MICROPHONE ARRAY MEASUREMENTS OF THE GRAND PIANO

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ABSTRACT

This treatise is concerned with a measurement method and current results of an on-going project performed at the Institute for Systematic Musicology in Hamburg, Germany. A series of measurements are taken on four concert grand pianos in eight different stages of production, starting with the glue-laminated soundboard planks and ending with the completely assembled piano in concert tuned state. The majority of the sound energy radiated by a grand piano originates from the soundboard, which amplifies the vibrations of the strings via the bridge. Due to the large size of the soundboard as well as its irregular shape, measuring deflection shapes is a nontrivial task. Common measurement methods such as piezoelectric accelerometers can affect the acoustic vibrations of the soundboard due to the added mass. To this end, a noninvasive microphone array method is utilized for the present work. The array consists of 105 microphones successively placed in 18 positions parallel to the soundboard, resulting in a total number of 1890 measurements of which 1289 microphones cover the actual surface. The Soundboard is excited using an acoustic vibrator at 14 positions associated with string termination points on the bass and main bridge. The utilised SineSweep technique is capable of separating the linear part of an impulse response of a weakly non-linear system from several non-linear parts, representing the harmonic distortion of various orders. The measured sound pressure is back-propagated to the radiating soundboard surface using a minimum energy method. The resulting deflection shapes due to the forced oscillation can be visualized up to 4 kHz. Impedance curves are calculated for the 14 input locations on the bridge. The empirical findings will contribute to the formulation of a real-time physical model to help piano makers estimate the impact of design changes on the generated sound.