

The Return of the Messiah: Modal Analysis and Bridge Admittance Modeling

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ABSTRACT

Phase one of a larger project to fully model the Messiah violin (1716) involves measurement of bridge admittance and radiativity profiles. The Messiah is believed to be the only Stradivarius in existence in as new state. Currently, the instrument is part of the collection of the Ashmolean Museum in Oxford, England and has been seldom played, in part because of an untreated internal crack in the top plate. In the context of the 300th anniversary of its construction, the violin was made available for one hour to perform a reduced set of minimally-invasive measurements from which to study its vibrational and acoustical properties. We present our first results of computing admittance and radiativity transfer functions from impact hammer, laser doppler vibrometer, and microphone measurements. The overall project goals are two-fold: to create a playable physical model and to "repair" the crack in simulation. Phase two and beyond incorporate a bow model with simplified thermal friction and hair dynamics and performance rendering from gesture capture. The present state of the instrument prohibits bringing its strings up to pitch and consequently measurements were required to be made at reduced tension. A second instrument, the Cremonese Stradivarius (1715), was subjected to the same measurement protocol twice: in a similarly detuned state and at pitch. The Cremonese was made by Antonio Stradivari just one year before the Messiah and its measurements provide a reference for compensation of string tension intended to regain an intact Messiah (by inference).

The paper presents details of admittance models of different resolutions combining modes estimated from admittance and from reference radiativity measurements. Bridge velocity and radiated sound pressure measurements were obtained from orthogonal impact hammer strikes in directions corresponding to the horizontal and vertical directions of the transverse motion of the strings (at the corner of the bass side of the bridge). Modal analysis from admittance measurements uses a technique which explores different resolutions (model orders). Modal analysis of the high-frequency region uses reference radiativity transfer functions. We compare the three sets of admittance models obtained: Messiah (detuned), Cremonese (detuned) and Cremonese (at pitch). A discussion of the next phase describes the 16 hemispherically-distributed microphone measurements also obtained and how these will be used to construct a spherical radiativity model.