

# Chapter XVI

## DSP Techniques for Sound Enhancement of Old Recordings

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### **ABSTRACT**

This chapter addresses digital signal processing techniques for sound restoration and enhancement. The most common sound degradations found in audio recordings, such as thumps, pops, clicks, and hiss are characterized. Moreover, the most popular solutions for sound restoration are described, with emphasis on their practical applicability. Finally, critical views on the performance of currently available restoration algorithms are provided, along with discussions on new tendencies observed in the field.

### **INTRODUCTION**

#### **A Brief History of Recording Technology**

The history of recorded sound starts around 1877 when Thomas A. Edison demonstrated a tinfoil cylinder phonograph that was capable of recording and reproducing human voice for the first time. The following decades were marked by continuous attempts to find more accurate ways to record and reproduce sounds. It is possible to divide the sound recording history roughly into three eras. The acoustic era lasted until the mid-20s when means to record and reproduce sound via electro-mechanical transducers were launched. The electric era witnessed the emergence and development of magnetic tape as well as stereophonic recordings. It reigned until about the beginning of the eighties, when digital recordings

came about boosted by the finalization of the compact disc standard in 1980, being a direct consequence of the developments of electronic computers, in conjunction with the ability to record data onto magnetic or optical media.

Nowadays, digital audio technology is found in most consumer audio appliances. Its objectives range from improving the quality of modern and old recording/reproduction techniques to achieving an adequate balance between storage space or transmission capacity requirements and sound quality. A comprehensive timeline with descriptions of the most prominent events that marked the recording technology history is provided by Coleman (2004), Morton (2000), and Schoenherr (2005).

## **Aims and Processing Chain**

The primary purpose of digital audio restoration is to employ digital signal processing to improve the sound quality of old recordings. A conservative goal consists of eliminating only the audible spurious artifacts that either are introduced by recording and playback mechanisms or result from aging and wear of recorded media, while retaining as faithfully as possible the original recorded sound (Godsill & Rayner, 1998a). Less restricted approaches would allow more intrusive sound modifications, such as elimination of the audience noises and correction of performance mistakes. An even more audacious concept could target at overcoming the intrinsic limitations of the recording media in order to obtain a restored sound with better quality than the originally recorded one.

In any case, a typical audio restoration chain starts with capturing the sound from old matrices and transferring it to a digital form. This stage is crucial for a successful restoration job, since it is likely to substantially affect the final sonic quality of the results. Sound transfer can be a tricky task due to the usual lack of standardization associated with obsolete recording and playback systems. The process may involve searching for the original matrices or best sounding copies and choosing the best way to play back a given matrix. Such job includes finding the right reproducing apparatus in good condition, as well as dealing with diverse recording equalization curves, among other issues.

Prior to the digital era it was already common to transfer sound from old medium types to more modern ones, for instance from 78 RPM (revolutions per minute) to LP (long-playing) disks. Also frequently seen during the electric era were attempts to enhance the sound quality of the recordings by analog means, either within the sound transfer process or at the playback stage (Burwen, 1978; Craven & Gerzon, 1975; Kinzie, Jr. & Gravereaux, 1973). The advent of the digital era and the progressive increases in computation power of digital processors made it possible to employ more and more involved signal processing techniques to digitized audio data. As a consequence, nowadays, audio restoration is mostly carried out through customized DSP algorithms meant to suppress and reduce audible undesirable noises or distortions that are still present in the signal after the sound transfer. Still within the digital domain, the de-noised signal can be further processed if necessary, for example, equalized, prior to the final remastering, which concludes the audio restoration chain.

## **Typical Degradations**

Most of the undesirable noises found in old recordings can be roughly classified, for didactic reasons, between global and localized disturbances (Godsill & Rayner, 1998a). As these names suggest, global disturbances affect the signal as a whole, whereas localized noises corrupt only limited portions of the signal. Typical examples of global degradations are continuous background disturbances or interfer-

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