Carmen: A physical approach for Room Acoustic Enhancement System

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Abstract

It is very common that the acoustic of ancient performing halls or musical spaces cannot be improved by refurbishment works, because of the high cost or because of the registered building. Even for high standing performing halls, demand of multipurpose hall, which require variable acoustic, is also growing. A new Acoustic Enhancement System has been developed and experienced in several halls. The physical statements on which Carmen is based are presented, as well as objective and subjective assessment of the enhanced acoustic.

Introduction

Each type of music requires specific acoustic conditions characterised by several objective criteria such as the reverberation time. It is well known that the required reverberation time (RT) for opera is shorter than for symphonic music.

For practical and economical reasons, more and more concert halls plan performances that need variable acoustics in the auditoria impossible to achieve with a unique architectural design. The acoustic correction of architectural defaults is another reason for installing reverberation enhancement systems (RES).

There are two distinct types of RES: regenerative and non-regenerative systems [1]. In regenerative systems the reverberation enhancement is produced by the acoustic feedback between loudspeakers and microphones spread over the walls and ceiling of the hall.

Non-regenerative systems use microphones placed relatively close to the stage to lower the acoustic feedback from the system loudspeaker relative to the direct sound. Reverberation enhancement is created by electronic delays and reverberators. The most inconvenient side effect of this method is very often a change in the colouration of the hall.

The Active Virtual Wall Principle

Considering that the acoustics of a hall originate basically from the reflections of sound from the walls and ceiling, the virtual wall principle corresponds best to the desired behaviour, without introducing electronic reverberators.

The active virtual wall principle was first proposed by Guicking [2]. An acoustic virtual wall consists of several independent active cells, each one comprised of a microphone, an electronic unit, a power amplifier and a loudspeaker placed very close to the microphone (cf. Fig. 1). The acoustic feedback from the loudspeaker to the associated microphone is controlled acoustically and electronically.

To fulfil the virtual wall a high cell density is expected but in practice having only a few cells readily permits the desired effects. The system cells act as diffuse reflecting elements. Having only two opposite virtual walls and a virtual ceiling increases the natural reflectivity so that an enhanced reverberation builds up from acoustic energy exchanges between the virtual walls.

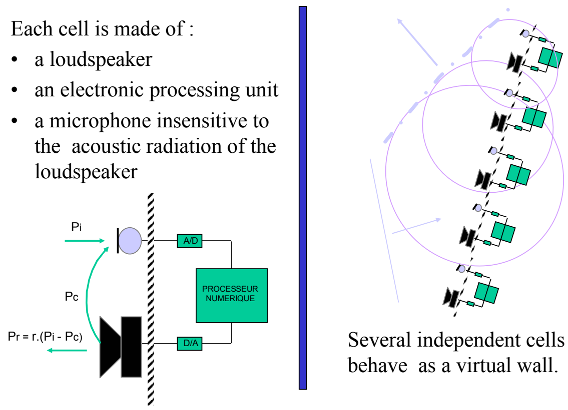

Figure 1: The Virtual Wall Principle

The Carmen System

The Carmen system has been developed based upon the virtual wall principle and is considered to be a regenerative system. The microphones are normally placed at a distance of 1m from the corresponding loudspeaker as characteristic for a "locally reacting system" [3].

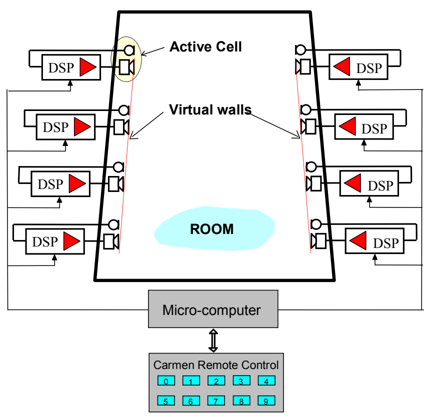

Figure 2: Carmen Block Diagram

Generally, the system is composed of 20 to 30 independent cells that are managed by a common controller (cf. Fig. 2). For acoustic corrections where no RT enhancement is needed, fewer cells are required. To achieve the desired acoustics, it is very important to choose carefully the cell positions in the hall in accordance with architectural conditions.

The possible RT increase is about 100% with 24 cells (cf. Fig. 3). Some spatial effects such as source broadening or higher envelopment by enhancing lateral reflections can be created. The characteristic of a “locally reacting system” is the space and time coherence preservation of the sound field. This produces a very natural sound field which is very important for musicians and listeners. The hearing localisation of the sound sources on stage is not influenced by the system.

Poor acoustics due to bad architecture, such as fan shaped halls or halls with very low ceilings, can be acoustically remodelled with the virtual walls so that for example some colorized contribution of the hall structure can be corrected.

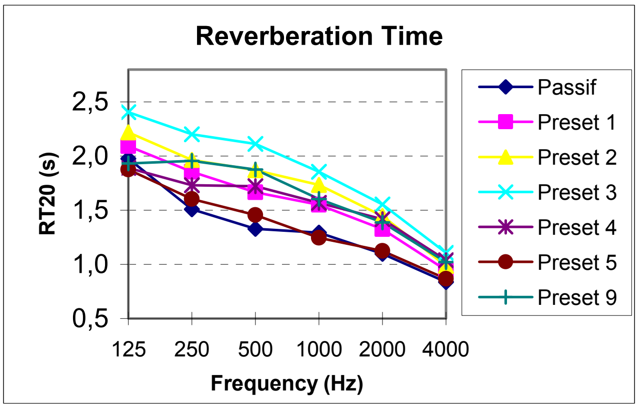

Figure 3: Reverberation time in a hall of 1200 seats

Installation parameters and results

Carmen has been available on the market since 1998. It has been installed and tested in more than 10 different halls. Six systems have been sold and it is currently used in 7 halls (one is moved every summer for a music festival).

The tuning of the system is quite easy; even though there are many parameters needed to be taken into account (cf. Fig. 4). They permit the adjustment of different configurations for performances. For example, for classical concerts with soloists, Carmen is generally tuned with a configuration with moderate RT and reinforced lateral reflections. To acoustically enlarge the hall some more delay is added and for more listener envelopment some gain introduced.

The system also provides a good methodology to solve the problem of seating located deep under the balconies of theatres used for concert performances. With cells located in the balcony soffit the enclosed sound becomes wider and richer because of additional contributions to the echogram that still respects the audio-visual impression coherence.

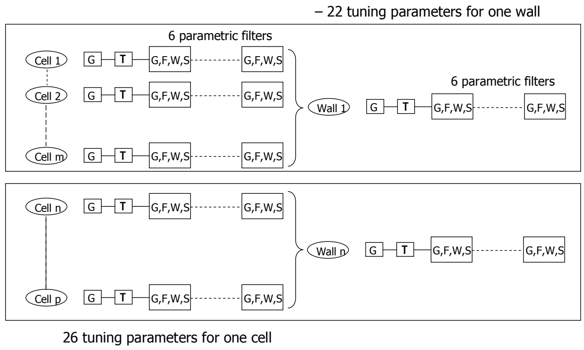

Figure 4: Carmen Tuning Parameters

Some subjective feedback

Generally scepticism from the musicians and conductors before the installation of a system is the biggest barrier. Once in place, the positive reactions from performers and listeners become the dominant feedback.

A survey was organized with a real orchestra and music professionals. The general impression was good with respect to the increased reverberance and brilliance. The presets with reinforced lateral reflections were preferred for concerts with soloists because of the enhanced envelopment. Presets with long RT and a high ceiling effect were preferred for romantic symphonies.

Summary

To answer the increasing demand for RES despite of the limitation of the classic systems, a locally reacting system based on the virtual wall principle has been developed. This system has no electronic reverberation and the acoustic enhancement is created by acoustic energy exchanges between different virtual walls. Some specific designs such as reinforced lateral reflections or broadening the volumes underneath balconies are possible.

References

[1] Kleiner, M. and Svenson, P. *Proceedings of ACTIVE95*, Newport Beach, CA, 39-54, 1995

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[3] Vuichard, O. and Meynial, X. *Acta Acoustica*, **86**, 853-859, (2000)