Low-cost and Low-complexity Optical Sound Restoration using Image and Sound Processing Techniques

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The worldwide movie collection includes a considerable amount of film copies that represent unique cultural samples of each era in which they were recorded. In contrast with the modern high-fidelity digital video and sound recording technologies that additionally offer unlimited playback times without data quality degradation, these old movie samples suffer from several playback distortion artifacts mainly induced by the playback mechanism itself, as well as the (usually improper) storing conditions. It is also a very common fact that only one copy of the above valuable video material is available. This renders the necessity of preserving it more demanding. Towards this aim, nowadays, the combination of analog data digitization techniques and the available digital audio/visual storage, processing and playback technologies represent one-way preservation solutions. Due to the large dynamic range of human hearing, when focusing on restoring the analog audio tracks optically printed on motion picture films, the above preservation procedure usually employs sophisticated algorithms and expensive dedicated hardware and high resolution digital equipment (such as a specially designed, high-resolution scanner). Aim of the current work is to introduce a methodology of digitizing optical printed sound from old tape recordings using common desktop equipment (such as a common scanner and a Personal Computer), as well as low-complexity audio signal processing techniques. More specifically, the proposed methodology includes a) the transformation of the optically-printed sound waveform to digital sound envelope data b) the conversion of the envelope data to 1-bit Pulse Width Modulated (PWM) coded samples that is applied for introducing the necessary high-frequency audio transitions and for enriching audio signal with additional frequency content and c) a typical FIR low-pass filtering stage producing the final high-resolution digital audio output. Moreover, a novel timing algorithm was also designed and employed for merging and synchronizing the successively scanned audio frames and deriving the necessary digital data clock information. During a sequence of tests performed using the above methodology, it was shown that the initial conversion of optical sound to envelope data reduces the resolution requirements of the scanning device employed. Typical results that will be provided in the full manuscript will typically include a) the overall restoration quality as a function of the scanning resolution employed and b) the direct, subjective comparison of the restored audio waveform versus the recordings obtained from the original films. The above results will be further used for defining the optimal scanning parameters values in terms of the final audio quality.