An iPhone-Based Binaural Recorder for Sound Quality Analysis

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Binaural recording and playback are widely used tools for sound quality analysis of consumer products and transport vehicles. The shortcomings of traditional systems are that they are expensive and difficult to use. The iPhone-based binaural recorder (referred as iPhone BR) was developed as shown in this article. The system included a binaural microphone, soundcard and user application. The hardware was tested according to IEC 61672 sound level meter standards. The system was tested in an anechoic chamber for accuracy of source positioning. The measurement accuracy was investigated by comparison with a dummy head. The iPhone BR system can be used for jury testing and sound quality analysis. The other applications of the system, such as sound intensity measurements, are also explored. The advantages of the iPhone based binaural recorder are data sharing, cloud database, low cost and simplicity.

Binaural recording and playback techniques were introduced in early 1970s. The first generation of binaural recording was based on an analog dummy head. The techniques were widely used to analyzing sound quality of consumer products and vehicles. More recently, portable hardware with headset microphones were introduced as convenient tools for binaural recording.

The iPhone has evolved into a powerful computing machine with exceptional capabilities with built in sensors such as microphones, GPS receiver, accelerometers and sensors. The iPhone developers now offer many sound measurement applications (apps) using built-in or external microphones. Interest in such sound measurement applications is growing among audio enthusiasts, educators, NVH engineers, acoustic researchers and the general public.[1,2] It has not been reported that the iPhone has been used for binaural recording and playback applications.

Binaural Recording Via iPhone

iPhone Specifications. The iPhone is not designed for acoustic measurement purposes. The microphone signals can be input through the 3.5-mm headset socket or through the lightening connector. The headset socket only takes one-channel signals, while the lightening connector can take two-channel signals. The iPhone has an electric current limit of 100 mA for any external devices. The hardware design has to consider those limitations.

The iPhone BR consists of a two-channel input, a two-channel output data acquisition card, an in-ear microphone, a lightening cable and the phone. Figure 1 shows the hardware connections. The ICCP-type (or IEPE) microphones are not suitable for this application, because the iPhone cannot provide enough current directly without an external battery. The in-ear microphones use measurement class capsules but with low power. The iPhone 6 and 6+ were used for all tests.

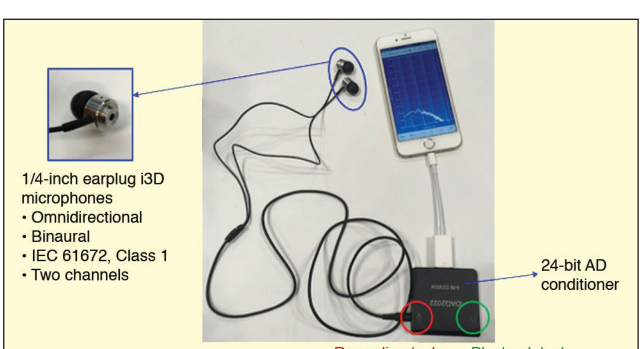


Figure 1. Binaural recording system hardware.

Based on a paper presented at Inter-Noise 2016, Hamburg, Germany, August 2016.

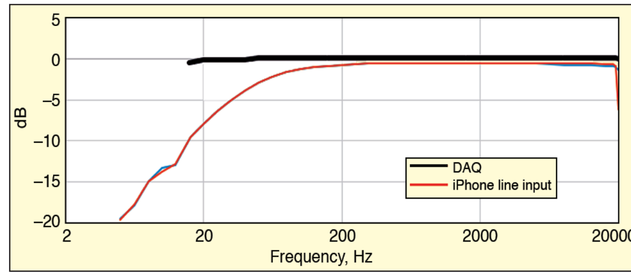
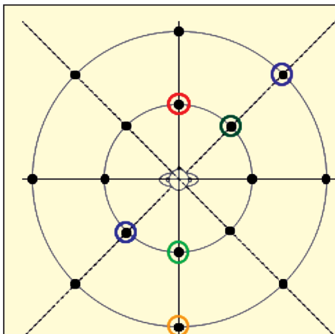


Figure 2. Frequency response of external DAQ and iPhone internal sound card.



	Angle	Distance, m
1	0	1
2	45	1
3	45	2
4	180	1
5	180	2
6	225	1

Figure 3. Six different specific positions of sound source.

iPhone Apps for Recording and Analysis. There are many apps in the Apple Store for recording and sound analysis. The first step of the study is to select an app for binaural recording and signal analysis. The SignalScopePro was selected for acoustic signal analysis and a Hindenburg field recorder was used for binaural recording. The apps have data sharing, GPS positioning and other iPhone functions.

Hardware Performance. The system was tested according to IEC 616172 sound level meter standards using electrical signal input. Figure 2 shows the frequency response of Channel 1 and 2 of the external DAQ. The comparison was also made with the iPhone internal soundcard mic input. It can be seen that the external DAQ has a flat response, which complied with IEC61672 Class 1 requirements. It is clearly shown that the iPhone internal soundcard has a low-frequency cut-off of 200 Hz.

The dynamic range of the system was tested using an input signal of 1000 Hz, Table 1 shows the measurement results. It can be seen that the iPhone BR system can take up to a 6.0 V_{rms} input signal. With 50 mV/Pa sensitivity microphones, the upper limit of sound pressure level measurement is 135 dB.

Table 1. Input dynamic range of system.

Input Voltage, mVrms	Channel 1, dB	Channel 2, dB	Reference, dB
50	94.0	94.0	94.0
158	104.0	104.0	104.0
500	114.0	114.0	114.0
1580	124.0	124.0	124.0
5000	134.0	134.0	134.0
6000	135.6	135.6	135.6

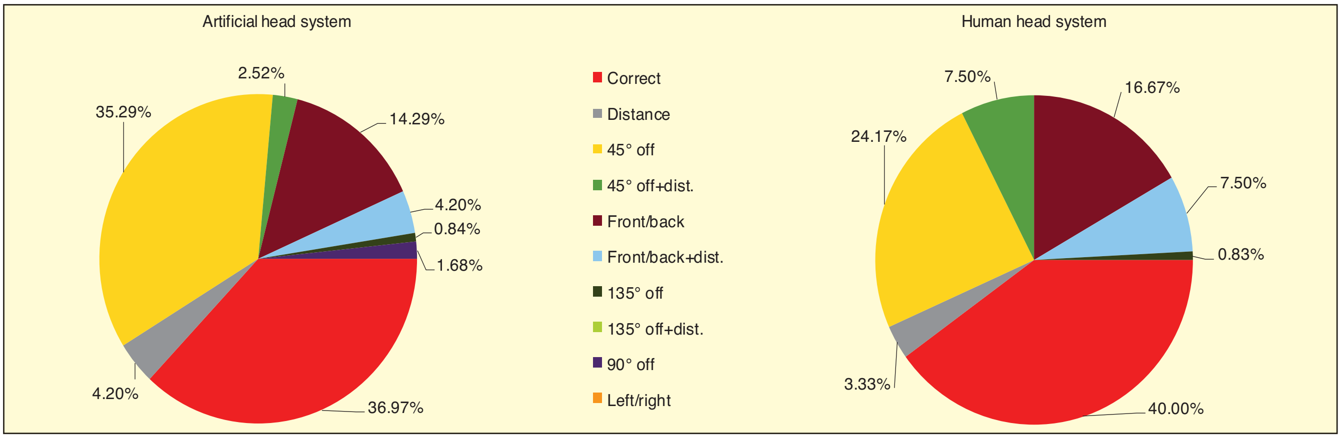


Figure 4. Jury listening test results for dummy head and human head respectively.

The noise floor of the iPhone BR system was tested in BSWA's full-anechoic chamber. The anechoic chamber itself has a background noise level of 16.5 dBA. The noise floor of the iPhone BR system was measured to be 33.6 dBA. The useful measurement range for the iPhone BR system is from 40 dBA to 135 dB, which covers most automotive NVH testing requirements.

Jury Listening Study

A jury listening study was used to determine how well the spatial information could be reproduced with the binaural system. Recordings were made with a speaker (sound source) in an anechoic chamber. The speaker was placed in six different positions relative to the recording head as shown in Figure 3. An audio sample of female speech was used for all recordings, and the difference between the dummy head and human ear were evaluated.

After recording the sample, 15 people were selected to listen to the 12 recorded samples with high-quality headphones and then asked about the location of the sound source. Figure 4 shows the survey results of the jury listening test. Four different angles were tested; about 70% of the choices were correct. More studies could be required for further evaluation of the iPhone BR system against a conventional dummy head system.

Conclusions

The iPhone-based binaural recorder was developed and tested. The system consists of a two-channel DAQ, binaural microphone, the iPhone and its application. It was found that the system complied with IEC61672 Class 1 standards for frequency response.

References

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