Digital Restoration of Moldy Aged Films (sap_0396)

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1 Introduction

Film is regarded as an important art form, often reflecting the culture from which it is stemmed. Films record our history, represent contemporary culture and have great artistic value. Thus, they are precious cultural assets. Unfortunately, because of aging, improper storage conditions and other reasons, old films are threaten with defects caused by decaying, dust, dirt, scratch and mold. Consequently, digital film restoration, repairing defects in films, has been recognized as an important issue by archives, content owners and film companies. This paper proposes a learning-based defect detection method and a flow-based defect repairing algorithm for greatly reducing manual efforts in film restoration. The main contributions include a novel example-based approach for defect detection and a restoration algorithm which can repair seriously damaged films.

2 Algorithm

As most restoration systems, we separate our restoration process into two stages: defect detection and video repairing.

Detection. We propose a novel learning-based method for automatic defect detection based on two observations. The defective parts often have intensity patterns distinguishing themselves from intact parts. In addition, defective parts often have less temporal coherence than intact parts.

As a first step, artists draw masks over the areas they regard as defective parts by hand on several frames. We then use AdaBoost [Viola and Jones 2004] to learn a classifier for automatic defect detection from these manually-annotated areas. Feature selection plays an essential part in AdaBoost. For each pixel, we first transform the intensity pattern of its 9×9 neighborhood into frequency domain. To account for the temporal incoherence in defective areas, we compute the differences between present frame and the images warped from two adjacent frames to the present frame, and to transform the differences to frequency domain in a same manner. Since intact parts can be well tracked by optical flows, the differences often exhibit low-frequency patterns. On the other hand, moldy parts often presents high-frequency components in the difference patterns. Thus, each pixel is associated with a 243d feature vector. AdaBoost is then employed for automatic feature selection.

Repairing. The aim of this stage is to coherently fill in the holes left by removing the defect areas. We repair the video using optical flows and a method similar to motion inpainting [Shiratori et al. 2006]. For filling defects in a frame, we find the optical flow between its previous and next frames. We assume that the motion can be well approximated by linear interpolation in such a short time. Hence, we simply fill in the holes by warping intact pixels from its two temporal neighbors using optical flows. Unfortunately, when the holes extend across multiple consecutive frames, the naive method does not work well. For such a case, we only copy warped pixels from intact parts, possibly only from one side. Certainly, only the outer areas of holes can be repaired more reliably. However, by repeating this process several times, more and more areas are filled up. By iteratively estimating optical flows and filling in the holes gradually from the outer to the inner, we can handle these difficult cases.

(a) Original frame (b) Repaired frame

Figure 1 Sample results from our digital restoration algorithm. On the left are the original defective frames (a) from a 1960's Taiwanese film, "Mistaken Love." Being kept in a humid condition, this film is seriously damaged by mold and dust. Applying our algorithm results in high-quality repaired frames (b).

3 Results

Figure 1 presents the restoration results for a 1960's Taiwanese black-and-white film, "Mistaken Love." This film is one of the early work in Taiwan's film history and is preserved by Chinese Taipei Film Archive (CTFA). Unfortunately, because of its bad storage condition, this film is seriously damaged by mold and dust as shown in Figure 1(a). Digimax Inc. was contracted with CTFA to repair this precious film. It was first digitalized to a sequence of 2048×1556 frames. Compared with other films to be repaired, the condition of this film is extremely bad as large areas are covered by mold. Thus, existing restoration software did not work well. It turned out that most restoration relied on artists' manual repair. As a result, on average, it took 8 hours to fix a 1-second segment with 24 frames. The cost is estimated to be around 100,000 USD for manually repairing a 5-min video. The repaired frames using our method are shown in Figure 1(b). The results may not be always perfect, and user adjustment and manual repairing are still required at times. However, overall, our method can greatly reduce the manual efforts and the cost. *(The results in the accompanied video were automatically generated without artist's retouching.)*

References

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