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Title:

A case study of introductory teaching method for architectural/environmental acoustics using a smartphone

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1. Introduction

In the introductory course of architectural and environmental acoustics for the first or second year students in universities, objective measurements of physical acoustical amounts using a measurement apparatus such as a sound level meter are not usually performed. Instead of an objective measurement, instructors try to interest students in acoustic environment by letting students listen to surrounding sound environment and note what and how sound are heard to make a ‘sound map’ etc. as an output. Such a method, based on the soundscape methodology [1], is widely used.

On the other hand, recently a smartphone, such as iPhone and Android, is widely used among students. There are many applications available at low cost, which enable smartphones to make various acoustical measurements, e.g., sound level, frequency spectrum measurements etc. Using

a smartphone with these applications, instead of costly measurement apparatus, it can be possible to introduce the objective measurement of physical acoustical amounts to introductory courses. This can make the course more advanced and interesting for students. In this way, a smartphone can become a strong educational tool for architectural/environmental acoustics.

In this letter, as a case study, we summarise the main results of a trial exercise to make a sound map with the physical measurement results by a smartphone that we assigned to the students. The trial exercise is supposed to be a possible assignment in the introductory course on environmental acoustics in the first or second year students of university [2].

2. Applications used and trial exercise for students

In the preliminary study, it was found that Android smartphones show large scatter in the measured results of sound pressure levels regardless of applications used [2]. On the contrary, devices using iOS (iPhone, iPod touch and iPad) do not show such a scatter but the measured results are all in good agreement. We conclude, therefore, that devices using iOS (iPhone, iPod touch and iPad) are suitable for the purpose of the present study.

The applications used in this trial are, 'SPL Meter' [3] for sound level measurement, and 'bs-spectrum' [4] for frequency spectrum measurement. The SPL Meter has A- and C-weighting, and Slow and Fast time constants. Its accuracy is tested by comparing its measured results with precision (Class 1) sound level meter, and found that, whereas there are a few decibel discrepancies at low frequencies around 125 Hz which can be attributed to the sensitivity of microphone preamplifier installed in the device, basically its accuracy is as good as general-purpose (Class 2) sound level meter. **An example of the comparison results is shown in Fig. 1.** Therefore, we asked students to use this application to measure sound pressure level to make a sound map as a trial assignment of introductory course. The bs-spectrum is also tested by comparing its measured results with the measured results by FFT analysing system in Windows PC. The results are in good agreement except at low frequencies around 125 Hz, which is caused by the same results as in SPL Meter as mentioned above. **An example of the comparison results is shown in Fig. 2.** The bs-spectrum can give only relative value, but it is considered to be useful and accurate enough for the present purpose.

Fig. 1

Fig. 2

Measuring frequency spectrum of sound is considered to be also useful, though rather advanced, in introductory course to promote more profound understanding of sound environment. In some trial assignments the 'bs-spectrum' is used to measure frequency spectrum and the students are encouraged to include the results in the sound map to make more detailed discussion.

3. Examples of results

In Fig. 3 an example of the sound map with the measured results of sound pressure level only. Even though it is a very simple sound map, students can understand the effect of the distance of a main traffic which is the main noise source in this area, and the effect of buildings to decrease the noise level, not only by their listening impression, but by the measured objective values.

Fig. 3

In Fig. 4 frequency spectra are measured and those results are also presented in the map. In this example, the dominant component of noise can be found not only by listening but by particular features of the measured frequency spectra. In this way, by measuring a frequency spectrum, the difference of sound environment can be understood by the visual impression of spectrum data also. This leads students to more advanced and clear, objective discussion on the sound environment.

Fig. 4

4. Some practical problems

As above, we have made a trial of possible exercises for students in introductory courses, and try to let the students do those trial exercises. All participated students recognised the benefit of objective measurements in introductory courses. After having finished these tasks, in the discussion with the students, the practical problems below were pointed out. These should be issues to resolve before this method is put into practice:

- (1) The applications used here are, though they are not expensive, not free. Some students may not prefer to use expense for such an application to make an exercise.
- (2) Smartphones are widely used among students, but not all students. Therefore, this method is rather better practised by making it as a group work.
- (3) If more advanced measurements will be introduced, such as L_{eq} measurements and band analyses, more expensive application will be needed.
- (4) For beginning students the basic theory and meaning of physical measurement of these values should be taught beforehand. Especially, frequency spectrum is rather difficult to understand for beginners.

Acknowledgements

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References

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- [2] K. Sakagami, F. Satoh and A. Omoto, “A case study of introductory teaching method for environmental acoustics using smartphone,” Transactions of Tech. Com. on Archi. Acoust., Acoust. Soc. Jpn., AA2012-10 (2012) (in Japanese)
- [3] <http://www.studiosixdigital.com/> (Reference 2012-10-22)
- [4] <http://www.bismark.jp/jp/bs-spectrum-iphone/index.html> (Reference 2012-10-22)

Captions of Figures

Fig. 1 An example of the comparison of the measured results of A-weighted sound pressure levels by the SPL Meter (installed on iPhone 4S) and a class 1 sound level meter. Some plots appears lower than the diagonal lines at 70 – 90 dB are results for 125 Hz, of which the discrepancy is attributed to the sensitivity of the microphone preamplifier in iPhone. Also some plots at low levels are scattered around the diagonal line, which can be considered to be caused by linearity problem in iPhone. These features are typical for all iOS devices.

Fig. 2 An example of the comparison of the measured results of the frequency spectra of pink noise measured by the bs-spectrum (installed on iPod touch 4) (top) and FFT analysing software on a PC (bottom). Spectrum levels measured by bs-spectrum at the frequencies lower than 100 Hz show decrease which is different of one measured by the PC. This is also attributed to the sensitivity of the microphone amplifier in iPod and typical for all iOS devices.

Fig. 3 An example of a sound map with results of sound pressure level measured by a smartphone.

Fig. 4 An example of a sound map with results of sound pressure level and frequency spectrum by a smartphone.

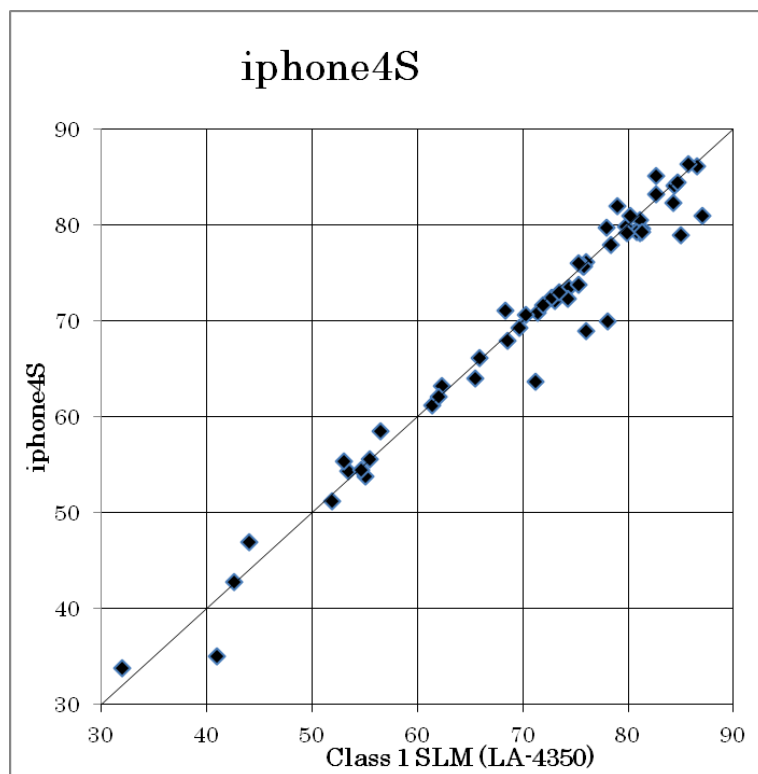


Fig. 1 (65mm)

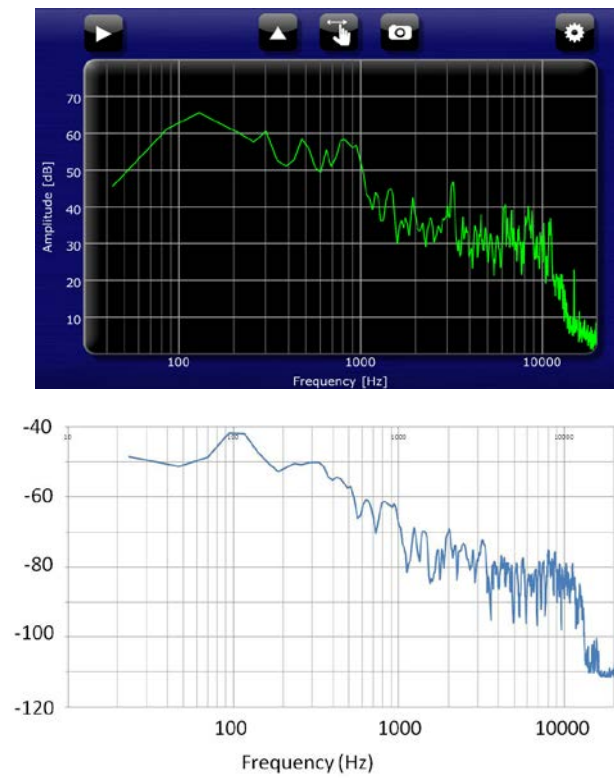
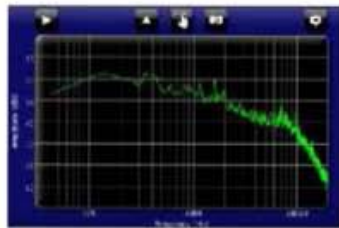


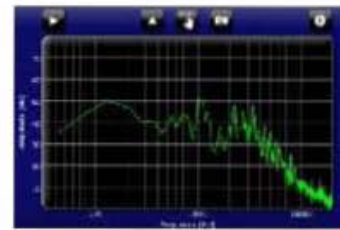
Fig. 2 (65mm)



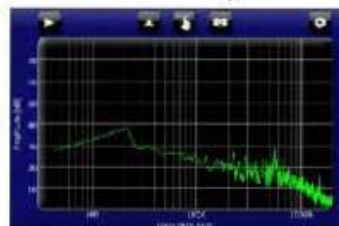
Fig. 3 (130mm)



(1) In front of Tbyonaka Sta., Near the Route 176.
68.0dBA(Slow, Peak). The location is in front of the Hankyu railway station, and near a fairly busy road. This was measured at around noon in which traffic was relatively lower. The noise level varies according to the traffic light. The above value was measured when the traffic light of the Route 176 is on green.



(2) North of Oike Primary School
55.6dBA (Slow, Peak). This was measured when the physical education is on in the school ground. It was rather quiet around the school with only slight traffic noise from the nearby main traffic. The noise level is around 45dBA when the teacher only spoke. The above value was measured when pupils raised their voices.



(3) Residential street (Honmachi, Tbyonaka-city, Osaka)
33.5dBA (Slow, Peak). This is very quiet residential street. There is a small park near this point, but there was no people in the park. Unless a person or a car was passing by, there was almost no sound. This point is far enough from main traffics and no traffic noise was heard.

Fig. 4 (130 mm)