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Music in the digital era: X-ray CT imaging analysis and 3D reproduction of historical wind instruments

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Historical musical instruments preserved in museum collections are objects originally made to communicate and entertain with the music they produced. Unfortunately, playing historical woodwinds is particularly problematic; indeed, the humidity produced by the musician's breath during a performance represents a significant risk in terms of conservation, such as possible formation of cracks and deformations of the wood. As a result, most museums do not allow historical wind instruments to be played, thus depriving them of their musical meaning. Until now, the creation of replicas has been based on manual measurements of the originals, and both measurement and manual manufacturing leave a considerable margin of choice to the maker, which makes unfaithful copies very common. Today, the possibility of using non-invasive analysis techniques and digital technologies for measurement and modelling offers new opportunities in this field. The presented project has the purpose of developing a methodology for the reproduction of ancient wind musical instruments from museum and private collections by means of digital technologies. In particular X-ray Computed Tomography (CT), computer modelling and 3D-printing, can be employed to recreate the sounds of ancient instruments for the contemporary public, preserving at the same time the physical integrity of the originals. X-ray CT scanning is a non-invasive technique already successfully applied for the study and analysis of internal structures and features of different types of cultural artefacts, in some cases also by means of synchrotron radiation [1]. The use of imaging techniques in the field of musical instruments has been validated by recent studies [2], in which shapes complexity, variety of materials and objects size make high-quality CT acquisition non-trivial. In this work, starting from indications and tips provided by the MUSICES project [3], in particular on the woodwind instruments measurements, tomographic analysis on three wind instruments made of wood with some ivory details were carried out: a piccolo flute of unknown manufacture and a baroque flute (Traversiere) by Lorenzo Cerino both from the late Eighteenth Century, and a copy of a renaissance recorder by Fulvio Canevari from the 1970s. The CT measurements were performed at the Physics Department of the University of Turin, in collaboration with the Chemistry Department. After the analysis of the obtained data and the digital modelling of the objects, high quality and precision copies were realized by means of 3D printing technology, comparable in terms of size with the original instruments. 3D printed parts were fitted and finished with traditional flute-making techniques, resulting in good sounding instruments. Acoustical analysis, based on both physical measurements and testing sessions with professional musicians, shows that the technology has a high potential for producing faithful copies of ancient instruments, although some present limitations need to be addressed.

References

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[3] Bär F.P. et al., *Recommendations For the Three-Dimensional Computed Tomography of Musical Instruments*, 2018