COMPARATIVE ANALYSIS OF THE SOGEUM AND DANSO DIRECTIVITY PATTERNS

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중심어: Directivity, Musical Instruments

Summary

Directivity measurements quantify the spatial variations in sound radiation from acoustic sources. Musical instrument directivities have many valuable applications in sound source modeling, microphone placements, auralizations, and room acoustics. While directivity measurements of Western instruments are becoming ubiquitous, traditional Korean instruments have not received as much attention until more recently. Jeong et al. measured hemi-spherical directivities of played traditional Korean instruments, including the gayageum, daegeum, jango, and a pansori singer.[1] Their 1/3rd-octave-band analyses used 10° angular resolution, with the resulting data applied to room acoustical design. This work compares high-resolution spherical directivity measurements for two traditional Korean instruments: the sogeum and the danso. Despite similarities in the instrument structures and materials, the instruments' directivities have distinctive features.

As suggested by Fig. 1, a semi-circular arc with 36 0.37 mm (0.5 in) microphones placed with 5° polar angle spacing assessed the directivities of the two instruments in an anechoic environment. Subsequent rotations of the arc in 5-degree azimuthal-angle steps enabled a full-spherical scan with 2,521 unique sampling positions, in line with the AES sampling standard for directivity measurements,[2] with the omission of the nadir (south-pole) measurement location due to obstructions from support structures. Both instruments were artificially excited using a blowing device with artificial lips created from putty. While the artificial excitation generated a relatively stable input signal, an additional microphone in the near-field of the instrument provided a suitable reference for calculating frequency response functions (FRFs) used for live speech and played musical instrument directivity measurements.[3] Directivity results followed from the FRFs with 1 Hz resolution. Subsequent smoothing using spherical harmonics reduced spatial measurement noise.[4]

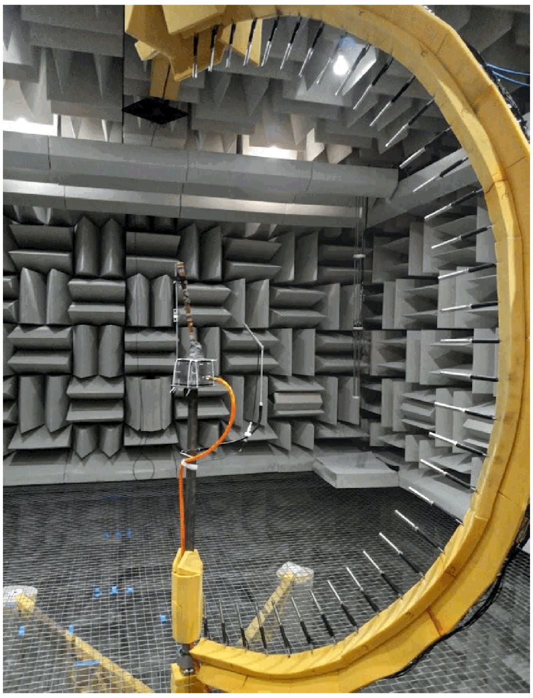

Figure 1. Directivity measurement system with danso and blowing box

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The directivity results confirmed the basic expectations from physical considerations and geometry. Because both instruments are essentially linearly arrayed tone hole instruments, the directional characteristics are roughly symmetric about the instrument axes. Additionally, the directivity patterns at lower frequencies are simpler; as frequency increases, many interference lobes develop with increasing wavelength.

While the directivity measurement system produced results for many fingerings and their respective harmonics, Fig. 2 shows select results for both instruments. The directivity balloons illustrate the relative levels on a 40 dB scale using both color and radius. The overlaid grid depicts the sampling positions covered by the measurement system; the 0° azimuthal angle marker is in the forward direction. The directivity balloons have been rotated from the measurement configuration so that the instrument orientation is more consistent with actual playing positions. Thus, for the danso results, shown in Fig. 2(a)-(c), the end of the instrument is oriented near the 180° polar angle marker. For the sogeum results, shown in Fig. 2(d)-(f), rotations orient the end of the instrument near the 270° azimuthal angle marker.

For the fundamental frequency of the danso with all tone holes open [Fig. 2(a)], the directivity pattern is a single lobe roughly axisymmetric about the instrument. Three lobes are visible for the second harmonic shown in Fig. 2(b). Finally, for the third harmonic, shown in Fig. 2(c), four lobes are visible with more significant asymmetry about the instrument axis. The sogeum with the first two tone holes covered also shows quasi-axisymmetric radiation patterns about the instrument axis. Its fundamental pattern, shown in Fig. 2(d), is nearly identical to that of the danso when considering the different instrument orientations. However, for its second harmonic, shown in Fig. 2(f), only two lobes are visible. The directivity of the third harmonic, shown in Fig. 2(f), shows the most substantial radiation to the side of the instrument.

Despite the similarities between the two instruments, each displays unique radiation characteristics, likely resulting from the instruments' different excitation forms and geometries. The sogeum is a transverse, side-blown flute, whereas the danso is an end-blown flute. Thus, one might expect the input impedances and isolated radiation characteristics of the mouthpieces to differ, leading to distinct radiation properties, even for similar downstream geometries.

While each instrument has its unique features, the directivity patterns of the sogeum and danso are fundamentally that of a linearly arrayed tone-hole instrument. As this work only considered artificially excited instruments, future work could include studying the directivities of played instruments, including the effects of musician diffraction and absorption. Equivalent point-source modeling involving the input impedance would also provide helpful insights into the differences between the two instruments.

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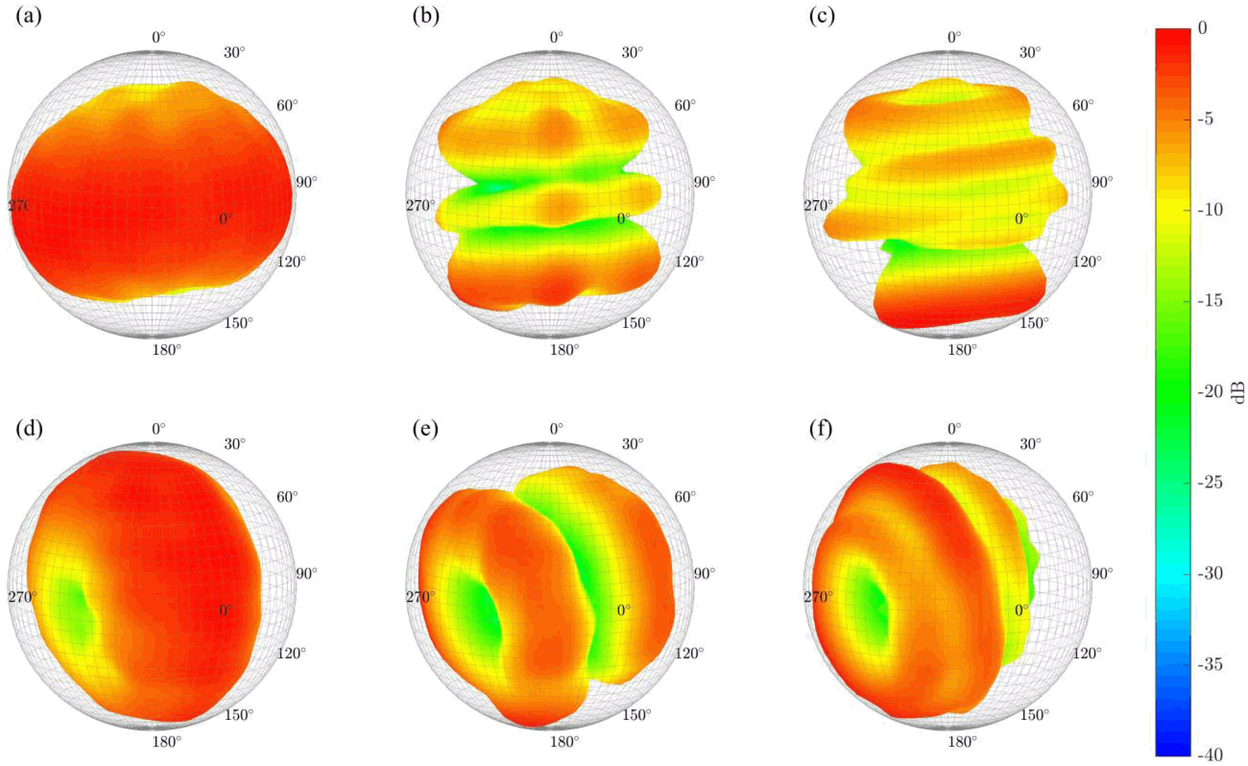

Figure 2. Danso directivity for all tone-holes open (a)-(c) and sogeum directivity for the first two tone holes covered (d)-(f). (a) Fundamental (759 Hz). (b) Second harmonic (1528 Hz). (c) Third harmonic (2272 Hz). (d) Fundamental (730 Hz). (e) Second harmonic (1467 Hz). (f) Third harmonic (2200 Hz).

참고문헌

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