JASA EDITORIAL

Introduction to the special issue on 3D sound reconstruction for virtual auditory displays: Applications in buildings[a]

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ABSTRACT:

This special issue on three-dimensional (3D) sound reconstruction for virtual auditory displays: applications in buildings contains six research papers. Among them, three articles describe virtual reconstruction of important theatres and opera houses. The remaining articles focus on theoretical approaches of virtual sound localization or auralization. © 2023 Acoustical Society of America. https://doi.org/10.1121/10.0024159

I. INTRODUCTION

Immersive and three-dimensional (3D) sound reconstruction of buildings has attracted the interest of several different researchers, belonging to universities, museums, academies, conservators, and restorers. The interest in virtual reality, especially applied to sound and acoustics, has extended to several industries that are investing many resources for developing new methods, improving existing techniques, and extending the applications to a broad number of cases, e.g., automotive, gaming, entertainment, and also military purposes. However, the most important (and relevant) applications of this theme are related to the sound reconstruction of historical (sometimes lost) buildings, considering sound and acoustics as a fundamental intangible cultural heritage.

Some of the articles published within this special issue are related to new methodologies or improvements of existing methodologies aimed at enhancing the 3D virtual reconstruction (and playback) of sound characteristics. Other articles report on important and considerable case studies, regarding world renowned opera houses or Ancient Roman theatres. Most of them came as extended versions of papers published at I3DA 2021: Immersive and 3D Audio Conference held in Bologna, Italy.

II. CONTRIBUTIONS IN THIS SPECIAL ISSUE

This special issue contains six articles, which can be divided into two different groups.

A. Methods for localization of sound sources

Yu *et al*. (2023) go into detail about the possibility of localizing virtual sound sources with amplitude panning.

The question about sound source localization represents an important issue for those involved in the sound reconstructions of buildings, especially when the sound source can move. Their approach represents an important contribution to this research field. Another paper related to 3D sound reproduction, but more focused on the perception of the sound, is authored by Jiang *et al*. (2023). This paper treats the question of modeling individual (personal) head-related transfer functions (HRTFs), which are fundamental for human perception, especially during binaural hearing. The method here proposed by the authors is based on a neural network and allows a rapid adaptation of the HRTFs to the listener. Kuntz *et al*. (2023) contribute the third paper regarding 3D auralization, with a particular focus on psychoacoustic experiments. More precisely, they describe the importance of the perception of the sound level pressure during these experiments and the importance of correct reproduction of this information during the subjective evaluation of the acoustic quality of a building.

B. Case studies on opera houses and an ancient Roman theatre

Bevilacqua and Iannace (2023a) analyze three different scenarios in the San Carlo Theatre in Naples, Italy. Their article starts from acoustic measurements and discoveries of early measurement conducted about 30 years ago for reconstruction of the sound atmosphere of this important Italian-style theatre. Their research represents an important contribution to the knowledge of the oldest existing Italian opera house. Tronchin and Bevilacqua (2023) study the virtual reconstruction of an unlucky theatre, the Tajo theatre in Lisbon. This theatre was designed by a member of the Bibiena family, but after only a few months, it was destroyed by the Lisbon earthquake, on November 1, 1775. Starting from the very accurate work of archeologists and historians, the authors propose the reconstruction of the acoustic characteristics of this lost theatre. Bevilacqua and Iannace (2023b)

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describe another world renowned ancient building, i.e., the Pompeii Roman Theatre. Their paper describes the results of acoustic measurements in the actual conditions and proposes two possible solutions for improving the acoustics for particular performances.

ACKNOWLEDGMENTS

We are grateful to all the contributors to this issue. We would also like to thank the editorial staff at JASA. We are also indebted to Professor Angelo Farina for his support.

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