

AUDIO- VISUAL CONSERVATION AND RESTITUTION OF THE ANCIENT THEATERS AND ODEA IN VIRTUAL ENVIRONMENT: ERATO RESEARCH PROJECT

Zerhan Yüksel ^a, Sevda Erdoğan ^a, Ruhi Ayangil ^b, Rengin Ünver ^a, Can Binan ^c, Cengiz Can ^c

^aYıldız Technical University, Arch. Fac. Building Physics Dept., Istanbul, Turkey
karabi@yildiz.edu.tr, serdogan@yildiz.edu.tr, runver@yildiz.edu.tr

^bYıldız Technical University, Art and Des. Fac. Music and Stage Arts Dept., Istanbul, Turkey
ruhi@ayangil.org.tr

^cYıldız Technical University, Arch. Fac. Restoration Dept., Istanbul, Turkey
binan@tnn.net, cecan@tnn.net

Özet

Tarihi yapıların koruma ve restorasyonunda günümüze değin yalnızca görsel algılamaya dayalı kavramlar göz önünde bulunduruluyordu. Oysa, akustik açıdan önemli mekanlarda biçimlendirilen ya da kendiliğinden oluşan işitsel ortam, insanın mekan algısının temel öğelerinden biridir. Bu yaklaşımdan yola çıkılarak, mimari miras kavramı son yıllarda akustiği de içine alacak biçimde genişletilmiştir. Eski yapıların akustiğinin dünya kültürel mirasının bir parçası olduğu, son on yılda yoğunlaşan interdisipliner çalışmaların da katkısıyla giderek daha geniş çevreler tarafından kabul edilmeye başlanmıştır. Avrupa Komisyonu 5. Çerçeve INCO-MED Programı kapsamında yürütülen CAHRISMA -Sinan Camilerinin Akustik Özelliklerinin Tanımlanması ve Yeniden Canlandırılması Yolu ile Akustik Mirasın Korunması- Araştırma Projesi (2000-2003), söz konusu kavramın yerleştirilmesinde öncü olmuştur. Aynı Çerçeve Programında yürütülmekte olan ERATO -Antik Tiyatro ve Odeonların Akustik Mirasının Belirlenmesi, Değerlendirilmesi ve Canlandırılması- Projesi (2003-2006) CAHRISMA Projesine benzer amaçlarla kurgulanmıştır. Her iki projede de, tarihi mekanların akustik ortamları öznel ve nesnel yöntemlerle belgelenmiş ve koruma alanında yeni bir yaklaşım olan “mekanların 3 boyutlu sanal ortamlarda işitsel-görsel simülasyonu” aracılığı ile korunması gerçekleştirilmiştir. Bu makalede, mimari koruma alanındaki kavramsal ve uygulamaya dönük yenilikler, ERATO Araştırma Projesi temel alınarak tanıtılmaktadır.

Anahtar kelimeler: Kültürel miras, Sanal koruma, Sanal restitüsyon, Mimari akustik, Antik tiyatro, Odeon,

Abstract

In the conservation and restoration of historical monuments, concepts related with visual sense were used to be taken into consideration. However, acoustical environment formed either spontaneously or consciously is one of the basic elements of human beings' perception of the architectural spaces having acoustical importance. Hence, architectural heritage concept has been broadened in recent years covering acoustics as well. The concept that acoustics of old buildings is part of cultural heritage is accepted more commonly by means of the interdisciplinary works done in the last decade. **CAHRISMA -Conservation of the Acoustical Heritage by the Revival and Identification of the Sinan's Mosques' Acoustics- Research Project** (2000-2003), carried out within the EC Fifth Framework INCO-MED Program pioneered implementing such a concept. **ERATO -Identification, Evaluation and Revival of the Acoustical Heritage of Ancient Theatres and Odea- Research Project** (2003-2006) hold at the same Framework Program, succeeds CAHRISMA Project with similar goals. In both projects acoustical environment of the spaces is documented by means of objective and subjective evaluations and an innovative way in conservation which is virtual conservation by the audio-visual reconstructions of spaces having acoustical importance in 3D virtual environments is provided. This article presents the conceptual and practical innovations created in the field of architectural conservation based on the ERATO Research Project.

Key words: Cultural heritage, Virtual conservation, Virtual restitution, Architectural acoustic, Antic theatre, Odeon,

1. Introduction

In some spaces such as concert-opera halls, theatres, religious buildings, where activities related to music and speech took place, acoustical perception is as much as and sometimes more important than visual

perception. Ancient places of performance, such as theatres, amphitheatres and circuses are among the very few monuments still - in some cases - serving the purpose for which they were originally designed. As ancient cultural landmarks, they form a heritage encompassing not only the monuments of Greco-Roman times

but also the history of the alterations made to them, the successive uses to which they were put and the cultural and artistic traditions associated with them [1]. Antic theaters and odea*, which are historical spaces being signified with their acoustical features, are the start point of nowadays culture of communal entertainment and attendance to music performance.

Regarding the architectural heritage, the Antic Greek and Roman theatres are among the most precious and spectacular items of the Mediterranean countries. Theatres and odea were the places where the public got together at the antic cities. Structures and functions of the antic Greek and Roman theatres are different; antic Greek theatres were generally religious places whereas Roman theatres were used for entertainment purposes. Being a part of the cultural heritage, they are therefore worth to be examined from acoustical aspects besides architectural features.

2. ERATO Project

Originated from the approaches mentioned in the introduction part, a research project entitled ERATO (Identification, Evaluation and Revival of the Acoustical Heritage of Ancient Theatres and Odea, 2003-2006) is implemented within the Fifth Framework European Commission INCO-MED Program. ERATO Project is designed in order to achieve acoustical and architectural heritage conservation and restitution of the selected examples of the Antic Greek and Roman theatre and odeon via audio-visual revival in 3D virtual environment. The virtual conservation and restitution aims to integrate the visual and acoustical simulations; so the revival of the related period's music, reproduction of the antic musical instruments, simulation of the moving sound sources are among the tasks besides acoustical and architectural works of the project. The development of the criteria for the modern use of antic theaters is also aimed in this project.

* Antic roofed theater; odeon (singular) and odea (plural).

ERATO Project is being realized by a consortium of seven entities from six countries. The team is constituted of acousticians, architects, restorators, musicians, computer graphic specialists in order to exemplify and illustrate the combined architectural heritage concept on a limited number of buildings. The participants are Technical University of Denmark-DTU (Denmark), Yıldız Technical University-YTU (Turkey), Hashemite University-HU (Jordan), Università degli Studi di Ferrara-UNIFE (Italy), AEDIFICE (France), Ecole Polytechnique Fédérale de Lausanne-EPFL (Switzerland) and University of Geneva-UNIGE (Switzerland).

The work is divided into nine work packages. List of the work packages and their lead contractors are given at the Table 1.

Table 1. Work packages of the Project and their lead contractors

WP No	WP Name	WP Lead Contractor
WP1	Project management	DTU
WP2	Taxonomy of theatres and odea	YTU
WP3	Music and performance	YTU
WP4	Acoustic measurements	UNIFE
WP5	Acoustic simulations	DTU
WP6	Visualizations of architecture and human beings	EPFL
WP7	Integrated acoustic and visual model	UNIGE
WP8	Relation between theatre, landscape and society	HU
WP9	Evaluation and dissemination	AEDIFICE

In order to decide sites to work on at the Project, information about the antic theaters are compiled from a broad geographical region of the Mediterranean Basin, where it is possible to see the application of the similar architectural design with a great success for a long period starting from approximately 6th Century BC coming up to nowadays. After the assessment of this compiled information on the important and well-known theaters and odea, typical samples from 1st and 2nd Centuries are selected to work on. Architectural and acoustical properties having importance to quote the ancient cultural

values to the future are considered in the selection criteria. Selected Theaters and odea are given in the Table 2.

Table 2. Historical buildings selected to work on at the ERATO Project

Theaters	Odea
Aspendos (Turkey, 2 nd Century A.D.)	Aphrodisias (Turkey, 1 st Century A.D.)
Jerash South (Jordan, 2 nd Century A.D.)	Aosta (Italy, 1 st Century A.D.)
Syracuse (Italy, 3 rd Century B.C.)	

Pictures of the selected buildings are given at Figures 1, 2, 3, 4 and 5.

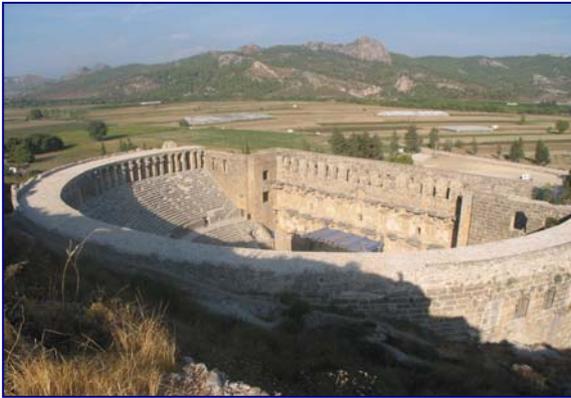


Figure 1. Aspendos Theater



Figure 2. Jerash South Theater



Figure 3. Syracuse Theater



Figure 4. Aphrodisias Odeon



Figure 5. Aosta Odeon

3. Virtual Conservation of Architectural – Acoustical Heritage

It is not always possible to illuminate architectural heritage by drawings and texts. By the developments of computer technology, it is now possible to recreate environments belonging to one of the different periods of the building in virtual reality and present it together with the artificial environment visualizing the cultural features of the related period [2]. Till nowadays these works were limited by visual

perception but now another dimension has been added to the architectural heritage concept, which is ‘acoustics’. As a result of the addition of this innovation to the virtual simulations, it is possible to combine vision and acoustics and create realistic virtual environments wherein the interiors could be seen, music could be heard or speeches could be listened as they were in the past.

In order to reach the aim of conserving the acoustical and architectural heritage of the selected buildings, a methodology, which was developed at the preceding research project CAHRISMA -carried out by the same consortium-, is used [3]. This methodology covers the phases given below:

- **Documentation**

- Architectural data
- Acoustical activities realized in the spaces
- Acoustical properties of the selected spaces

- **Simulation**

- Visual simulation
- Acoustical simulation
- Combined 3D real time simulation

- **Restitution**

- Visual and acoustical simulations of the spaces, suitable to their original uses at different periods.

4. Documentation

Documentation phase covers of collecting all architectural and acoustical data concerning the edifice to be conserved/restituted.

4.1. Documentation of the Architectural Data

Architectural data collection is carried out from literature and in situ; from the literature, the most recent results in history of architecture, archaeology, theater history are investigated and gathered. Architectural projects (plans and sections) of the selected spaces are obtained. Restitutions of the selected monuments made by different experts such as Lanckoronski, Texier, Izenour, Bernardi, are evaluated [4]. Restitutions of Aspendos Theatre made by

Lanckoronski and Bernardi are shown at the Figure 6.

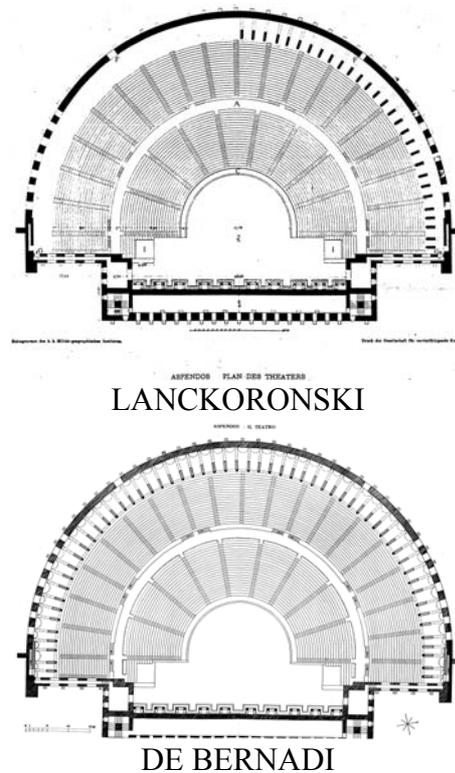


Figure 6. Restitutions of Aspendos made by Lanckoronski and De Bernardi.

Photographic and video recordings of the related spaces are taken. Color and light properties of surface materials and external daylight illuminances are measured in situ (Figure 7). Sun position and external daylight illuminances are calculated according to average sky model at the Aspendos Theatre and Aphrodisias Odeon.



Figure 7. Color measurement at the Aspendos Theater from Cavea (Lower section seating rows)

4.2. Documentation of the Acoustical Activities Performed in the Spaces

The optimum acoustical environment of a room is directly related to the type of the acoustical activity (speech and type of music) that will be performed in this space; a space appropriate for speech or a certain kind of music can be unsuitable for another kind of music. Therefore, in order to classify acoustical activities such as music or theater performances, data related to activities performed in the antic theaters and odea is gathered from history of architecture, archeology and history of music fields. Previous different musical investigations related to the subject are researched and sound recordings of examples from antic music samples recorded by different groups are reached [5, 6, 7].

Antic frescos and mosaics are also elements used at the source investigation (Figure 8).



Figure 8. A Pompeii wall mosaic showing aulos, cymbal and tympanon from Roman Period's musical instruments (Naples Archeological Museum) [8].

Ancient musical instruments pertaining to the period worked on are also examined and samples, one from each from four basic instrument groups (aerophone, cordophone, membranophone and idiophone), respectively aulos, kithara, tympanon and scabellum are designed and reproduced using original materials (Figure 9).



Figure 9. Antic period's musical instruments reproduced under the consultancy of Yıldız Technical University (from left to right; scabellum, aulos, tympanon, kithara).

Texts and poems to be used in the project are selected by taking into account criteria such as ease of performance and convenience to the period. Samples of the related period's music pieces are composed in scope of the project harmonious with the reproduced instruments and compositions are recorded in anechoic room and in situ using these reproduced instruments. Performance during the anechoic room recordings is seen in Figure 10. Recordings done in order to qualify original acoustic signals in the spaces will also lead to compose the data base for the auralizations and subjective evaluation of the spaces.



Figure 10. Performers during the anechoic recordings of antic music samples.

4.3. Documentation of the Acoustical Properties of the Spaces

In order to determine acoustical properties of the recent circumstances of the spaces, objective evaluations covering measurements and calculations are realized. Architectural acoustics' measurements at the selected spaces are realized by two different teams (DTU, UNIFE) in order to get comparable results,

according to ISO 3382 standards. Impulse responses recorded at the designated source-receiver positions provide data for monaural and binaural analysis of the sound field and acoustical parameters such as RT, T20, T30, EDT, ts, C80, D50, G, STI, LEF are measured [9, 10]. Reverberation time (T30) graphic of Aspendos Antic Theater, which acoustic parameters are measured in scope of the ERATO Project, is given as an example in Figure 11. According to the preliminary results, it is realized that although Aspendos Theater is an open space, it is almost suitable to the optimum acoustical conditions previewed for enclosed spaces.

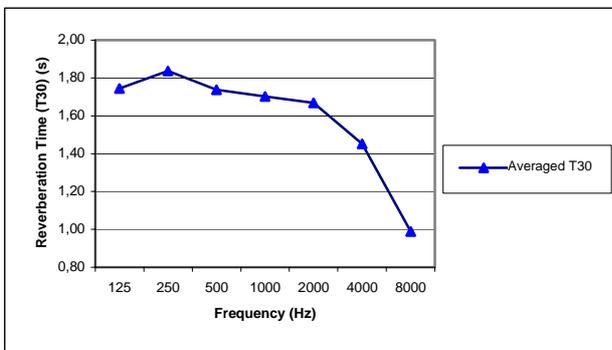


Figure 11. Averaged T_{30} values measured at Aspendos Theater [11].

5. Simulation

Virtual architectural spaces based on acoustical and visual realistic findings are contemporary scientific bridges unifying past to future. Data and findings obtained through the documentation works are aimed to provide the information necessary for combined acoustical and visual simulations for the realistic conservation of the architectural heritage.

5.1. Visual Simulation

3D models of the spaces selected at the ERATO Project are produced in 3D Max software for virtual visual simulations, using the data obtained from architectural drawings and visual recordings; new rendering and illumination techniques and a novel software are used for reconstruction of the monuments with maximum visual impact and a clear work

methodology, which can be applied for any digital reconstructing project [12]. Virtual human models are created in order to increase realism of the reconstructed spaces. A virtual crowd suitable to the scenario is also created with these models and is inserted into the 3D virtual real-time simulations of the buildings for recreating life inside architectural models (Fig. 12) [13].



Figure 12. Audience designed for Aphrodisias Odeon (EPFL)

5.2. Acoustical Simulation

Acoustical simulation softwares give the possibility both to the calculations of the acoustical parameters values in a certain position inside the space and auralizations** for definite source/receiver positions. As the modeling of the selected spaces is based on the architectural drawings, detailed complementary works are first realized on the project. Acoustical simulations of the spaces are realized by modeling in Odeon, a software used for auditorium acoustics. Acoustical parameters' values obtained from simulations are tested by comparing to the measurements' results.

Auralizations are one of the opportunities provided by the simulations. Auralizations for different occupancy- absorption circumstances, source-receiver positions can be obtained by using anechoic recordings and virtual acoustic models. By means of auralizations, program

** *Auralization is a term introduced to be used in analogy with visualization to describe rendering audible (imaginary) sound fields. Several modeling methods are available in architectural acoustics for this purpose. Together with new hardware implementations of signal processing routines, auralization forms the basis of a powerful new technology for room simulation and aural event generation [15].*

user could hear the sounds diffused from a designated source in a selected point of space, such as he/she is placed at the receiver position from a selected distance from the source (Project web site: <http://www.at.oersted.dtu.dk/~erato/index.htm>)

Auralizations realized based upon the detailed architectural and acoustical data, provide virtual conservation and revival of the space's acoustical environment by including sources suitable to its function and types of sounds. Auralizations achieved at the ERATO Project are used in visual simulations in order to obtain a realistic environment [14].

6. Restitutions

A benefit of virtual simulation of a space is the possibility of simulation of its different acoustical and visual properties after it was once formed in virtual environment. This fact gives the possibility of restitutions of the different periods. Spaces selected to work on at the ERATO Project will be modeled and conserved in virtual environment with their recent and ancient visual and acoustical properties via the superposition of visual and acoustical simulations. Whereas visual virtual modeling process of the Aspendos Theater is ongoing by EPFL and UNIGE teams, YTU team also modeled it in two configurations; recent state and covered with velum which may create significant differences in the acoustical field. The acoustical effect of the velum is being investigated by DTU. Virtual modeling of the Aspendos Theater and its velum is seen at the Figure 13.

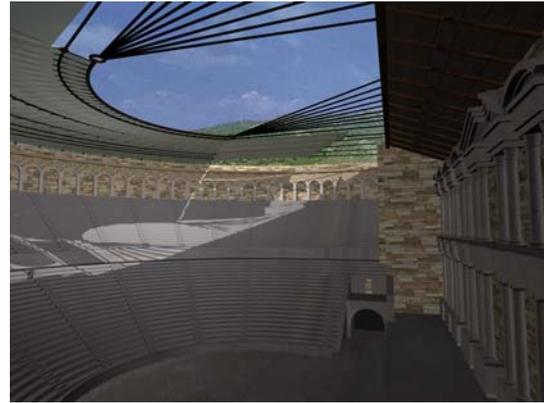


Figure 13. Virtual modeling of Aspendos Theater with and without velum [16].

3D OpenGL view of the detailed models of the Aspendos Theater (with stage and partly occupied by audience) and restitution are given at Figure 14.

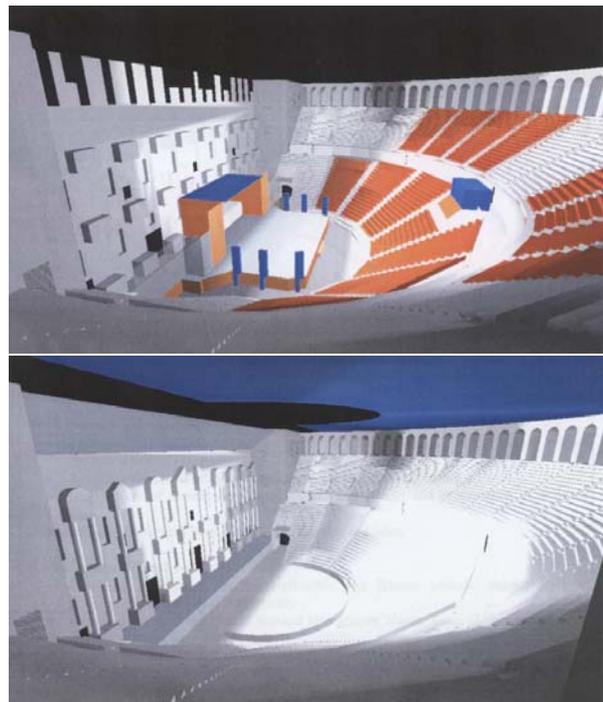


Figure 14. Odeon 3D OpenGL view of the detailed model of the Aspendos Theater with modern stage and partly occupied by an audience (above), restitution of its original state (below) [4].

7. Conclusion

Documentation of acoustical properties of historical places having acoustical function and virtual conservation of buildings covering their

visual and acoustical properties, are influential developments in order to enrich architectural heritage concept. This innovative approach approves also the notion mentioned at the Verona Charter which is “Today, the objective is to preserve a store of scientific information, manage the monuments in the perspective of development and where circumstances permit, infuse ancient sites once more with their full role of places of artistic creation, shared enjoyment and emotion [1]”.

Virtual conservations and restitutions realized for the selected spaces at the ERATO Project constitute an example for transferring recent and lost visual- acoustical properties from nowadays to the future. They can also be a medium to improve the interest to the archeological sites and easily be part of virtual architectural and/or archeological museums.

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