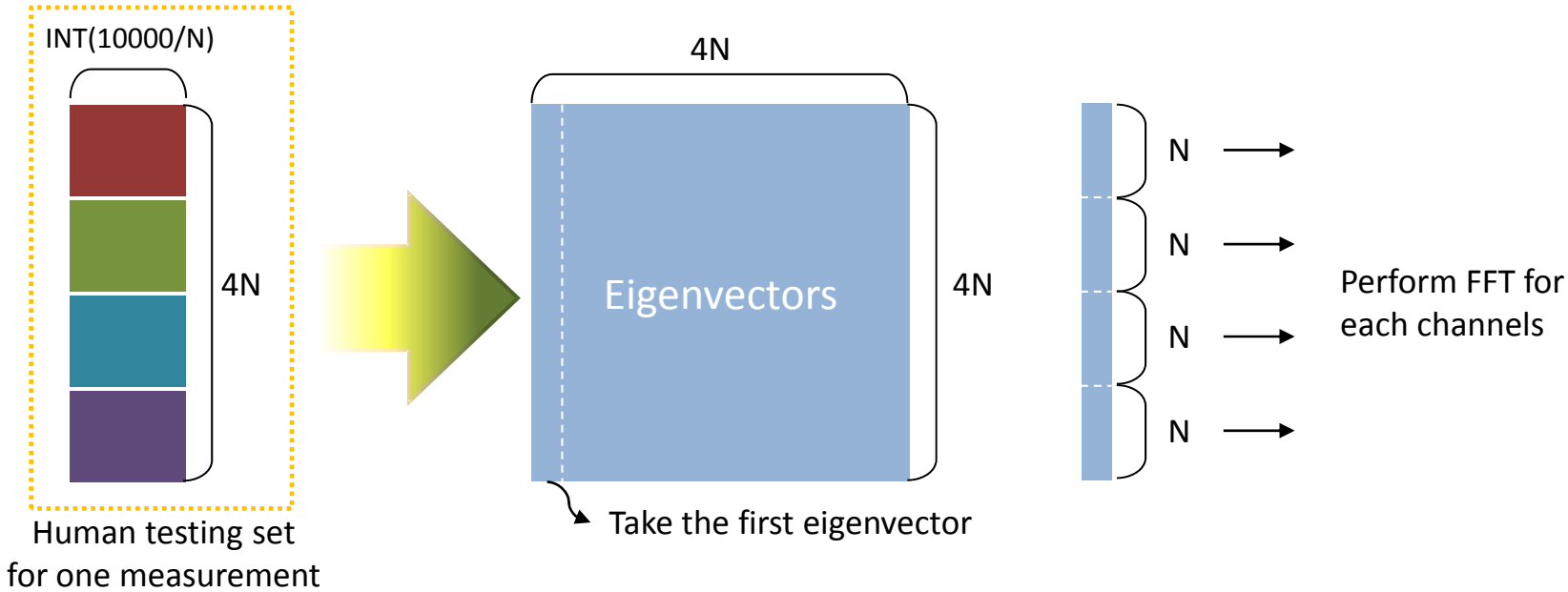
Singular Value Decomposition





Human testing set
for one measurement

Singular Value Decomposition



The first eigenvector is corresponding to the largest singular value according to follow :

$$A = USV^T$$

where *A* is data matrix, *U* and *V* are unitary matrices (*U* : eigenvectors of AA^T, *V* : eigenvectors of A^TA)

The eigenvalues indicate the proportion of total variance. The most principle component of directivity of vector A could be explained in :

$$u_1 * s_1$$

where the s_1 is square root of the largest eigenvalue (in other word, the largest singular value) , u_1 is the first column of matrix U. The u_1 is corresponding to s_1.

Processing order

I. Perform FFT

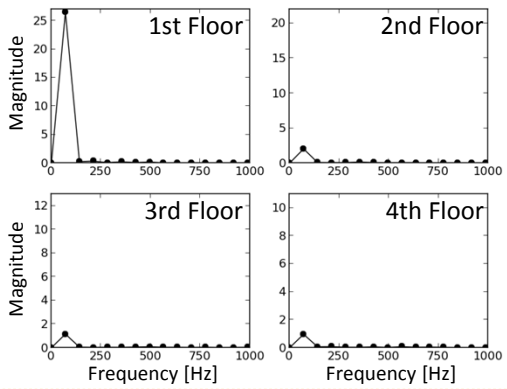
II. Extract maximum magnitude values in each FFTed signals

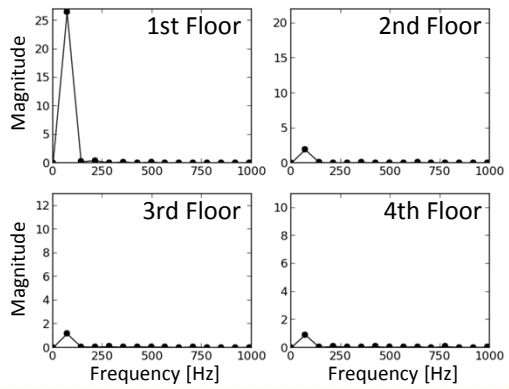
III. Normalization

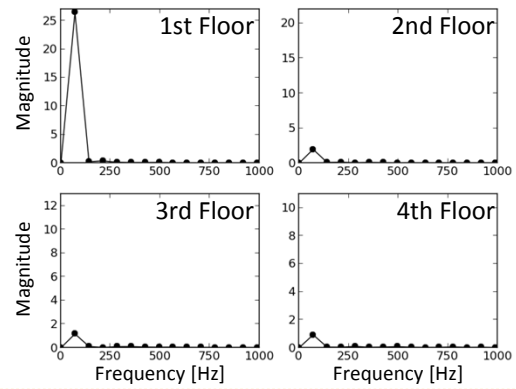
IV. Send to Admin

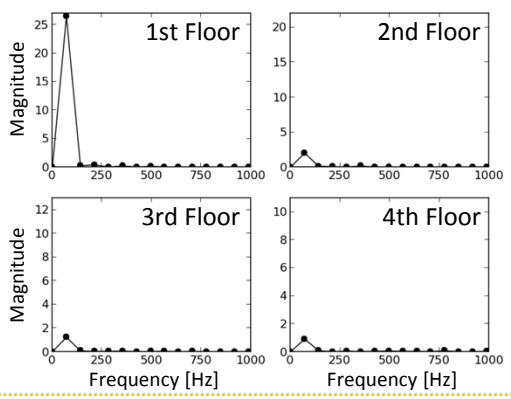
   i. Haptic codes are displayed in range of 0 to 250. This is equal to duration (ms) of vibro-tactile of glove.

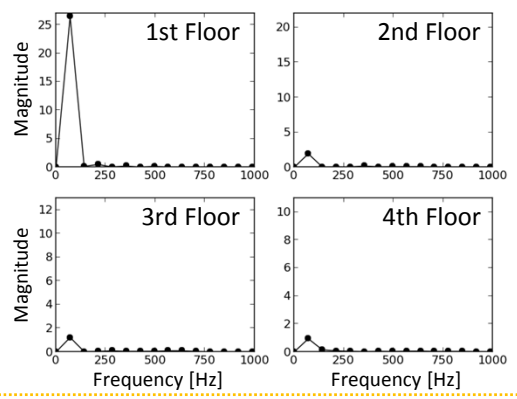
FFT Graphs for the case with no damage

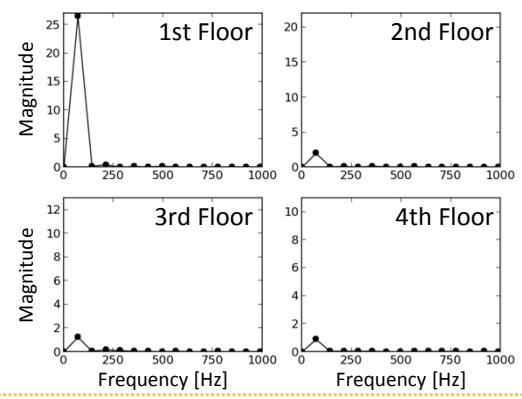


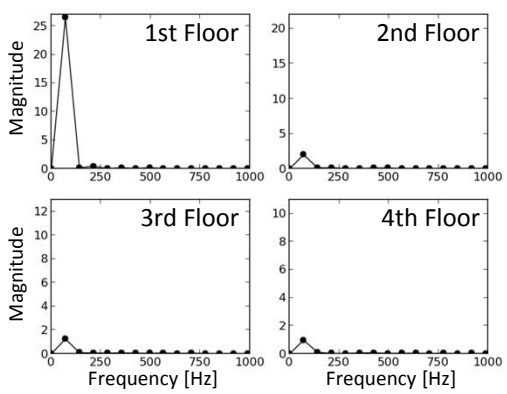


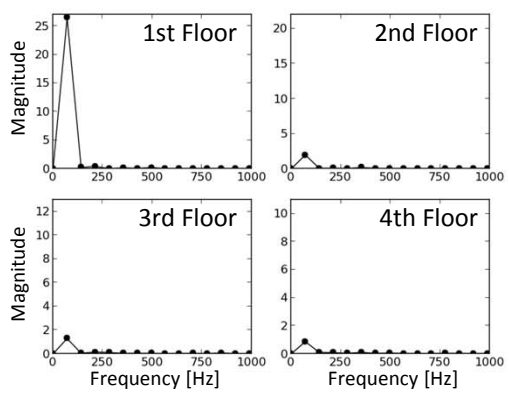






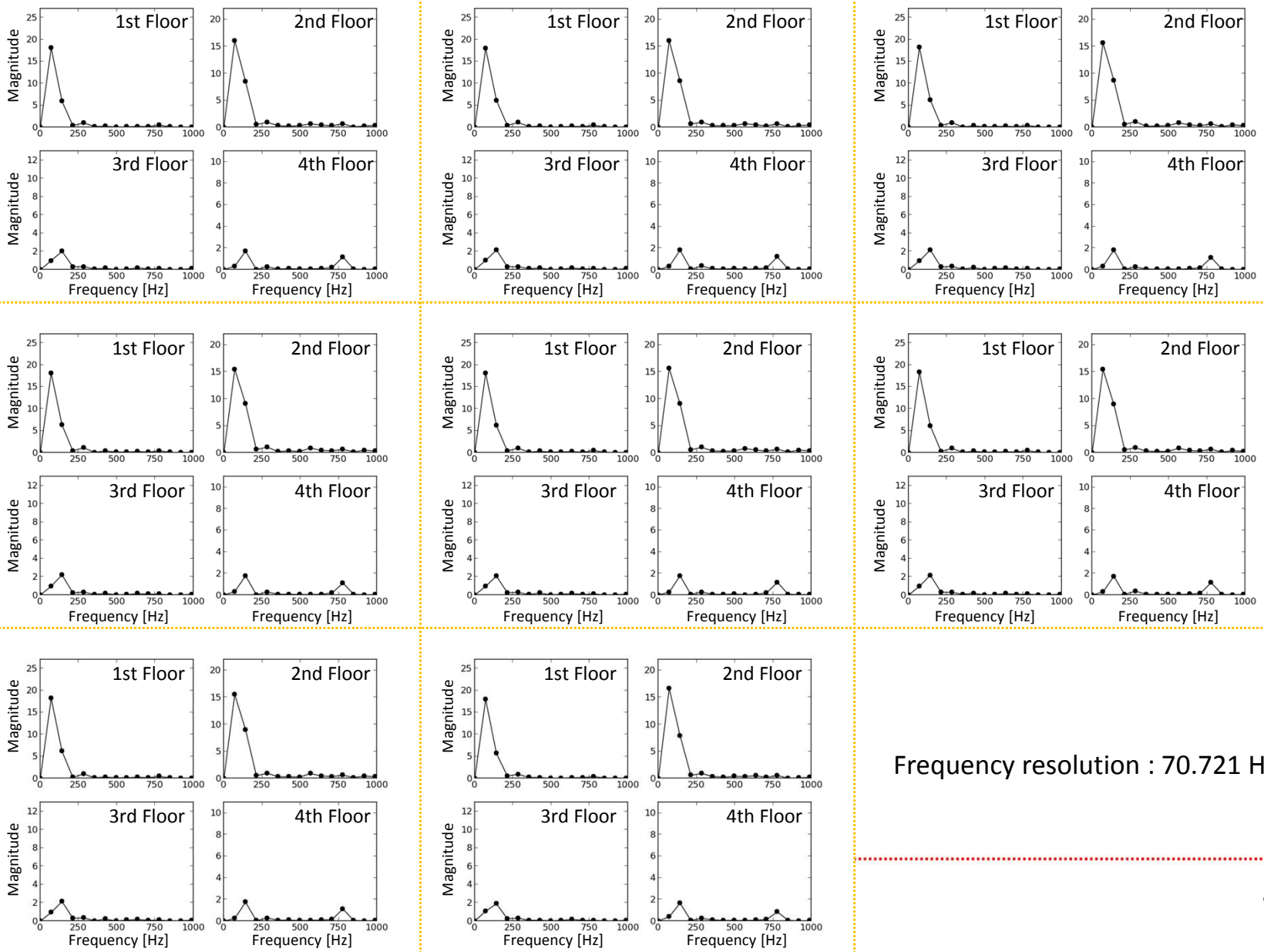






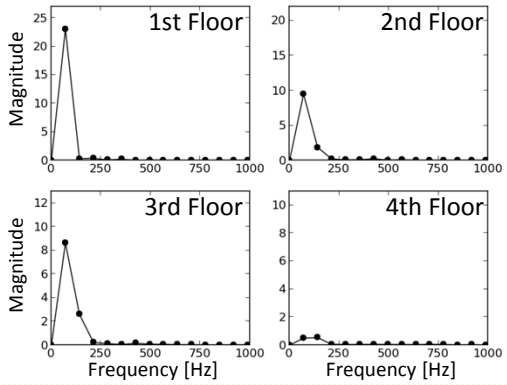
Frequency resolution : 70.721 Hz

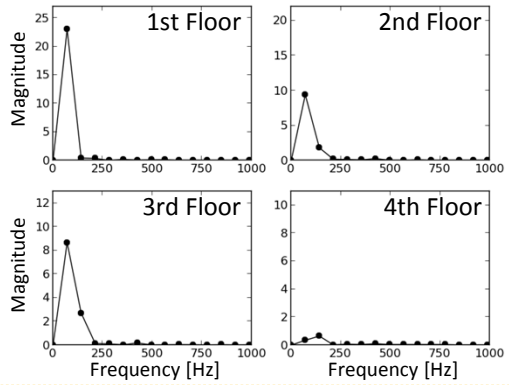
FFT Graphs for the case with damage on first floor

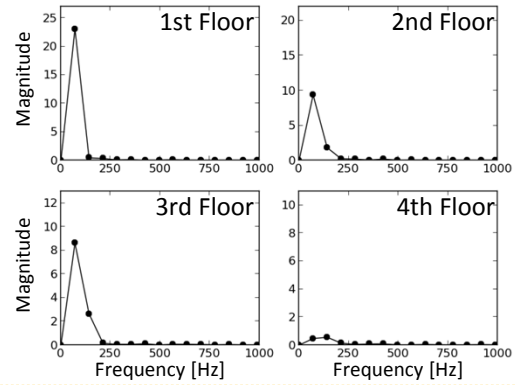


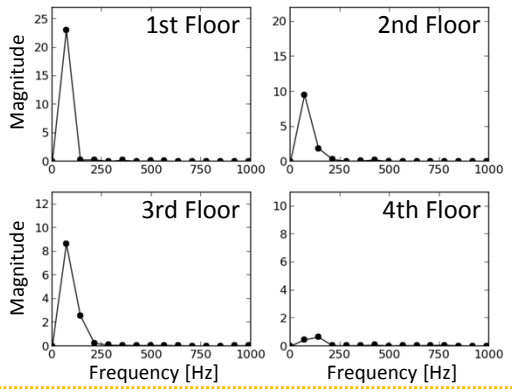
Frequency resolution : 70.721 Hz

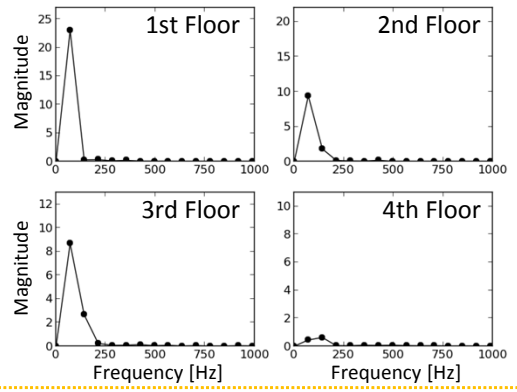
FFT Graphs for the case with damage on second floor

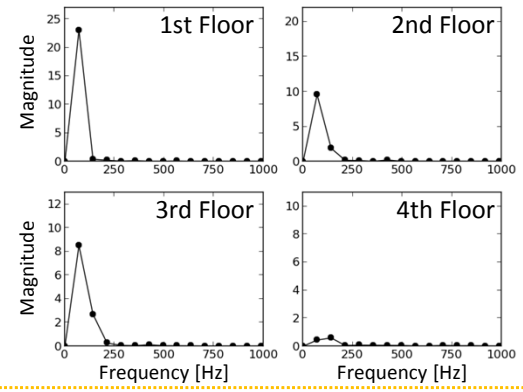


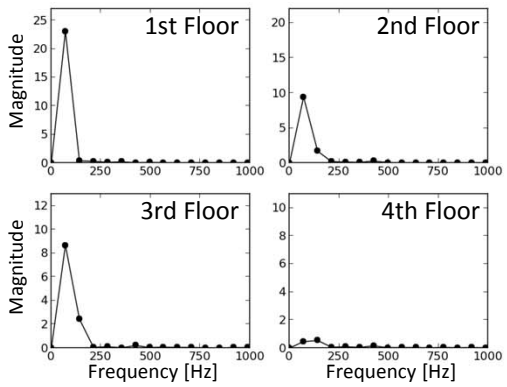


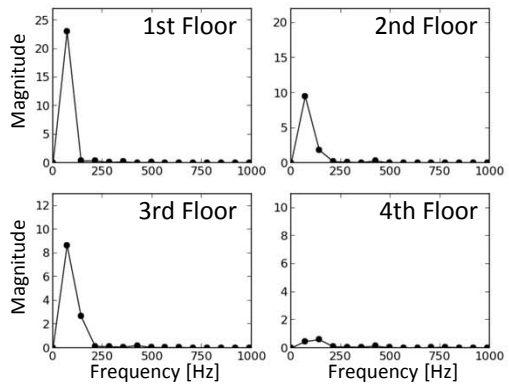






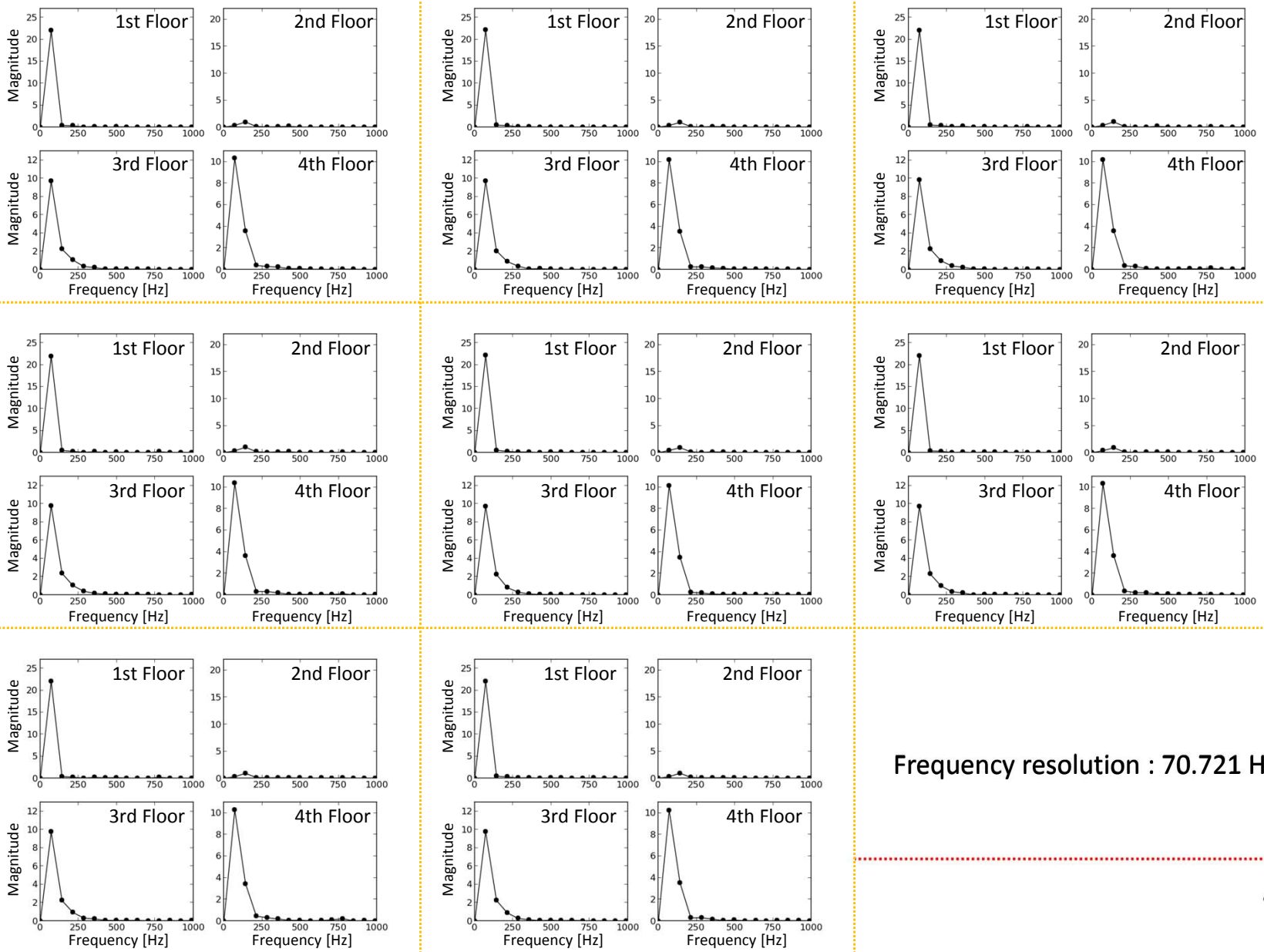






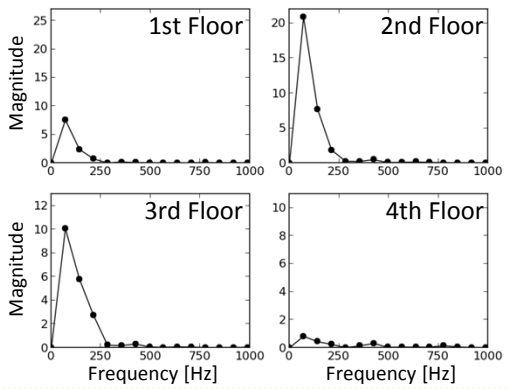
Frequency resolution : 70.721 Hz

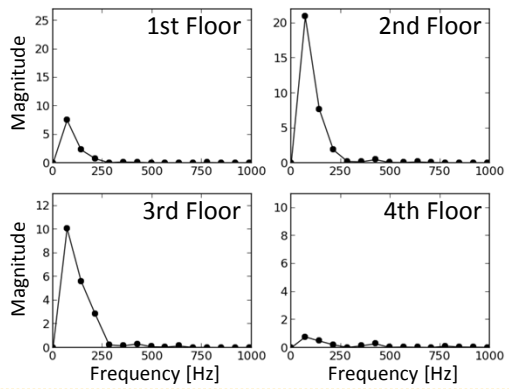
FFT Graphs for the case with damage on third floor

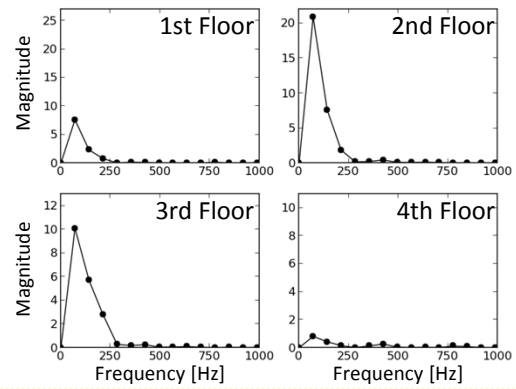


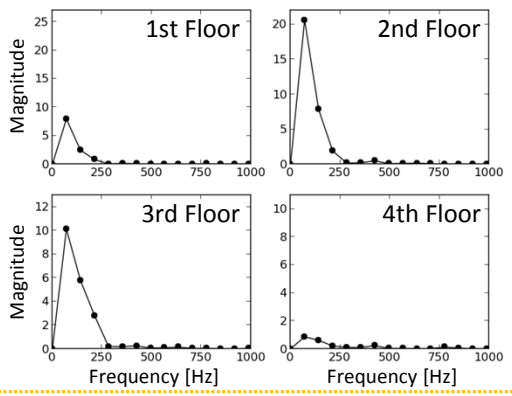
Frequency resolution : 70.721 Hz

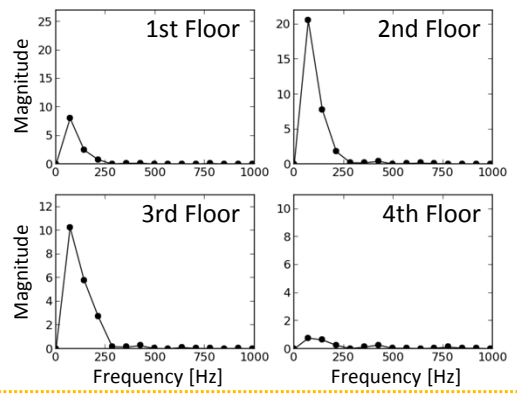
FFT Graphs for the case with damages on first and second floors

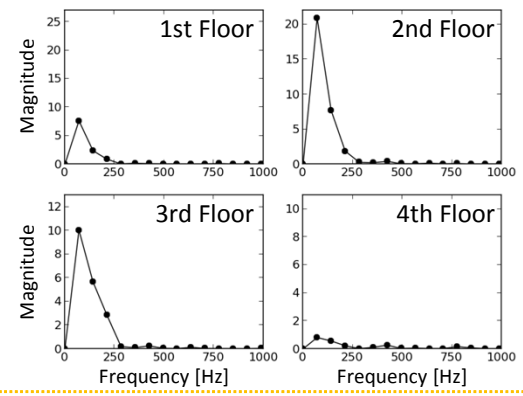


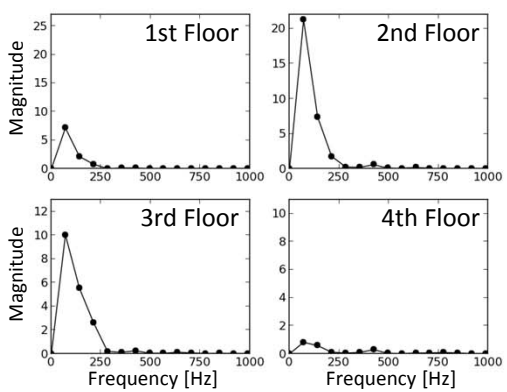


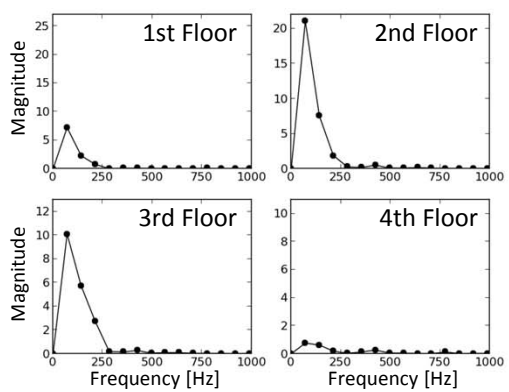






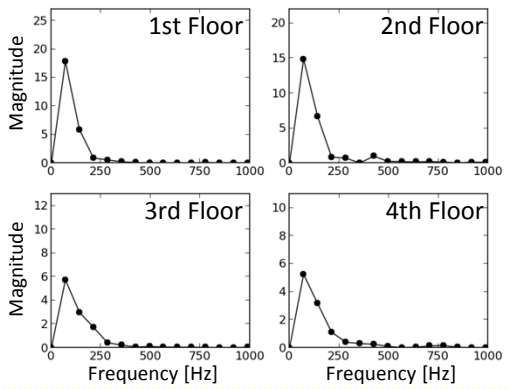


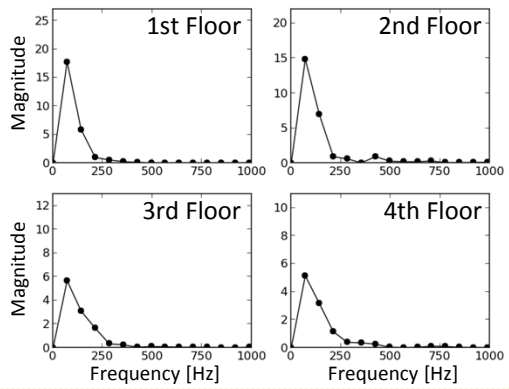


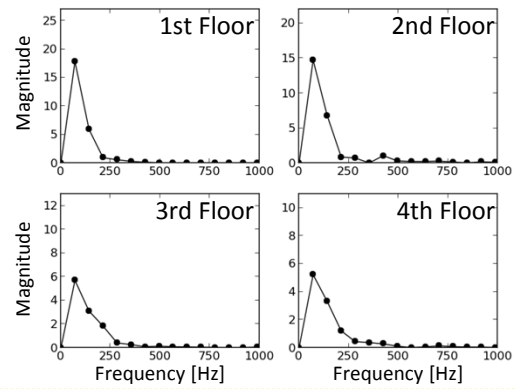


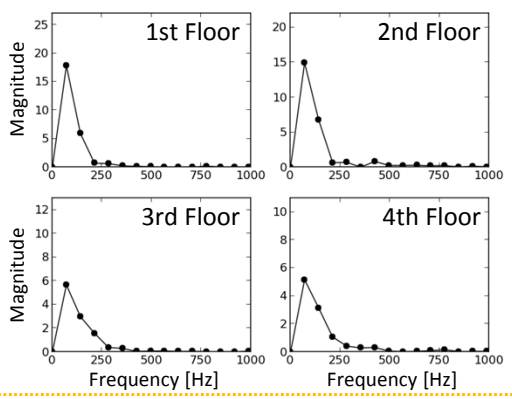
Frequency resolution : 70.721 Hz

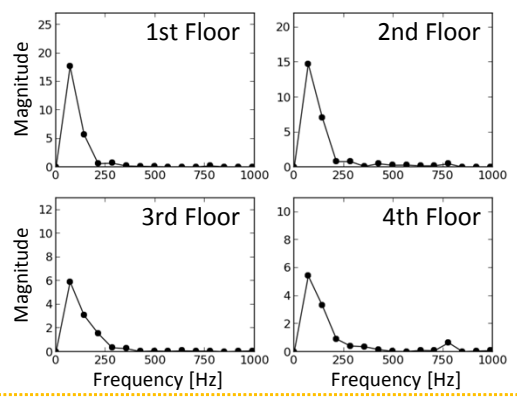
FFT Graphs for the case with damages on first and third floors

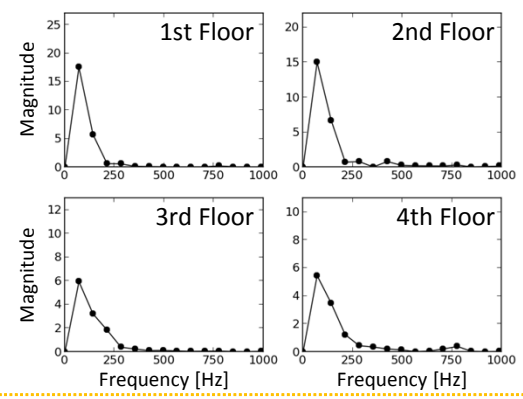


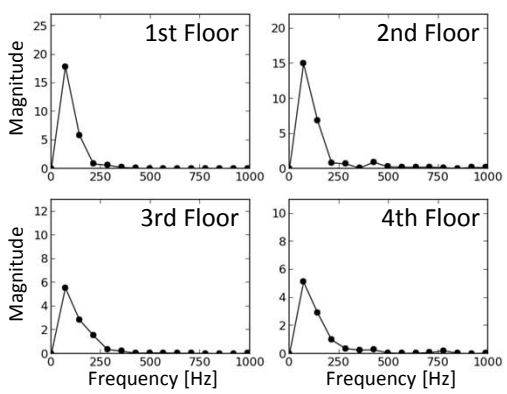


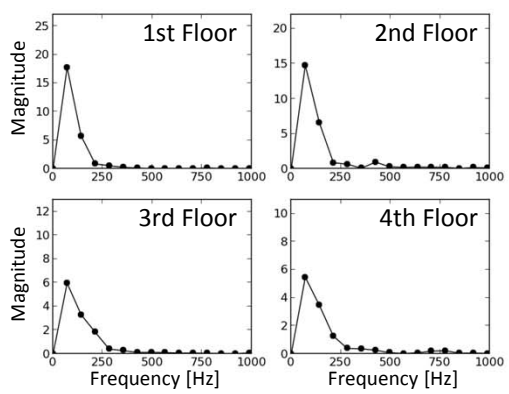






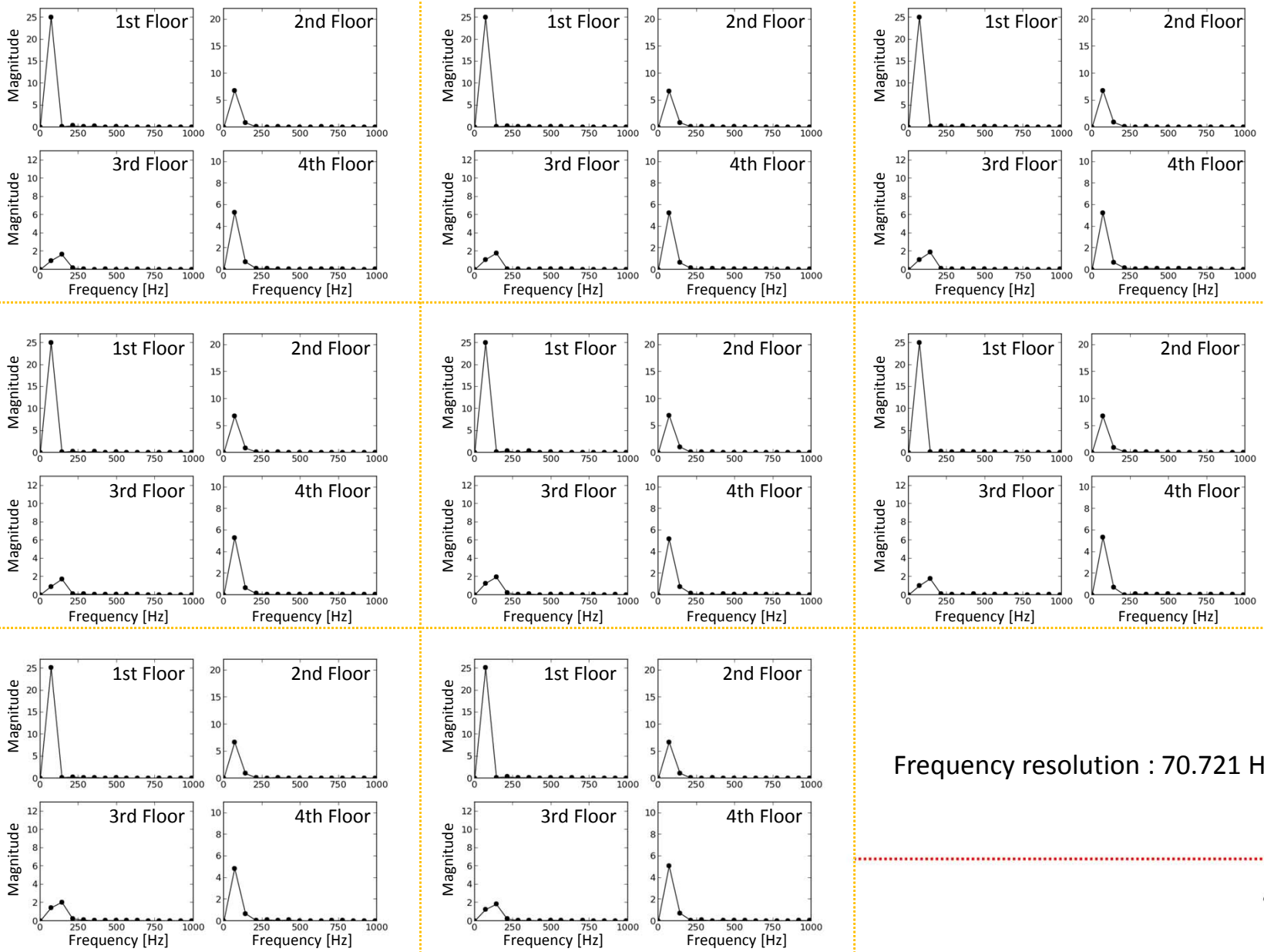






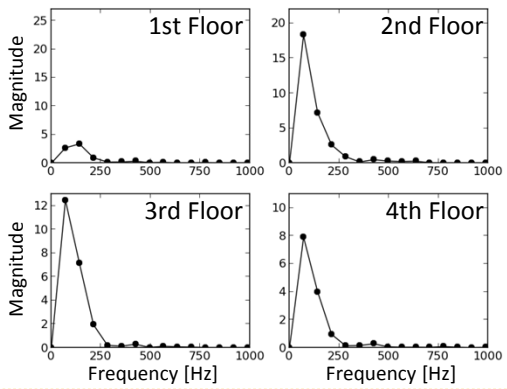
Frequency resolution : 70.721 Hz

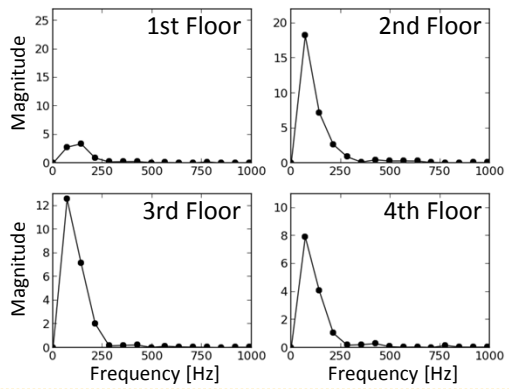
FFT Graphs for the case with damages on second and third floors

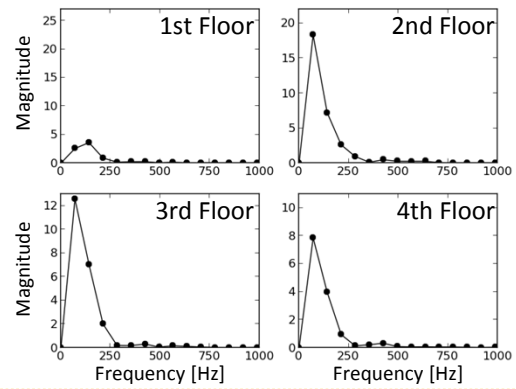


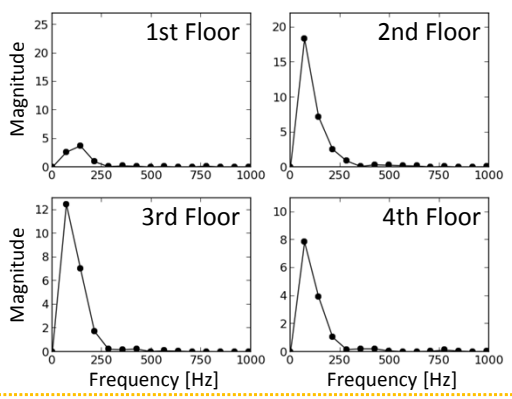
Frequency resolution : 70.721 Hz

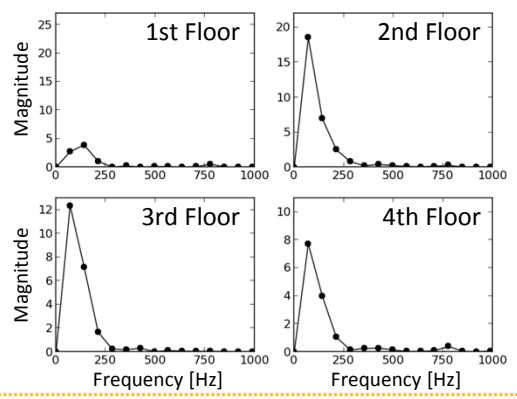
FFT Graphs for the case with damages on all floors

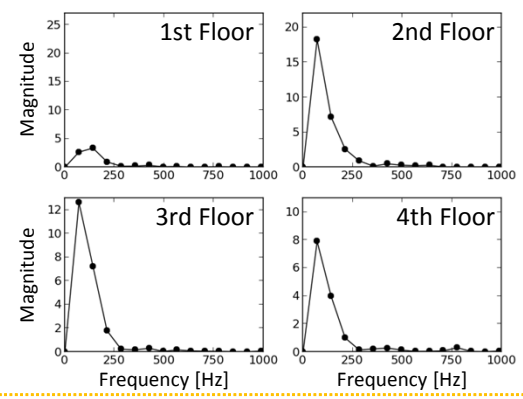


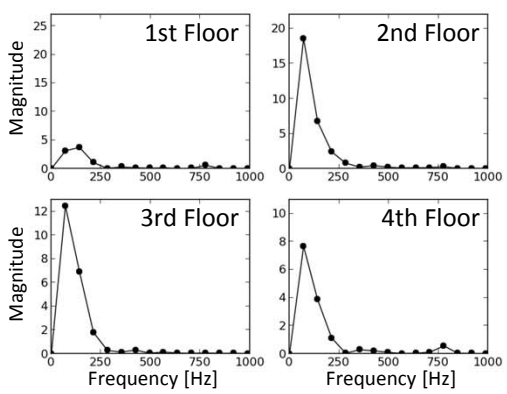


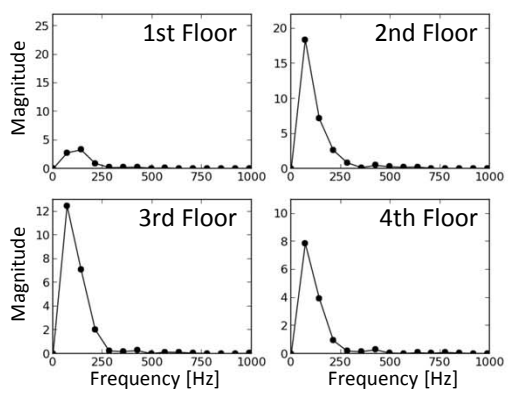






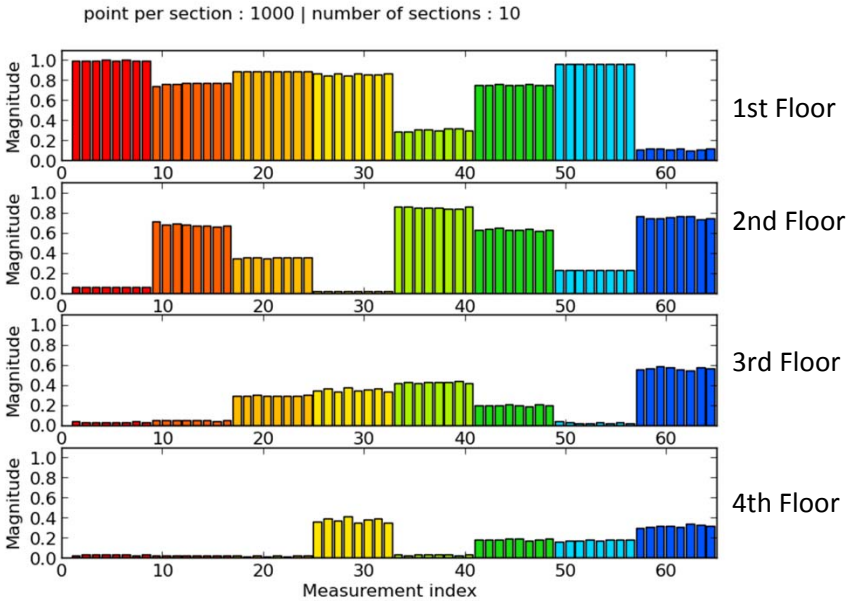


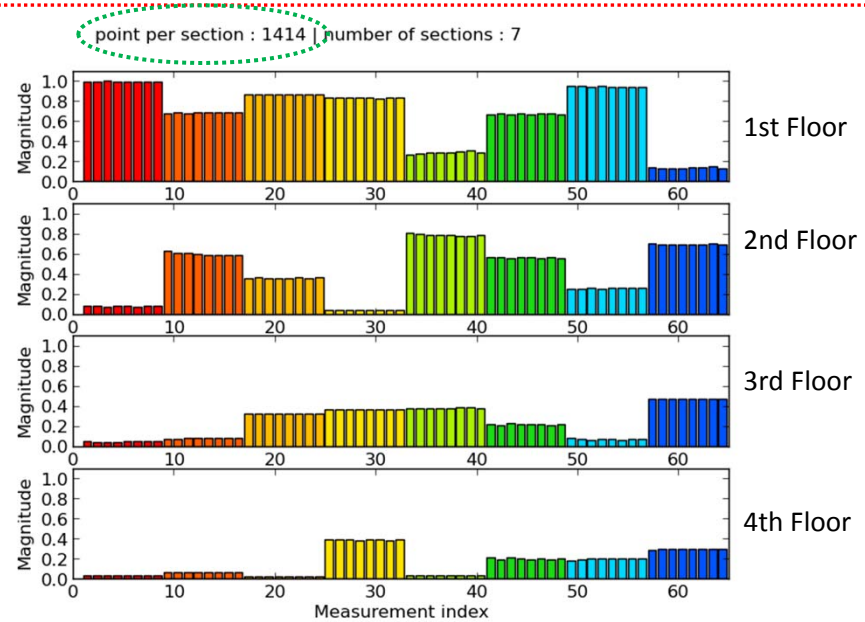


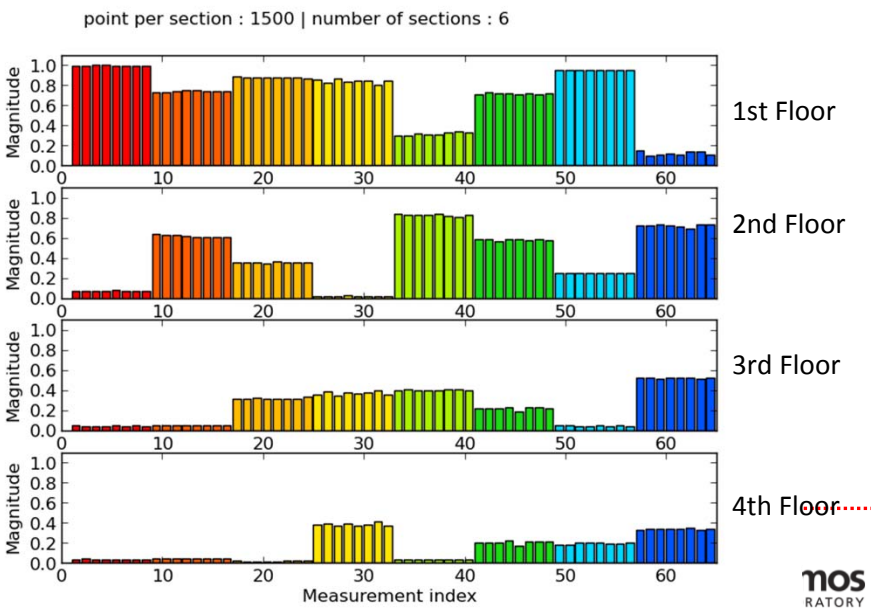


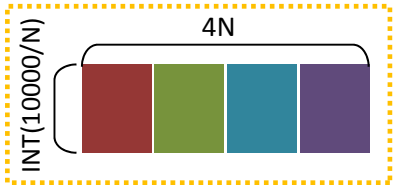
Frequency resolution : 70.721 Hz

Maximum magnitude values (the different numbers of N)









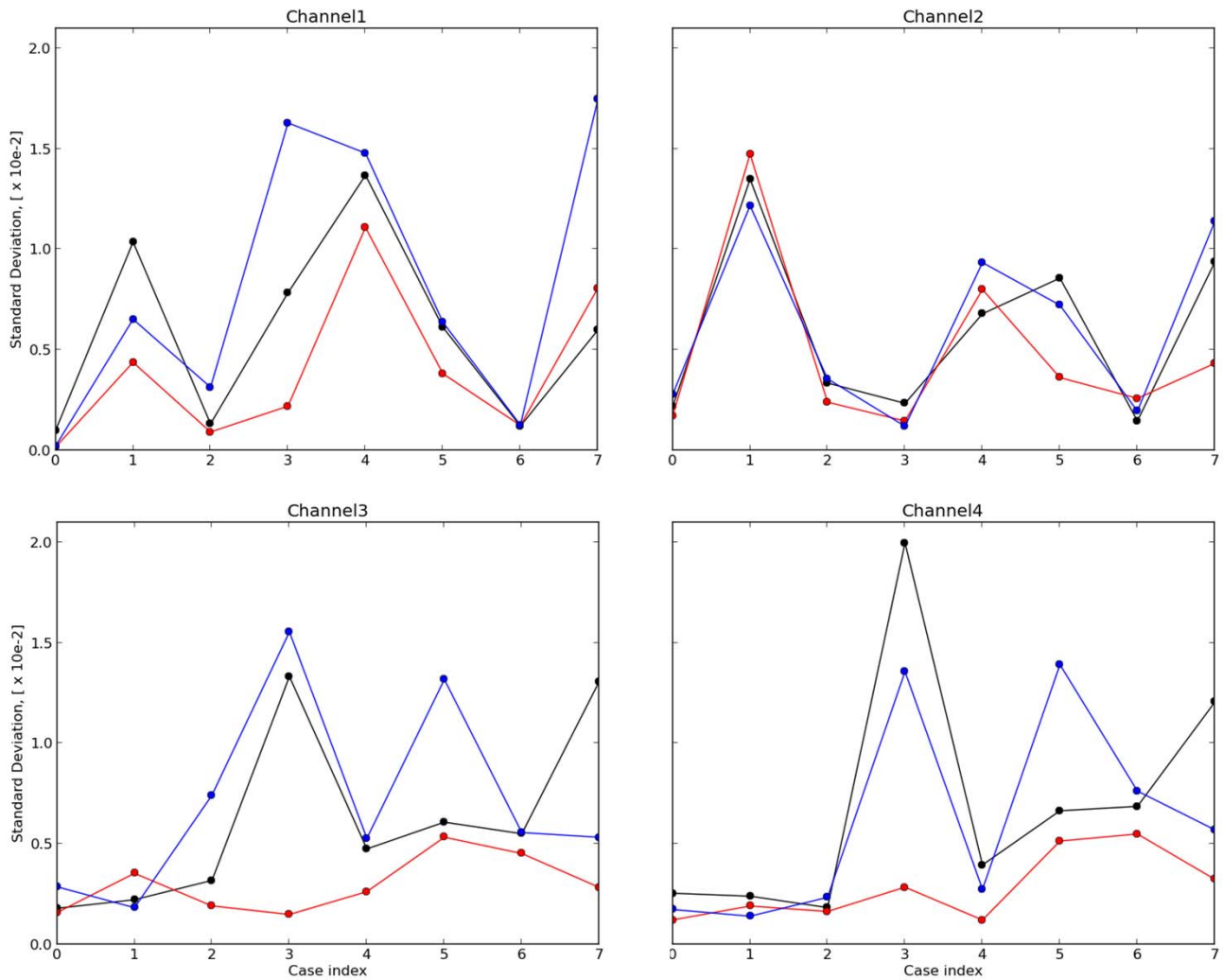
N : the number of points for one section

O : Damaged

Bumper	Case							
	0	1	2	3	4	5	6	7
3rd	-	-	-	O	-	O	O	O
2nd	-	-	O	-	O	-	O	O
1st	-	O	-	-	O	O	-	O

Case 0
Case 1
Case 2
Case 3
Case 4
Case 5
Case 6
Case 7

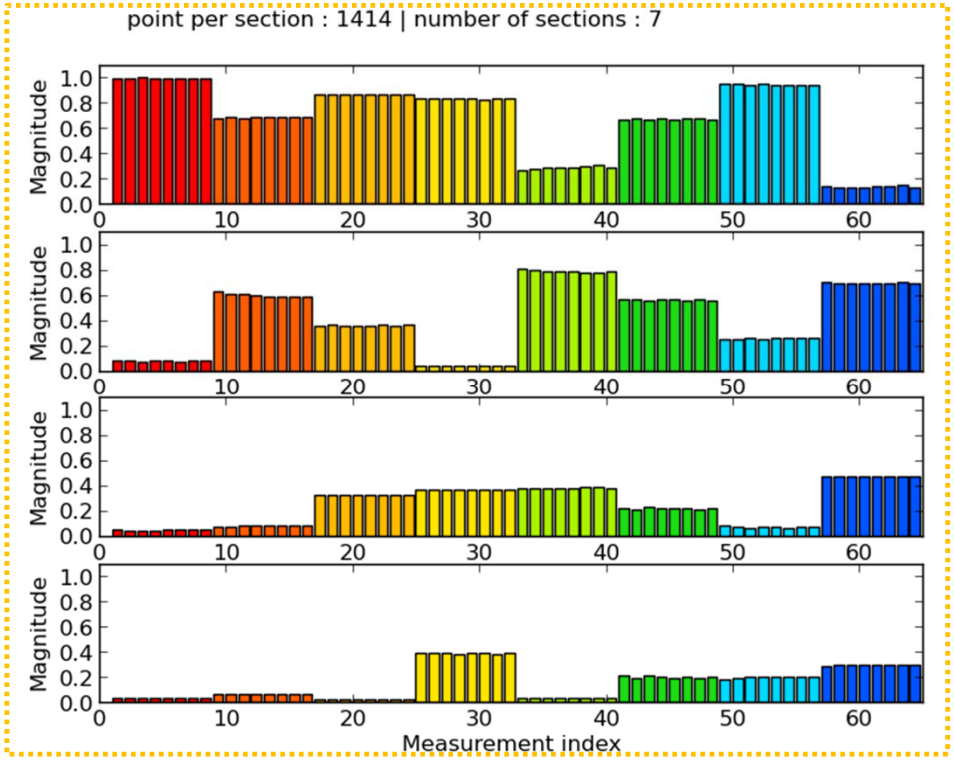
Standard deviation for each channels



The structure have excitation frequency of 70.7 Hz and sampling rate of 100kSa/sec. One cycle was explained in 707 points.

The results with 1000 points and 1500 points show higher standard deviation value for some cases ; ~~not stable(?)~~

Haptic code generation



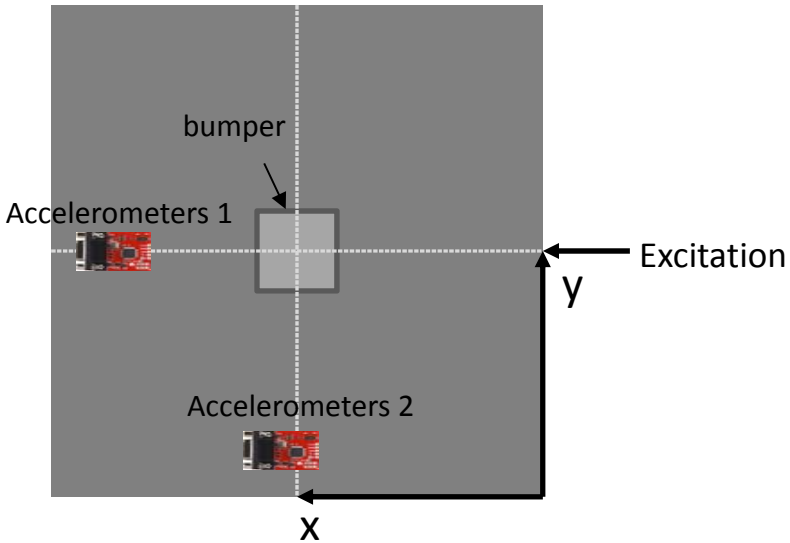
Multiply 250

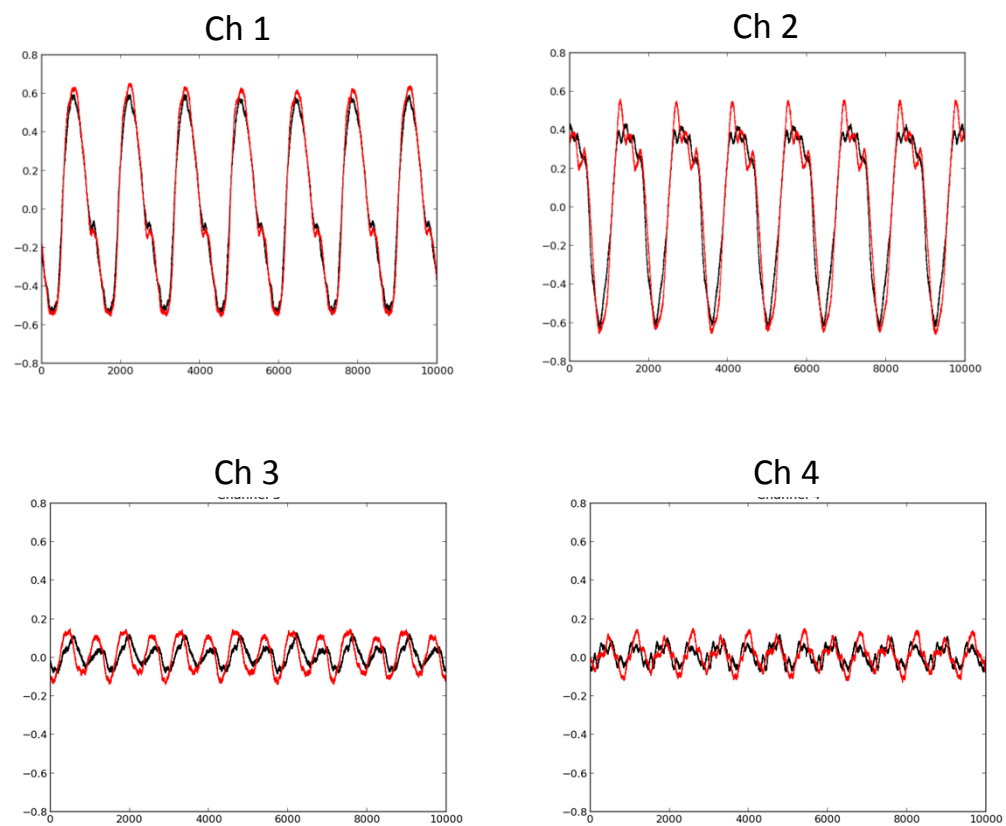
4 bytes Haptic code

Conclusion

1. Shear-building structure
2. Singular Value Decomposition, eigenvector
3. Effect of signal rearrangement
4. Haptic codes generation

Effect of accelerometers' position





The signals were acquired under the state of case 1

Appendix

Yunshil Choi at the LANL Engineering Institute

Yunshil Choi at the LANL Engineering Institute